BS EN 62612:2013

BSI Standards Publication

Self-ballasted LED lamps for general lighting services with supply voltages >50 V – Performance requirements

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National foreword

This British Standard is the UK implementation of EN 62612:2013. It is identical to IEC 62612:2013. It supersedes DD IEC/PAS 62612:2009 which is withdrawn.

The UK participation in its preparation was entrusted by Technical Committee CPL/34, Lamps and Related Equipment, to Subcommittee CPL/34/1, Electric lamps.

A list of organizations represented on this committee can be obtained on request to its secretary.

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Published by BSI Standards Limited 2013

ISBN 978 0 580 67932 2
ICS 29.140.01; 31.080.10

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This British Standard was published under the authority of the Standards Policy and Strategy Committee on 30 September 2013.

Amendments/corrigenda issued since publication

Date	Text affected

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 62612

August 2013

ICS 29.140.01

English version

Self-ballasted LED lamps for general lighting services with supply voltages > 50 V - Performance requirements

(IEC 62612:2013)

Lampes à LED autoballastées pour l'éclairage général avec des tensions d'alimentation > 50 V - Exigences de performances (CEI 62612:2013)

LED-Lampen mit eingebautem Vorschaltgerät für Allgemeinbeleuchtung mit Versorgungsspannungen > 50 V - Anforderungen an die Arbeitsweise (IEC 62612:2013)

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CENELEC

European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

CEN-CENELEC Management Centre: Avenue Marnix 17, B - 1000 Brussels

Ref. No. EN 62612:2013 E

Foreword

The text of document 34A/1662/FDIS, future edition 1 of IEC 62612, prepared by SC 34A "Lamps" of IEC/TC 34A "Lamps and related equipment" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN 62612:2013.

The following dates are fixed:

• latest date by which the document has to be implemented at national level by publication of an identical national standard or by endorsement	(dop)	2014-04-23
• latest date by which the national standards conflicting with the document have to be withdrawn	(dow)	2016-07-23

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Endorsement notice

The text of the International Standard IEC 62612:2013 was approved by CENELEC as a European Standard without any modification.

In the official version, for Bibliography, the following notes have to be added for the standards indicated :

IEC 60598	NOTE	Harmonised as EN 60598.
IEC 60901	NOTE	Harmonised as EN 60901.
IEC 61547	NOTE	Harmonised as EN 61547.
CISPR 15:2005	NOTE	Harmonised as EN 55015:2006 (not modified)

Annex ZA
(normative)

Normative references to international publications with their corresponding European publications

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.

NOTE When an international publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

Publication	Year	Title	EN/HD	Year
IEC 60050	Series	International Electrotechnical Vocabulary (IEV)	-	-
IEC 60068-2-14	-	Environmental testing - Part 2-14: Tests - Test N: Change of temperature	EN 60068-2-14	-
IEC 60081	-	Double-capped fluorescent lamps - Performance specifications	EN 60081	-
IEC 60630	-	Maximum lamp outlines for incandescent lamps	EN 60630	-
IEC 61000-3-2	2005	Electromagnetic compatibility (EMC) - Part 3-2: Limits - Limits for harmonic current emissions (equipment input current <= 16 A per phase)	EN 61000-3-2	2006
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	EN 61000-4-7	-
IEC/TR 61341	-	Method of measurement of centre beam intensity and beam angle(s) of reflector lamps	EN 61341	-
IEC/TS 62504	-	General lighting - LEDs and LED modules - Terms and definitions	-	-
IEC 62560	-	Self-ballasted LED-lamps for general lighting services by voltage > 50 V - Safety specifications	EN 62560	-
IEC/TR 62732	-	Three-digit code for designation of colour rendering and correlated colour temperature	-	-
CIE 13.2	1974	Methods of measuring and specifying colour rendering properties of light sources	-	-
CIE 13.3	1995	Method of measuring and specifying colour rendering of light sources	-	-
CIE S 017/E	2011	ILV: International Lighting Vocabulary	-	-
CIE 191	1996	The photometry and goniophotometry of luminaires	-	-
CIE 177	2007	Colour rendering of white LED light sources	-	-

CONTENTS

INTRODUCTION

This International Standard is the first edition of a performance standard (precursor: IEC/PAS 62612) for self-ballasted LED lamps for general lighting applications and acknowledges the need for relevant tests for this new source of electrical light, sometimes called “solid state lighting”.

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.

SELF-BALLASTED LED LAMPS FOR GENERAL LIGHTING SERVICES WITH SUPPLY VOLTAGES > 50 V – PERFORMANCE REQUIREMENTS

1 Scope

This International Standard specifies the performance requirements, together with the test methods and conditions, required to show compliance of LED lamps with integral means for stable operation, intended for domestic and similar general lighting purposes, having:

- a rated power up to 60 W;
- a rated voltage of > 50 V a.c. up to 250 V a.c.;
- a lamp cap as listed in IEC 62560.

These performance requirements are additional to the safety requirements in IEC 62560.

The only feature provided by this standard, when applied for replacement purposes, is information on maximum lamp outlines.

The requirements of this standard relate to type testing. This standard covers LED lamps that intentionally produce white light, based on inorganic LEDs.

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

The life time of LED lamps 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 manufacturer's life time claim, past an operational time as stated in 7.1, 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, provided before the test is started.

In order to validate a life time claim, several methods of test data extrapolation exist. 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 E.

NOTE When lamps 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 lamp.

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 (all parts), *International Electrotechnical Vocabulary* (available at <http://www.electropedia.org>).

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

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

IEC 60630, *Maximum lamp outlines for incandescent lamps*

IEC 61000-3-2:2005, *Electromagnetic compatibility (EMC) – Part 3-2: Limits – Limits for harmonic current emissions (equipment input current ≤ 16A per phase),* Amendment 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/TS 62504, *General lighting – LEDs and LED modules – Terms and definitions*

IEC 62560, *Self-ballasted LED-lamps for general lighting services by voltage > 50 V – Safety specifications*

IEC/TR 62732, *Three-digit code for designation of colour rendering and correlated colour temperature*

CIE 13.2:1974, *Methods of measuring and specifying colour rendering properties of light sources*

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

CIE S 017/E:2011, *ILV: International Lighting Vocabulary*

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/TS 62504 and IEC 60050-845 as well as the following apply.

3.1
rated value
quantity value for a characteristic of an LED lamp for specified operating conditions

Note 1 to entry: 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

Note 1 to entry: Specification of test voltage is made in A.2.

3.3
lumen maintenance (of an LED lamp)
luminous flux maintenance
ratio of the luminous flux emitted by an LED lamp at a given time in its life to its initial luminous flux, the lamp being operated under specified conditions

Note 1 to entry: This ratio x is generally expressed in per cent.

Note 2 to entry: The lumen maintenance of an LED lamp is the effect of decrease of the lumen output of the LED(s) or a combination of this with failure(s) of LED(s) if the lamp contains more than one LED.

[SOURCE: IEC 60050-845:1987, 845.07.65, modified — the term "LED" and the note 2 to entry are added]

3.4
initial value
photometric, colorimetric and electrical characteristics at the end of the ageing period and stabilisation time

3.5
maintained value
photometric, colorimetric and electrical characteristics at an operational time, including stabilisation time

Note 1 to entry: The operational time is stated in 7.1.

3.6
life (of an individual LED lamp)
L_x
length of time during which an LED lamp provides at least claimed percentage of the initial luminous flux, under standard conditions

Note 1 to entry: An LED lamp has thus reached its end of life, when it no longer provides claimed percentage of the initial luminous flux. Life is always published in combination of life (L_x) at lumen maintenance (x) and the failure fraction (F_y) (see 3.8)

Note 2 to entry: Any built-in electronic controlgear, however, may show a sudden end of life failure. The definition 3.6 implies that an LED lamp 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.

3.7
rated lamp life
length of time during which a population of LED lamps provides at least the claim for luminous flux percentage x and less or equal the claim for failure fraction percentage y, as declared by the manufacturer or responsible vendor

Note 1 to entry: For sample size see Clause 7.

Note 2 to entry: Notes to entry 1 and 2 of 3.6 apply.

Note 3 to entry: Rated lamp life is expressed in hours.

3.8
failure fraction at rated life
F_y
percentage y of a number of LED lamps of the same type, that at their rated life designates the percentage (fraction) of failures

Note 1 to entry: This failure fraction expresses the combined effect of all components of an LED lamp including mechanical components, 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 2 to entry: For self-ballasted LED lamps normally a failure fraction of 10 % or/and 50 % are being applied, indicated as F_{10} and/or F_{50}.

3.9
photometric code
colour designation of an LED lamp giving white light as defined by the correlated colour temperature and the CIE 13.2:1974 general colour rendering index

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

Note 2 to entry: The definition of photometric code may be further reviewed with regard to IEC/TR 62732.

