IS 16103 (Part 2) : 2012

(Reaffirmed 2017)

भारतीय मानक

सामान्य प्रकाश व्यवस्था के लिए एल ई डी मौडयूल

भाग 2 कार्यकारिता अपेक्षाएँ

Indian Standard

LED MODULES FOR GENERAL LIGHTING

PART 2 PERFORMANCE REQUIREMENTS

ICS 29.140.99

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Electric Lamps and Their Auxiliaries Sectional Committee, ETD 23

FOREWORD

This Indian Standard (Part 2) was adopted by the Bureau of Indian Standards, after the draft finalized by the Electric Lamps and Their Auxiliaries Sectional Committee had been approved by the Electrotechnical Division Council.

This standard specifies the performance requirements for LED modules for general lighting services. The other part in the series is:

Part 1 Safety requirements

This standard covers the performance requirements for LED modules for general lighting applications and acknowledges the need for relevant tests for this new source of electrical light, sometimes called 'solid state lighting'.

The standard is seen in close context with simultaneously developed performance standard for luminaires in general and for LED luminaires. Changes in the LED module standard shall have impact on the luminaire standards and *vice versa*, due to the behaviour of LED. Therefore, in the development of the present standard, mutual consultancy of experts of both products has taken place.

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.

Following three types of LED modules are covered:

a) with integral control gear,
b) with means of control on board, but with separate control gear (semi-ballasted), and
c) with complete external control gear.

This standard is based on IEC 62717 and document 34A/11445/NP 'LED module for general lighting — Performance requirements' issued by the International Electrotechnical Commission (IEC) with following modifications:

a) Schedule of type test and acceptance test has been incorporated,
b) Requirements for emission has been added, and
c) Referred to standards have been changed.

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

Indian Standard

LED MODULES FOR GENERAL LIGHTING

PART 2 PERFORMANCE REQUIREMENTS

1 SCOPE

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

a) *Type* 1 — Self-ballasted LED modules for use on dc supplies up to 250 V or on ac supplies up to 1 000 V at 50 Hz.
b) *Type* 2 — LED modules operating with external control gear connected to the mains voltage, and having further control means inside (semi-ballasted) for operation under constant voltage, constant current or constant power.
c) *Type* 3 — LED modules where the complete control gear is separate from the module for operation under constant voltage, constant current or constant power.

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

NOTES

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

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

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

This standard covers LED modules that intentionally produce white light, based on inorganic LEDs.

These performance requirements are additional to the safety requirements specified in IS 16103 (Part 1) : 2012 'LED modules for general lighting : Part 1 Safety requirements'.

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 standardized. For that reason the acceptance or rejection of a manufacturers life time

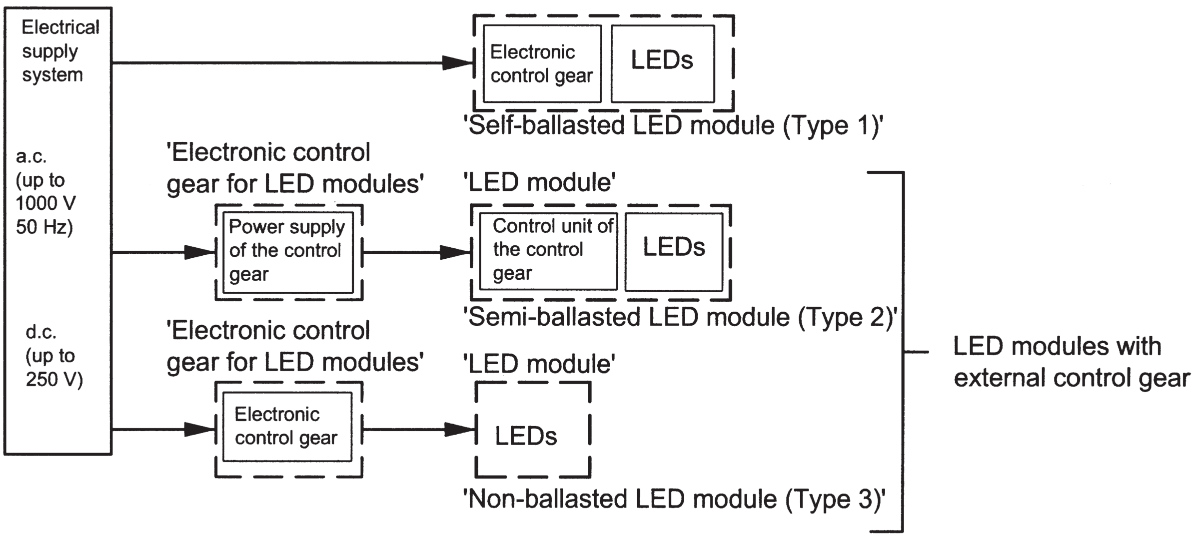


FIG. 1 TYPES OF LED MODULES

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 are lumen-depreciation character categories showing behaviour in agreement with manufacturer's information which are provided before the test is started.

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

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

NOTES

1 When modules are operated in a luminaire, the claimed performance data can deviate from the values established through this standard due to the luminaire components that has an impact performance of the module.

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

3 Protection for water and dust ingress (*see* **B-4**).

1.2 It may be expected that self-ballasted LED modules which comply with this standard shall start and operate satisfactorily at voltages between 90 percent and 110 percent of rated supply voltage. LED modules with external control gear are expected to start and operate satisfactorily in combination with the specified control gear complying with IS 15885 (Part 2/Sec 13) : 2012 'Lamp controlgear: Part 2 Particular requirements, Section 13 d.c. or a.c. supplied electronic controlgear for LED modules'.

All LED modules are expected to start and operate satisfactorily when operated under the conditions specified by the module manufacturer and in a luminaire complying with IS 10322 (Part 1) : 2012 'Luminaires: Part 1 General requirements and tests'.

1.3 For compliance with EMC requirements, only those types of LED modules are subject to EMC requirements which fall under the following category:

a) In case of harmonic current are directly connected to the mains and have active elements on board;
b) In case of radiated or conducted disturbances are directly connected to the mains (Type 1) or to a battery; and
c) In case of immunity are directly connected to the mains (Type 1) or to a battery.

2 REFERENCES

The standards given below contain provisions which, through reference in this text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of these standards.

IS No.	*Title*
1885 (Part 16/ Sec 1) : 1968	Electrotechnical vocabulary: Part 16 Lighting, Section 1 General aspects
2418 (Part 1) : 1977	Tubular fluorescent lamps for general lighting services: Part 1 Requirements and tests
2500 (Part 1) : 2000	Sampling procedures for inspection by attributes: Part 1 Sampling schemes indexed by acceptance quality limit (AQL) for lot-by-lot inspection
6873 (Part 5) : 1999	Limits and methods of measurement of radio disturbance characteristics: Part 5 Electrical lighting and similar equipment
10322 (Part 1) : 2011	Luminaires: Part 1 General requirements and tests
11000 (Part 14/ Sec 1 to 3) : 1984	Basic environmental testing procedures for electronic and electrical items: Part 14 Test N, change of temperature
16101 : 2012	General lighting — LED and LED modules — Terms and definitions
16103 (Part 1) : 2012	LED modules for general lighting: Part 1 Safety requirements
16104 : 2012	d.c. or a.c. supplied electronic control gear for LED modules — Performance requirements
16106 : 2012	Method of electrical and photometric measurements of solid state lighting (LED) products

3 TERMINOLOGY

For the purpose of this standard the definitions given in IS 16101 and IS 1885 (Part 16/Sec 1) and the following shall apply.

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

3.2 Test Voltage, Current or Power — Input voltage, current or power at which tests are carried out.

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

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

3.4 Initial Values — Photometric and electrical characteristics at the end of the ageing period and/or stabilization time.

3.5 Maintained Values — Photometric and electrical characteristics at an operational time as stated in **6.1** including stabilization time.

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

NOTES

1 For sample size (*see* **6**).

2 Note 2 under **3.7** shall apply.

3 For explanation of the figure L_xF_y (*see* Annex C).

3.7 Life (of an Individual LED Module)(L_x) — Length of time during which a LED module provides more than claimed percentage '*x*' of the initial luminous flux, under standard test conditions.

