الهيئـــة السعوديـــة للمواصفـــات والمقاييـس والجــودة
Saudi Standards, Metrology and Quality Org (SASO)

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نماذج الصمام الثنائي الباعث للضوء (الليد)

لأغراض الإضاءة العامة – متطلبات الأداء

LED modules for general lighting - Performance requirements

ICS: 29.140.99

مقدمة

قامــت الهيئــة الســعودية للمواصــفات والمقــاييس والجــودة بتبنــي المواصــفة القياســية رقــم " IEC 62717/2014 " نماذج الصمام الثنائي الباعث للضوء (الليد) لأغراض الإضاءة العامة – متطلبات الأداء " والتي أصدرتها " الهيئة الدولية الكهرتقنية" وقد تم ترجمتها إلى اللغة العربية وذلك بواسطة الفريق الفني "الانارة وملحقاتها".

وقد اعتمدت هذه اللائحة الفنية السعودية دون إدخال أي تعديلات فنية عليها .

Foreword

Saudi Standards, Metrology and Quality Organization (SASO) has adopted Standard No. (IEC 62717/2014) "LED modules for general lighting - Performance requirements" issued by International Electrotechnical Commission which has been translated into Arabic by the technical team (lighting and accessories).

This standard has been approved as a Saudi Technical Regulation without any technical modifications.

CONTENTS

LED MODULES FOR GENERAL LIGHTING – PERFORMANCE REQUIREMENTS

1 Scope

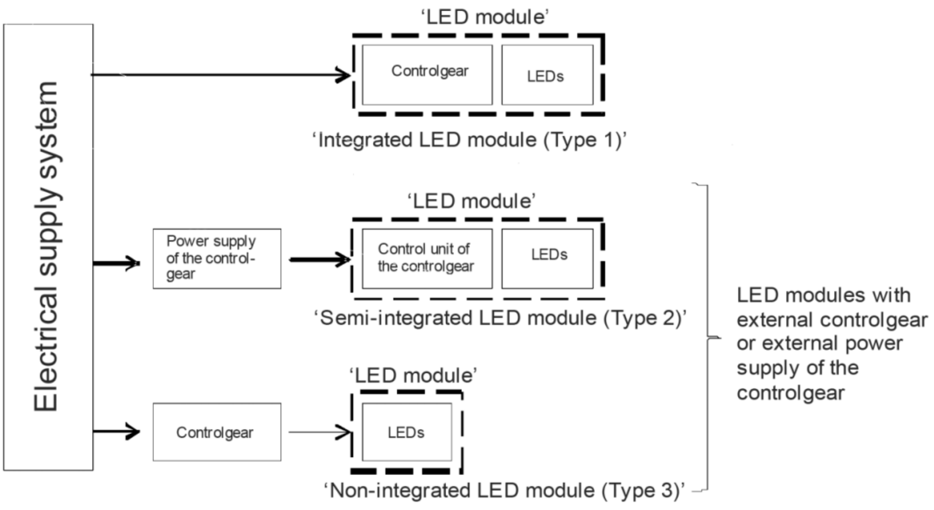
1.1 General

This International Standard 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 distinguished and schematically shown in Figure 1:

Type 1: integrated 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.

Type 2: LED modules operating with part of separate controlgear connected to the mains voltage, and having further control means inside ("semi-integrated") for operation under constant voltage, constant current or constant power.

Type 3: LED modules where the complete controlgear is separate from the module (non-integrated) for operation under constant voltage, constant current or constant power.



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

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

A LED module with separate controlgear can be either a non-ballasted LED module or a semi-ballasted LED module.

Figure 1 – Types of LED modules

The requirements of this standard relate only to type testing.

Recommendations for whole product testing or batch testing are under consideration.

This standard covers LED modules, based on inorganic LED technology that produces white light.

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, past an operational time as stated in 6.1, is out of the scope of this standard.

Instead of life time validation this standard has opted for lumen maintenance codes at a defined finite test time. Therefore, the code number does not imply a prediction of achievable life time. The categories, represented by the code, 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 pass/fail criterion 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 C.

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

The separate electronic controlgear for LED modules as mentioned in Type 2 and Type 3 is not part of the testing against the requirements of this standard.

Protection for water and dust ingress, see B.3.

1.2 Statement

It may be expected that integrated LED modules which comply with this standard will start and operate satisfactorily at voltages between 92 % and 106 % of rated supply voltage. LED modules with separate controlgear are expected to start and operate satisfactorily in combination with the specified controlgear complying with IEC 61347-2-13 and IEC 62384. All LED modules are expected to start and operate satisfactorily when operated under the conditions specified by the LED module manufacturer and in a luminaire complying with IEC 60598-1.

The requirements for individuals apply for 95 % of the population.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60050-845:1987, *International Electrotechnical Vocabulary – Chapter 845: Lighting*

IEC 60068-2-14, *Environmental testing – Part 2-14: Tests – Test N: Change of temperature*

IEC 60068-3-5:2001, *Environmental testing – Part 3-5: Supporting documentation and guidance – Confirmation of the performance of temperature chambers*

IEC 60081, *Double-capped fluorescent lamps – Performance specifications*

IEC 61000-3-2:2005[1], *Electromagnetic compatibility (EMC) – Part 3-2: Limits – Limits for harmonic current emissions (equipment input current ≤ 16 A per phase)*
IEC 61000-3-2:2005/AMD 1:2008
IEC 61000-3-2:2005/AMD 2:2009

IEC 61000-4-7, *Electromagnetic compatibility (EMC) – Part 4-7: Testing and measurement techniques – General guide on harmonics and interharmonics measurements and instrumentation, for power supply systems and equipment connected thereto*

IEC TR 61341, *Method of measurement of centre beam intensity and beam angle(s) of reflector lamps*

IEC 61347-2-13, *Lamp controlgear – Part 2-13: Particular requirements for d.c. or a.c. supplied electronic controlgear for LED modules*

IEC 62031:2008, *LED modules for general lighting – Safety specifications*

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

CIE 13.3:1995, *Method of measuring and specifying colour rendering properties of light sources*

CIE 121:1996, *The photometry and goniophotometry of luminaires*

CIE 177:2007, *Colour rendering of white LED light sources*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 62504 and IEC 60050-845, as well as the following apply.

3.1
test voltage, current or power
input voltage, current or power at which tests are carried out

Note 1 to entry: Specification of test voltage, current or power is given in A.2.

3.2
luminous flux maintenance factor
lumen maintenance factor
Unit: %

ratio, expressed as a percentage x, of the luminous flux emitted by the light source at a given time in its life to its initial luminous flux emitted

Note 1 to entry: The lumen maintenance factor of a LED light source includes optical parts degradation, the effect of decrease of the luminous flux output of the LED package and failure(s) of individual LED packages if the LED light source contains more than one LED package.

3.3
initial value
photometric and electrical characteristics at the end of the ageing period and stabilisation time

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[1] Third edition. This edition has been replaced in 2014 by IEC 61000-3-2:2014, *Electromagnetic compatibility (EMC) – Part 3-2: Limits – Limits for harmonic current emissions (equipment input current ≤ 16 A per phase).*

[SOURCE: IEC 62612:2013, 3.4, modified — The word 'colorimetric' and the note to entry have been deleted]

3.4
maintained value
photometric and electrical characteristic at an operational time under standard test conditions, including stabilisation time

Note 1 to entry: The test conditions are given in this standard.

3.5
parametric failure
luminous flux
failure of an operating LED module to produce luminous flux higher than or equal to the luminous flux relating to the lumen maintenance factor x

Note 1 to entry: For the purpose of this standard, the LED product is a LED module.

Note 2 to entry: For illustration of gradual failure mode, causing a parametric failure, see Figure C.1.

3.6
abrupt failure
failure of a LED product to operate or to produce luminous flux

Note 1 to entry: For the purpose of this standard, the LED product is a LED module.

Note 2 to entry: The term “complete failure” is commonly used for the same purpose.

Note 3 to entry: For illustration of abrupt failure mode, see Figure C.1.

3.7
median useful life (of LED modules)
life (of LED modules)
L_x
length of time during which 50% (B_{50}) of a population of operating LED modules of the same type have parametrically failed to provide at least percentage x of the initial luminous flux

Note 1 to entry: The median useful life includes operating LED modules only.

[SOURCE: IEC 60050-845:1987, 845-07-61, modified – new definition]

3.8
abrupt failure probability
$F(t)$
probability of an LED module, taken from a population of LED modules of the same type, to fail to operate after a given time, t

Note 1 to entry: $LSF(t) = 1 - F(t)$, LSF is Lamp Survival Factor, [CIE 097 modified].

3.9
abrupt failure value
AFV
percentile of LED modules failing to operate at median useful life, L_x

Note 1 to entry: $AFV = F(L_x) \times 100$ %; $LSF(L_x) = 1 - F(L_x)$

Note 2 to entry: Example: Given L_x=20 000 h and $AFV = F$(20 000 h) $\times$ 100 % = 7 % results in LSF(20 000 h) = 1 – 0,07 = 0,93.

3.10
time to abrupt failure
C_y
length of time during which y % of a population of initially operating LED modules of the same type fail to produce any luminous flux

Note 1 to entry: The time to abrupt failure includes inoperative LED modules only.

Note 2 to entry: $C_{\mathrm{AFV}} = L_{\mathrm{x}}$.

3.11
combined failure value
CFV
percentile of LED modules failing by either parametric or abrupt failure modes at median useful life, L_{x}

Note 1 to entry: $CFV = 50 + 0{,}5 \times AFV$

Note 2 to entry: Example: Given AFV = 15% results in $CFV = 50 + 0{,}5 \times 15 = 57{,}5\%$

3.12
combined life (of LED lamps)
$M_{\mathrm{x}}F_{\mathrm{y}}$
length of time during which y% (F_{y}) of a population of initially operating LED lamps of the same type failed by either parametric or abrupt failure modes

Note 1 to entry: The combined life (of LED lamps) includes operating and non-operating LED lamps.

3.13
median combined life (of LED lamps)
M_{x}
length of time during which 50 % (F_{50}) of a population of initially operating LED lamps of the same type have failed by either parametric or abrupt failure modes

Note 1 to entry: The median combined life (of LED lamps) includes operating and non-operating LED lamps.

3.14
photometric code[2]
colour designation of a LED module giving white light is defined by the Correlated Colour Temperature and the general colour rendering index

Note 1 to entry: The definition of photometric code is given in IEC 62504 as light colour designation.