3.10
stabilisation time
time, which the LED lamp requires to obtain stable photometric conditions with constant electrical input for each measurement

Note 1 to entry: An LED lamp may be regarded as stable at stable thermal conditions.

3.11
ageing
preconditioning period of the LED lamps before initial values are taken

3.12
type
LED lamp, representative of the production

3.13
family
group of LED lamps that have same design characteristics, distinguished by common features of materials, components, and/or method of processing

3.14
type test
conformity test on one or more LED lamps, representative of production

[SOURCE: IEC 60050-151:2001, 151.16.16, modified — the word “items” is replaced with “LED lamps”]

3.15
type test sample
one or more LED lamps submitted by the manufacturer or responsible vendor for the purpose of the type test

3.16
LED lamp efficacy
quotient of the luminous flux emitted by the power consumed by the LED lamp

Note 1 to entry: Efficacy is expressed in lm/W.

3.17
LED die
block of semi-conducting material on which a given functional circuit is fabricated

SEE: Figure F.1 for a schematic built-up of an LED die.

3.18
LED package
single electrical component encapsulating principally one or more LED dies, possibly with optical elements and thermal, mechanical, and electrical interfaces

Note 1 to entry: The component does not include the control unit of the controlgear, does not include a cap, and is not connected directly to the supply voltage.

Note 2 to entry: An LED package is a discrete component and part of the LED lamp. For a schematic built-up of an LED package, see Figure F.2.

3.19
t_{LED}-point
designated location of the point where to measure the performance temperature t_{LED} at the surface of the LED package

3.20
displacement factor
expressed by $\cos\varphi_1$, where φ_1 is the phase angle between the fundamental of the mains supply voltage and the fundamental of the mains current

3.21
directional lamp
lamp having at least 80 % luminous flux within a solid angle of π sr (corresponding to a cone with angle of 120°)

4 General requirements on tests

The LED lamps for which compliance with this standard is claimed shall comply with the requirements of the relevant safety standard IEC 62560. For measurement of lamp characteristics, see Annex A.

It may be expected that self-ballasted LED lamps, which comply with this standard will start and operate satisfactorily at voltages between 92 % and 106 % of rated supply voltage and at an ambient air temperature between –20 °C and 40 °C and in a luminaire complying with IEC 60598-1.

The requirements for individual LED lamps apply to 95 % of the production population.

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

5 Marking

5.1 General requirements for marking

In addition to IEC 62560, marking data as requested by Table 1 shall be provided by the manufacturer or responsible vendor, and placed as specified in 5.2.

5.2 Places of marking

See Table 1.

Table 1 – Required markings

	Product	Packaging	Product datasheets, leaflets or website
a) Rated luminous flux (lm), centre beam intensity and beam angle (see Note 1)	X	X	X
b) Lamp photometric code (see Annex B)	–	X	X
c) Rated life (h) and the related lumen maintenance (x)	–	X	X
d) Failure fraction (F_y), corresponding to the rated life	–	X	X
e) Lumen maintenance code (see Table 5)	–	–	X
f) Rated colour (for example: F 2700 to F 6500, see Table 3) including initial and maintained colour variation category (see Table 4)	–	X	X
g) Rated colour rendering index	–	X	X
h) Ageing time (h), if different to 0 h	–	–	X
i) Rated efficacy (lm/W) (see Note 2)	–	–	X
j) Dimensions, including dimensional tolerances	–	–	X
k) Displacement factor (see Note 3 and Annex D)	–	–	X

These requirements are minimal. Additional regional regulatory marking requirements may exist and overrule.

NOTE 1 For directional lamps, centre beam intensity and beam angle are measured according to IEC/TR 61341.

NOTE 2 Efficacy of directional lamps can be classified with a luminous flux defined in a 120° (π sr) cone or 90° (0,6 π sr) cone, see A.3.2.

NOTE 3 In Japan, the power factor instead of the displacement factor is relevant.

Key

X = required

– = not required

6 Dimensions

The LED lamp dimensions shall comply with the requirements as indicated by the manufacturer or responsible vendor. If an outline as per IEC 60630 is claimed, then the maximum outlines shall not be exceeded.

If the luminaire itself or any covering (if applicable) does not interfere with the dimensions of LED lamps, such lamps are also suitable as replacement.

Compliance is checked by inspection.

7 Test conditions

7.1 General test conditions

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

Additional LED lamps within the same family (see 3.13) may be subjected to decreased testing duration. For identification of a family see Table 2, for details on sample sizes for family testing see Table 6.

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

All tests are conducted on n LED lamps of the same type. The number n shall be a minimum of products as given in Table 6. LED lamps used in the endurance tests shall not be used in other tests.

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

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

7.2 Creation of lamp families to reduce test effort

7.2.1 General

Lamp families have been created with the aim of guiding LED lamp manufacturers towards platform designs and thus allowing the possibility to use data of the existing baseline product that has already been tested for an operational period as stated in 7.1. The baseline product is considered to be the first LED lamp complying with this standard and designated to be part of the family.

7.2.2 Variations within a family

Each family of LED lamps requires a case-by-case consideration. The range of LED lamps should be manufactured by the same manufacturer, under the same quality assurance system. The type variations of the range (e.g. Correlated Colour Temperature (CCT), see 10.1) 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 lamps for type testing are given in definition 3.13 and used in Table 2.

The testing time may be reduced within a family down to 1 000 h[1] in case variations of part characteristics are within the conditions given in Table 2.

[1] Value under consideration.

Table 2 – Variations allowed within a family

Part characteristics where variations are allowed (see Note 2)	Conditions for acceptance
Housing/chassis, heat sink/heat management	t_{LED} (location and value given by the LED lamp supplier) and other components remain at the same or at a lower value, if the rated life time is the same or higher than the baseline product, as indicated and specified by the manufacturer or responsible vendor (see also Note 1).
Optics (see Note 1)	The test results showing the effect of optical material change shall be documented in the manufacturer's technical file.
LED package	t_{LED} remains at the same or at a lower value, if the rated life time is the same or higher than the baseline product. as indicated and specified by the manufacturer or responsible vendor
Controlgear	t_{LED} remains at the same or at a lower value, if the rated life time is the same or higher than the baseline product, as indicated and specified by the manufacturer or responsible vendor. A statistical failure rate calculation based on an MTBF (mean time between failures) calculation by the manufacturer shall show equal or lower failure rate of the electronic controlgear.
NOTE 1 Optics include for instance secondary optics (lenses), reflectors, trims and gaskets and their interconnections. The results relate to changes in luminous flux, peak luminous intensity, luminous intensity distribution, beam angle, shift in colour co-ordinates, shift in CCT (see 10.1) and shift in colour rendering index (CRI) (see 10.2). NOTE 2 Any change on part tolerances are documented in the manufacturer's technical file. NOTE 3 Examples are under consideration.	

7.2.3 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 lamp:

– chromaticity co-ordinates,
– colour rendering index,
– lumen maintenance code,
– results of accelerated operational life test.

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

Compliance:

For all of the tested units in a sample, the measured values of an LED lamp (the initial and maintained value) shall not move beyond the values 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 lamps in a sample shall pass the test.

8 Lamp input

8.1 Lamp power

For conditions see Annex A.

Compliance:

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

The average of initial power consumed by the LED lamps in the measured sample shall not exceed the rated power by more than 7,5 %.

8.2 Displacement factor

The displacement factor of self-ballasted LED lamps shall be measured according to Annex C. LED lamps with dimming control shall be adjusted to maximum light output.

NOTE 1 In Japan, the power factor instead of the displacement factor is relevant.

NOTE 2 Annex D gives an explanation and relation of displacement factor, distortion factor and power factor.

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

Compliance:

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

9 Light output

9.1 Luminous flux

Luminous flux is measured according to Annex A.

Compliance:

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

The average initial luminous flux of the LED lamps in the measured sample shall not be less than the rated luminous flux by more than 7,5 %.

9.2 Luminous intensity distribution, peak intensity and beam angle

9.2.1 General

The requirements of 9.2.4 and 9.2.5 are to be applied to LED lamps having a directional (spot) distribution.

Luminous intensity distribution of an LED lamp may be specific for an application.

9.2.2 Measurement

The intensity of light emitted from the LED lamp in different directions is measured using a goniophotometer. All photometric data shall be declared for the LED lamp operating at a temperature given in Clause A.1.

The allowed photometric variations, detailed in the following subclauses, are to take into account the manufacturing tolerances.

9.2.3 Luminous intensity distribution

The initial distribution of luminous intensity shall be in accordance with that declared by the manufacturer.

Compliance is under consideration.

9.2.4 Peak intensity value[2]

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

Compliance is checked according to Annex A.

9.2.5 Beam angle value[3]

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

Compliance is checked according to Annex A.