NOTES

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

2 A LED module has thus reached its end of life, when it no longer provides claimed percentage *x* of the initial luminous flux. Life is always published as combination of life L_x and failure fraction F_y (*see* **3.8**).

3.8 Failure Fraction (F_y) — The percentage '*y*' of a number of LED modules of the same type that at their rated life designates the percentage (fraction) of failures.

NOTES

1 This failure fraction expresses the combined effect of all components of a module including mechanical, as far as the light output is concerned. The effect of the LED could either be less light than claimed or no light at all.

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

3.9 Photometric Code — Colour designation of a LED module giving white light is defined by the Correlated Colour Temperature and the CIE 1974 general colour rendering index.

NOTES

1 Definition of photometric code is given in IS 16101 as light colour designation.

2 Photometric code is under consideration.

3.10 Stabilization Time — Time, which the LED module requires to obtain stable photometric conditions with constant electrical input.

NOTE — LED modules may be regarded stable at stable thermal conditions.

3.11 Ageing — Preconditioning period of the LED module.

3.12 Type — LED modules, representative of the production.

3.13 Family — Group of LED modules that have,

a) same method of control and operation (self-ballasted, semi-ballasted, non-ballasted);

b) same classification according to the method of installation, *see* **6** of IS 16103 (Part 1);

c) same class of protection against electrical shock; and

d) 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 modules, representative of the production.

3.15 Type Test Sample — One or more LED modules submitted by the manufacturer or responsible vendor for the purpose of the type test.

3.16 t_p Point — The designated location of the point where to measure the performance temperatures t_p and $t_{p\,Max}$ at the surface of the LED module.

3.17 t_p Temperature

Temperature at the t_p point, related to the performance of the LED module.

NOTES

1 $t_p \leq t_c$. This is only the case if the location of t_p and t_c is the same. For t_c, *see* **3.10** of IS 16103 (Part 1).

2 The location of t_p and t_c can be different, but the value of t_c is leading.

3 For a given life time, the t_p temperature is a fixed value, not a variable.

4 There can be more than one t_p, depending on the life time claim.

3.18 Recommended Maximum LED Module Operating Temperature ($t_{p\,Max}$)

Maximum t_p temperature, as declared by the manufacturer or responsible vendor.

NOTES

1 $t_{p\,Max} \leq t_c$. This is only the case if the location of $t_{p\,Max}$ and t_c is the same. For t_c, *see* **3.10** of IS 16103 (Part 1).

2 The location of $t_{p\ Max}$ and t_c can be different, but the value of t_c is leading.

3.19 Semi-ballasted LED Module — Module which carries the control unit of the control gear and operated by the separate power supply of the control gear.

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

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

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

3.21 Power Supply of the Control Gear — Electronic device, being part of the control gear, capable of controlling current, voltage or power within design limits. The device contains no additional LED control capabilities.

NOTES

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

2 The energy source of a power supply can be either a battery or the electrical supply system.

3.22 LED Module Efficacy — Quotient of the luminous flux emitted by the power consumed by the LED module.

NOTE — The efficacy is expressed in lm/W.

3.23 LED Die — Block of semi-conducting material on which a given functional circuit is fabricated.

NOTE — For a schematic built-up of a LED die, *see* Fig. 8.

3.24 LED Package — An assembly of one or more LED dies, possibly with optical element and thermal, mechanical, and electrical interfaces. The device does not include the control unit of the controlgear, does not include an standardized lamp cap, and is not connected directly to the mains.

NOTE— A LED package is a discrete component and part of the LED module. For a schematic built-up of a LED package, *see* Fig. 9.

3.25 Acceptance Test — Tests carried out on samples taken from a lot for the acceptance of the lot.

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 $t_{p\ Max}$, except for the t_p point (item x), the dimensions (item xiv) and the availability of a heat sink (item xv).

NOTE — This information is in addition to the mandatory marking required by IS 16103 (Part 1).

For scaleable modules (*see* **6.1**) and mark the reference dimensions in the leaflet.

Table 1 Required Markings and Places of Marking[1)]

(*Clause* 4.1)

Sl No. (1)	Parameters (2)	Product (3)	Packaging (4)	Product Datasheets, Leaflets or Website (5)
i)	Rated luminous flux, lm	—	x	x
ii)	Photometric code (*see* Annex D[2)])	—	x	x
iii)	Rated life (h) and the associated rated lumen maintenance factor (x)	—	x	x
iv)	Failure fraction (F_y), corresponding to the rated life	—	x	x
v)	Lumen maintenance code (*see* Table 6)	—	—	x
vi)	Rated chromaticity co-ordinate values both initial and maintained (*see* Table 5).	—	—	x
vii)	Correlated colour temperature, in K	—	—	x
viii)	Rated colour rendering index	—	—	x
ix)	$t_{p\ Max}$[3)] of LED module, in °C	x[4)]	—	x
x)	t_p point	x[3)]	—	x
xi)	Ageing time, in h, if different to 0 h	—	—	x
xii)	Ambient temperature range	—	—	x
xiii)	Efficacy in lm/W	—	—	x
xiv)	Dimensions, including dimension tolerances	—	—	x
xv)	Availability of a heat sink	—	—	x

NOTE — 'x' = required, '—' = not required.

[1)] Regulatory requirements, if any may apply and overrule.

[2)] Under consideration.

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

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

4.2 Additional Marking

If the module does not have an own heat sink, the module manufacturer shall provide this information.

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 recommended $t_{p\ Max}$ 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

Sl No.	Item	$t_{p\ point\ (1)}$	$t_{p\ point}$	$t_{p\ Max}$
(1)	(2)	(3)	(4)	(5)
i)	t_p temperature (°C) measured at the $t_{p\ point}$	*	*	*
ii)	Rated life time (h)	*	*	*

NOTES

1 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.

2 Verification is currently not covered in this standard.

* Values to be declared by the LED module manufacturer.

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

Table 3 Optional Marking and Location of Marking

Sl No.	Parameters	Product	Packaging	Product, Data Sheet, Leaflets or Website
(1)	(2)	(3)	(4)	(5)
i)	Luminous intensity distribution	—	—	x
ii)	Beam angle	—	—	x
iii)	Peak intensity	—	—	x

NOTE — 'x' = required, '—' = not required.

4.3 BIS Certification Marking

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

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

5 DIMENSIONS

All of the tested items in a sample shall be within the dimensional tolerances as declared by the manufacturer or responsible vendor.

Compliance is checked by inspection.

6 TEST CONDITIONS

6.1 General Test Conditions

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

NOTE — Additional LED modules within the same family (*see* **3.13**) may be subjected to decreased testing duration. For identification of a family *see* Table 4, for details on sample sizes for family testing, *see* Table 7.

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 external reference power supply and reference controlgear, 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 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, for example modules of linear geometry, but 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 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 family aims to guide LED module manufacturers towards to platform designs thus to allow the possibility to use data of the existing baseline product that had 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 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 (for example CCT) should be essential 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 or certification authority.

Requirements for the identification of a family of LED modules for type testing are given in **3.13** and used in Table 4.

Testing time may be reduced within family for 1 000 h in case variations within part characteristics are fulfilled with conditions given in Table 4.

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 module:

a) Chromaticity co-ordinates;
b) Colour rendering index;
c) Lumen maintenance code; and
d) Results of acceleration operated life test.

Documentation of data shall be provided to the testing authority in manufacturer's manual or instruction sheet.

For all of the tested items 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 MODULE POWER

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

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

The 97.5 percent (*see* Note 1) one-sided upper confidence limit for the sample mean of power shall not exceed 110 percent of the rated power value.

The 97.5 percent (*see* Note 1) upper confidence limit for sample size *n* according Table 7 is calculated by the formula:

$$\overline{X} + \left(t_{n-1;\,0.975} \cdot \frac{S}{\sqrt{n}} \right)$$

Table 4 Allowed Variations within Family
(*Clause* 6.2.2)

Sl No. (1)	Part Characteristics Intended to be Varied (2)	Conditions for Acceptance (3)
i)	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 the same value as indicated and specified by the manufacturer or responsible vendor (*see also* Note 1).
ii)	Optics (*see* Note 2)	The test results showing the effect of optical material change shall be documented in the manufacturer's technical file.
iii)	LED package	t_p remains at the same value as indicated and specified by the manufacturer or responsible vendor (*see also* Note 1).
iv)	Controlgear (Applicable for Type 1 or Type 2 LED modules)	t_p remains at the same value as indicated and specified by the manufacturer or responsible vendor. A statistical failure rate calculation based on a MTBF calculation by manufacturer must show equal or lower failure rate of the electronic controlgear.