3.15
t_{p}-point
the designated location of the point where to measure the performance temperatures t_{p} and $t_{\mathrm{p\ rated}}$ at the surface of the LED module

3.16
t_{p} temperature
temperature at the t_{p}-point, related to the performance of the LED module

Note 1 to entry: $t_{\mathrm{p}} \leq t_{\mathrm{c}}$. This is only the case if the location of t_{p} and t_{c} is the same. For t_{c}, see 3.10 of IEC 62031:2008.

Note 2 to entry: For a given life time, the t_{p} temperature is a fixed value, not a variable.

Note 3 to entry: There can be more than one t_{p}, depending on the lifetime claim.

2 Under consideration.

3.17
recommended maximum LED module operating temperature value
$t_{p\ rated}$
maximum operating temperature to which the rated performance characteristics are declared by the manufacturer or responsible vendor

Note 1 to entry: $t_{p\ rated} \le t_c$. This is only the case if the location of $t_{p\ rated}$ and t_c is the same. For t_c, see 3.10 of IEC 62031:2008.

3.18
LED die
block of semi-conducting material on which a given functional circuit is fabricated

Note 1 to entry: For a schematic built-up of a LED die, see Figure G.1.

3.19
displacement factor
expressed by cos φ_1, where φ_1 is the phase angle between the fundamental of the mains supply voltage and the fundamental of the mains current

3.20
scaleable LED module
LED module which is designed according to a certain design rule and can be expressed by the characteristics proportional to a specific geometrical dimension

Note 1 to entry: e.g. a linear LED module which is designed so that the consumed power per unit length is a constant value. In case of 10 W consumed power, the total luminous flux is 500 lm per 50 cm LED module length. In case of 20 W consumed power, the total luminous flux is 1 000 lm per 100 cm LED module length. LED modules are considered scaleable, if arranged on one reel or similar bigger unit.

3.21
family
group of LED modules that having the same characteristics and method of control (integrated, semi-integrated, non integrated), the groups are distinguished by common features of materials, components, and/or method of processing

4 Marking

4.1 Mandatory marking

Information on the parameters shown in Table 1 shall be provided by the manufacturer or responsible vendor and be located as described.

The information shall be related to the maximum performance operating temperature $t_{p\ rated}$, except for the t_p-point (item j), the dimensions (item n) and the availability of a heat sink (item o).

This information is in addition to the mandatory marking required by IEC 62031.

For scaleable modules, refer to 6.1 and mark the reference dimensions in the leaflet.

Table 1 – Mandatory marking and location of marking [1]

Parameters	LED module	Packaging	LED module datasheets, leaflets or website
a) Rated luminous flux (lm)	–	x[5]	x
b) Photometric code (See Annex D) [4]	–	x[5]	x
c) Rated median useful life (h) and the associated rated	–	-	x

Parameters	LED module	Packaging	LED module datasheets, leaflets or website
lumen maintenance factor (x)			
d) Rated abrupt failure value (%)	–	-	x
e) Lumen maintenance code (see Table 6)	–	–	x
f) Categories of rated chromaticity coordinate values both initial and maintained (see Table 5)	–	–	x
g) Correlated colour temperature (K)	–	–	x
h) Rated colour rendering index	-	–	x
i) $t_{p\ rated}$ [3] of LED module (°C)	x [2]	–	x
j) t_p-point	x [3]	–	x [3]
k) Ageing time (h), if different from 0 h	–	–	x
l) Ambient temperature range	–	–	x
m) Rated efficacy (lm/W)	–	–	x
n) Dimensions, including dimensional tolerances	–	–	x
o) Availability of a heat sink	–	–	x
s) Displacement factor	-	-	x
t) Temperature ramping			
1 K/min or	-	-	x
10 K/min	-	-	x

[1] Regional requirements may apply and overrule.

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

[3] In case t_p-point and t_c point are at the same position, then the t_p-point is not marked separately on the LED module, but given in the product datasheet. The marking of t_p-point can optionally be on the product or on the product datasheets/leaflets/websites.

[4] Under consideration.

[5] Marking according to a) and b) of Table 1 is not required on the packaging where the product is not delivered in an end-consumer packaging.

(x = required, – = not required)

4.2 Additional marking

For built-in and integral LED modules with or without heat management means, the relations between at least 3 temperatures at the t_p-point including the recommended $t_{p\ rated}$ according to Table 1 and each estimated life time may be provided by the manufacturer or responsible vendor. See Table 2 as an example.

For independent LED modules, the relations between at least 3 ambient temperatures including 25 °C and each estimated life time may be provided by the manufacturer or responsible vendor. See Table 2 as an example.

Table 2 – LED module life time information

t_p temperature (°C) measured at the t_p-point	XX [a]	XX [a]	XX [a]
Rated life time (h)	XX XXX[a]	XX XXX[a]	XX XXX[a]

[a] Values to be declared by the LED module manufacturer

Additional information from the LED module manufacturer to the tabled t_p temperatures and life time is allowed. For the chosen life time, t_p is a fixed value.

NOTE Verification is currently not covered by this standard.

In addition to 4.1, the marking as given in Table 3 may be used.

Table 3 – Optional marking and location of marking

Parameters	LED module	Packaging	LED module datasheets, leaflets or website
a) luminous intensity distribution	–	–	x
b) beam angle	–	–	x
c) peak intensity	–	–	x
(x = required, – = not required)			

5 Dimensions

All measured dimensions of a LED module in a sample shall be within the tolerances as declared by the manufacturer or responsible vendor.

Compliance is checked with suitable means of measurement.

6 Test conditions

6.1 General test conditions

The LED modules for which compliance with this standard is claimed shall comply with the requirements of the safety standard IEC 62031.

For compliance with EMC requirements except harmonics, reference is made to regional requirements. For relevant standards see Bibliography.

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.

Testing duration is 25 % of rated life time up to a maximum of 6 000 h.

NOTE Additional LED modules within the same family (see 3.21) can be subjected to decreased testing duration. Table 4 gives details regarding family identification while Table 7 gives details on sample sizes for family testing.

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

All tests are conducted on n LED modules of the same type. The number n shall be a minimum of products as given in Table 7. 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 separate reference power supply and separate reference control gear, respectively. Specification of the reference power supply and reference controlgear shall be made by the LED module manufacturer or responsible vendor.

LED modules with dimming control shall be adjusted to maximum light output for all tests.

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

LED modules which are scaleable, e.g. LED modules of linear geometry, but of very long length, shall be tested at a length of 50 cm or, if not scaleable there, at the nearest value to 50 cm. The LED module manufacturer shall indicate which controlgear is suitable for this length.

6.2 Creation of module families to reduce test effort

6.2.1 General

The introduction of a family aims to guide LED module manufacturers in platform designs to allow thereby the possibility to use data of the existing baseline product that has already been tested at an operational time as stated in 6.1. The baseline product is considered to be the first LED module complying with this standard and designated to be part of the family.

6.2.2 Variations within a family

Each family of LED modules requires a case-by-case consideration. The range of LED modules should be manufactured by the same manufacturer, under the same quality assurance system. The type variations of the range (e.g. CCT) should be essentially identical with respect to materials used, components and construction applied. Type test sample(s) should be selected with the cooperation of the manufacturer and the testing station.

Requirements for the identification of a family of LED modules for type testing are given in definition 3.21 and used in Table 4.

Testing time may be reduced within family for 1 000 h[3] in case variations within part characteristics are fulfilled with conditions given in Table 4. Critical components remain the same or the same technology is used and material with updated generation.

Table 4 – Allowed variations within a family

Part characteristics intended to be varied	Conditions for acceptance
Housing/chassis, heat sink/heat management	Temperature measurement point value of LED package (location and its value given by the LED module supplier) and other components remains at the same value or at a lower value, if the rated life time is the same or higher as the baseline product, as indicated and specified by the manufacturer or responsible vendor (see also NOTE 1).
Optics (see NOTE 2)	The test results showing the effect of optical material change shall be documented in the manufacturer’s technical file.
LED package	t_p remains at the same value or at a lower value, if the rated life time is the same or higher as the baseline product, as indicated and specified by the manufacturer or responsible vendor (see also NOTE 1)
Controlgear (Applicable for Type 1 or Type 2 LED modules)	t_p remains at the same value or at a lower value, if the rated life time is the same or higher as the baseline product, as indicated and specified by the manufacturer or responsible vendor. A statistical failure shall show equal or lower failures.

3 Value under consideration.

NOTE 1 The value of t_p can be used as long as the correlation between the temperature measurement value of LED and t_p is defined (process under consideration).

NOTE 2 Optics includes for instance secondary optics (lenses), reflectors, trims and gaskets and their interconnections. The results can relate to changes in luminous flux, luminous peak intensity, luminous intensity distribution, beam angle, shift in colour coordinates, shift in CCT (correlated colour temperature) and shift in CRI (colour rendering index).

Any change on part tolerances are documented in the manufacturer’s technical file.

6.2.3 Compliance testing of family members

The following performance characteristics of members within a family at initial and after reduced testing time shall be in line with the values provided by the responsible manufacturer or vendor of the LED module:

– chromaticity coordinates,
– colour rendering index,
– lumen maintenance code,
– results of acceleration operated life test.

Documentation of data shall be provided to the testing station in the manufacturer’s technical file.

Compliance:

For all of the tested LED modules in a sample, the measured values of a LED module (the initial and maintained value) shall not move beyond the values as indicated by the manufacturer or responsible vendor. The measured values shall be of the same category or code as the provided values or better. All the LED modules in a sample shall pass the test.

7 Electrical LED module input

7.1 LED module power

For measurement conditions, see Annex A.

Compliance:

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

The penultimate paragraph of 1.1 should be regarded.

7.2 Displacement factor (u.c.)

The displacement factor of integrated LED modules (Type 1) shall be measured according to Annex E. LED modules with dimming control shall be adjusted to maximum light output.

Displacement factor measurement of semi- and non-integrated LED modules (Type 2 and Type 3) is not applicable.

NOTE 1 See Annex F for explanation and relation of displacement factor, distortion factor and power factor.

NOTE 2 The distortion factor is covered by IEC 61000-3-2:2005/AMD 2:2009 which deals with the limitations of harmonic currents injected into the public supply system.

Compliance:

The measured displacement factor for each individual module of the sample shall not be less than the marked value by more than 0,05.