9.3 Efficacy

LED lamp efficacy shall be calculated from the measured initial luminous flux of the individual LED lamp divided by the measured initial input power of the same individual LED lamp. For measurement of luminous flux see A.3.3.

Compliance:

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

10 Colour nomenclature, variation and rendering

10.1 Colour variation categories

Reference is made to Annex D of IEC 60081. The rated colour of a lamp should preferably be one of the following seven values:

F2700, P2700, F3000, F3500, F4000, F5000 or F6500

For reference purposes, the standardised chromaticity co-ordinates and CCT (see CIE S 017/E:2011) values corresponding to these colours are given in Table 3 (Source: IEC 60081, Clause D.2, modified):

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2 Compliance criteria for the average value of the peak intensity are under consideration.

3 Compliance criteria for the average value of the beam angle value are under consideration.

Table 3 – Colour

Colour marking	CCT (Tc)	Chromaticity coordinates	
		x	y
F 6500	6400	0,313	0,337
F 5000	5000	0,346	0,359
F 4000	4040	0,380	0,380
F 3500	3450	0,409	0,394
F 3000	2940	0,440	0,403
F 2700	2720	0,463	0,420
P 2700	2700	0,458	0,410
The letters in the colour marking designation stand for: F = Values from IEC 60081, Annex D P = Value close to the Planckian curve			

The initial chromaticity co-ordinates are measured. A second measurement of maintained chromaticity co-ordinates is made at an operational time as stated in 7.1. The measured actual chromaticity co-ordinate values (both initial and maintained) shall fit within 1 of 4 categories (see Table 4), which correspond to a particular MacAdam 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 lamp.

Compliance:

For compliance of family members, refer to 7.2.3.

For all of the tested units in a sample, the measured chromaticity co-ordinate values of an LED lamp (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). The measured values shall be of the same category as the rated values or better. The sample units for the chromaticity coordinate measurement shall be selected from four different batches4.

CCT and chromaticity co-ordinates are measured according to Annex A.

Table 4 – Tolerance (categories) on rated chromaticity co-ordinate 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+
NOTE The behaviour of the chromaticity co-ordinates is expressed by marking the two measurement results of both the initial chromaticity co-ordinates and the maintained chromaticity co-ordinates. An example is given in Annex B. This standard applies mainly to retrofit LED lamps for which it is important that the chromaticity corresponds as much as possible to the lamps to be replaced. 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 (compact) fluorescent lamps and other discharge lamps.		

4 The colour variation between the units in a sample from different production runs resembles the variation within longer periods of production.

10.2 Colour rendering index (CRI)

The initial colour rendering index (CRI) of an LED lamp is measured. A second measurement is made at an operational time as stated in 7.1.

See A.3.6 for more details.

Compliance:

For all tested units in a sample the measured CRI values shall not decrease 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.*

11 Lamp life

11.1 General

Life of an LED lamp (as defined in 3.6) is the combined effect of gradual light output degradation, mostly caused by material degradation (see 11.2) and abrupt light output degradation, mostly caused by electrical component failure (see 11.3, endurance tests as an indication for reliability and life). Both elements are tested.

Reference is made to the definitions 3.3 and 3.8, the latter describing the indicated fraction of tested lamps of a sample (F_y) that may fail the requirements of the tests under 11.2 and 11.3.

On request, reduction of luminous flux due to zero lumen output and due to degradation of the LED material in the measured sample may be given separately.

11.2 Lumen maintenance

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

NOTE 1 As the typical life of an LED lamp is (very) long, it is regarded as impractical and time consuming within the scope of this standard 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 lamp.

NOTE 2 The actual LED behaviour with regard to lumen-maintenance can differ considerably per type and per manufacturer. It is not possible to express the lumen-maintenance of all LEDs 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 into lumen depreciation over LED lamp life are under consideration.

This standard has opted for lumen maintenance codes (see Figure 1) that cover the initial decrease in lumen output until an operational time as stated in 7.1. There are three codes of lumen maintenance compared to the initial lumen output (see Table 5).

Table 5 – Lumen maintenance code at an operational time as stated in 7.1

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 7.1. The initial luminous flux value is normalized to 100 %; it is used as the first data point for determining lamp life. The measured luminous flux value at an operational time as stated in 7.1 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 7.1.

NOTE 4 This will give additional insight as to the reliability of the measured values, but assigning a code does not imply a prediction of achievable life time. Code 9 could be better or worse than Code 7.

For marking of the lumen maintenance (x) and the lumen maintenance categories, 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 7.2.3.

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

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

b) The calculated lumen maintenance shall correspond with the lumen maintenance code as defined and provided by the manufacturer or vendor.

Given a sample of n pieces (individuals) of LED lamps according to Table 6 being subjected to the 6 000 h (or 25 % of rated life), it is deemed to having passed the test, if at the end of the test, the number of failed units is smaller or equal to the number claimed by the manufacturer. This standard gives the following guide for calculation:

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

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

NOTE 5 Calculation, based on 25 %[5] of claimed failure fraction F_y:
claimed failure fraction F_{50} gives 25 % × F_{50} (= 50 %) × n (= 20) = 2,5, rounded off to next lower integer gives 2 LED lamps allowed to fail.

Claimed failure fraction F_{10} gives 25 % × F_{10} (= 10 %) × n (= 20) = 0,5, rounded off to next lower integer gives 0 LED lamps allowed to fail.

In order to set a practical pass/fail criteria of reasonable quality this standard has chosen for a linear relation of the claimed failure fraction with the specified test time, being 25 % of rated life (with a maximum of 6 000 h).

5 Assuming test time lower than the claimed life time, failure fraction at the end of the test is lower than the failure fraction at rated life. There is also no general relation between the failures at the end of the test in relation to the claimed failure fraction.

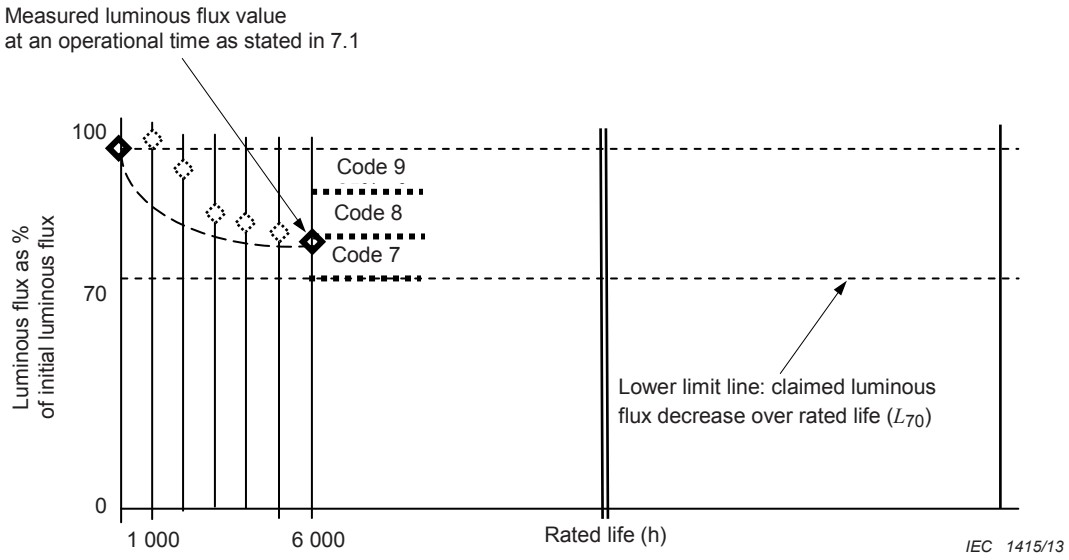

Figure 1 – Luminous flux depreciation over test time

11.3 Endurance tests

11.3.1 General

LED lamps shall be subjected to the following tests specified in 11.3.2 to 11.3.4.

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

11.3.2 Temperature cycling test

Temperature cycling test according IEC 60068-2-14 with specified rate of change

The LED lamp is placed in a test chamber in which the temperature is varied from –10 °C to +40 °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 at each extreme temperature and 1 h transfer time (1 K/min) between the extreme temperatures. The LED lamp is switched on at test voltage for 34 min and off for 34 min.

If a supplier claims suitability for operation at extended conditions (voltages or temperatures outside of normal conditions, including high humidity) then:

a) lamps shall be tested under claimed extended conditions; and

b) lamps shall start and operate satisfactorily under claimed extended conditions; and

c) lamps shall meet all performance claims for operation under claimed extended conditions, which may differ from the performance claims under the general conditions for measurement specified in Annex A.

Compliance:

At the end of the test all the LED lamps 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 68 min is chosen to get a phase shift between temperature and switching period.

The temperature requirements of Clause A.1 do not apply.

NOTE 2 The purpose of this test is to check the mechanical strength of the assembly.

