भारतीय मानक
Indian Standard

IS 16102 (Part 2) : 2017

सामान्य प्रकाश सेवाओं के लिए स्वतः जलने वाले एल ई डी लैंप

भाग 2 कार्यकारिता अपेक्षाएँ

(पहला पुनरीक्षण)

Self-Ballasted LED Lamps for General Lighting Services

Part 2 Performance Requirements

(First Revision)

ICS 29.140.99

भारतीय मानक ब्यूरो
BUREAUOFINDIANSTANDARDS
मानक भवन, 9 बहादुरशाह ज़फर मार्ग, नई दिल्ली-110002
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI-110002
www.bis.org.in www.standardsbis.in

December 2017 **Price Group 7**

Lamps and Related Equipments Sectional Committee, ETD 23

FOREWORD

This Indian Standard (First Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Lamps and Related Equipments Sectional Committee had been approved by the Electrotechnical Division Council.

This standard specifies the performance requirements for self-ballasted LED lamps for general lighting services for supplies from above 50V ac up to 250V ac at 50 Hz.

This standard is published in two parts. The other part in the series is:

Part 1 Safety requirements

This standard was originally published in 2012. This first revision has been contemplated with a view:

a) To align with the latest international practice; and
b) To incorporate the experience gained in implementation of the earlier version.

This standard is based on IEC 62612 : 2013 'Self-ballasted LED lamps for general lighting services for voltage above 50 V 'Performance requirements' issued by the International Electrotechnical Commission (IEC). In this revision, the following modifications have been made:

a) Rated voltage restricted up to 250 V ac,
b) Lamps operated on dc supply are removed from the scope of this standard,
c) Rated input power of lamps has been restricted up to 25 W,
d) Introduction of family and group concept,
e) Criteria of selection and compliance of samples incorporated,
f) Requirement of efficacy has been added, and
g) Power factor requirement of lamps of rating below 5 W has been modified. The requirement of power factor of rating 5 W and above remains unchanged.

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

SELF-BALLASTED LED LAMPS FOR GENERAL LIGHTING SERVICES

PART 2 PERFORMANCE REQUIREMENTS

(First Revision)

1 SCOPE

This standard (Part 2) 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) a rated power from 1 W to 25 W;
b) a rated voltage above 50 V ac up to and including 250 V ac at 50 Hz;
c) a lamp cap as listed in IS 16102 (Part 1): 'Self-ballasted LED lamps for general lighting services: Part 1 Safety requirements'.

These performance requirements are additional to the safety requirements specified in IS 16102 (Part 1).

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 acceptance and type testing.

This standard covers LED lamps that intentionally produce white light, based on inorganic LEDs. This standard does not cover self-ballasted LED-lamps that intentionally produce tinted or coloured light neither does it covers OLEDs.

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 standardized. 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.

NOTES

1 When lamps are operated in a luminaire, the claimed performance data can deviate from the values established from this standard due to variation or changes in the luminaire components that might impact the performance of the lamp.

2 Higher wattage lamps are under consideration.

It can be expected that self-ballasted LED lamps, which comply with this standard will start and operate satisfactorily at voltages between 90 percent and 110 percent of rated supply voltage and at an ambient air temperature between -10°C and 40°C and in a luminaire complying with IS 10322 (Part 1).

If the manufacturer or the responsible vendor claims suitability for operation at different conditions, for instance, at higher voltage, temperature or humidity then lamps shall start and operate satisfactorily under claimed different conditions and the same shall be verified by tests.

2 REFERENCES

The following Indian Standards with latest versions/ amendments, if any, are necessary adjunct to this standard.

IS No.	*Title*
1885 (Part16/ Sec 1) : 1968	Electrotechnical vocabulary : Part 16 Lighting, Section 1 General aspects
2418 (Part 2)	Tubular fluorescent lamps for general lighting service: Part 2 Performance requirements (*under print*)
6873 (Part 5) : 2012	Limits and methods of measurement of radio disturbance characteristics : Part 5 Electrical lighting and similar equipment (*second revision*)
9000 (Part 14/ Sec 1)	Basic environmental testing procedures for electronic and electrical items: Part 14 Test N: Change of temperature, Section 1 Test Na: Rapid change of temperature (thermal shock) with prescribed time