NOTES

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).

2 Optics includes for instance secondary optics (lenses), reflectors, trim and gasket and their interconnections. The results should relate to changes in luminous flux, luminous peak intensity, luminous intensity distribution, beam angle, shift in colour co-ordinates, shift in CCT and shift in CRI.

3 Any change on part tolerances shall be documented in the manufacturer's manual or instruction sheet.

where, $\overline{X}$, S and n are the sample average, standard deviation and number of LED modules respectively and $t_{n-1,\ 0.975}$ is the t-statistic for a 97.5 percent confidence limit for n –1 degrees of freedom.

NOTES

1 Under consideration; in discussion: 95 percent one-sided confidence interval.

2 Note 2 of **1.1** should be regarded.

3 For sample sizes, *see* calculations given in Annex E.

8 LIGHT OUTPUT

8.1 Luminous Flux

Luminous flux is measured according to Annex A.

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

The 97.5 percent (*see* Note 1) one-sided lower confidence limit for the sample mean luminous flux shall not exceed 90 percent of the rated luminous flux value.

The 97.5 percent (*see* Note 1) lower confidence limit for sample size '*n*' according Table 7 is calculated by the following formula:

$$\overline{X} - \left(t_{n-1;\,0.975} \cdot \frac{S}{\sqrt{n}} \right)$$

where $\overline{X}$ and S are the sample average and standard deviation and number of LED modules respectively and $t_{n-1,0.975}$ is the t-statistic for a 97.5 percent confidence limit for n –1 degrees of freedom.

NOTES

1 Under consideration; in discussion: 95 percent one-sided confidence interval.

2 For sample sizes, *see* calculations given in Annex E.

8.2 Luminous Intensity Distribution, Peak Intensity and Beam Angle

8.2.1 *General*

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

NOTE — Luminous intensity distribution of a LED module may 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_p as per **A-1**.

NOTE — The allowed photometric variations detailed shall be considered on 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.

Compliance is under consideration.

8.2.4 *Peak Intensity Value*

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 percent of the rated intensity.

Compliance is checked according to Annex A.

NOTE — The average value and confidence level are under consideration.

8.2.5 *Beam Angle Value*

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 percent of the rated value.

Compliance is checked according to Annex A.

NOTE — The average value and confidence level are under consideration.

8.3 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 all tested items in a sample, the LED module efficacy shall not be less than 90 percent 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 co-ordinates is made at an operational time as stated in **6.1**. The measured actual 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 of an individual LED module.

For compliance of family members, *see* **6.2.3**.

For all of the tested items in a sample, the measured chromaticity coordinate values of a LED module (the initial value and maintained value) shall not move beyond the chromaticity coordinate 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 items for the chromaticity coordinate measurement shall be selected from four different batches (*see* Note).

NOTE — The colour variation between the items in a sample from different production runs resembles the variation within longer periods of production.

Table 5 Tolerance (Categories) on Rated Chromaticity Coordinate Values

Sl No.	Size of MacAdam Ellipse, Centred on the Rated Colour Target	Colour Variation Category	
		Initial	Maintained
(1)	(2)	(3)	(4)
i)	3-step	3	3
ii)	5-step	5	5
iii)	7-step	7	7
iv)	>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 co-ordinates and maintained chromaticity coordinates.

For an example, *see* Annex D.

NOTES

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

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

3 See Annex A for measurement method of chromaticity co-ordinates 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.

For compliance of family members, *see* **6.2.3**.

For all of the tested items 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 specified in **6.1**.

For all tested items in a sample the measured CRI values shall not have decreased by more than,

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

10 LED MODULE LIFE

10.1 General

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

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

NOTE — 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.

10.2 Lumen Maintenance

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

NOTES

1 As the typical life of a LED module is (very) long, it is within the scope of this standard regarded unpractical and time consuming to measure the actual lumen reduction over life (for example L_{70}). For this reason this standard relies on test results to determine the expected lumen maintenance code of any LED module.

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

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

4 Compliance of lumen maintenance after 25 percent of life time or 6 000 h implies that the lamps would have a nominal life of 25 000 h.

5 An optimised test duration for future consideration is given in Annex G.

This standard has opted for 'lumen maintenance categories' (*see* Fig. 2) that cover the initial decrease in lumen output until an operational time as stated in **6.1**. There are three categories of lumen maintenance compared to the initial lumen output (*see* Table 6).

Table 6 Lumen Maintenance Code at an Operational Time as Stated in 6.1

Sl No.	Lumen Maintenance (percent)	Code
(1)	(2)	(3)
i)	≥ 90	9
ii)	≥ 80	8
iii)	≥ 70	7

The initial luminous flux shall be measured. The measurement is repeated at an operational time as specified in **6.1**. The initial luminous flux value is normalized to 100 percent; it is used as the first data point for determining module life. The measured luminous flux value at an operational time as specified in **6.1** shall be expressed as maintained value which is equal to the percentage of the initial value.

NOTES

1 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 specified in **6.1**.

2 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 "1" could be better or worse than Code "3".

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

For compliance of family members, at 25 percent of rated life with a maximum of 6 000 h test duration, reference shall be made to **6.2.3**.

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

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

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

Given a sample of n pieces (individuals) of LED modules according to Table 7 being subjected to the 6 000 h (or 25 percent of rated life), it is deemed to having passed the test, if at the end of the test, the number of failed items is smaller or equal to the number claimed by the manufacturer. This standard gives the following guide for calculation:

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

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

NOTE — Calculation, based on 25 percent[1)] of claimed failure fraction F_y:

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

Claimed failure fraction F_{10} gives 25 percent × F_{10} (= 10 percent) × *n* (= 20) = 0.5, rounded off to next lower integer gives 0 LED modules allowed to fail.

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*

Temperature cycling test according to IS 11000 (Part 14/Sec 1 to 3) shall be checked with specified rate of change.

The LED module is placed in a test chamber in which the temperature is varied from –10°C to +50°C[2)] over a 4 h period and for a test duration of 250[3)] periods (1 000 h). A 4 h period consists of 1 h holding on each extreme temperature and 1 h transfer time (1K/min) between the temperature extremes. The LED module is switched on and off for 17 min.

Compliance shall be checked by the following:

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.

NOTES

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

2 The temperature requirements of Annex A, **A-1** do not apply.

[1)] 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. 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 percent of rated life (with a maximum of 6 000 h).

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

[3)] Under consideration.