11.3.3 Supply switching test

At test voltage, the lamp 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 hours (example: 10 k cycles if rated life is 20 000 h.).

The temperature requirements of Clause A.1 do apply.

NOTE The purpose of this test is to check the endurance of the built-in electronic components.

Compliance:

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

11.3.4 Accelerated operational life test

The LED lamp shall be operated continuously without switching at a test voltage and at a temperature corresponding to 10 K (see last paragraph and the note) above the maximum specified operating temperature, if declared by the manufacturer and over an operational time of 1 000 h. If there is no declared value then the test shall be performed at 50 °C. Any thermal protecting devices that would switch off the LED lamp or reduce the light output shall be bypassed.

Compliance:

For compliance of family members, refer to 7.2.3.

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

The temperature requirements of Clause 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 would lead to chemical or physical effects from which no conclusions on real life can be made.

NOTE This test is to check for catastrophic failures.

12 Verification

The minimum sampling size for type testing shall be as given in Table 6. The sample shall be representative of a manufacturer’s production.

Table 6 – Sample sizes

1	2	3	4
Clause or subclause	**Test**	**Minimum number of units in a sample for an operational time as stated in 7.1**	**Minimum number of units in a sample for testing a family at reduced test duration after changing product feature according to 7.2**
7.2[a]	t_{LED}-point	Same 5 units for all tests	Same 5 units for all tests
6	Dimensions		
9.2.3	Luminous intensity distribution		
9.2.4	Peak intensity value		
9.2.5	Beam angle value		
8.1	Lamp power	Same 20 units for all tests	Same 5 units for all tests
8.2	Displacement factor(See Note)		
9.1	Luminous flux		
9.3	Efficacy		
10.1	Chromaticity tolerance		
10.2	Correlated colour temperature		
10.3	Colour rendering index		
11.2	Lumen maintenance		
11.3.2	Temperature cycling, energised	10	5
11.3.3	Supply voltage switching	10	5
11.3.4	Accelerated operational life test	10	5
NOTE In Japan, the power factor instead of the displacement factor is relevant.			
[a] Temperature measurement only for family compliance testing.			

Annex A
(normative)

Method of measuring lamp 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 lamp.

For air movement requirements see 4.3.2 CIE 121:1996.

If not exempted by specific clause, lamps shall be operated free burning in a vertical position, cap-up, unless otherwise specified by the manufacturer or responsible vendor.

a) Operate the lamp and record the luminous flux or luminous intensity and the lamp power as temperature/time depending variables.

b) During stabilisation period, measurements of luminous flux or luminous intensity and lamp power are made at least at 1 min intervals. The lamp under test may be regarded as stable and suitable for test purpose, if the difference of maximum and minimum readings of luminous flux or luminous intensity observed over the last 15 min is less than 0,5 % and for lamp power is less than 1 %.

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

c) Subsequent measurements of other lamps of the same type within the sample need not repeat the full stabilisation time in the photometer. According to the lamp warm-up curves established in step b), the duration in time shall be identified at which stabilisation is achieved.

d) The subsequent lamps are submitted to a stabilisation (operation of the light source prior to mounting into the photometer) on basis of the stabilisation time observed in step c). Lamps may then be measured after 15 min in the photometer, applying the criterion of step b).

NOTE 1 Normally the observed stabilisation process is a slow decrease in luminous flux or luminous intensity 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 establishment of a relevant CIE standard.

A.2 Test voltage

A.2.1 General

The test voltage shall be stable within ± 0,5 %, during stabilization 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 supply voltage 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 %.

The procedure for applying the test voltage and test frequency in conjunction with the type of tests is summarised in Figure A.1 to Figure A.3.

NOTE Additional regional requirements may exist and overrule.

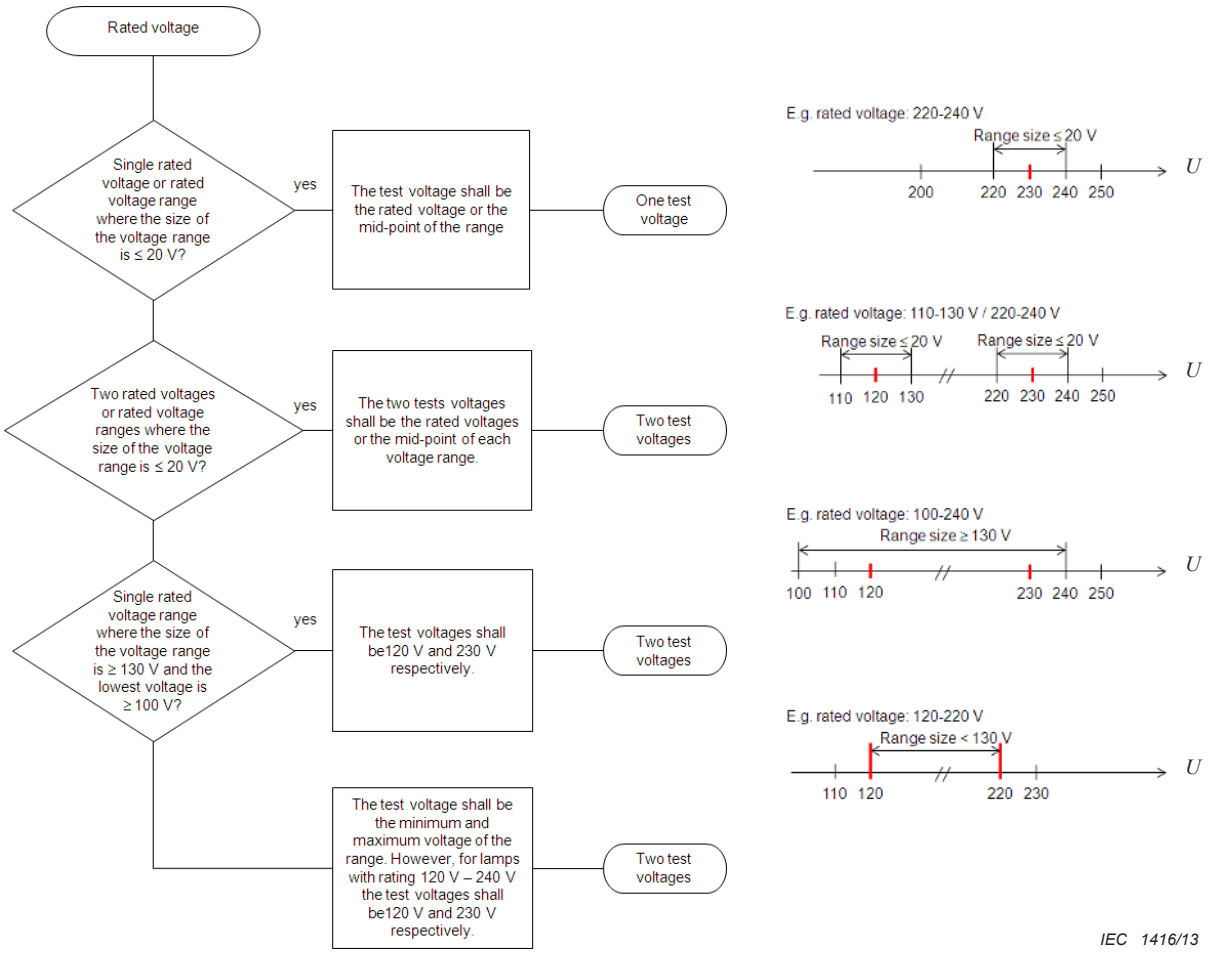

Figure A.1 – Relation of rated voltage to test voltage

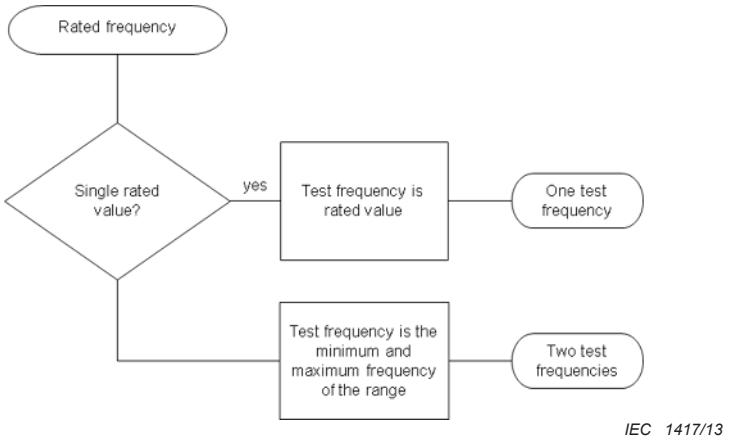

Figure A.2 – Relation of rated frequency to test frequency

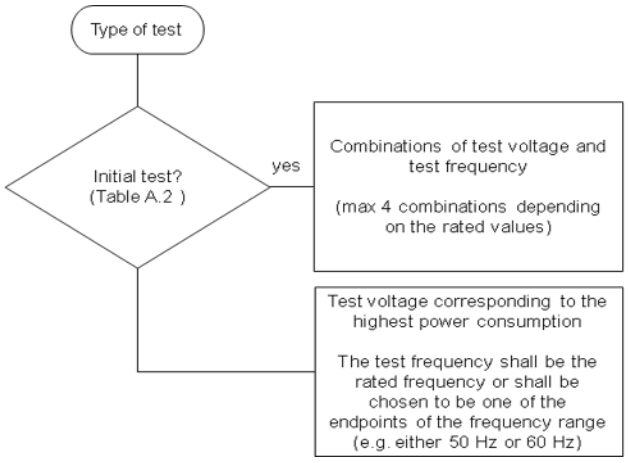

Figure A.3 – Relation of type of tests to test voltage and test frequency

A.2.2 Relation of rated voltage to test voltage

A.2.2.1 Lamps with a single rated voltage or rated voltage range where the size of the voltage range is ≤ 20 V

For these lamps the test voltage shall be the rated voltage or the mid-point of the range.