IS No.	*Title*
	of transition — Two chamber method (*first revision*)
14700 (Part 3/Sec 2) : 2008	Electromagnetic compatibility: Limits, Section 2 Limits for harmonic current emissions (*first revision*)
(Part 4/Sec 7) : 2006	Testing and measurement techniques, Section 7 General guide on harmonic and inter-harmonics measurements and instrumentation, for power supply systems and equipment connected thereto
16101 : 2012	General lighting — LEDs and LED modules — Terms and definitions
16102 (Part 1) : 2012	Self ballasted LED lamps for general lighting services: Part 1 Safety requirements
16105 : 2012	Method of measurement of lumen maintenance of solid-state light (LED) sources
16106 : 2012	Method for the electrical and photometric measurements of solid-state lighting (LED) products
IS/IECTR 61341 : 2010	Method of measurement of centre beam intensity and beam angle(s) of reflector lamps

3 TERMINOLOGY

For the purposes of this standard, the terms and definitions given in IS 1885 (Part 16/Sec 1) and IS 16101 as well as the following shall apply.

3.1 Rated Value

Quantity value for a characteristic of an LED lamp for specified operating conditions.

NOTE — The value and the conditions specified in this standard, or assigned by the manufacturer or responsible vendor.

3.2 Test Voltage

Voltage at which tests are carried out

NOTE — The voltage for conducting the relevant tests is given in **A-2**.

3.3 Lumen Maintenance (LED Lamp)

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.

NOTES

1 This ratio *x* is generally expressed in per cent.

2 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.

3 The lumen maintenance is also termed as luminous flux maintenance.

3.4 Initial Value

Photometric, colorimetric and electrical characteristics at the end of the ageing period and stabilization time

3.5 Mantained Value

Photometric, colorimetric and electrical characteristics at an operational time, including stabilization time.

NOTE — The operational time shall be as specified in **7.1**.

3.6 Life (individual LED lamp) (Lx)

Length of time during which an LED lamp provides at least claimed percentage of the initial luminous flux, under standard test conditions.

NOTES

1 A LED lamp is considered to have reached its end of life, when it no longer provides claimed percentage of the initial luminous flux. Life shall be always published in combination of life (Lx) at lumen maintenance (x) and the failure fraction (Fy) (*see* **3.8**).

2 Any built-in electronic control gear, however, may show a sudden end of life failure. The definition given in **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.

NOTES

1 For sample size *see*, **13**.

2 Notes 1 and 2 of **3.6** shall apply.

3 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.

NOTES

1 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.

2 For self-ballasted LED lamps normally a failure fraction of 10 percent or/and 50 percent are being applied, indicated as F10 or/and F50.

3.9 Photometric Code

Colour designation of an LED lamp giving white light as defined by the correlated colour temperature and the general colour rendering index.

NOTES

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

2 An example of the construction of the photometric code is given in Annex B.

3.10 Stabilization Time

Time, which the LED lamp requires to obtain stable photometric conditions with constant electrical input for each measurement.

NOTE — An LED lamp may be regarded as stable under stable thermal conditions.

3.11 Ageing

Preconditioning period of the LED lamps before measurement of the initial values in terms of electrical and photometric parameters.

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, construction and/or method of processing.

3.14 Type Test

A test or series of tests made on one or more sample of LED lamp representative of production, for the purpose of checking compliance of the design of a given product with the requirements of the relevant standard.

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 (lm/W)

Quotient of the luminous flux emitted by the power consumed by the LED lamp.

3.17 LED Die

Block of semi-conducting material on which a given functional circuit is fabricated.

3.18 LED Package

Single electrical component encapsulating principally one or more LED dies, possibly with optical elements and thermal, mechanical, and electrical interfaces.

NOTES

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

2 An LED package is a discrete component and part of the LED lamp.

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 Power Factor

The ratio of the measured active input power to the product of the supply voltage (rms) and the supply current (rms).

3.21 Directional Lamp

Lamp having at least 80 percent luminous flux within a solid angle of π sr (corresponding to a cone with angle of 120°).

3.22 Peak Intensity

The highest value of the luminous intensity regardless of whether or not it occurs on the optical beam axis.

NOTE — The peak intensity is expressed in candela.

3.23 Centre Beam Intensity

The value of the luminous intensity measured on the optical beam axis.

NOTE — The centre beam intensity is expressed in candela.

3.24 Beam Angle

The angle between two imaginary lines in a plane through the optical beam axis, such that these lines pass through the centre of the front face of the lamp and through points at which the luminous intensity is 50 percent of the centre beam intensity.

3.25 Acceptance Test

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

3.26 Batch

All the lamps of one type put forward at one time for acceptance test

4 GENERAL REQUIREMENTS ON TESTS

The LED lamps for which compliance with this standard is claimed shall comply with the safety requirements specified in IS 16102 (Part 1). Method of measurement of lamp characteristics is given in Annex A.