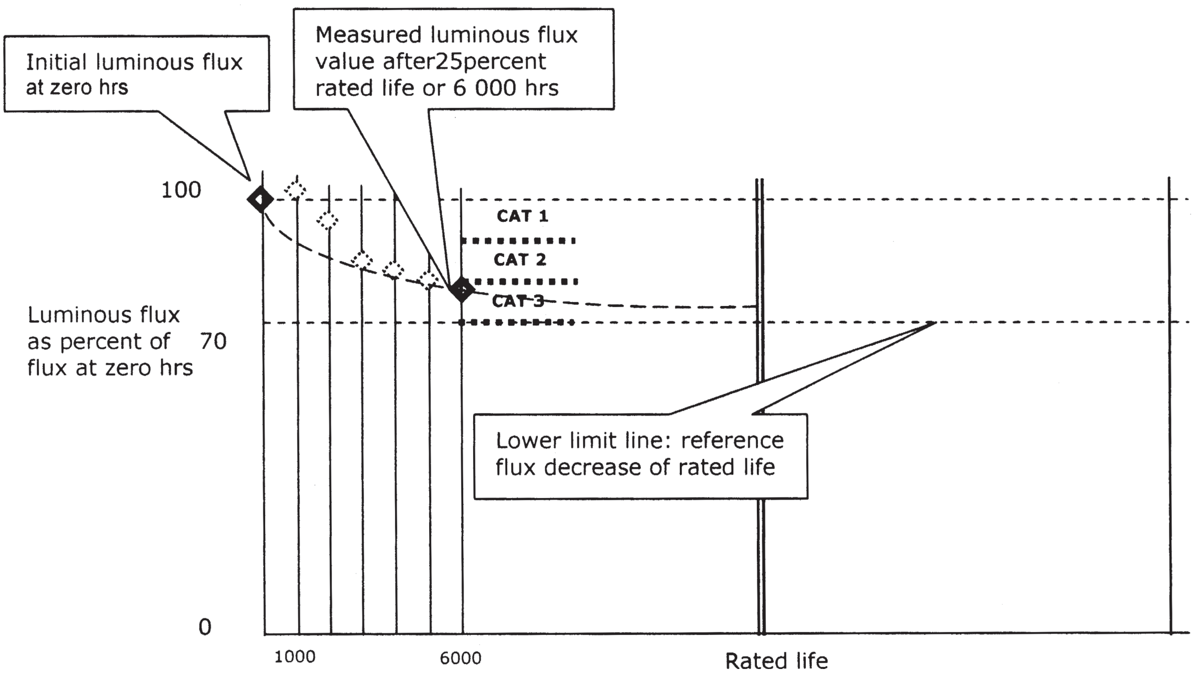


FIG. 2 LUMINOUS FLUX DEPRECIATION OVER LIFE

10.3.3 *Supply Switching Test*

At test voltage, current or power, the 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*: 10K cycles if rated life is 20K h).

NOTE — The temperature requirements of Annex A, **A-1** shall apply.

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* Note 2) above the maximum recommended operating temperature $t_{p\ Max}$, over an operational time as stated in **6.1**. Any thermal protecting devices that would switch off the LED module or reduces the light output at a threshold temperature greater than $t_{p\ Max}$, shall be bypassed.

For compliance of family members, *see* **6.2.3**.

At the end of this period, and after cooling down to room temperature, all the modules shall remain alight (*see* Note 3) for at least 15 min.

NOTES

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

2 LED module manufacturer or responsible vendor may declare higher temperature above $t_{p\ Max}$ as indicated, but Note 1 must be respected.

3 "Alight" means the claimed lumen maintenance according to Table 6, with an acceptable decrease of *x* percent ("*x*" is under consideration).

4 The temperature requirements of Annex A, **A-1** do not apply.

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.

12 INFORMATION FOR LUMINAIRE DESIGN

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

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

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

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

a) in case of harmonic current are directly connected to the mains and have active elements on board;
b) in case of radiated or conducted disturbances are directly connected to the mains (Type 1) or to a battery; and
c) in case of immunity are directly connected to the mains (Type 1) or to a battery.

13.1.1 LED module shall comply with the terminal voltage limits given in Table 8.

13.1.2 Where the light source is operated at a frequency exceeding 100 Hz, the lamp shall comply with the lamp shall comply with the field strength limits given in Table 9.

14 TESTS

14.1 Classification of Tests

14.1.1 *Type Tests*

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

Table 7 Sampling Sizes
(*Clause* 11)

Sl No. (1)	Ref of Clause (2)	Test (3)	Permitted Accumulation of Test Records Between Module Groups (4)	Minimum Number of Samples (5)
i)	4.1	$t_{p\ Max}$	Same 5 items for all test	Same 5 items for all test
ii)	4.1	$t_{p\ point}$		
iii)	5	Dimensions including dimensional tolerances		
iv)	8.2.3	Luminous intensity distribution		
v)	8.2.4	Peak intensity value		
vi)	8.2.5	Beam angle value		
vii)	7	Power	Same 20 items for all test	Same 5 items for all test
viii)	8.1	Luminous flux		
ix)	8.3	Efficacy		
x)	9.1	Chromaticity tolerance		
xi)	9.2	Correlated colour temperature		
xii)	9.3	Colour rendering index		
xiii)	10.2	Lumen maintenance		
xiv)	10.3.2	Temperature cycling energized	20	5
xv)	10.3.3	Supply voltage switching	20	5
xvi)	10.3.4	Supply voltage switching	10	5
xvii)	13	Test for radiated/conducted emission	10	5

Table 8 Limits of Frequency Range Against Emission
(*Clause* 13.1.1)

Sl No.	Frequency Range	Limits dB(μV)[1]	
		Quasi Peak	Average
(1)	(2)	(3)	(4)
i)	9 kHz-50 kHz[2]	110	—
ii)	50 kHz-150 kHz[2]	90-80[3]	—
iii)	150 kHz-0.5 MHz	66-56[3]	56-46[3]
iv)	0.5 MHz-2.51 MHz	56	46
vi)	2.51 MHz-3.0 MHz	73	63
vii)	3.0 MHz-5.0 MHz	56	46
viii)	5.0 MHz-30.0 MHz	60	50

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

Table 9 Limits of Loop Diameter Against Transient Frequency Range
(*Clause* 13.1.2)

Sl No.	Frequency Range	Limits of Loop Diameter dB(μA) [1]		
		2m	3m	4m
(1)	(2)	(3)	(4)	(5)
i)	9 kHz-70 kHz	88	81	75
ii)	70 kHz-150 kHz	88-58[2]	81-51[2]	75 to 45[2]
iii)	150 kHz-2.2 MHz	58-26[2]	51-22[2]	45 to 16[2]
iv)	2.2 MHz-3.0 MHz	58	51	45
v)	3.0 MHz-30.0 MHz	22	15 to 16[3]	9 to 12[3]

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

a) Marking (*see* **4**);
b) Dimension (*see* **5**);
c) Module power (*see* **7**);
d) Luminous flux (*see* **8.1**);
e) Luminous intensity (*see* **8.2**);
f) Module efficacy (*see* **8.3**);
g) Chromaticity coordinates and corelated colour temperature (*see* **9.1**);
h) Colour rendering index (CRI) (*see* **9.2**);
j) Lumen maintenance (*see* **10.2**);
k) Endurance (*see* **10.3**); and
m) Emission (radiated and conducted) of radio frequency disturbances (*see* **13**).

14.2 Acceptance Test

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

a) Marking (*see* **4**);
b) Dimension (*see* **5**);
c) Module power (*see* **7**);
d) Luminous flux (*see* **8.1**);
e) Luminous intensity (*see* **8.2**);
f) Module efficacy (*see* **8.3**);
g) Chromaticity coordinates and corelated colour temperature (*see* **9.1**); and
h) Colour rendering index (CRI) (*see* **9.2**).

ANNEX A

(*Clauses* 6.1, 7, 8.1, 9.1 *and* 10.3.2)

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 percent maximum and steady state operation of the LED module.

Maintenance (*see* **10.2**) and supply switching (*see* **10.3.3**) operation shall be conducted in the temperature interval ($t_{p\ Max}$-5, $t_{p\ Max}$). For the supply switching test, the temperature requirement is applicable only to the ON time. The value of $t_{p\ Max}$ shall not be exceeded. An appropriate heat sink or additional heating may need to be applied to obtain the correct $t_{p\ Max}$ value. For testing purposes, the $t_{p\ point}$ shall be marked easily accessible.

Final test results are to be presented as if testing had been executed at the maximum recommended operating temperature ($t_{p\ Max}$) of the LED module. Tests may be performed at different temperatures; for this, the relation between the two temperatures has to be established at beforehand in an unambiguous manner. In case of doubt, depending on the type of control circuit the module manufacturer is using, the t_p measurement shall be done at the most onerous condition of operation. The value of $t_{p\ Max}$ shall be reported in the marking clause.

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

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

Measurement of light output and module operating voltage, current or power within the 15 min stabilization period shall be taken once a minute. During the final 5 min of stabilization time, the difference of maximum and minimum readings of light output and module operating voltage, current or power shall be less than 1 percent of the average of the final 5 readings. If this is not feasible, a subsequent 15 min stabilization period shall be taken. A maximum of 3 stabilization periods of 15 min is considered sufficient for all type of LED modules.

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

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

A-2 ELECTRICAL CHARACTERISTICS

A-2.1 Test Voltage, 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 to the temperature of the module.

A-2.2 Ageing

LED modules do not require any ageing prior to testing.

A-3 PHOTOMETRIC CHARACTERISTICS

A-3.1 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 the most adverse effect to the temperature of the LED module.

A-3.2 Luminous Flux

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

NOTES

1 Reference may be made to Indian Standard for the information on measurement of luminous flux.

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

3 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 reference characteristics declared at t_p.