8 Light output

8.1 Luminous flux

Luminous flux is measured according to Annex A.

Compliance:

The initial luminous flux of each individual LED module in the measured sample shall not be less than the rated luminous flux by more than 10 %.

8.2 Luminous intensity distribution, peak intensity and beam angle

8.2.1 General

The requirements of 8.2.4 and 8.2.5 shall be applied to LED modules having a directional (spot) distribution.

NOTE Luminous intensity distribution of a LED module can be specific for an application.

8.2.2 Measurement

The intensity of light emitted from the LED module in different directions is measured using a goniophotometer. All photometric data shall be declared for the LED module operating at its temperature $t_{\mathrm{p\ rated}}$ per Clause A.1.

The allowed photometric variations detailed should take account of manufacturing tolerances.

8.2.3 Luminous intensity distribution

The distribution of luminous intensity shall be in accordance with that declared by the manufacturer. The measurement is conducted according to A.3.3.

Compliance is under consideration.

8.2.4 Peak intensity value[4]

Where a peak intensity value is provided by the manufacturer or responsible vendor, the initial peak intensity of each individual LED module in the measured sample shall not be less than 75 % of the rated intensity.

Compliance is checked according to Annex A.

8.2.5 Beam angle value[5]

Where a beam angle value is provided by the manufacturer or responsible vendor, the beam angle value of each individual LED module in the measured sample shall not deviate by more than 25 % of the rated value.

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4 Average value and confidence level are under consideration.

5 Average value and confidence level are under consideration.

Compliance is checked according to Annex A.

8.3 Luminous efficacy

LED module efficacy shall be calculated from the measured initial luminous flux of the individual LED module divided by the measured initial input power of the same individual LED module. For measurement of luminous flux, see A.3.2.

Compliance:

For all tested LED modules in a sample, the LED module efficacy shall not be less than 80% of the rated LED module efficacy as declared by the manufacturer or responsible vendor.

9 Chromaticity coordinates, correlated colour temperature (CCT) and colour rendering

9.1 Chromaticity coordinates

The initial chromaticity coordinates are measured. A second measurement of maintained chromaticity coordinates is made at an operational time as stated in 6.1. The measured chromaticity coordinate values (both initial and maintained) shall fit within one of 4 categories (see Table 5), which correspond to a particular MacAdams ellipse around the rated chromaticity coordinate value, whereby the size of the ellipse (expressed in n-steps) is a measure for the tolerance or deviation in the chromaticity coordinates of an individual LED module.

Compliance:

For compliance of family members, refer to 6.2.3.

For all of the tested LED modules in a sample, the measured chromaticity coordinate values of a LED module (the initial value and maintained value) shall correspond to categories of chromaticity coordinates which shall not move beyond the chromaticity coordinate tolerance category as indicated by the manufacturer or responsible vendor (see Table ٥). The measured values shall correspond to the same category as the rated values or better. The sample LED modules for the chromaticity coordinate measurement shall be selected from four different batches[6]*.*

Table 5 – Tolerance (categories) on rated chromaticity coordinate values

Size of MacAdam ellipse, centred on the rated colour target	Colour variation category	
	Initial	Maintained
3-step	3	3
5-step	5	5
7-step	7	7
>7-step ellipse	7+	7+

The behaviour of the chromaticity coordinates of a LED module shall be expressed by stating the two measurement results of both initial chromaticity coordinates and maintained chromaticity coordinates. For an example, see Annex D.

6 The colour variation between the LED modules in a sample from different production runs resembles the variation within longer periods of production.

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 target points are under consideration.

NOTE 1 The tolerance areas are based on the ellipses defined by MacAdam, published in the Journal of the Optical Society of America, 1943, as normally applied for fluorescent lamps and other discharge lamps.

NOTE 2 See Annex A for measurement method of chromaticity coordinate values for LED modules.

9.2 Correlated colour temperature (CCT)

Preferred values to ensure interchangeability are under consideration. The four-digit CCT value is divided by 100 and the resulting figure is rounded off to the next integer number, when using the photometric code in Annex D.

Compliance:

For compliance of family members, refer to 6.2.3.

For all of the tested LED modules in a sample, the measured correlated colour temperature shall not move beyond the values as declared by the manufacturer or responsible vendor.

9.3 Colour rendering index (CRI)

The initial colour rendering index (CRI) of a LED module is measured. A second measurement is made at an operational time as stated in 6.1.

Compliance:

For all tested LED modules in a sample the measured CRI values shall not have decreased by more than:

– *3 points from the rated CRI value (see Table 1) for initial CRI values, and*
– *5 points from the rated CRI value (see Table 1) for maintained CRI values.*

10 LED module life

10.1 General

Life of an individual LED module as explained in Annex C, is limited by a 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 as an indication for reliability and life). Both elements are tested.

Reference is made to the definitions of 3.2 and 3.7, the latter describing the Median Useful Life and indicated fraction (B_{50}) of tested LED modules of a sample that may fail the requirements of the tests under 10.2 and 10.3.

10.2 Lumen maintenance

The rated lumen maintenance factor may vary depending on the application of the LED module. Dedicated information on the chosen percentage should be provided by the manufacturer.

NOTE 1 As the typical life of a LED module is (very) long, it is within the scope of this standard regarded impractical 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 code of any LED module.

NOTE 2 The actual lumen maintenance of LED modules can 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.

NOTE 3 Other methods providing more advanced insight in lumen depreciation over LED module life are under consideration.

This standard has opted for "lumen maintenance codes" (see Figure 2) that cover the initial decrease in lumen output until an operational time as stated in 6.1. There are three codes which define lumen maintenance in percent of the initial luminous flux (see Table 6).

Table 6 – Lumen maintenance code at an operational time as stated in 6.1

Lumen maintenance %	**Code**
≥ 90	9
≥ 80	8
≥ 70	7

The initial luminous flux shall be measured. The measurement is repeated at an operational time as stated in 6.1. The initial luminous flux value is normalized to 100 %; it is used as the first data point for determining LED module life. The measured luminous flux value at an operational time as stated in 6.1 shall be expressed as maintained value (= percentage of the initial value).

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 an operational time as stated in 6.1.

NOTE 4 ‹-this will give an additional insight as to the reliability of the measured values, but assigning a code does not imply a prediction of achievable life time. LED modules with higher code could be better or worse than LED modules with lower code.

For marking of the lumen maintenance factor (x) and the lumen maintenance codes, see Table 1.

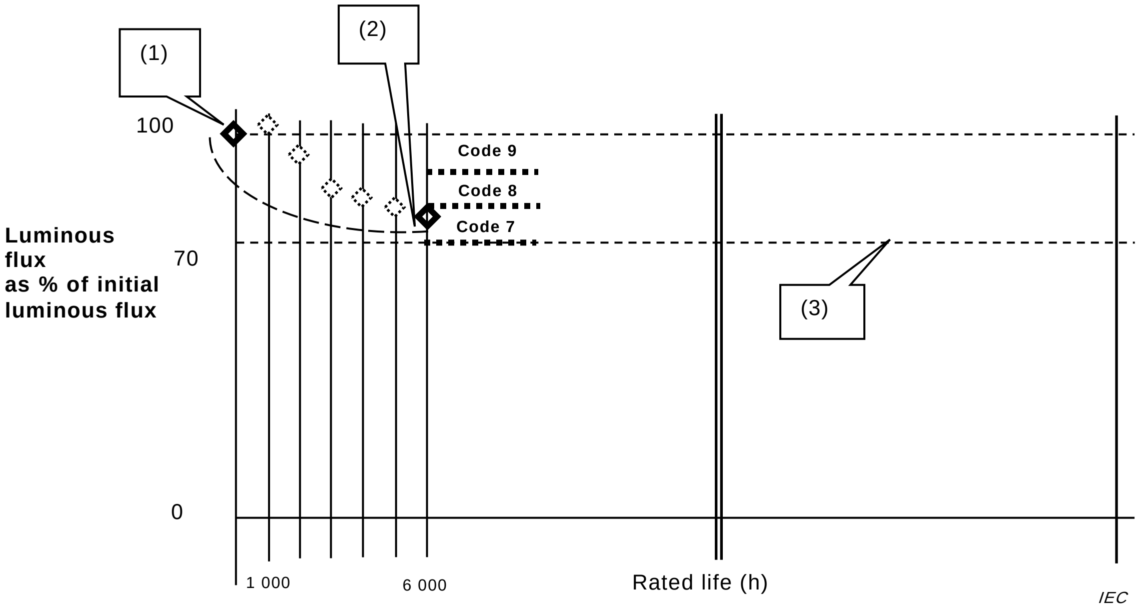
Compliance at 25 % of rated life with a maximum of 6 000 h test duration:

For compliance of family members, refer to 6.2.3.

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

1) *The measured luminous flux value at 25 % of rated life (with a maximum duration of 6 000 h) shall not be less than the luminous flux, multiplied by the rated lumen maintenance factor (x).*
2) *The calculated lumen maintenance being the ratio of the measured initial and maintained luminous flux shall correspond with the "lumen maintenance code" as declared by the manufacturer or responsible vendor.*

Given a sample of n of LED modules according to Table 7 being subjected to the 25 % of rated lifetime test with a maximum of 6 000 h, it is deemed to having passed the test, if at the end of the test, at least 90 % of the LED modules have passed.



Key

(1) Initial luminous flux

(2) Measured luminous flux value at an operational time as stated in 6.1

(3) Lower limit line: claimed flux decrease over rated life L_{70}

Figure 2 – Luminous flux depreciation over test time

10.3 Endurance tests

10.3.1 General

LED modules shall be subjected to the following tests specified in 10.3.2 to 10.3.4.

NOTE All tests can be carried out in parallel with different LED modules.

10.3.2 Temperature cycling test

10.3.2.1 General

The temperature cycling test shall be conducted according IEC 60068-2-14, Test Nb: Change of temperature with specified rate of change, and the following conditions. Either of the alternative tests 10.3.2.2 and 10.3.2.3 may be chosen.

10.3.2.2 Alternative test 1 with 10 K/min

10.3.2.2.1 Test set up

The LED module shall be mounted on an appropriate heat sink and operated in the test chamber according IEC 60068-3-5 and with settings for t_p as requested by this standard, at nominal current respectively at test voltage. The heat sink shall be such that after thermal stabilisation, the LED module is operating at its maximum rated t_p temperature (± 10 K) (according to Table 2) in a test chamber temperature of 40 °C ± 10 °C. The test chamber temperature at which t_p is reached is the maximum ambient temperature of the temperature cycle. The minimum ambient temperature is obtained by subtracting 50 K from this temperature. These two temperatures are used for the temperature cycle.