Self-ballasted LED lamps shall be able to start and operate satisfactorily at any voltages between 90 percent and 110 percent of rated supply voltage and at an ambient air temperature between –10°C and 40°C and also in a luminaire complying with IS 10322 (Part1).

5 MARKING

5.1 General Requirements for Marking

In addition to the marking specified in IS 16102 (Part 1), marking as specified in Table 1 shall be provided by the manufacturer or responsible vendor.

5.2 Places of Marking

The required information to be provided on the product, packaging or product leaflets, product datasheet and website shall be as specified in Table 1.

5.3 BIS Certification Marking

The self-ballasted LED lamps may also be marked with the Standard Mark.

5.3.1 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.

6 DIMENSIONS

The LED lamp dimensions shall comply with the requirements as indicated by the manufacturer or responsible vendor.

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 provided the lamp cap is the same.

Compliance is checked by inspection.

7 TEST CONDITIONS

7.1 General Test Conditions

Testing duration is 25 percent 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 11.

Test conditions for testing t_{LED}, 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 10. 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

Table 1 Required Marking
(*Clauses* 5.1 *and* 5.2)

Sl No.	Parameter	Product	Packaging	Product Datasheets, Leaflets or Website
(1)	(2)	(3)	(4)	(5)
i)	Rated luminous flux (lm), centre beam intensity and beam angle (*see* Note 1)	x	x	x
ii)	Lamp photometric code (*see* Annex B)	–	x	x
iii)	Rated life (*h*) and the related lumen maintenance (*x*)	–	x	x
iv)	Failure fraction (F_y), corresponding to the rated life	–	x	x
v)	Rated correlated colour temperature (for example: F 2700 to F 6500, *see* Table 7)	x	x	X
vi)	Rated colour rendering index	–	x	x
vii)	Ageing time (h), if different to 0 h	–	–	x
viii)	Rated efficacy (lm/W)	x	x	x
ix)	Dimensions, including dimensional tolerances	–	–	x
x)	Power factor	x	x	x

NOTES
1 For non-directional lamps, centre beam intensity and beam angle are not mandatory.
2 For directional lamps, centre beam intensity and beam angle are measured according to IS/IEC TR 61341.
Key: x = required, – = not required.

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 [for example Correlated Colour Temperature (CCT) given in **10.1**] should be essentially identical with respect to materials used, components and construction applied.

Requirements for the identification of a family of LED lamps for type testing are given in **3.13** and in Table 2.

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

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 manufacturer or responsible vendor of the lamp:

a) Chromaticity co-ordinates,
b) Colour rendering index,
c) Lumen maintenance code, and
d) Results of accelerated operational life test.

For all of the tested units in a sample, the measured values of an LED lamp (the initial and maintained value) shall not vary beyond the values indicated by the manufacturer or responsible vendor.

The measured values shall be of the same category or code as per the declared values or better. The maximum number of LED lamps in a sample which can fail in individual tests and in the groups is given in Table 11.

8 LAMP INPUT

8.1 Lamp Power

The test conditions for the measurement of lamp power shall be as given in 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 percent.

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 percent.

Table 2 Variations Allowed within a Family
(*Clauses* 7.1 *and* 7.2.2)

Sl No.	Components where Variations are allowed (*see* Note 2)	Conditions for Acceptance
(1)	(2)	(3)
i)	Housing and heat sink	t_{LED} (location and value given by the LED lamp supplier) and temperature of 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 and Note 3).
ii)	Optics (*see* Note 1)	The test results showing the effect of optical material change shall be documented in the manufacturer's record.
iii)	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 (*see also* Note 3).
iv)	Control gear	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 control gear.

NOTES

1 Optics includes 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**).

2 Any change on part tolerances are documented in the manufacturer's record.

3 No additional tests are required for claimed lower rated life time, provided t_{LED} is same or lower than baseline product.

8.2 Power Factor

The measured power factor for each individual lamp of the sample shall not be less than 0.9 for lamp rated wattages 5 W and above. For lamp rated wattages less than 5 W, minimum measured power factor should be 0.5.