For lamps having two rated frequencies (e.g. 50/60 Hz) or a frequency range (e.g. 50-60 Hz), the test frequency shall be the end points of the frequency range, e.g. 50 Hz and 60 Hz.

NOTE Examples in Table A.1.

Table A.1 – Relation of rated voltage to test voltage

Rating	U_{test} (V)	f_{test} (Hz)
230 V 50 Hz	230	50
120 V 60 Hz	120	60
220-240 V 50 Hz	230	50
110-130 V 60 Hz	120	60
220-240 V 50-60 Hz	230	50
	230	60

A.2.2.2 Lamps with two rated voltages or rated voltage ranges where the size of the voltage range is ≤ 20 V

For these lamps (for example 120/230 V or 110-130 V and 220-240 V), there shall be two test voltages. The two tests voltages shall be the rated voltages or the mid-point of each voltage range.

For lamps having two rated frequencies (e.g. 50/60 Hz) or a frequency range (e.g. 50-60 Hz), the test frequency shall be the end points of the frequency range, e.g. 50 Hz and 60 Hz.

NOTE Example of rating: 110-130 V / 220-240 V 50-60 Hz

Test voltage and frequency:

1) U_{test} = 120 V, f_{test} = 50 Hz
2) U_{test} = 120 V, f_{test} = 60 Hz

3) U_{test} = 230 V, f_{test} = 50 Hz
4) U_{test} = 230 V, f_{test} = 60 Hz

A.2.2.3 Lamps with a single rated voltage range where the size of the voltage range is ≥ 130 V and the lowest voltage is ≥ 100 V

For these lamps (for example 100-240 V), there shall be two test voltages. The test voltages shall be 120 V and 230 V respectively.

For lamps having two rated frequencies (e.g. 50/60 Hz) or a frequency range (e.g. 50-60 Hz), the test frequency shall be the end points of the frequency range, e.g. 50 Hz and 60 Hz.

NOTE Example of rating: 100-240 V 50-60 Hz

Test voltage and frequency:

1) U_{test} = 120 V, f_{test} = 50 Hz
2) U_{test} = 120 V, f_{test} = 60 Hz
3) U_{test} = 230 V, f_{test} = 50 Hz
4) U_{test} = 230 V, f_{test} = 60 Hz

A.2.2.4 Lamps with other rated voltage ranges

For lamps having a voltage range not already included in A.2.2.1 to A.2.2.3, the test voltage shall be the minimum and maximum voltage of the range. However, for lamps with rating 120 V – 240 V the test voltages of A.2.3. apply.

For lamps having two rated frequencies (e.g. 50/60 Hz) or a frequency range (e.g. 50-60 Hz), the test frequency shall be the endpoints of the frequency range, e.g. 50 Hz and 60Hz.

NOTE Examples of rating: 120-220 V 50-60 Hz

Test voltage and frequency:

1) U_{test} = 120 V, f_{test} = 50 Hz
2) U_{test} = 120 V, f_{test} = 60 Hz
3) U_{test} = 220 V, f_{test} = 50 Hz
4) U_{test} = 220 V, f_{test} = 60 Hz

A.2.3 Tests

A.2.3.1 Initial tests

For the purpose of this standard, initial tests are defined as in Table A.2.

Table A.2 – Initial tests

Clause or subclause	Test
8.1	Lamp power
8.2	Displacement factor
9.1	Luminous flux
9.2.3	Luminous intensity distribution
9.2.4	Peak intensity value
9.2.5	Beam angle value
9.3	Efficacy
10.1	Chromaticity tolerance (initial)
10.1	Correlated colour temperature (initial)
10.2	Colour rendering index (initial)
NOTE In Japan, the power factor instead of the displacement factor is relevant.	

A.2.3.2 Lifetime tests and endurance tests

For the purpose of this standard, lifetime and endurance tests are defined as in Table A.3.

Table A.3 – Lifetime and endurance tests

Clause or subclause	Test
10.1	Chromaticity tolerance (maintained)
10.1	Correlated colour temperature (maintained)
10.2	Colour rendering index (maintained)
11.2	Lumen maintenance
11.3.2	Temp. cycling, energised
11.3.3	Supply voltage switching
11.3.4	Accelerated operation life test

A.2.4 Requirements

A.2.4.1 Lamps with a single rated voltage or rated voltage range where the size of the voltage range is ≤ 20 V

The tests in Table A.2 shall be carried out at all the combinations of the test voltage and test frequencies as established in A.2.2.1.

Ageing and measurement for the tests in Table A.3 shall be carried out at the test voltage in A.2.2.1. The test frequency shall be the rated frequency or shall be chosen as one of the endpoints of the frequency range (e.g. 50 Hz or 60 Hz) and the same frequency shall be used for both ageing and measurement. The testing of both frequency endpoints in one sample is allowed.

A.2.4.2 Lamps with two rated voltages or rated voltage ranges where the size of the voltage range is ≤ 20 V

The tests in Table A.2 shall be carried out at all the combinations of the test voltages and test frequencies as given in A.2.2.2.

Ageing and measurement for the tests in Table A.3 shall be carried out at the test voltage of A.2.2.2 corresponding to the highest power consumption of the LED lamp. The test frequency shall be the rated frequency or shall be chosen to be one of the endpoints of the frequency range (e.g. either 50 Hz or 60 Hz) and the same frequency shall be used for both ageing and measurement. The testing of both frequency endpoints in one sample is allowed.

A.2.4.3 Lamps with a single rated voltage range where the size of the voltage range is ≥ 130 V and the lowest voltage is ≥ 100 V

The tests in Table A.2 shall be carried out at all the combinations of the test voltages and test frequencies as established in A.2.2.3.

Ageing and measurement for the tests in Table A.3 shall be carried out at the test voltage of A.2.2.3 corresponding to the highest power consumption of the LED lamp. The test frequency shall be the rated frequency or shall be chosen to be one of the endpoints of the frequency range (e.g. either 50 Hz or 60 Hz) and the same frequency shall be used for both ageing and measurement. The testing of both frequency endpoints in one sample is allowed.

A.2.4.4 Lamps with other rated voltage ranges

The tests in Table A.2 shall be carried out at all the combinations of the test voltages and test frequencies as established in A.2.2.4.

Ageing and measurement for the tests in Table A.3 shall be carried out at the test voltage of A.2.2.4 corresponding to the highest power consumption of the LED lamp. The test frequency shall be the rated frequency or shall be chosen to be one of the endpoints of the frequency range (e.g. either 50 Hz or 60 Hz) and the same frequency shall be used for both ageing and measurement. The testing of both frequency endpoints in one sample is allowed.

A.3 Electric and photometric characteristics

A.3.1 Test voltage

The test voltage shall be the voltage as determined in A.2.4.

A.3.2 Ageing

LED lamps normally do not require any ageing prior to testing. However, the manufacturer may define an ageing period of up to 1 000 h.

A.3.3 Luminous flux

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

In case of directional lamps the luminous flux shall be measured in a solid angle of 90° (0,6 π sr). In case of directional lamps having the beam angle greater than 90°, the luminous flux shall be measured in a solid angle of 120° (π sr).

NOTE 1 Method of measuring the luminous flux of LED lamps 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.

A.3.4 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 lamp and any optical attachments or accessories that the LED lamp has been specified for use with. Luminous intensity distribution data shall be provided for the LED lamp in accordance with an established international or regional format[6].

A.3.5 Peak intensity

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

A.3.6 Beam angle

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

The beam angle is not determined by the half peak, but by the half centre beam intensity.

A.3.7 Colour rendering

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

A.3.8 Chromaticity co-ordinate values

Reference is made to IEC 60081, Annex D.