A-3.3 Luminous Intensity Distribution

Luminous intensity distribution shall be measured in accordance with Indian Standard (*under preparation*).

Luminous intensity distribution data shall be available for all variations of the LED module and any optical attachments or accessories that the LED module has been specified for use with. Luminous intensity distribution data shall be provided for the LED module in accordance with an established format.

A-3.4 Peak Intensity

The peak intensity shall be measured in accordance with Indian Standard (*under preparation*).

A-3.5 Beam Angle

The beam angle shall be measured in accordance with Indian Standard (*under preparation*).

NOTE — 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 with Indian Standard (*under preparation*).

A-3.7 Chromaticity Coordinate Values

Reference is made to IS 2418 (Part 1) for chromaticity coordinates.

Chromaticity coordinate values of LED modules may depend on the radiation angle. The manufacturer shall provide information on the method used.

ANNEX B

(*Clauses* 1.1 *and* 12)

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 LUMINOUS FLUX OF LEDS

Under consideration.

B-3 BINNING PROCEDURE OF WHITE COLOUR LEDS

Under consideration.

B-4 INGRESS PROTECTION

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

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

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

LED modules, classified as 'integral' shall not be separately tested.

ANNEX C

(*Clauses* 1.1 *and* 3.6)

EXPLANATION OF RECOMMENDED LIFE TIME METRICS

C-1 INTRODUCTION

Life time of LED modules can be far more than what practically can be verified with testing. Furthermore the decrease in light output differs per manufacturer making general prediction methods difficult. This standard has opted for lumen maintenance categories that cover the initial 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 module cannot be confirmed nor rejected in most cases. The recommended metrics for specifying LED module life time is explained below and differs from the pass/fail criterion of the life time test as in **10.2**.

C-2 LIFE TIME SPECIFICATION

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

C-3 LIFE TIME SPECIFICATION FOR GRADUAL LIGHT OUTPUT DEGRADATION

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

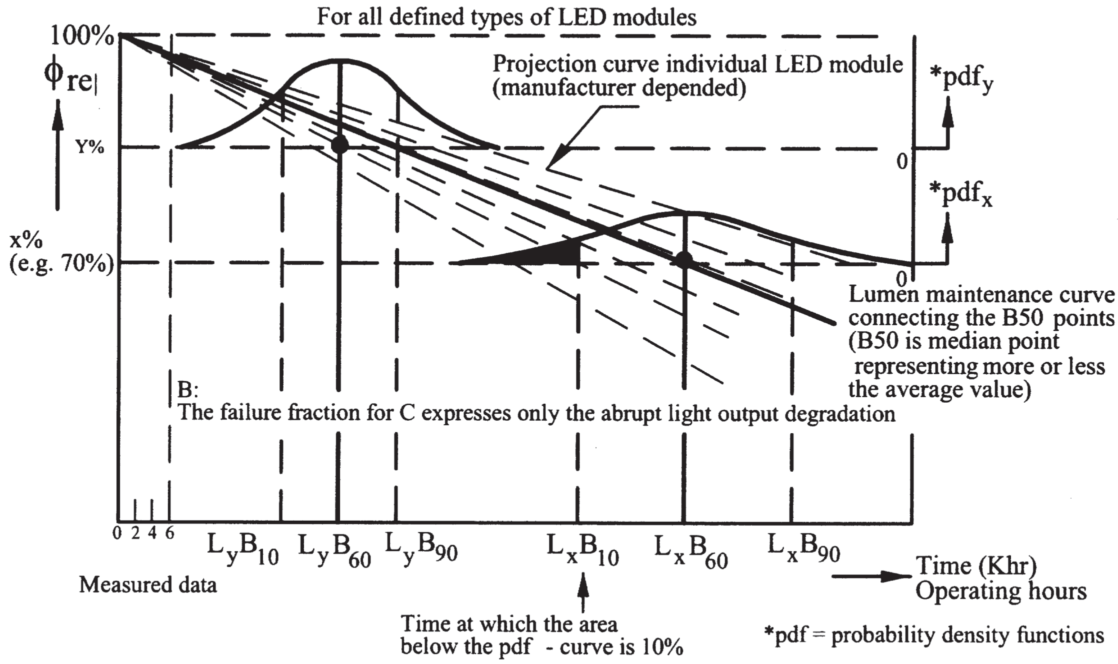
The failure fraction for B_y expresses only the gradual light output degradation as a percentage *y* of a number of LED modules of the same type that at their rated life designates the percentage (fraction) of failures. Abrupt light output degradation is exempted. The light output threshold level for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

The shape of the probability density function (pdf) and the shape of the projection curve in Fig. 3 is for illustration purpose only. Probability density function can be Weibull, Lognormal, Exponential or Normal depending on the measured data and used projection method.

The failure function *F*(*t*) or Cumulative Distribution Function {*CDF*(*t*)}, is the failure percentile as function of time. This is mathematically expressed as follows:

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

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



All dimensions in millimetres.

FIG. 3 LIFE TIME SPECIFICATION FOR GRADUAL LIGHT OUTPUT DEGRADATION

Explanation of failure fraction for *B*:

Example — Considering a lumen maintenance threshold level of 70 percent, 10 percent of the population failed at time $L_{70}B_{10}$ indicated by the grey area in Fig. 3 mathematically 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- 4 LIFE TIME SPECIFICATION FOR ABRUPT LIGHT OUTPUT DEGRADATION

Example: L_0C_{10} is understood as the life time where light output is 0 percent for 10 percent of the population (*see* Fig. 4).

The failure fraction for C_y expresses only the abrupt light output degradation as a percentage *y* of a number of LED modules 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 **C-6** for recommended fraction values for C_y.

C-5 COMBINED GRADUAL AND ABRUPT LIGHT DEGRADATION

Example — $L_{70}F_{50}$ is understood as the life time where light output is ≥ 70 percent for 50 percent of the population. The failure fraction for *F* expresses the gradual light output degradation including abrupt light output degradation. The light output threshold level for *L* and failure fraction for *F* is free to be chosen by the manufacturer.

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

Step 1 — Reliability curve for gradual light output degradation (Fig. 5);

Step 2 — Reliability curve for abrupt light output degradation (Fig. 6); and

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

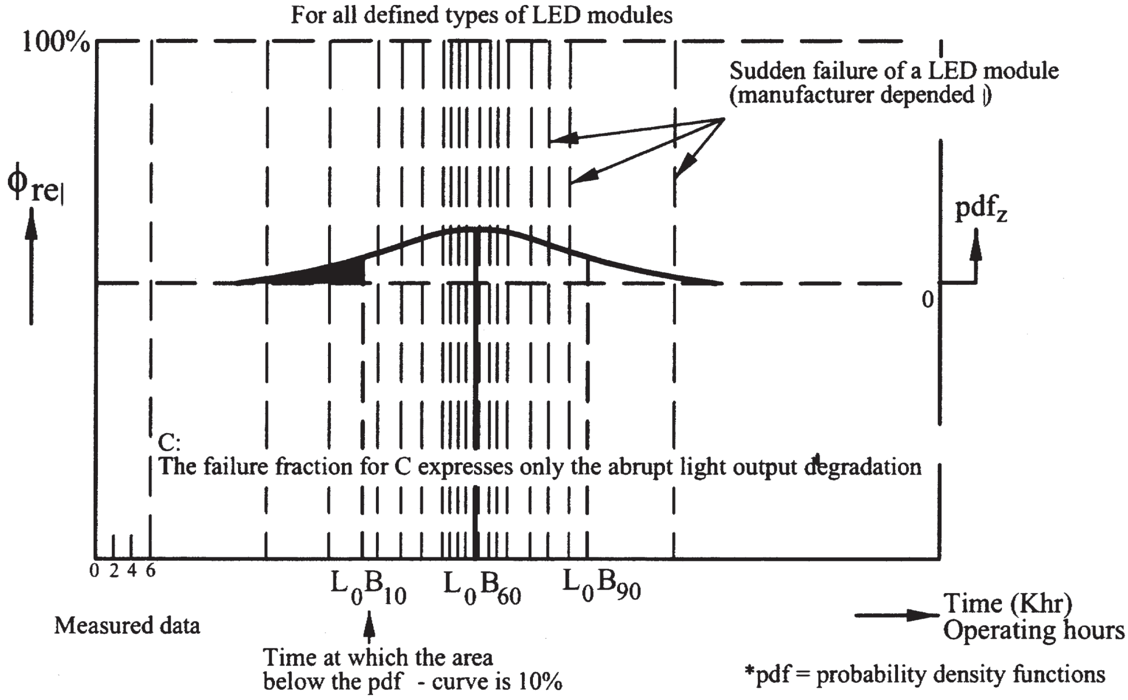
Step 3 — Reliability curve for combined degradation (Fig. 7).