8.3 Harmonics

The harmonics of the input current when measured in accordance with IS 14700 (Part 3/Sec 2) shall be as given in **8.3.1** and **8.3.2.**

8.3.1 Compliance to harmonics of input current is not applicable for lamp rated wattages below and equal to 5 W.

8.3.2 For lamps having an active rated input power more than 5 W the harmonic current shall comply with one of the following two sets of requirements:

a) the harmonic currents shall not exceed the power-related limits of Table 3, col 2, or

b) the third harmonic current, expressed as a percentage of the fundamental current, shall not exceed 86 percent and the fifth shall not exceed 61 percent. Moreover, the wave form of the input current shall be such that it begins to flow before or at 60°, has its last peak (if there are several peaks per half period) before or at 65° and does not stop flowing before 90°, where the zero crossing of the fundamental supply voltage is assumed to be at 0°.

Table 3 Limits for Harmonic Current
(*Clause* 8.3.2)

Sl No.	Harmonic Order	Maximum Permissible Harmonic Current	
	n	mA/W	A
(1)	(2)	(3)	(4)
i)	3	3.4	2.3
ii)	5	1.9	1.14
iii)	7	1.0	0.77
iv)	9	0.5	0.40
v)	11	0.35	0.33
vi)	$13 \leq n \leq 39$ (odd harmonics only)	3.85/*n*	0.15 15/*n*

NOTE — Harmonic current less than 0.6 percent of the input current measured under test conditions or less than 5 mA whichever is greater are to be disregarded.

8.4 Emission of Radio Frequency Disturbances

The emission (radiated and conducted) of radio frequency disturbances when measured in accordance with IS 6873 (Part 5) shall be as given in **8.4.1** and **8.4.2**.

8.4.1 LED lamp shall comply with the mains terminal voltage limits given in Table 4.

Table 4 Disturbance Voltage Limits at Mains Terminals
(*Clause* 8.4.1)

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
v)	2.51 MHz – 3.0 MHz	73	63
vi)	3.0 MHz – 5.0 MHz	56	46
vii)	5.0 MHz – 30 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.

8.4.2 Where the LED lamp is operated at a frequency exceeding 100 Hz, the lamp shall comply with the field strength limits given in Table 5.

Table 5 Radiated Disturbance Limits
(*Clause* 8.4.2)

Sl No.	Frequency Range	Limits for Loop Diameter (dB μA)[1]		
		2 m	3 m	4 m
(1)	(2)	(3)	(4)	(5)
i)	9 kHz – 70 kHz	88	81	75
ii)	70 kHz – 150 kHz	88–58[2]	81–51[2]	75–45[2]
iii)	150 kHz – 2.2 MHz	58–26[2]	51–22[2]	45–16[2]
iv)	2.2 MHz – 3.0 MHz	58	51	45
v)	3.0 MHz – 30 MHz	22	15–16[3]	9–12[3]

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

9 LIGHT OUTPUT

9.1 Luminous Flux

For the purpose of selection of samples, the grouping of lamps based on the luminous flux (lumen) and CCT as given in Table 6 shall be followed.

The method of measurement of luminous flux shall be according to Annex A.

Table 6 Grouping of Lamps Based on the Luminous Flux (Lumen) and CCT
(*Clause* 9.1)

Sl No.	Lamp Group Designation	CCT(K) 2 700 to < 3 500		CCT (K) 3 500 to <5 000		CCT (K) 5 000 to 6 500	
		Luminous Flux Range (lm)		Luminous Flux Range (lm)		Luminous Flux Range (lm)	
(1)	(2)	(3)		(4)		(5)	
i)	A	100	500	100	500	100	500
ii)	B	501	1 000	501	1 000	501	1 000
iii)	C	1 001	1 500	1 001	1 500	1 001	1 500
iv)	D	1 501	2 500	1 501	2 500	1 501	2 500
v)	E	>2 500 lm		>2 500 lm		>2 500 lm	

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 percent.

The average initial luminous flux of the measured samples shall not be less than the rated luminous flux by more than 7.5 percent.

Lamps with different rated lumens and wattages falling under the same lumen group as given in Table 6 will not require separate testing and certification under this standard if they satisfy the family criteria given in **7.2**.

9.2 Luminous Intensity Distribution, Peak Intensity and Beam Angle

9.2.1 *General*

The requirements of peak intensity and beam angle only applies to LED lamps having a directional (spot) distribution commonly known as directional lamps and is given in **9.2.4** and **9.2.5.**

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 **A-1**.

The allowed photometric variations, detailed in **9.2.3**, **9.2.4** and **9.2.5** is based on the manufacturing tolerances taken into consideration.

9.2.3 *Luminous Intensity Distribution*

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

NOTE — Compliance is under consideration.