When the manufacturer declares in his literature a temperature range with minimum and maximum temperatures, these values shall be used.

The test shall consist of 250 cycles.

10.3.2.2.2 Test procedure

1) From the stable condition of the LED module operating at its maximum ambient temperature (evaluated in 10.3.2.2) the LED module shall be switched off and the ambient temperature inside the test chamber shall be decreased at a rate of 10 K/min to the minimum test temperature.
2) The switched off LED module shall be held at the minimum ambient temperature level for 50 min. After this period the LED module shall be switched on and off at the low ambient temperature 10 times with the cycle 10 s ON / 50 s OFF.
3) Switch on the module.
4) Increase the temperature in the test chamber at a rate of 10 K/min to the maximum ambient test chamber temperature.
5) The switched on LED module shall be held at the maximum ambient temperature level for 50 min. After this period the LED module shall be switched on and off at the high ambient temperature 10 times with the cycle 10 s ON / 50 s OFF.
6) Repeat steps 1) to 5), 249 times.

Compliance:

At the end of the test all the LED modules shall operate and have a luminous flux which stays within the claimed lumen maintenance code for a period of at least 15 min and show no physical effects of temperature cycling such as cracks or delaminating of the label.

The temperature requirements of A.1 do not apply.

10.3.2.3 Alternative test 2 with 1 K/min

The LED module is placed in a test chamber in which the temperature is varied from –10 °C to +50 °C[7] over a 4 h period and for a test duration of 250[8] periods (1 000 h).

The LED module is mounted on an appropriate heat sink to reach its maximum rated t_p temperature at +50°C test chamber temperature.

A 4 h period consists of 1 h holding on each extreme temperature and 1 h transfer time (1 K/min) between the temperature extremes. The LED module is switched on and off for 17 min.

Compliance is checked as follows:

At the end of the test, all the LED modules shall operate and have a luminous flux which stays within the claimed lumen maintenance code for a period of at least 15 min and show no physical effects of temperature cycling such as cracks or delaminating of the label.

NOTE 1 The switching period of 34 min is chosen to get a phase shift between temperature and switching period.

NOTE 2 The temperature requirements of A.1 do not apply.

NOTE 3 LED modules without or with integrated heatsink maybe do not reach the maximum rated t_p temperature at +50 °C test chamber temperature.

---

7 Under consideration. When the manufacturer declares in his literature a temperature range with minimum and maximum temperatures, these values should be used.

8 Under consideration.

10.3.3 Supply switching test

At test voltage, current or power, the LED module shall be switched on and off for 30 s each. The cycling shall be repeated for a number equal to half the rated life in h (example: 10 000 cycles if rated life is 20 000 h.).

The temperature requirements of A.1 apply.

Compliance:

At the end of the test all the LED modules shall operate and have a luminous flux which stays within the claimed lumen maintenance code for a period of at least 15 min.

10.3.4 Accelerated operation life test

The LED module shall be operated continuously without switching at test voltage and at a temperature corresponding to 10 K (see last paragraph) above the maximum recommended operating temperature $t_{p\ rated}$, over an operational time of 1 000 h. Any thermal protecting devices that would switch off the LED module or reduces the light output at a threshold temperature $> t_{p\ rated}$, shall be bypassed.

Compliance:

For compliance of family members, refer to 6.2.3.

At the end of this period, and after cooling down to room temperature and being stabilised, all the LED modules have an allowed decrease of light output at the end of the test of max. 20 % compared to the initial value, for at least 15 min.

The temperature requirements of A.1 do not apply.

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 $t_{p\ rated}$ would lead to chemical or physical effects from which no conclusion on real life can be made.

LED module manufacturer or responsible vendor may declare higher temperature above $t_{p\ rated}$ as indicated, but the precedent paragraph shall be respected.

NOTE This test is to check for catastrophic failures.

11 Verification

The minimum sampling size for type testing shall be as given in Table 7. The sample shall be representative of a manufacturer's production.

Table 7 – Sample sizes

<table>
<tr><th>1</th><th>2</th><th>3</th><th>4</th></tr>
<tr><th>Clause or subclause</th><th>Test</th><th>Minimum number of LED modules in a sample for an operational time as stated in 6.1</th><th>Minimum number of LED modules in a sample for testing a family at reduced test duration after changing product feature according to 6.2</th></tr>
<tr><td>4.1 i)</td><td>$t_{p\ rated}$</td><td rowspan="3">Same 1 LED module for all tests</td><td rowspan="6">Same 1 LED module for all tests</td></tr>
<tr><td>4.1 j)</td><td>t_p-point</td></tr>
<tr><td>5</td><td>Dimensions including dimensional tolerances</td></tr>
<tr><td>8.2.3</td><td>Luminous intensity distribution</td><td rowspan="3">Same 5 LED modules for all tests</td></tr>
<tr><td>8.2.4</td><td>Peak intensity value</td></tr>
<tr><td>8.2.5</td><td>Beam angle value</td></tr>
<tr><td>7</td><td>Power</td><td rowspan="7">Same 10 LED modules for all tests</td><td rowspan="7">Same 3 LED modules for all tests</td></tr>
<tr><td>8.1</td><td>Luminous flux</td></tr>
<tr><td>8.3</td><td>Efficacy</td></tr>
<tr><td>9.1</td><td>Chromaticity coordinates</td></tr>
<tr><td>9.2</td><td>Correlated colour temperature</td></tr>
<tr><td>9.3</td><td>Colour Rendering Index</td></tr>
<tr><td>10.2</td><td>Lumen maintenance</td></tr>
<tr><td>10.3.2</td><td>Temperature cycling, energised</td><td>5</td><td>3</td></tr>
<tr><td>10.3.3</td><td>Supply voltage switching</td><td>5</td><td>3</td></tr>
<tr><td>10.3.4</td><td>Accelerated operation life test</td><td>5</td><td>3</td></tr>
</table>

12 Information for luminaire design

For information for luminaire design, see Annex B.

Annex A
(normative)

Method of measuring LED module characteristics

A.1 General

Unless otherwise specified, all measurements shall be made in a draught free room at a temperature of 25 °C with a tolerance of ±1 °C, a relative humidity of 65 % maximum and steady state operation of the LED module.

For air movement requirements, see 4.3.2 of CIE 121:1996.

For temperature measurement, equipment as specified in the informative Annex H may be used.

Maintenance (10.2) and supply switching (10.3.3) operation shall be conducted in the temperature interval ($t_{\mathrm{p\ rated}}$ – 5, $t_{\mathrm{p\ rated}}$) at a rated maximum ambient temperature specified by the manufacturer, with a tolerance of (+0 K, –5 K). In case there is no rated maximum ambient temperature, the ambient temperature range (20 °C to 25 °C) shall be used. For the supply switching test, the temperature requirement is applicable only to the ON time. The value of $t_{\mathrm{p\ rated}}$ shall not be exceeded. An appropriate heat sink or additional heating may need to be applied to obtain the correct $t_{\mathrm{p\ rated}}$ value. For testing purposes, the t_{p}-point shall be marked easily accessible. Even if the location is different for t_{p} and t_{c}, the value of t_{c} shall not be exceeded.

All test results shall be presented as if testing had been executed at the maximum recommended operating temperature ($t_{\mathrm{p\ rated}}$) of the LED module. Tests may be performed at different temperatures; for this, the relation between the two temperatures ($t_{\mathrm{p\ rated}}$ and a different t_{p} where this t_{p} shall be within the range of manufacturer's provided data) has to be established beforehand in an unambiguous manner by data provided by the LED module manufacturer. In case of doubt the reference measurement is performed at $t_{\mathrm{p\ rated}}$. Depending on the type of control circuit that the LED module manufacturer is using, the t_{p} measurement shall be done at the most onerous condition of operation. The value of $t_{\mathrm{p\ rated}}$ shall be reported in Clause 4.

The manufacturer shall provide, on request, information on the method used to reproduce the claimed characteristics declared at t_{p}-point.

The test voltage, current or power shall be stable within ± 0,5 % during stabilisation periods, this tolerance being ± 0,2 % at the moment of measurements. For ageing and luminous flux maintenance testing the tolerance is 2 %. The total harmonic content of the input shall not exceed 3 %. The harmonic content is defined as the r.m.s. summation of the individual harmonic components using the fundamental as 100 %. All tests shall be carried out at rated frequency. In the case of a range, measurements shall be carried out at the frequency value corresponding to the most adverse effect on the temperature of the LED module.

For stabilisation, the following steps need to be conducted.

1) Ascertain that the LED module has thermal management, either integrated or externally equipped.
2) Operate the LED module and record the light output as a time depending variable and note the typical electrical mode of operation (by voltage, current or power)
3) During stabilisation period, measurements of light output are made at least at 1 min intervals. The LED module under test may be regarded as stable and suitable for test

purpose, if the difference of maximum and minimum readings of light output observed over the last 15 min is less than 0,5 % .

If stabilisation conditions are not achieved within 45 min the measurement may be started and the observed fluctuations shall be reported.

4) In order to accelerate subsequent measurements of other LED modules of the same type a pre-stabilisation (operation of the light source prior to mounting in the test system) may be applied on basis of the stabilisation time observed in step 3 and subsequent LED modules may be measured after 15 min in the test system.

NOTE 1 normally the observed stabilisation process is a slow decrease in light output until thermal stability. However, due to the electronics, fluctuations can still occur near thermal stability and stabilisation criteria not met.

NOTE 2 the conditions of stabilisation are subject to change due to the establishing of a relevant CIE standard.

Unless otherwise specified for a specific purpose by the manufacturer or responsible vendor, LED 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, current or power

The test voltage, current or power shall be the rated voltage, current or power (for tolerance see A.1). In the case of a range, measurements shall be carried out at the input value corresponding to the most adverse effect on the temperature of the LED module.

A.2.2 Ageing

LED modules do not require any ageing prior to testing. However, the manufacturer may define an ageing period of up to 500 h.

A.3 Photometric characteristics

A.3.1 Test voltage, current or power

See A.2.1.

A.3.2 Luminous flux

The initial and maintained luminous flux shall be measured after stabilisation of the LED module.

NOTE 1 Method of measuring the luminous flux of LED modules is under consideration.