C-6 RECOMMENDED LIFE TIME METRICS

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

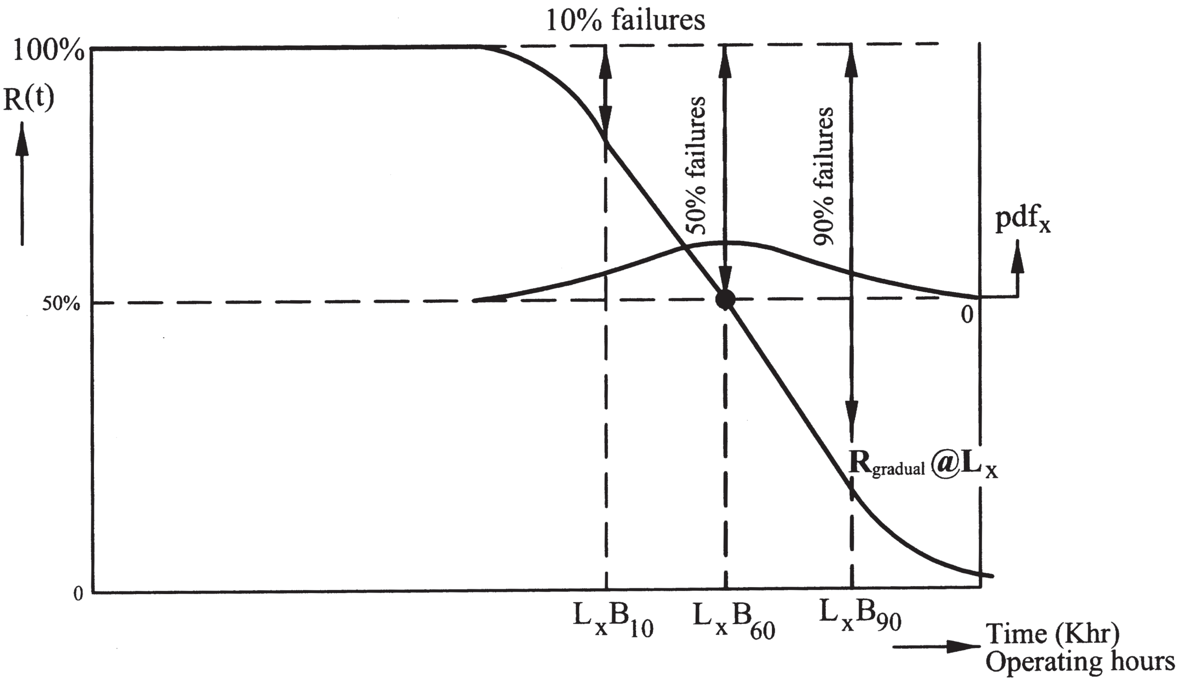
See Table 10 for recommended values of *x* and *y*.

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



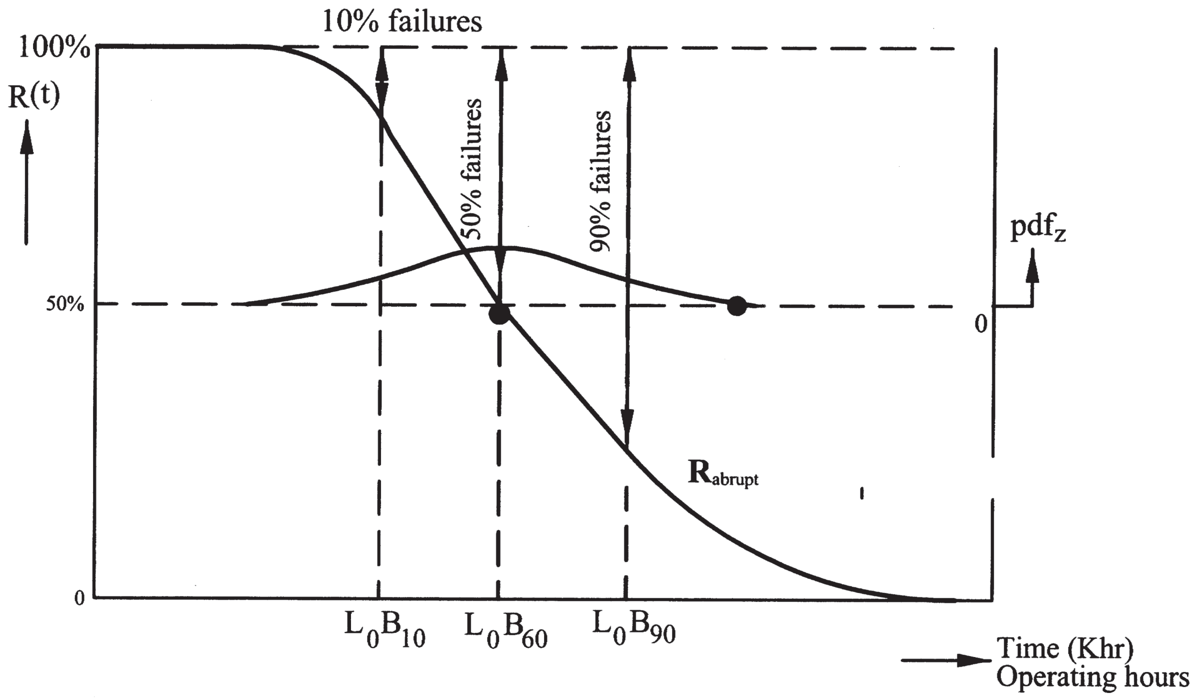
All dimensions in millimetres.

FIG. 4 LIFE TIME SPECIFICATION FOR ABRUPT LIGHT OUTPUT DEGRADATION



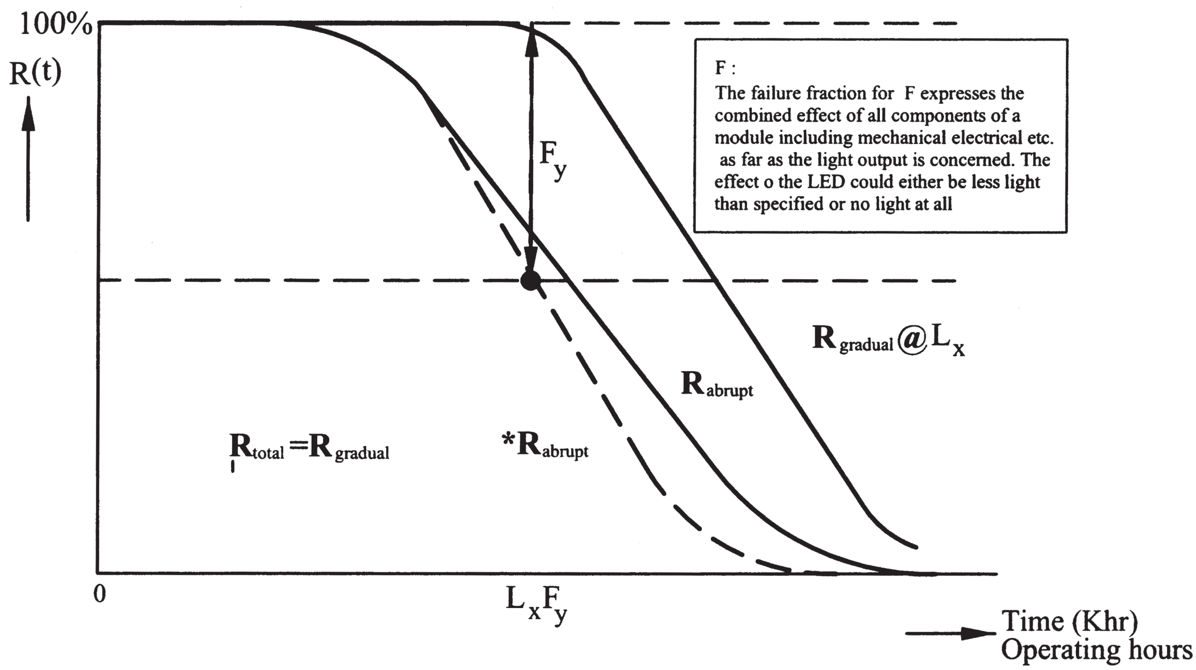
All dimensions in millimetres.