If the chromaticity is only related to a given direction, the radiation angle shall be declared by the manufacturer.

If the radiation angle is not mentioned, the chromaticity is considered as the spatial chromaticity 4π (2π for reflector lamps).

The manufacturer shall provide information on the method used.

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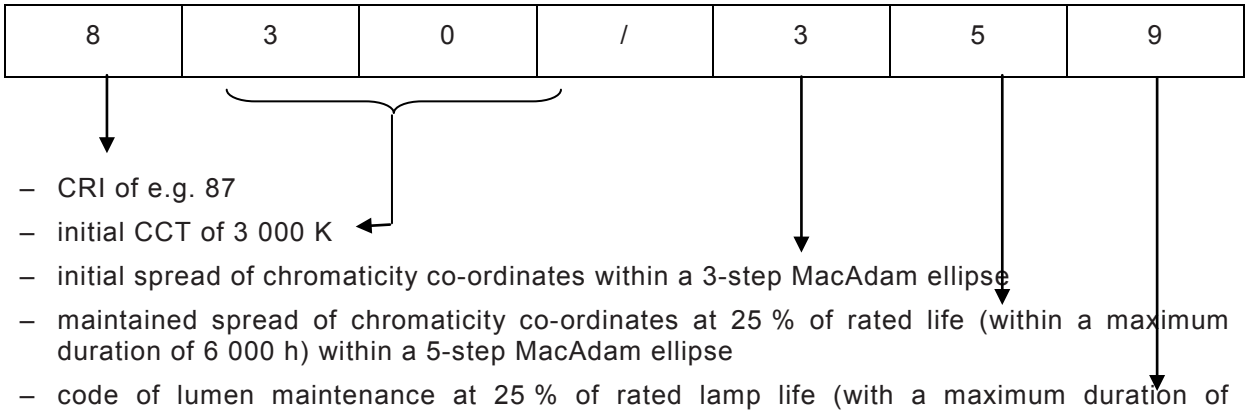
6 Information regarding acceptable regional standards for photometric data formats is under consideration.

Annex B
(normative)

Explanation of the photometric code

Example of a lamp photometric code like 830/359, meaning:



– CRI of e.g. 87
– initial CCT of 3 000 K
– initial spread of chromaticity co-ordinates within a 3-step MacAdam ellipse
– maintained spread of chromaticity co-ordinates at 25 % of rated life (within a maximum duration of 6 000 h) within a 5-step MacAdam ellipse
– code of lumen maintenance at 25 % of rated lamp 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, see IEC/TR 62732:

CRI = 70 to 79→ code 7

CRI = 80 to 89 → code 8

CRI = ≥ 90 → code 9

The highest value is 9.

NOTE 1 In Japan, the requirements on colour classification and indication is specified in JIS Z9112.

NOTE 2 In the U.S.A., the requirements on colour classification and indication are specified in ANSI C78.377.

Annex C
(normative)

Measurement of displacement factor

C.1 General

The phase angle (φ_1) of the displacement factor ($\cos(\varphi_1)$) of 8.2 shall be measured according to the definition of Clause C.2 and with the measurement requirements of Clause C.3.

NOTE In Japan, the power factor instead of the displacement factor is relevant.

C.2 Phase-angle definition

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

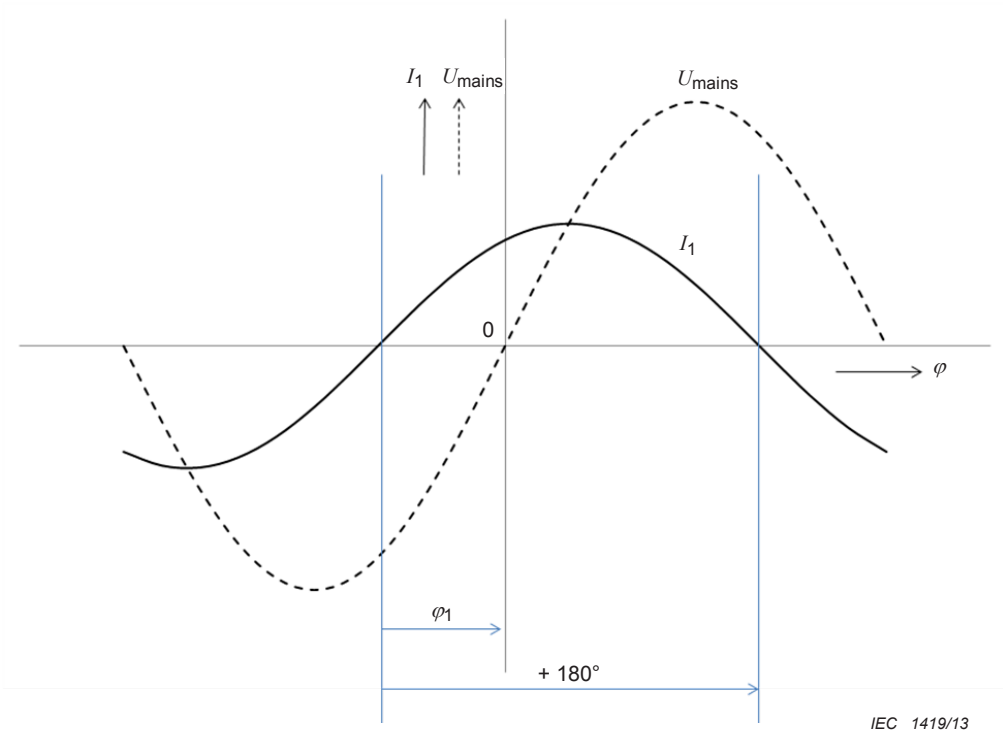


Figure C.1 – Definition of the 1st harmonic current phase-angle (φ_1) (I_1 leads U_{mains}, $\varphi_1 > 0$)

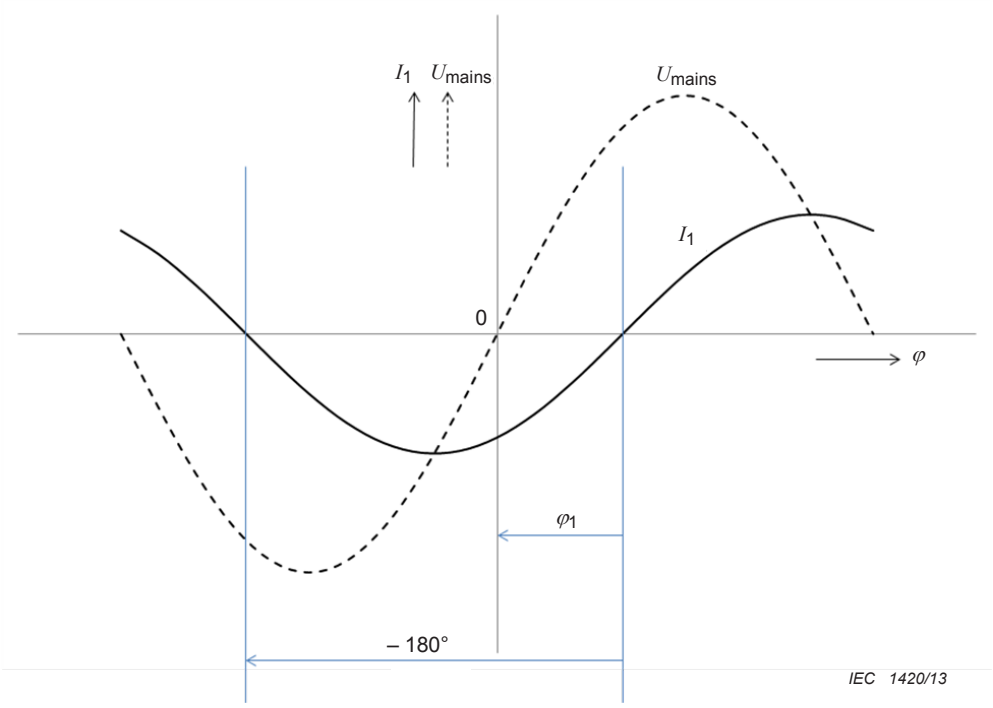


Figure C.2 – Definition of the 1st harmonic current phase-angle (φ_1) (I_1 lags U_{mains}, $\varphi_1 < 0$)

C.3 Measurement requirements

C.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.

C.3.2 Requirements for measurement equipment

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

C.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 clauses: See Clause C.5 of IEC 61000-3-2:2005, Amendment 2:2009.

NOTE Test conditions for LED light sources in Clause C.5 of IEC 61000-3-2:2005, Amendment 2:2009 are under consideration.

Annex D
(informative)

Explanation of displacement factor

D.1 General

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

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

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

with

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

and

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

resulting in

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

Angle φ_1 is the phase 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 is in the equation below:

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

where

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

D.2 Recommended values for displacement factor

No negative effects on the power grid are to be expected from self-ballasted LED lamps when complying with the recommendation as in Table D.1.