NOTE 2 Reference is made to document CIE 84. IES LM-79-08 as well as Annex B of JIS C 8155:2010 contain valuable information on measuring luminous flux.

If the LED module requires additional heating or heat sinking, provisions in the measurement setup should be taken to maintain the requested temperature at t_p. The manufacturer should provide, on request, information on the method used to reproduce the claimed characteristics declared at t_p.

A.3.3 Luminous intensity distribution

Luminous intensity distribution shall be measured in accordance with CIE 121 and IEC TR 61341.

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 international or regional format. Information about file formats can be found in IEC 62722-1, Annex A, for informative (not normative) purposes.

Information about photometric data and file formats can be found in IEC 62722-1 (in preparation), Clause 6 and Annex A, for informative (not normative) purposes.

A.3.4 Peak intensity

The peak intensity shall be measured in accordance with IEC TR 61341.

A.3.5 Beam angle

The beam angle shall be measured in accordance with IEC TR 61341.

It should be taken care that the beam angle is not determined by the half peak, but by the half centre beam intensity.

A.3.6 Colour rendering

Measurement of colour rendering index shall be made in accordance to CIE 13.3 and CIE 177.

A.3.7 Chromaticity coordinate values

Reference shall be made to IEC 60081, Annex D: Chromaticity coordinates.

Chromaticity coordinate values of LED modules may depend on the radiation angle. Spatially averaged chromaticity coordinates shall be used, unless otherwise specified by the manufacturer. This may be accomplished by sphere photometry or other declared means.

Annex B
(informative)

Information for luminaire design

B.1 Temperature stability

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

B.2 Binning procedure of white colour LEDs

See IEC 62707-1.

B.3 Ingress protection

In case a ‘built-in’ LED module forms part of the luminaire enclosure and is applied in an application with a certain IP classification the LED module specification shall reflect this. Final assessment will be done on the luminaire.

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

An “independent” classified LED module should be tested to the specified IP rating according to IEC 60598-1.

LED modules, classified as “‘integral” should not be separately tested.

Annex C
(informative)

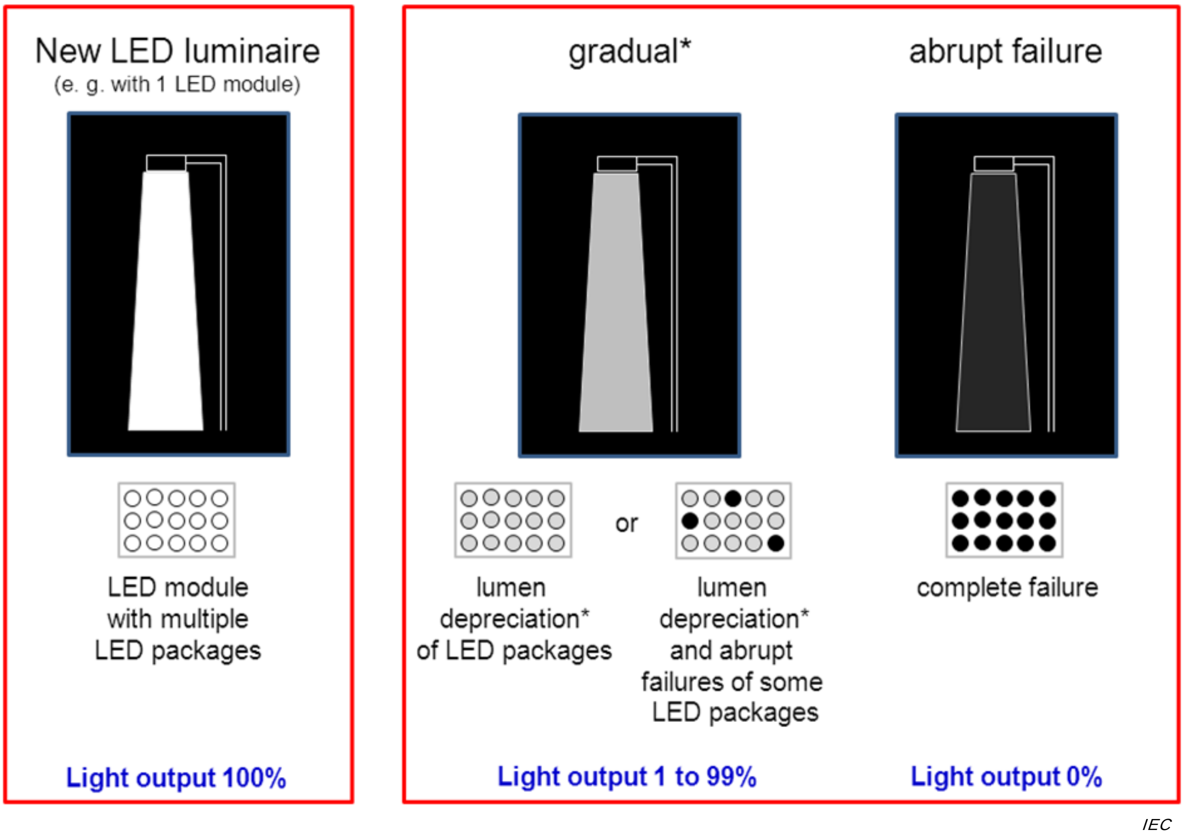
Explanation of recommended LED product lifetime metrics

C.1 General

Life of an individual LED module is the length of time during which an individual LED module provides at least percentage *x* of the initial luminous flux, under standard test conditions. The end of life of an individual LED module can be reached by both parametric and abrupt failures (operating and inoperative LED modules).

NOTE For better readability, the term LED product is used which has to be considered as LED based lighting product.

An abrupt failure of a LED module is a failure of the entire module and not necessarily a failure of single LED packages. A failure of single LED packages in a LED module with multiple packages usually contributes to overall gradual light output degradation of that LED module. At the time the light output of the LED module becomes less than claimed percentage *x* it is considered a parametric failure of the LED module. Figure C.1 gives an illustration of gradual and abrupt failure modes, causing parametric and abrupt failures, in a luminaire comprised of a single LED module.



* Overall lumen depreciation includes also optical parts degradation of the LED luminaire; gradual lumen depreciation below *x* percent leads to a parametric failure.

Figure C.1 – Lumen output over life of a LED-based luminaire comprised of a single LED module

Life time of LED products 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 standard has opted for lumen maintenance codes that cover the decrease in luminous flux until an operational time as stated in 6.1. Due to this limited test time the claimed life of a LED product cannot be confirmed nor rejected. The recommended metrics for specifying LED product life is explained below and provides the background for the pass/fail criterion of the lifetime test as in 10.2.

It is recommended for LED products to specify the lumen maintenance apart from the abrupt failures in a standardised way giving more insight in light output behaviour.

C.2 Life time specification for gradual light output degradation

The length of time until a percentage y of a population of operating LED modules reaches gradual light output degradation of a percentage x is called the useful life (or "B_y life") and expressed in general as L_xB_y.

When light output lower than the lumen maintenance factor x is called a parametric failure because the product produces less light but still operates. "B_{10}" life is the age at which 10 % of products have failed parametrically. The age at which 50 % of the LED modules parametric fail, the "B_{50} life", is called median useful life. The population includes operating LED modules only; non-operative modules are excluded.

Example: L_xB_y = $L_{70}B_{10}$ is understood as the length of time during which 10 % (B_{10}) of a population of operating LED modules of the same type have failed (parametrically) to maintain 70 % of their initial luminous flux.

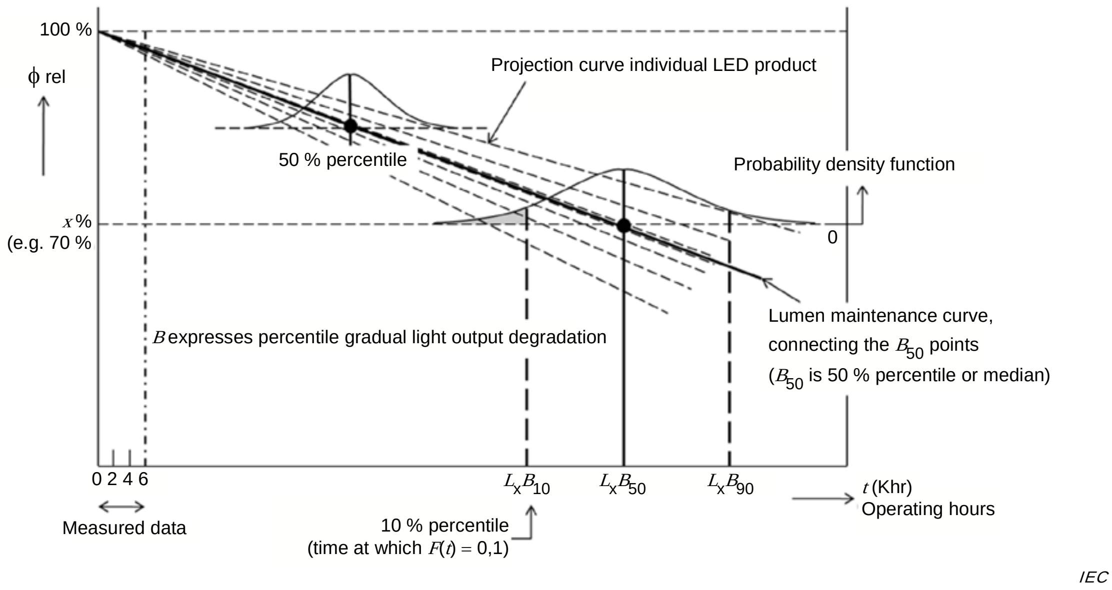


Figure C.2 – Life time specification for gradual light output degradation

The shape of the probability density function (*pdf*) and the shape of the projection curve in Figure C.2 are for illustration purpose only. The probability density function can be Weibull, lognormal, exponential or normal depending on the measured data and selected 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 $F(t\text{=infinite})$ is 1 (100 %). In other words the total area below the pdf curve from time is zero to infinity is one, meaning the whole population fails eventually.

Explanation of B:

Example: Considering a lumen maintenance factor x of 70 %, 10 % of the population failed at time $L_{70}B_{10}$ indicated by the grey area in Figure C.2, 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.

C.3 Lifetime specification for abrupt light output degradation

The length of time until a percentage y of a population of LED modules reaches abrupt light output degradation of a percentage y is called the time to abrupt failure and expressed as C_y. The time to abrupt failure (or "C life") expresses the age at which a given percentage, y, of LED modules have failed abruptly. See Figure C.3.