FIG. 5 RELIABILITY CURVE $R_{GRADUAL}$ FOR GRADUAL LIGHT OUTPUT DEGRADATION



All dimensions in millimetres.

FIG. 6 RELIABILITY CURVE R_{ABRUPT} FOR ABRUPT LIGHT OUTPUT DEGRADATION



All dimensions in millimetres.

FIG. 7 COMBINED $R_{GRADUAL}$ AND R_{ABRUPT} DEGRADATION

Table 10 Recommended *x* and *y* Values for Life Time Metrics to be Used in Life Time Specification

(*Clause* C-6)

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

NOTE — LED modules with constant lumen output are under consideration.

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

ANNEX D

(*Clause* 9 and *Table* 1)

EXPLANATION OF THE PHOTOMETRIC CODE

D-1 Example of photometric code likes 830/359, meaning:

8	3	0	/	3	5	9

a) Initial CRI of for example 77;
b) Initial CCT of 3 000K;
c) Initial spread of chromaticity coordinates within a 3-step MacAdam Ellipse;
d) Maintained spread of chromaticity co-ordinates at 25 percent of rated life (with a maximum duration of 6000 h) with a 5-step MacAdam Ellipse;
e) Code of lumen maintenance at 25 percent of rated life (with a maximum duration of 6 000 h), in this example: ≥ 90 percent of the 0 h value.

D-2 The colour rendering value is expressed as one figure which is obtained by using the intervals:

CRI = 67 – 76 → code ‘7’

CRI = 77 – 86 → code ‘8’

CRI = 87 ≥ 90 → code ‘9’

The highest value is 9.

ANNEX E

(*Clauses* 7 *and* 8.1)

MEANING OF CONFIDENCE INTERVALS

E-1 The purpose of the calculation is to have sufficiently confidence of the average value. It says nothing of the spread of the population of LED modules in the field.

Example: Suppose a sample of 20 LED modules, calculate the average of, for instance the measured power. Take again a random sample of 20 modules, calculate the average, and so forth. One sees the average value varies. It is this variation which is described by a *t*-distribution and what the base is of the calculation (*see* Table 10).

For the calculation of the confidence interval, the *t*-distribution is used due to relative small sample size (<50 items).

Mathematically it is as follows:

$$X_1, X_2 \ldots\ldots\ldots\ldots X_n \sim Nid\,(\mu, \sigma^2)$$

where

Nid = normally independent distributed;

$X_1, X_2 \ldots\ldots\ldots\ldots X_n$ is a measured sample, consisting of a number of *n* individuals;

σ^2 = population variance (unknown);

μ = population mean (unknown); and

n = sample size.

From the above it follows:

$$\bar{X} \sim N\left(\mu, \frac{\sigma^2}{n}\right)$$

$\bar{X}$ = distribution of the sample average, resulting from various sampling out of $X_1, X_2, \ldots. X_n$.

N = normal distributed

Rewriting:

$$\frac{\bar{X} - \mu}{\sigma / \sqrt{n}} \sim N(0,1)$$

$$\frac{\bar{X} - \mu}{S / \sqrt{n}} \sim t_{n-1}$$

S = sample standard devision, t_{n-1} is distribution with parameter $v = n - 1$

v = the number of degrees of freedom

$$P\left(-t_{n-1,\,a/2} < \frac{\bar{X} - \mu}{S / \sqrt{n}} < t_{n-1,\,a/2}\right) = 1 - \alpha$$

$1 - \alpha$ = confidence interval (two sided)

P = probability with value $(1 - \alpha)$% that the mean of the population (that is of the whole production) lies within the left and right boundary.

Rewriting:

$$P\left(\bar{X} - t_{n-1,\,\alpha/2} \cdot \frac{S}{\sqrt{n}} < \mu < \bar{X} + t_{n-1,\,\alpha/2} \cdot \frac{S}{\sqrt{n}}\right) = 1 - \alpha$$

Left sided confidence interval

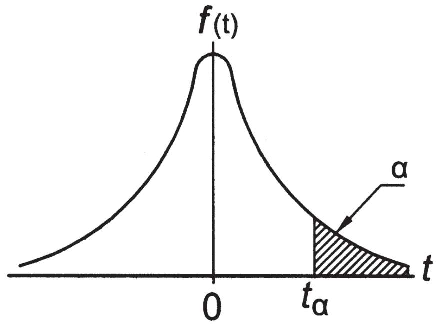
$$P\left(\mu < \bar{X} + t_{n-1,\,\alpha} \cdot \frac{S}{\sqrt{n}}\right)$$

$$= 1 - \alpha \left[\leftarrow, \bar{X} + t_{n-1,\,\alpha} \cdot \frac{S}{\sqrt{n}}\right]$$

Right sided confidence interval

$$P\left(\bar{X} - t_{n-1,\,\alpha} \cdot \frac{S}{\sqrt{n}} < \mu\right)$$

$$= 1 - \alpha \left[\bar{X} + t_{n-1,\,\alpha} \cdot \frac{S}{\sqrt{n}}, \rightarrow\right]$$



Example: *t*-DISTRIBUTION WITH RIGHT SIDED CONFIDENCE INTERVAL $(1 - \alpha)$

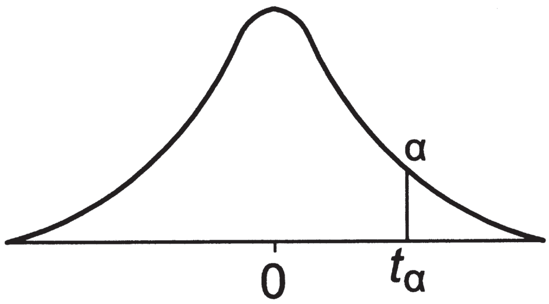
Example:

n = 20, confidence level 97.5% (single sided)

$\rightarrow v = n - 1 = 19$, $\alpha = 1 - 0.975 = 0.025$, Look up in Table 1 : $t_{19,0.025} = 2.093$

$$\bar{X} \pm t_{19,0.025} \cdot \frac{S}{\sqrt{20}} = \bar{X} \pm 0.468.\, S$$

Table 11 Values of the *t*-Distribution
(*Clause* E-1)



ν	α = 0.10	α = 0.05	α = 0.025	α = 0.01	α = 0.008 33	α = 0.006 25	α = 0.005	*ν*
1	3.078	6.314	12.706	31.821	38.204	50.923	63.657	1
2	1.886	2.920	4.303	6.965	7.650	8.860	9.925	2
3	1.638	2.353	3.182	4.541	4.857	5.392	5.841	3
4	1.533	2.132	2.776	3.747	3.961	4.315	4.604	4
5	1.476	2.015	2.571	3.365	3.534	3.810	4.032	5
6	1.440	1.943	2.447	3.143	3.288	3.521	3.707	6
7	1.415	1.895	2.365	2.998	3.128	3.335	3.499	7
8	1.397	1.860	2.306	2.896	3.016	3.206	3.355	8
9	1.383	1.833	2.262	2.821	2.934	3.111	3.250	9
10	1.372	1.812	2.228	2.764	2.870	3.038	3.169	10
11	1.363	1.796	2.201	2.718	2.820	2.891	3.106	11
12	1.356	1.782	2.179	2.681	2.780	2.934	3.055	12
13	1.350	1.771	2.160	2.650	2.746	2.896	3.012	13
14	1.345	1.761	2.145	2.624	2.718	2.864	2.977	14
15	1.341	1.753	2.131	2.602	2.694	2.837	2.947	15
16	1.337	1.746	2.120	2.583	2.673	2.813	2.921	16
17	1.333	1.740	2.110	2.567	2.655	2.793	2.898	17
18	1.330	1.734	2.101	2.552	2.639	2.775	2.878	18
19	1.328	1.729	**2.093**	2.539	2.625	2.759	2.861	**19**
20	1.325	1.725	2.086	2.528	2.613	2.744	2.845	20
21	1.323	1.721	2.080	2.518	2.602	2.732	2.831	21
22	1.321	1.717	2.074	2.508	2.591	2.720	2.819	22
23	1.319	1.714	2.069	2.500	2.582	2.710	2.807	23
24	1.318	1.711	2.064	2.492	2.574	2.700	2.797	24
25	1.316	1.708	2.060	2.485	2.566	2.692	2.787	25
26	1.315	1.706	2.056	2.479	2.559	2.684	2.779	26
27	1.314	1.703	2.052	2.473	2.553	2.676	2.771	27
28	1.313	1.701	2.048	2.467	2.547	2.669	2.763	28
29	1.311	1.699	2.045	2.462	2.541	2.663	2.756	29
inf.	1.282	1.645	1.960	2.326	2.394	2.498	2.576	inf.