9.2.4 *Peak Intensity Value*

Where a peak intensity value is provided by the manufacturer or responsible vendor, the initial peak intensity of each individual LED lamp in the measured sample shall not be less than 75 percent of the rated intensity. The test shall be carried out in accordance with Annex A.

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

9.2.5 *Beam Angle Value*

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 percent of the rated value. The test shall be carried out in accordance with Annex A.

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

9.3 Efficacy

LED lamp efficacy shall be calculated from the measured initial luminous flux of the individual LED lamp and the measured initial input power of the same individual LED lamp and shall not be less than 80 percent 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 IS 2418 (Part 2). The rated colour of a lamp shall preferably be one of the following seven values.

F 2700, F 3000, F 3500, F 4000, F 5000, F 5700 or F 6500

The standardized chromaticity co-ordinates and CCT values corresponding to these colours are given in Table 7.

For lamps, with non-standard chromaticity coordinates, the rated values shall be assigned by the manufacturer or responsible vendor.

Table 7 Colour
(*Clause* 10.1)

Sl No.	Colour	CCT (T_c)	Chromaticity Co-ordinates	
			X	*Y*
(1)	(2)	(3)	(4)	(5)
i)	F 6500	6400	0.313	0.337
ii)	F 5700	5700	0.329	0.342
iii)	F 5000	5000	0.346	0.359
iv)	F 4000	4040	0.380	0.380
v)	F 3500	3450	0.409	0.394
vi)	F 3000	2940	0.440	0.403
vii)	F 2700	2720	0.463	0.420

NOTE — The letters in the colour marking designation stands for:
F = Values from Annex B of IS 2418 (Part 2).

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 8), 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.

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.

Sample pertaining to family members the requirements given in **7.2.3** shall be followed.

The CCT and chromaticity co-ordinates shall be measured according to Annex A.

10.2 Colour Rendering Index (CRI)

The initial colour rendering index (CRI) of an LED lamp shall be measured in accordance with **A-3.7**. The second measurement for maintained values is made at an operational time as specified in **7.1**.

For all tested units in a sample the measured CRI values shall not decrease by more than the values given below:

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.

Table 8 Tolerance (Categories) on Rated Chromaticity Co-ordinate Values
(*Clause* 10.1)

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	absolute values	absolute values

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 MacAdams normally applied for (compact) fluorescent lamps and other discharge lamps.

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 test is therefore carried out to assess the reliability and life of the lamp.

The fraction of tested lamps of a sample (F_y) that may fail to comply with the requirements of the tests under **11.2** are defined in **3.3** and **3.8.**

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.

NOTE — Compliance of lumen maintenance after 25 percent of life time or 6 000 h implies that the lamps would have a life of 25 000 h or as declared by the manufacturer with a failure fraction of B_{50}.

11.2 Lumen Maintenance

The lumen maintenance figure may vary depending on the application of the LED lamp. This standard specifies 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 an LED lamp is very long compared to other light sources, it is regarded as impractical and time consuming within the scope of this standard to measure the actual lumen reduction over life at L_{70}. This standard therefore relies on test results to determine the expected lumen maintenance code of any LED lamp.

2 The actual LED behaviour with regard to lumen-maintenance can differ considerably per type and per manufacturer. It is therefore 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.

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

4 Any values better than specified above shall be provided by the manufacturer as agreed to between the manufacturer and the buyer.

This standard has opted for lumen maintenance codes that cover the initial decrease in lumen output up to the operational period as specified in **7.1**. There are three codes of lumen maintenance compared to the initial lumen output (*see* Table 9).

Table 9 Lumen Maintenance Code at the Operational Time Stated in 7.1
(*Clause* 11.2)

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

The initial luminous flux of all the lamps under test shall be measured as per the method described in Annex A. The initial luminous flux value measured shall be normalized to 100 percent and shall be used as the first data point for determining lamp life. All the lamps under test are then operated continuously in normal environmental temperature between 15°C to 40°C for an operational time as stated in **7.1** following which the measurement of luminous flux is repeated. The measured luminous flux value at an operational time as given in **7.1** shall be expressed as maintained value which is the percentage of the initial value.

The lumen flux shall be measured at 0 h (initial value), at 1 000 h and at the end of an operational period as specified in **7.1**.

NOTE — Assigning a code does not imply a prediction of achievable life time. Code 9 could be better or worse than Code 7.

Marking of the lumen maintenance and the lumen maintenance categories of individual lamps shall be in accordance with Table 1.