Example: C_{10} is understood as the length of time during which 10 % of the population of initially operating LED modules of the same type fail to produce any luminous flux at all.

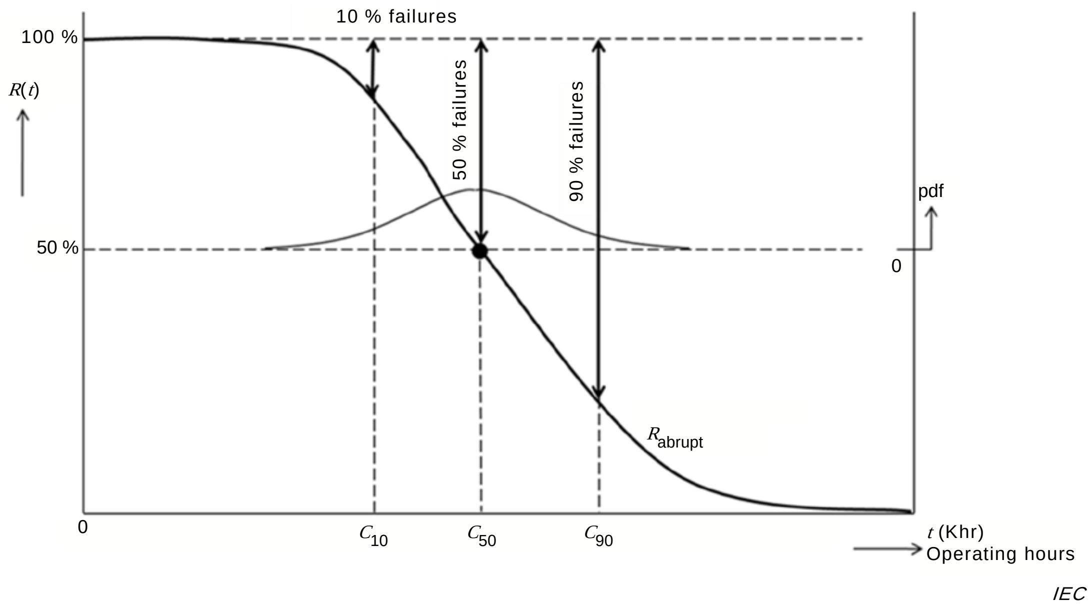


Figure C.3 – Reliability curve R_{abrupt} for abrupt light output degradation

C.4 Combined gradual and abrupt light output degradation

The length of time until a percentage y of a population of LED lamps reaches combined gradual and abrupt light output degradation, meaning the LED lamps have either parametrically failed, no longer producing at least x % of their initial luminous flux, or abruptly failed, is called the LED Lamp Life (or "F_y life") and expressed as M_xF_y.

For example: $M_xF_y = L_{70}F_{10}$ is understood as the length of time during which 10 % (F_{10}) of a population of LED lamps of the same type have failed by either parametric or abrupt failure modes (producing less than 70% of their initial luminous flux or no luminous flux).

The "F_{50} life", is defined as the median LED lamp life and called M_x.

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

Step 1: Reliability curve for parametric failures due to gradual light output degradation (see Figure C.4).

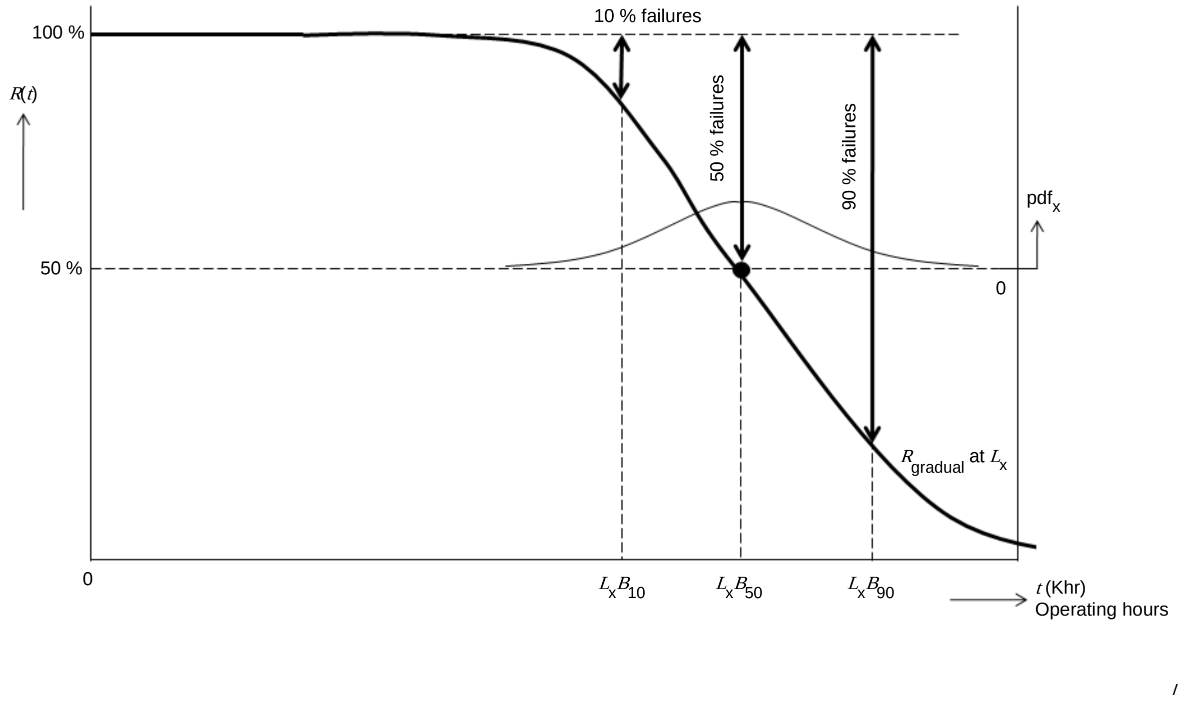


Figure C.4 – Reliability curve R_{gradual} for gradual light output degradation

Step 2: Reliability curve for abrupt light output degradation (see Figure C.3).

The reliability curve in Figure C.3 expresses also the survivals of the LED products.

Step 3: Reliability curve for combined degradation (see Figure C.5).

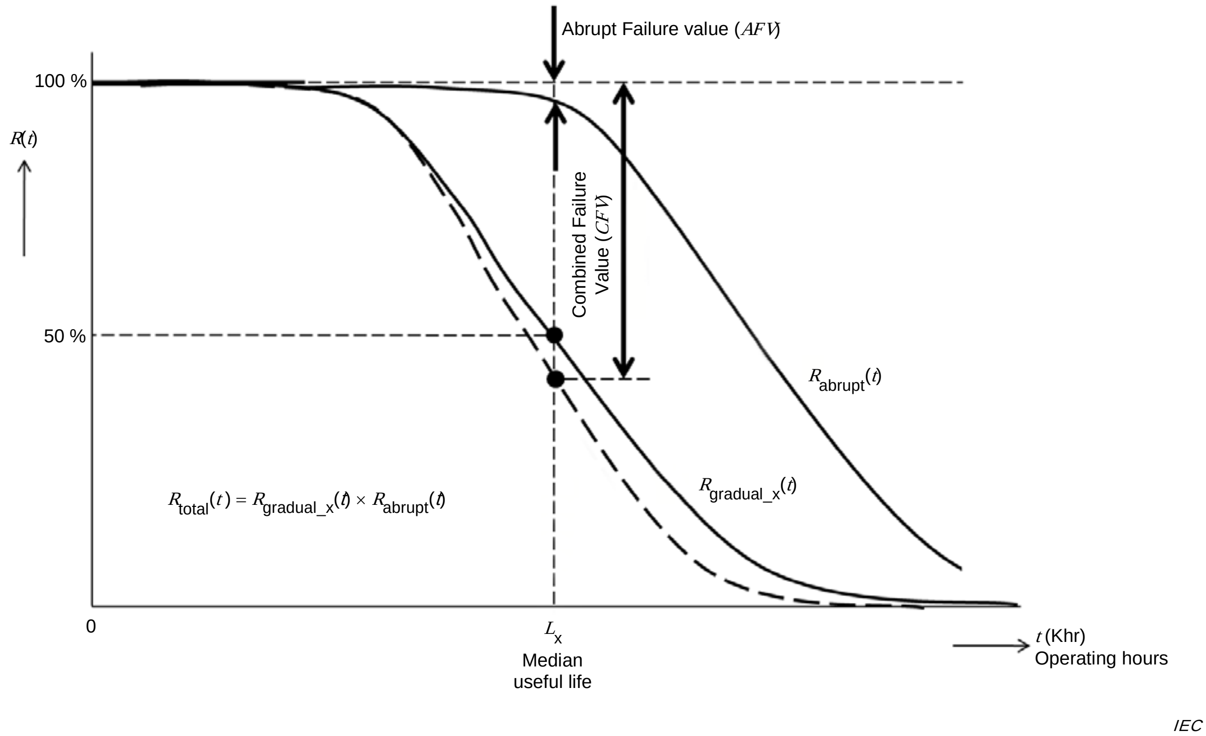


Figure C.5 – Combined R_{gradual} and R_{abrupt} degradation

C.5 Overview of LED lifetime metrics and related lighting product groups

Different lifetime metrics for lighting products are used in the industry to communicate with a variety of end users. For ordinary persons using LED lamps, it is sufficient to give the median life on basis of combined failure criteria, including abrupt and parametric failures. Professionally trained customers in the lighting market may require the estimated time to failure functions, both abrupt and parametric (luminous flux maintenance), separately for their lighting products. With the values from these failure functions they can make calculations for lighting installations including maintenance cycle estimations

Figure C.6 gives an overview of the different lifetime metrics, explained in this annex and the related products. The upper frame A represents quantities from the failure functions more of interest to professionals while the lower frame B gives the simple quantities for the general communication to the market.