Table D.1 – Recommended values for displacement factor

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

Annex E
(informative)

Explanation of recommended life time metrics

E.1 General

Life time of LED lamps can be far more than what can be practically verified with testing. Furthermore the decrease in light output differs with the manufacturer making general prediction methods difficult. This standard has opted for lumen maintenance categories that cover the initial decrease in luminous flux until an operational time as stated in 7.1. Due to this limited test time the claimed life of an LED lamp cannot be confirmed nor rejected in most cases. The recommended metrics for specifying LED lamp life time is explained below and provides the background for the pass/fail criterion of the life time test as in 11.2.

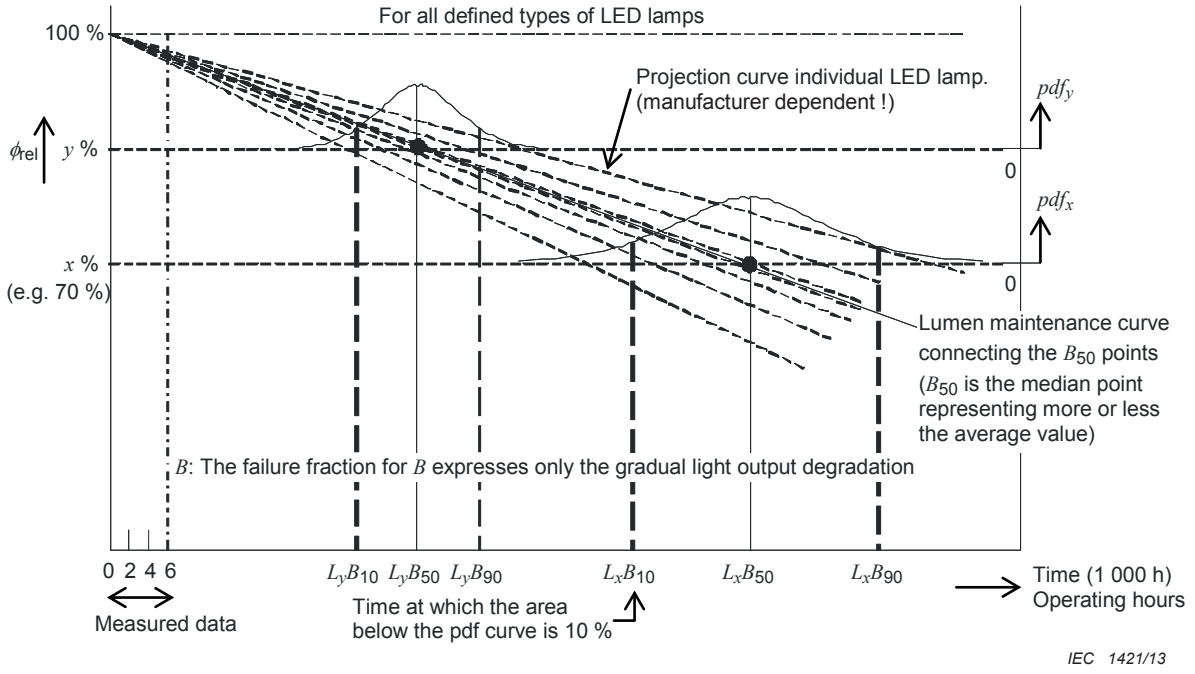
E.2 Life time specification

It is recommended for LED lamps 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 the life time where light output is ≥ 70 % for 50 % of the population.

The failure fraction for B_y expresses only the gradual light output degradation as a percentage y of a number of LED lamps of the same type that at their rated life designates the percentage (fraction) of failures. Abrupt light output degradation is exempted. The light output threshold level for L and failure fraction for B_y are free to be chosen by the manufacturer. See Clause E.6 for recommended fraction values for B_y.



Key

pdf probability density function

Figure E.1 – 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 E.1 are for illustration purposes 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 (100 %). 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 70 %, 10 % of the population failed at time $L_{70}B_{10}$ indicated by the grey area in Figure E.1. The mathematical expression is as follows:

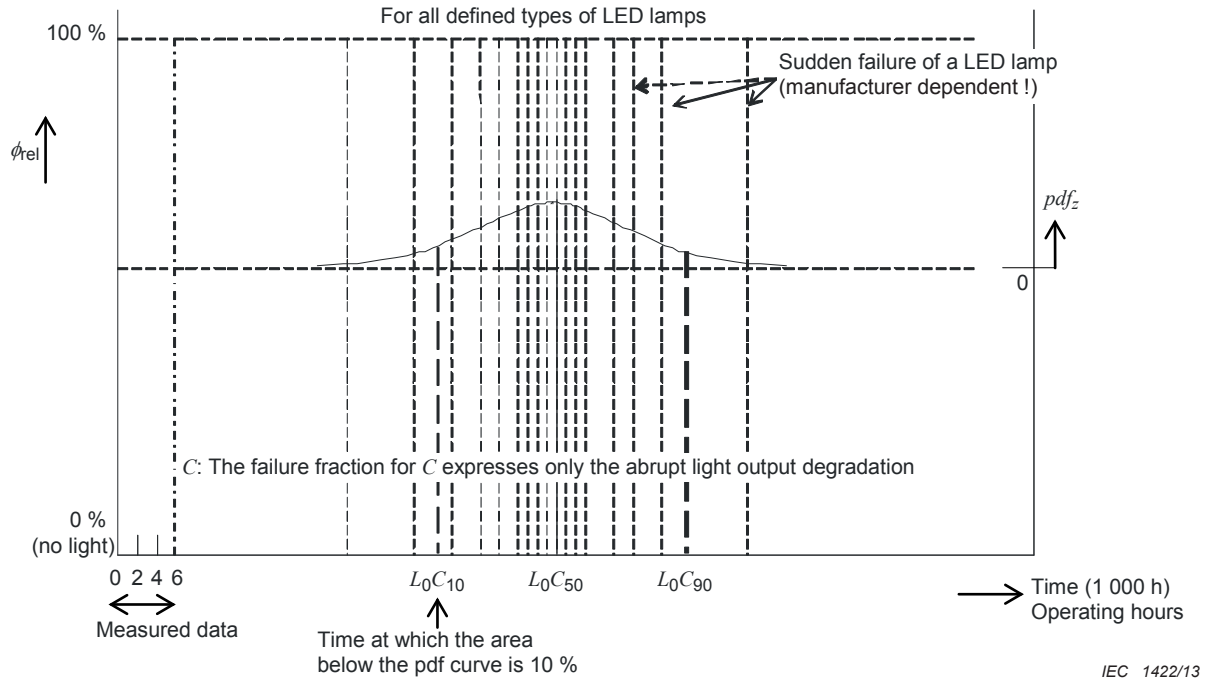
$$F(L_{70}B_{10}) = CDF(L_{70}B_{10}) = \int_0^{L_{70}B_{10}} pdf_{70}(t)dt = 0{,}1 \rightarrow 10\%$$

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

E.4 Life time specification for abrupt light output degradation

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

The failure fraction for C_y expresses only the abrupt light output degradation (see Figure E.2) as a percentage y of a number of LED lamps of the same type that at their rated life designates the percentage (fraction) of failures. The failure fraction for C_y is free to be chosen by the manufacturer. See Clause E.6 for recommended fraction values for C_y.



Key

pdf probability density function…

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 the life time where light output is ≥70 % for 50 % 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 are 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 (see Figure E.3)

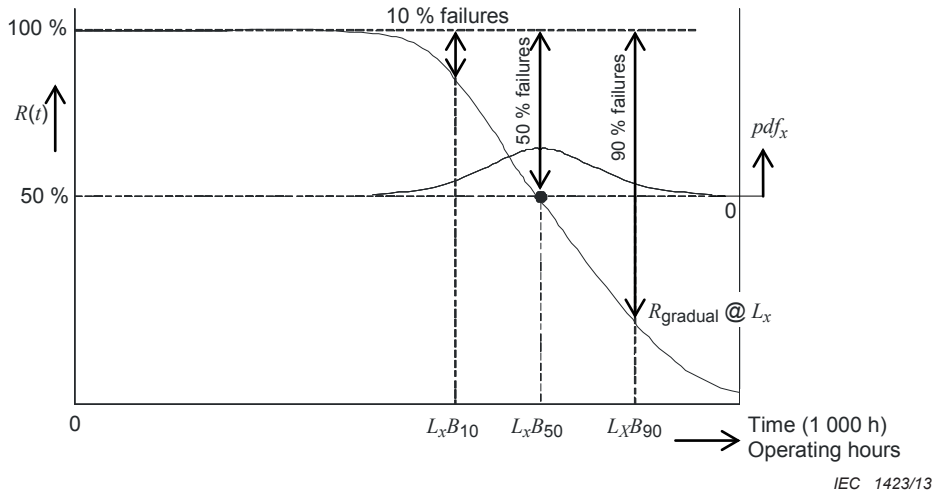


Figure E.3 – Reliability curve $R_{gradual}$ for gradual light output degradation