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

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

a) The measured luminous flux value at 25 percent of rated life with a maximum duration of 6 000 h shall not 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 10 being subjected to 25 percent of rated life (with a maximum of 6 000 h), it is deemed to have 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:

a) When F_{50} is specified, at least '*n*-2' individual lamps shall have passed;
b) When F_{10} is specified, at least '*n*' individual LED lamps shall have passed.

NOTES

1 Calculation, based on 25 percent of claimed failure fraction F_y:

a) 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 lamps allowed to fail.

b) 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 lamps allowed to fail.

c) In order to assess the pass or 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 Assuming that the test time is lower than the claimed life time, failure fraction at the end of the test will be 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.

For compliance of family members, conditions given in **7.2.3** shall be followed.

11.3 Endurance Tests

11.3.1 *General*

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

NOTE — All tests can be carried out in parallel with different sets of new LED lamps.

11.3.2 *Temperature Cycling Test*

The LED lamp shall be subjected to temperature cycling test in accordance with IS 9000 (Part 14/Sec 1) with specified rate of change as given below.

The LED lamp shall be tested for initial luminous flux and then placed in a test chamber in which the temperature is varied between –10°C to + 40°C over a period of 4 h and for a test duration of 250 periods corresponding to 1000 h. A 4 h period shall comprise 1 h holding at each extreme temperature and 1 h transfer time at the rate of 1°C/min between the two extreme temperatures. The LED lamp shall be switched on at test voltage for 34 min and switched off for 34 min.

If a manufacturer claims suitability for operation at extended conditions in respect of voltages or temperatures which are beyond the normal operating conditions, including high humidity, the lamps shall be able to comply with the following:

a) The lamps shall be tested under claimed extended condition,

b) The lamps shall be able to start and operate satisfactorily under these extended conditions, and

c) Should meet the compliance criteria below:

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 shall show no physical effects of temperature cycling such as cracks.

NOTE — The switching period of 68 min is chosen to get a phase shift between temperature and switching period.

The temperature requirements given in **A-1** however shall not apply.

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

11.3.3 *Supply Switching Test*

At the 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, for example, 10 k cycles if rated life is 20 000 h.

The temperature requirements of A-1 shall 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 normally for a period of at least 15 min.

11.3.4 *Accelerated Operational Life Test*

The LED lamp shall be tested for initial luminous flux and then operated continuously without switching at the test voltage and at a temperature corresponding to 10°C (*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, solely applied for their function of switching at certain temperature, that would switch off the LED lamp or reduce the light output shall be bypassed.

Compliance:

For compliance of family members, *see* **7.2.3**.

At the end of this test, and after cooling down to room temperature and being stabilized, all the lamps shall have a at least a luminous flux of 70 percent compared to the initial value for at least 15 min.

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

An accelerated test should not evoke fault modes or failure mechanisms which are not related to normal life effects. For example, a too high temperature increase 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 DIMMING

The dimming requirements of LED lamps are under consideration.

13 VERIFICATION

13.1 Type Tests

The minimum sampling size for type testing and the acceptance criteria shall be as given in Table 10 and Table 11. The sample shall be representative of a manufacturer's production. A minimum number of 40 lamps are required for baseline product and 20 samples for each family product for Type Test.

Table 10 Sample Sizes for Type Tests
(*Clause* 13.1)

Sl No.	Clause or Sub-clause	Test	Minimum Number of Units in a Sample for an Operational Time as Stated in 7.1	AQL – Maximum Number of Units that are Allowed to Fail	
				In Individual Tests	In the Group of Tests
(1)	(2)	(3)	(4)	(5)	(6)
i)	**7.2**[1)]	t_{LED}-point	1 unit for each test[2)]	Not applicable	Not applicable
ii)	**9.2.3**[1)]	Luminous intensity distribution			
iii)	**8.3**	Harmonics		0	0
iv)	**8.4**	Emission of radio frequency disturbance		0	
v)	**5**	Marking	5 units for all tests	0	2
vi)	**6**	Dimensions		1	
vii)	**9.2.4**	Peak intensity value		1	
viii)	**9.2.5**	Beam angle value		1	
ix)	**8.2**	Power factor		1	
x)	**8.1**	Lamp power	Same 20 units for all tests	4	5
xi)	**9.1**	Luminous flux		4	
xii)	**9.3**	Efficacy		4	
xiii)	**10.1**	Chromaticity tolerance (initial and maintained)		4	
xiv)	**10.2**	Colour rendering index (initial and maintained)		2	
xv)	**11.2**	Lumen maintenance		0 or 2[3)]	
xvi)	**11.3.2**	Temperature cycling, energized	5	1	2
xvii)	**11.3.3**	Supply voltage switching	5	1	
xviii)	**11.3.4**	Accelerated operational life test	5	1	

[1)] t_{LED}-point and luminous intensity distribution to be tested and recorded. Measurement of t_{LED}-point is only for reference purpose for family compliance.