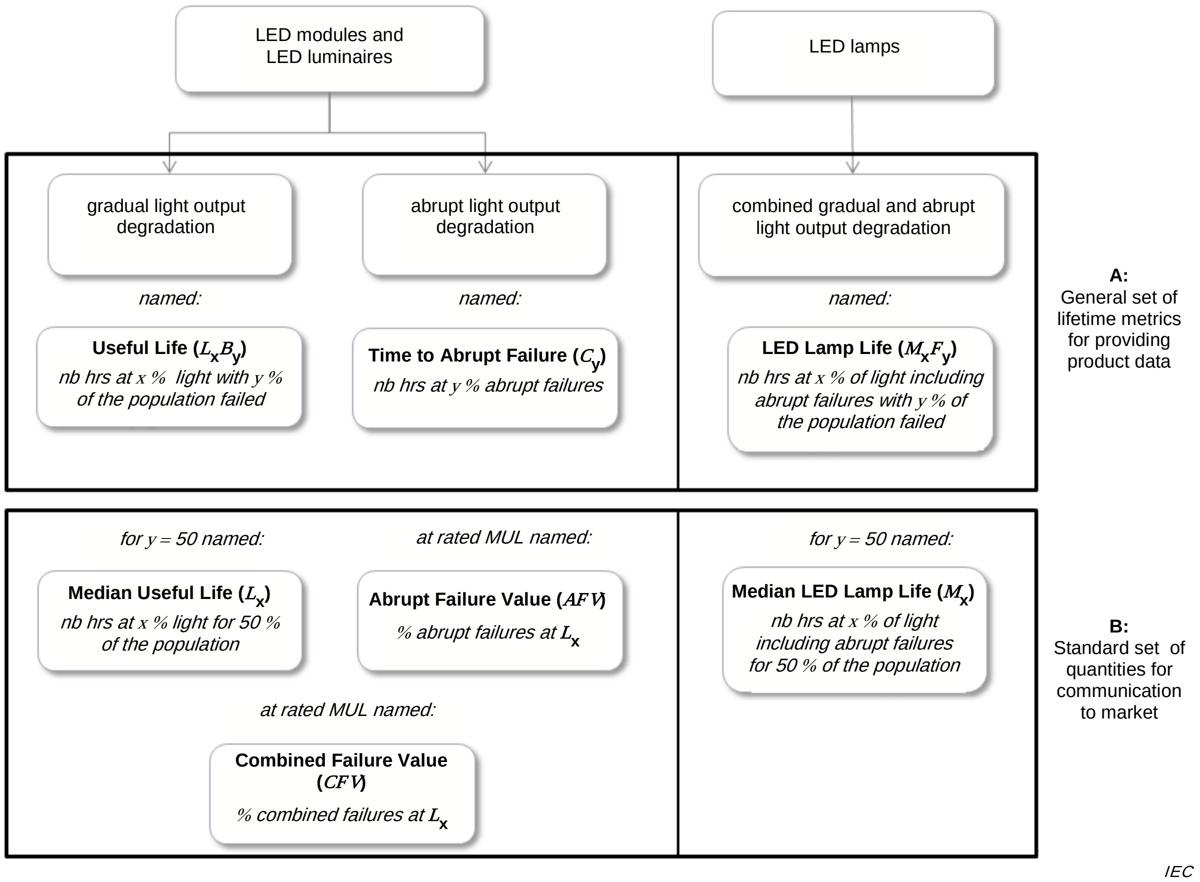


Figure C.6 – Overview of LED lifetime metrics

C.6 Example life time metric values

The introduction of the median useful life L_x (see 3.7) together with the abrupt failure value (see 3.9) and median LED lamp life (see 3.13), provides a comprehensive set of definitions for communicating lifetime related specifications for LED products.

When specifying different values, see Tables C.1, C.2 and C.3 below for example values. Individual LED packages or LED dies within a LED product are not addressed.

In many LED products the lifetime metric values are interrelated. As the lumen maintenance factor rating increases, the rated life and AFV values will generally tend to decrease (see Table C.4)

NOTE LED modules with constant lumen output are under consideration.

Table C.1 – Example lifetime metric values for lumen maintenance factor ratings

numbers in %

	L_x		
X	70	80	90

Table C.2 – Example lifetime metric values for abrupt failure

numbers in %

AFV		
3	5	10

Table C.3 – Example lifetime metric values of x for median LED lamp life (combined failures)

numbers in %

M_x			
x	70	80	90

Table C.4 – Example lifetime metric values

x (%)	70	80	90
Rated life, L_x(h)	30 000	20 000	10 000
AFV (%)	3	2	1,5

Annex D
(normative)

Explanation of the photometric code

Example of photometric code like 830/359, meaning:

8	**3**	**0**	**/**	**3**	**5**	**9**

– initial **CRI** of e.g. 87

– initial **CCT** of 3 000 K

– **initial** spread of **chromaticity coordinates** within a 3-step MacAdam ellipse

– **maintained** spread of **chromaticity coordinates** at 25 % of rated life (with a maximum duration of 6 000 h) within a 5-step MacAdam ellipse

– code of lumen maintenance at 25 % of rated life (with a maximum duration of 6 000 h), in this example: ≥90 % of the 0 h value.

The colour rendering value is expressed as one figure which is obtained by using the intervals:

CRI = 70 to79 → code 7

CRI = 80 to 89 → code 8

CRI = 90 to ≥90 → code 9

The highest value is 9.

NOTE In Japan, the requirements on colour classification and indication is specified in JIS Z 9112.

Annex E
(normative)

Measurement of displacement factor

E.1 General

The phase shift angle (φ_1) of the displacement factor ($\cos(\varphi_1)$) of 7.2 shall be measured according to the definition of E.2 and with the measurement requirements of Clause E.3

E.2 Phase shift angle definition

The phase shift angle φ_1 between the fundamental (I_1) harmonic current and the mains voltage (U_{mains}) is determined as described in Figures E.1 and E.2:

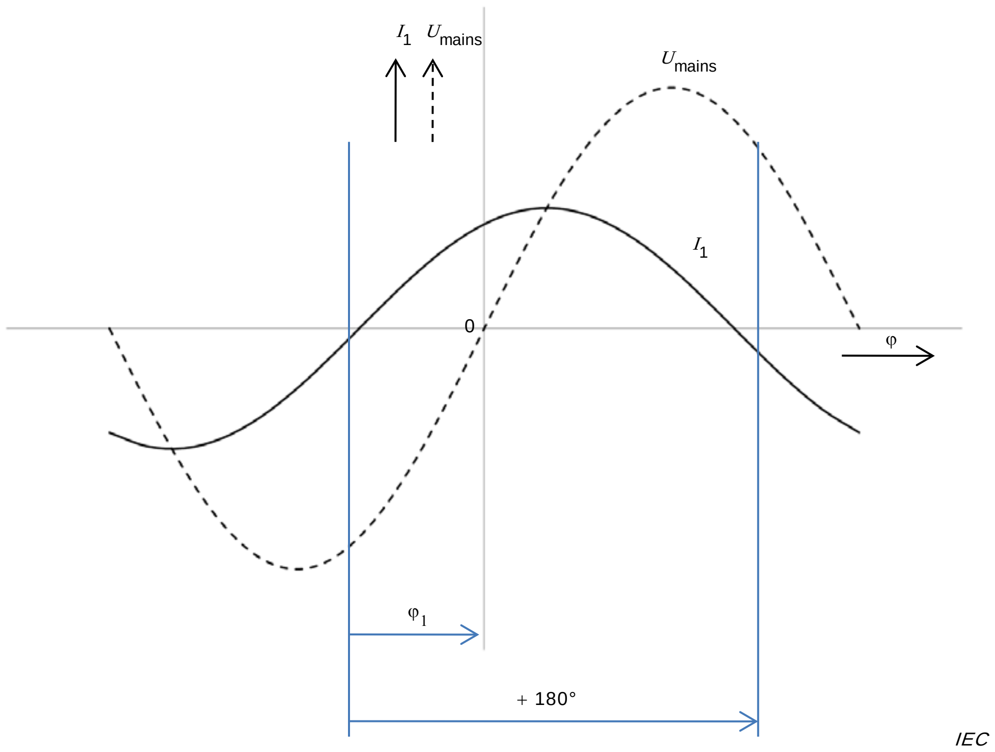


Figure E.1 – Definition of the fundamental current phase shift angle φ_1 (I_1 leads U_{mains}, $\varphi_1 > 0$)

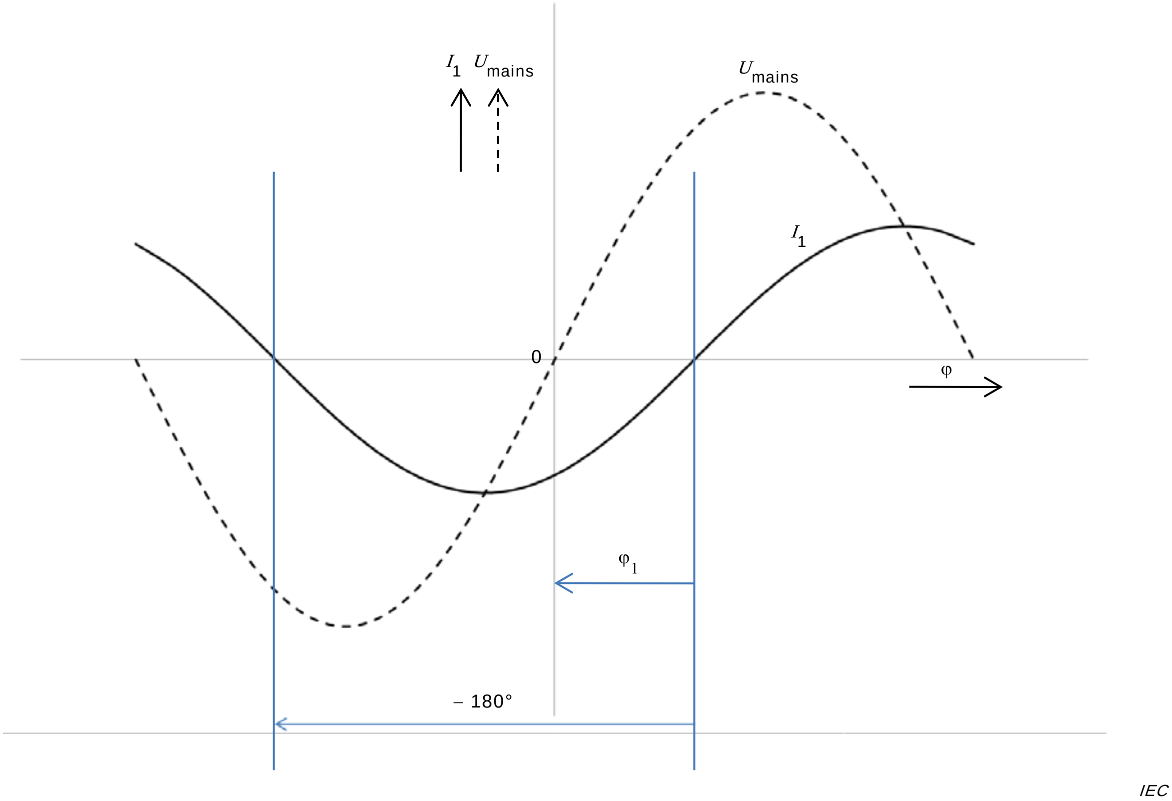


Figure E.2 – Definition of the fundamental current phase shift angle φ_1 (I_1 lags U_{mains}, $\varphi_1 < 0$)

E.3 Measurements requirements

E.3.1 Measurement circuit and supply source

The measurement circuit and the supply source are defined in Annex A of IEC 61000-3-2:2005.