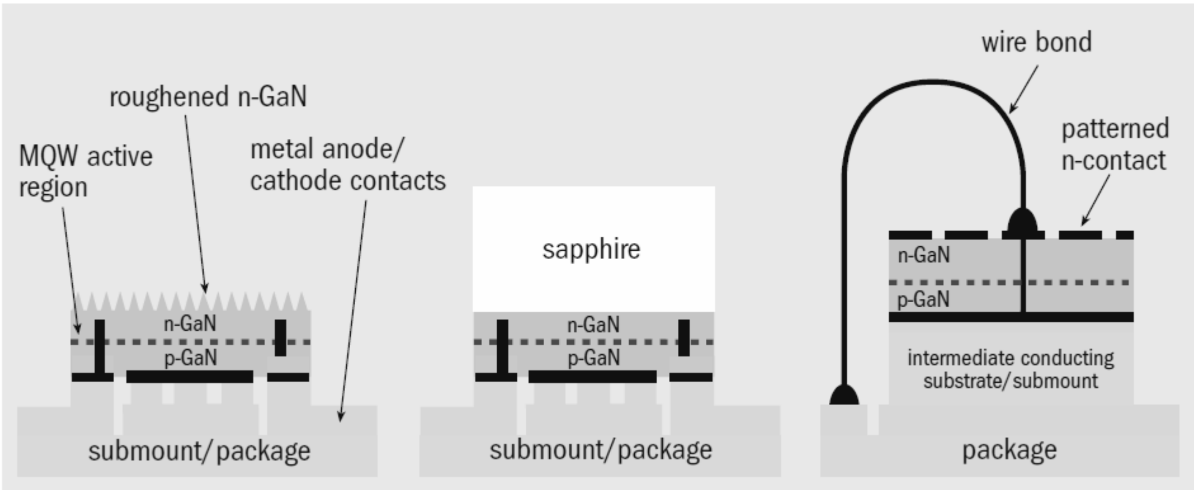
ANNEX F

(*Clauses* 3.23 *and* 3.24)

EXAMPLES OF LED DIES AND LED PACKAGES

F-1 LED DIE

Schematic examples of LED dies are given in Fig. 8.



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

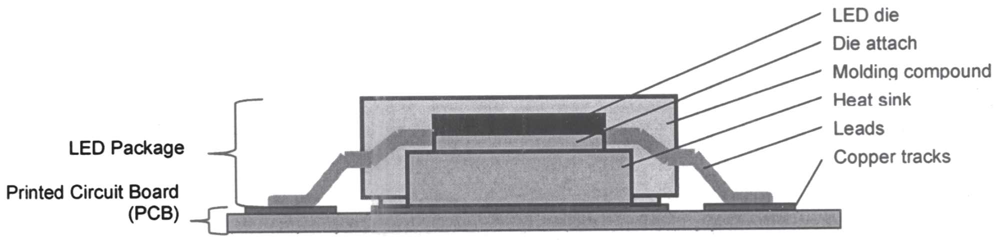
Key:

MQW: Multi Quantum Well.

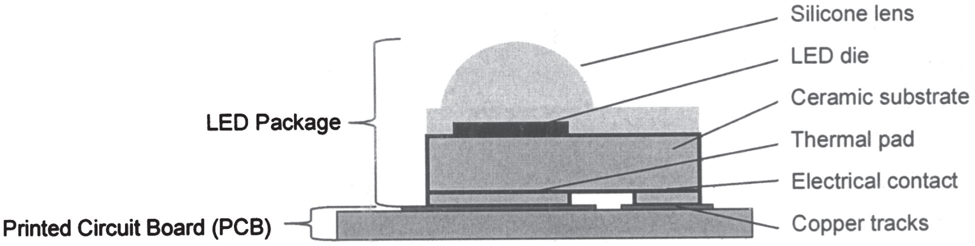
FIG. 8 SCHEMATIC DRAWINGS OF LED DIES

F-2 LED PACKAGE

Schematic examples of LED packages are given in Fig. 9.



a) Surface mounted LED package with lead wires



b) Surface mounted LED package without lead wires

FIG. 9 SCHEMATIC DRAWINGS OF LED PACKAGES

ANNEX G
(*Clause* 10.2)

OPTIMIZED TEST DURATION FOR FUTURE CONSIDERATION

G-1 INTRODUCTION

The testing time of 25 percent of rated lifetime with a maximum of 6 000 h may affect the speed of introduction of new LED modules in a very rapidly developing market.

Practical experience with LED modules, resulting in a better prediction of LED module maintenance behaviour, colour coordinates, CCT, CRI, peak intensity, intensity distribution and beam angle should allow a future transition to a shorter testing time, manifested in this standard.

At present knowledge, a future review could take up a testing time of 2 000 h or even less. This Annex is deemed to assist the transition in pointing out those clauses in which changes will be necessary.

G-2 CHANGES IN THIS STANDARD, OWNED TO OPTIMIZE TESTING DURATION

6.1 General Test Conditions

Replace the first paragraph with the following:

Test duration is 2 000 h for LED modules making use of components where long term test data of are available. If component long-term test data is not available, the manufacturer shall conduct testing for 25 percent of rated life up to a maximum of 6 000 h of the LED module.

Compliance criteria for allowance of 2 000 h test duration.

Component test data for the principle components shall cover at least 25 percent of rated LED module lifetime up to a maximum of 6 000 h. The principle components, where applicable, shall be LED packages, electronics, diffusers (including. remote phosphors), lenses, reflectors and active cooling systems.

Apart from the full set of data provided upon the 2 000 h, the manufacturer or responsible vendor shall also provide the expected data for at least 25 percent of rated LED module lifetime up to a maximum of 6 000 h of,

a) chromaticity coordinates; and
b) lumen maintenance code.

Testing of principle components is not within the scope of this document.

NOTE — Method how to obtain test data or principle components and their interaction on LED module level is under consideration.

9.1 Chromaticity Coordinates

Insert the following after the last paragraph.

In addition the following applies for optimized test duration of 2 000 h:

Initial colour variation code for 2 000 h and 6 000 h test shall be the same. Maintained colour variation category of 2 000 h test shall be equal to or lower than that of the test at 25 percent of rated LED module lifetime up to a maximum of 6 000 h.

9.3 Colour Rendering Index (CRI)

Replace the compliance criteria with the following:

For all tested items in a sample, the measured CRI values shall not have decreased by more than,

a) 3 points from the rated CRI value (*see* Table 1) for initial CRI values;
b) 4 points from the rated CRI value, when tested for 2 000 h for maintained CRI; and
c) points from the rated CRI value, when tested for 6 000 h for maintained CRI.

10.2 Lumen Maintenance

Insert the following after the last paragraph, before Fig. 2:

Compliance with 2 000 h test duration:

For compliance of family members, refer to sub-clause **6.2.3**.

An individual LED module tested for 2 000 h is considered having passed the test when the following criteria have been met:

a) The measured flux value at 2 000 h shall never be less than the maximum lumen maintenance value related to the rated life as defined and provided by the manufacturer or responsible vendor.
b) The measured lumen maintenance shall correspond with the 2 000 h lumen maintenance code as defined and provided by the manufacturer or responsible vendor.

For all of the tested items in a sample, the measured values shall be of the same maintenance code as the provided values. All the LED modules in a sample shall pass the test.

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Review of Indian Standards

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Amendments Issued Since Publication

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