[2)] The sample need not be the same for all the tests.

[3)] The failures in lumen maintenance test is related to failure function (F10/F50) as defined in **11.2**.

13.2 Acceptance Tests

The method of selection of lamps for tests is given in **15** of IS 16102 (Part 1). Sample Size and acceptance criteria for acceptance test is 15 lamps (Table 12).

13.3 Accidentally Broken Lamps

Lamps which are accidentally broken before any test is started shall be replaced to ensure that the required number of test lamps completes the test.

NOTE — In order to avoid delay, it is recommended that spare lamps be available through the tests.

14 TESTS

14.1 Type Tests

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

a) Marking (*see* **5**),
b) Dimension (*see* **6**),
c) Wattage and power factor (*see* **8.1** and **8.2**),
d) Luminous flux and efficacy (*see* **9.1** and **9.3**),
e) Peak intensity (*see* **9.2.4**),
f) Beam angle (*see* **9.2.5**),
g) Colour chromaticity and colour rendering index (CRI) (*see* **10.1** and **10.2**),
h) Life (*see* **11**),
j) Harmonics (*see* **8.3**), and
k) Emission (radiated and conducted) of radio frequency disturbances (*see* **8.4**).

Table 11 Sample Size for Testing of Family
(*Clause* 13.1)

Sl No.	Clause or Sub-clause	Test	Minimum Number of Units in a Sample for Testing a Family at Reduced Test Duration According to 7.2	AQL-Maximum Number of Units that are Allowed to Fail	
				In Individual Tests	In the Group of Tests
(1)	(2)	(3)	(4)	(5)	(6)
i)	**7.2**[1)]	t_{LED}-point	1 unit for each test[2)]	Not applicable	Not applicable
ii)	**9.2.3**[1)]	Luminous intensity distribution			
iii)	**8.3**	Harmonics		0	0
iv)	**8.4**	Emission of radio frequency disturbance		0	
v)	**5**	Marking		0	
vi)	**6**	Dimensions	5 units for all tests	1	2
vii)	**9.2.4**	Peak intensity value		1	
viii)	**9.2.5**	Beam angle value		1	
ix)	**8.2**	Power factor		1	
x)	**8.1**	Lamp power		1	
xi)	**9.1**	Luminous flux	Same 5 units for all tests	1	1
xii)	**9.3**	Efficacy		1	
xiii)	**10.1**	Chromaticity tolerance (initial and maintained)		1	
xiv)	**10.2**	Colour rendering index (initial and maintained)		1	
xv)	**11.2**	Lumen maintenance		1	
xvi)	**11.3.2**	Temperature cycling, energized	3	1	1
xvii)	**11.3.3**	Supply voltage switching	3	1	
xviii)	**11.3.4**	Accelerated operational life test	3	1	

[1)] t_{LED}-point and luminous intensity distribution to be tested and recorded. Measurement of t_{LED}-point is only for reference purpose for family compliance.

[2)] The sample need not be the same for all the tests.

14.2 Acceptance Tests

The following shall constitute as acceptance tests:

a) Marking (*see* **5**),
b) Dimension (*see* **6**),
c) Wattage and power factor (*see* **8.1** and **8.2**),
d) Luminous flux (*see* **9.1**), and
e) Colour chromaticity and colour rendering index (CRI) (*see* **10.1** and **10.2**).

Table 12 Sample Size for Acceptance Tests[1)]
(*Clauses* 13.1 *and* 14.2)

Sl No.	Clause or Sub-clause	Test	Minimum Number of Units in a Sample	AQL-Maximum Number of Units that are Allowed to Fail	
				In Individual Tests	In the Group of Tests
(1)	(2)	(3)	(4)	(5)	(6)
i)	**5**	Marking		0	
ii)	**6**	Dimensions	5 units for all tests[2)]	1	0
iii)	**8.2**	Power factor		1	
iv)	**8.1**	Lamp factorx		2	
v)	**9.1**	Luminous flux		2	
vi)	**9.3**	Efficacy	Same 10 units for all tests	2	3
vii)	**10.1**	Chromaticity tolerance (initial)		2	
viii)	**10.2**	Colour rendering index (initial)		2	

[1)] Acceptance tests are defined in **14.2**.
[2)] The sample need not be the same for all the tests.