E.3.2 Requirements for measurement equipment

The requirements for measurement equipment are defined in IEC 61000-4-7.

E.3.3 Test conditions

The test conditions for the measurements of the displacement / phase-angle associated with some types of equipment are given in the following clause: see C.5 of IEC 61000-3-2:2005/AMD 2:2009.

NOTE Test conditions for LED light sources in IEC 61000-3-2:2005, C.5 are under consideration.

Annex F
(informative)

Explanation of displacement factor

F.1 General

The metric power factor (λ) is a composite metric and consists of the primary metrics displacement factor ($\kappa_{displacement}$) and distortion factor ($\kappa_{distortion}$).

The relation between the composite metric λ and its primary metrics $\kappa_{displacement}$ and $\kappa_{distortion}$ is as follows:

$$\lambda = \kappa_{displacement} \cdot \kappa_{distortion}$$

with

$$\kappa_{displacement} = \cos\varphi_1$$

and

$$\kappa_{distortion} = \frac{1}{\sqrt{1 + THD^2}}$$

resulting in

$$\lambda = \frac{\cos\varphi_1}{\sqrt{1 + THD^2}}$$

Angle φ_1 is the phase shift angle between the fundamental of the supply voltage and the fundamental of the mains current. The total harmonic distortion (THD) is quantified by the harmonics of the mains current, according to IEC 61000-3-2. The relation between the individual harmonics of the mains current and the THD_i is in below equation:

$$THD = \sqrt{\sum_{n=2}^{40}\left(\frac{I_n}{I_1}\right)^2}$$

where

I_n is the amplitude of the n^{th} harmonic of the mains current.

F.2 Recommended values for displacement factor

No negative effects on the power grid are to be expected from integrated LED modules (Type 1) when complying with the recommendation as in Table F.1.

Table F.1 – Recommended values for displacement factor

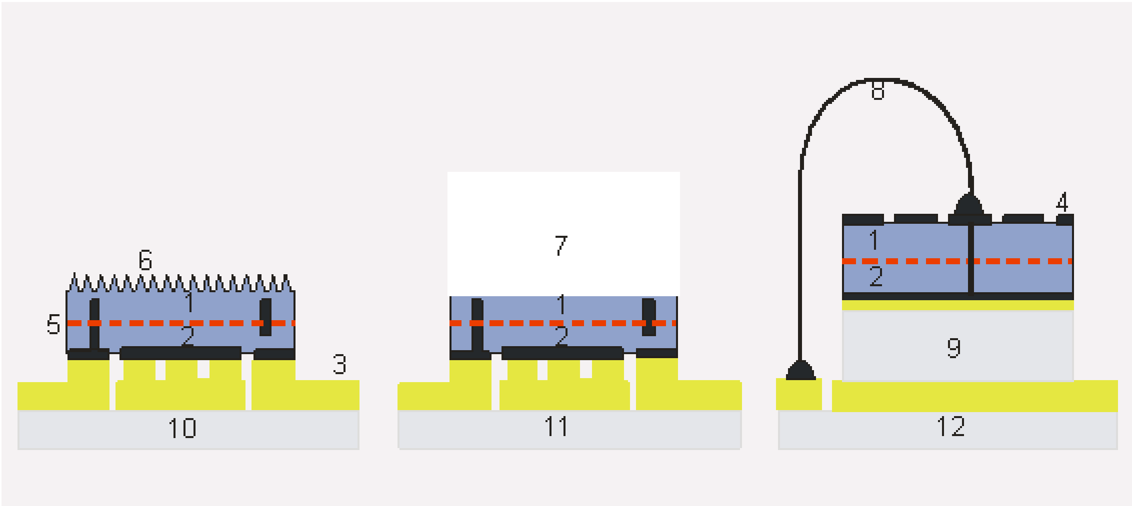
Metric	**P ≤ 2 W**	**2 W < P≤ 5 W**	**5 W < P ≤ 25 W**	**P > 25 W**
$\kappa_{displacement}$ ($\cos\varphi_1$)	No limit	≥ 0,4	≥ 0,7	≥ 0,9
The values are practical examples and give guidance.				

Annex G
(informative)

Examples of LED dies and LED packages

G.1 LED die

Schematic examples of LED dies are given in Figure G.1.



Key

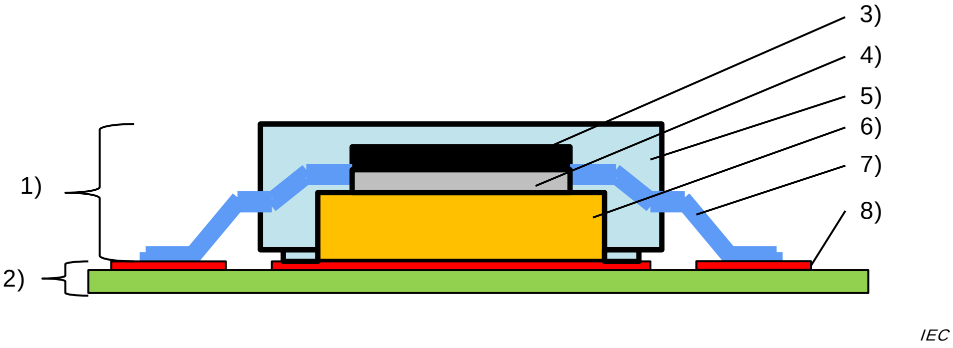
1 n-GaN
2 p-GaN
3 metal anode/cathode contacts
4 patterned n-contact
5 MQW active region (Multi Quantum Well)
6 roughened n-GaN
7 sapphire
8 wire bond
9 intermediate conducting substrate/submount
10 submount/package
11 submount/package
12 package

a) Thin-film-flip-chip LED **b) Flip-chip LED** **c) Vertical thin-film-chip LED**

Figure G.1 – Schematic drawings of LED dies

G.2 LED package

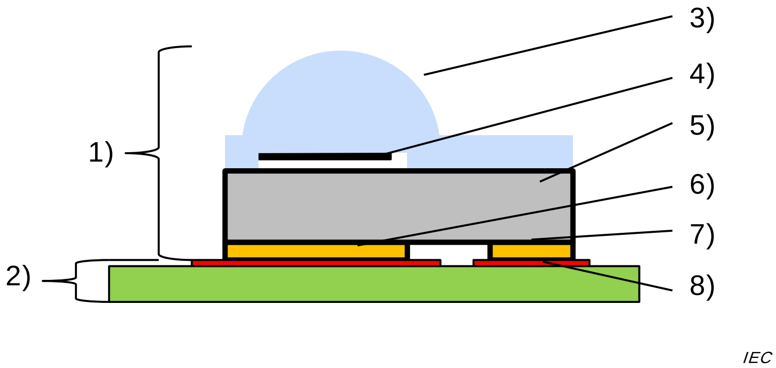
Schematic examples of LED packages are given in Figure G.2.



Key

1 LED package
2 Printed Circuit Board (PCB)
3 LED die
4 Die attach
5 Moulding compound
6 Heat sink
7 Leads
8 Copper tracks

a) Surface mounted LED package with lead wires



Key

1 LED package
2 Printed Circuit Board (PCB)
3 silicone lens
4 LED die
5 ceramic substrate
6 thermal pad
7 electrical contact
8 copper tracks

b) Surface mounted LED package without lead wires

Figure G.2 – Schematic drawings of LED packages

Annex H
(informative)

Test equipment for temperature measurement

H.1 General

The following recommendations refer to methods of making temperature measurements on LED modules in a draught-proof enclosure. They are derived from IEC 60598-1, Annex K when methods of measurement have evolved as being particularly suitable for LED modules; alternative methods may be used, if it is established that they are of at least equal precision and accuracy.

H.2 Set-up and procedure

It is recommended to have a measurement set up able to achieve an uncertainty of measurement of ± 2,5 °C.

Temperatures of solid materials are usually measured by means of thermocouples. The output voltage is read by a high-impedance device such as a potentiometer. With a direct-reading instrument, it is important to check that its input impedance is suited to the impedance of the thermocouple. Temperature-indicators of the chemical type are at present suitable only for rough checks of measurement.

The thermocouple wires should be of low thermal conductivity. A suitable thermocouple consists of 80/20 nickel-chromium paired with 40/60 nickel-copper (or with 40/60 nickel-aluminium). Each of the two wires (usually of strip form, or circular in section) is fine enough to pass through a 0,3 mm hole. All the end-portions of the wires liable to be exposed to radiation have a high-reflectance metal finish. The insulation of each wire is of suitable temperature and voltage rating; it is also thin but robust.

Thermocouples are attached to the measuring point with minimum disturbance of thermal conditions and with low-resistance thermal contact.

The following methods have been found useful for attaching thermocouple junctions at measuring points. Adequate adhesive solutions should be selected depending on LED module specification (especially with regard to power density at the measurement point).

a) Soldering to a metal surface (with a minimum amount of solder) (solder under current-carrying parts should be avoided).
b) By an adhesive (minimum amount required). The adhesive should not separate the thermocouple from the measuring point. An adhesive used with a translucent material should be as translucent as possible. A suitable adhesive for use with glass is formed of one part of sodium silicate to two parts of calcium sulphate, with water medium.

   On non-metal parts, the last 20 mm of the thermocouple are attached to the surface to offset the flow of heat from the measuring point.

The average ambient temperature in the draught-proof enclosure is taken as the air temperature at a position near one of the perforated walls on a level with the centre of the LED module. The temperature is usually measured by a thermocouple soldered to a metal mass of approximately 30 g shielded against radiation by a double-walled cylinder of polished metal open at the top and bottom.

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