Step 2: Reliability curve for abrupt light output degradation (see Figure E.4)

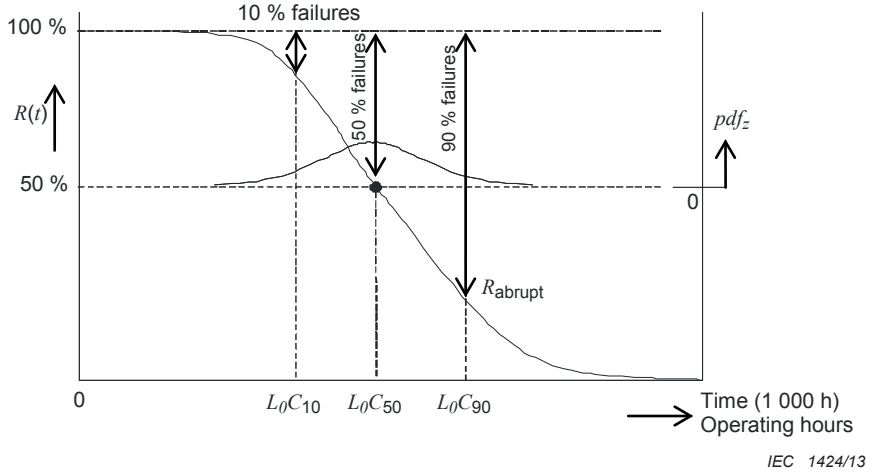


Figure E.4 – Reliability curve R_{abrupt} for abrupt light output degradation

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

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

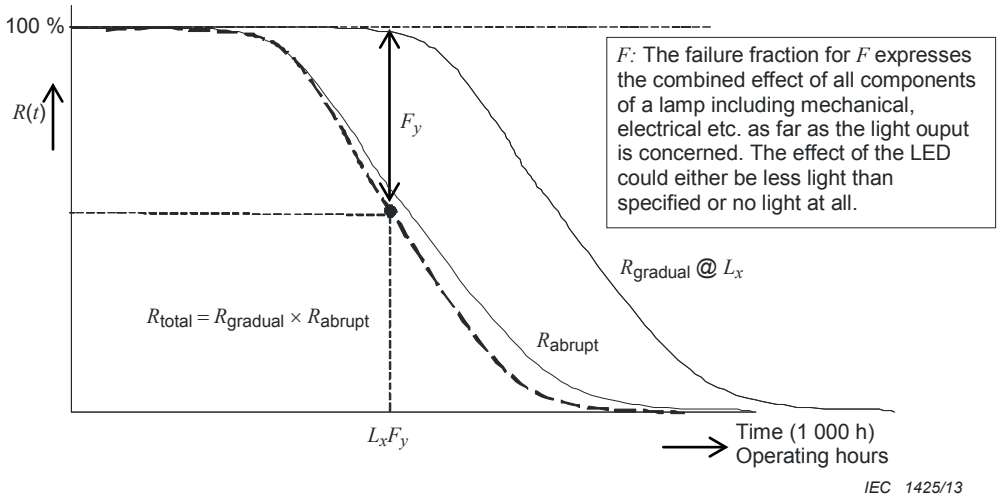


Figure E.5 – Combined $R_{gradual}$ and R_{abrupt} degradation

E.6 Recommended life time metrics

For the 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 E.1 below for recommended values of x and y.

Table E.1 – Recommended x and y values for life time metrics to be used in life time specification

Numbers in %

	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 lamps with constant lumen output are under consideration.														

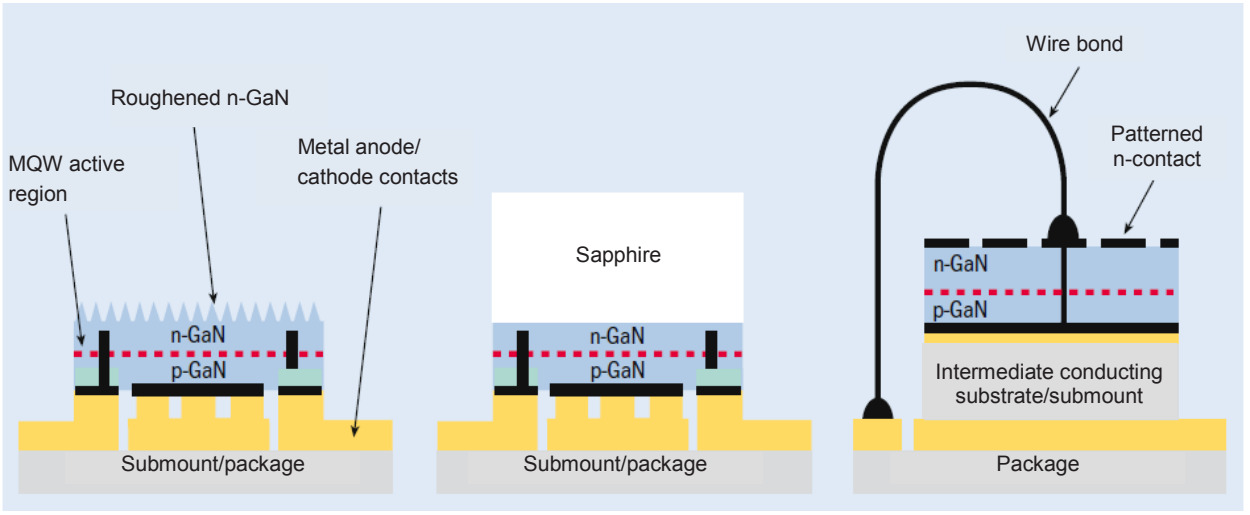
Individual LED packages or LED dies within the LED lamp are not addressed.

Annex F
(informative)

Examples of LED dies and LED packages

F.1 LED die

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



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

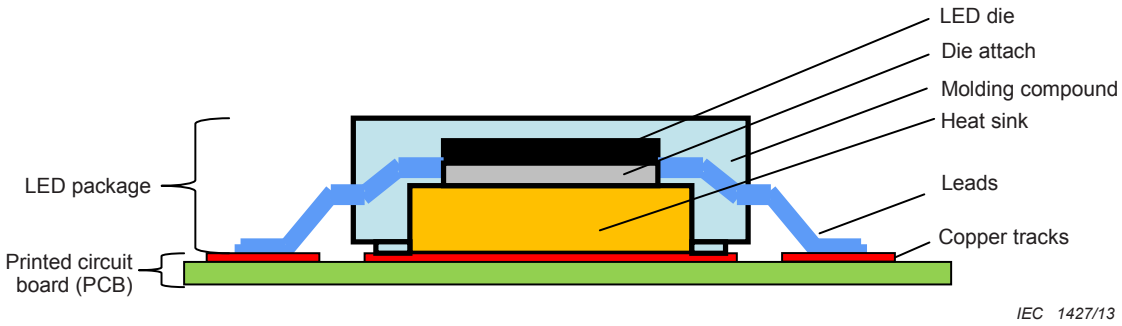
Key

MQW Multi quantum well

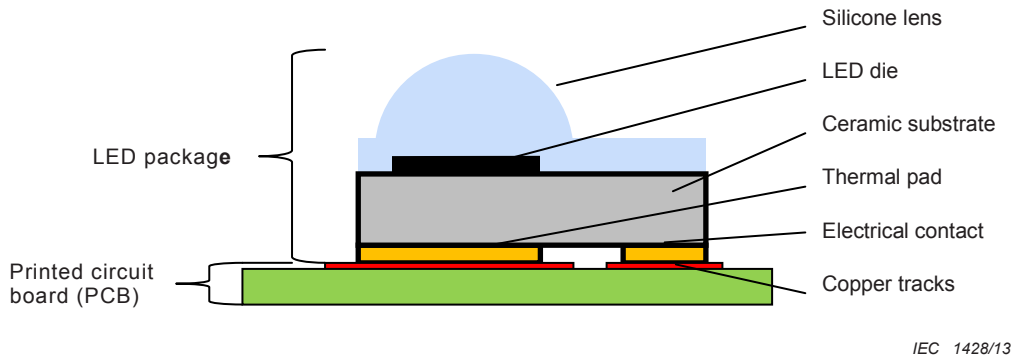
Figure F.1 – Schematic drawings of LED dies

F.2 LED package

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



a) Surface mounted LED package with lead wires



b) Surface mounted LED package without lead wires

Figure F.2 – Schematic drawings of LED packages

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7 Under development to revise JIS Z 9112:2004 and will be published in 2012.

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