ANNEX A

(*Clauses* 3.2, 4, 7.1, 8.1, 9.1, 9.2.4 *and* 9.2.5)

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 27°C with a tolerance of ± 1°C, a relative humidity of 65 percent maximum and steady state operation of the LED lamp.

For air movement requirements, *see* IS 16106.

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 the stabilization, measurements of luminous flux or luminous intensity and electrical lamp power are made at least at an interval of 1 min. The LED lamp shall be operated for at least 30 min and it is considered stable and suitable for test purpose, if the relative difference of maximum and minimum readings of light output and electrical power observed over the last 15 min is less than 0.5 percent of the minimum reading. If the LED lamp is pre-burned, it does not need to be operated for 30 min, and it is considered stable if the readings of the last 15 min meet above requirement.

   If the LED lamp exhibit large fluctuations and stabilization conditions are not achieved within 45 min of operation due to the fluctuations, the measurement may be started and the observed fluctuations shall be reported. However if, instead of random fluctuations, a slow decrease of gradient in the measured values is still observed, then the measurements should be started only when the stabilization criteria are met.

   NOTE — Normally the observed stabilization process is a slow decrease in light output until thermal stability is reached. However, due to the electronics, fluctuations can still occur near thermal stability.

c) The stabilization is strongly related to thermal equilibrium of the components. A pre-burning (operation of the light source prior to mounting in the measurement system) may be applied to reduce the stabilization time in the

measurement system. In particular for measurement of a number of products of the same type, measurement time may be reduced if it has been demonstrated that the pre-burning method produces the same stabilized condition as when using the normal procedure.

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

NOTE — Normally the observed stabilization 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.

A-2 TEST VOLTAGE

A-2.1 General

The test voltage 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 supply voltage shall not exceed 3 percent. The harmonic content is defined as the r.m.s. summation of the individual harmonic components using the fundamental as 100 percent.

The test voltage shall be as specified in **A-2.2.**

NOTE — The harmonic content is defined as the r.m.s. summation of the individual harmonic components using the fundamental as 100 percent.

A-2.2 Relation of Rated Voltage to Test Voltage

The test voltage shall be the rated voltage or the mid-point of the voltage range as specified in Table 13.

Table 13 Relation of Rated Voltage to Test Voltage
(*Clause* A-2.2)

Sl No.	Rating	U_{test} (V)
(1)	(2)	(3)
i)	240 V	240
ii)	220-240 V	240

A-2.3 Tests

A-2.3.1 *Initial Rating Tests*

The initial rating tests and the relevant clauses shall be as given in Table 14.

A-2.3.2 *Lifetime Tests and Endurance Tests*

For the purpose of this standard, lifetime and endurance tests are defined in Table 15.

Table 14 Initial Tests
(*Clause* A-2.3.1)

Sl No.	Clause/Sub-clause	Test
(1)	(2)	(3)
i)	**8.1**	Lamp power
ii)	**8.2**	Power factor
iii)	**9.1**	Luminous flux
iv)	**9.2.3**	Luminous intensity distribution
v)	**9.2.4**	Peak intensity value
vi)	**9.2.5**	Beam angle value
vii)	**9.3**	Efficacy
viii)	**10.1**	Correlated colour temperature (initial)
ix)	**10.1**	Chromaticity tolerance (initial)
x)	**10.2**	Colour rendering index (initial)

Table 15 Lifetime and Endurance Tests
(*Clause* A-2.3.2)

Sl No.	Clause/Sub-clause	Test
(1)	(2)	(3)
i)	**10.1**	Correlated colour temperature (maintained)
ii)	**10.1**	Chromaticity tolerance (maintained)
iii)	**10.2**	Colour rendering index (maintained)
iv)	**11.2**	Lumen maintenance
v)	**11.3.2**	Temperature cycling, energized
vi)	**11.3.3**	Supply voltage switching
vii)	**11.3.4**	Accelerated operation life test

A-2.4 Requirements

The test voltage shall be the rated voltage or the mid-point of the voltage range.

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 specify an ageing period.

A-3.3 Luminous Flux

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

A-3.4 Luminous Intensity Distribution

Luminous intensity distribution data shall be made available by the manufactures for all variations of the LED lamp and any optical attachments or accessories that the LED lamp has been specified for use with and shall be tested in accordance with IS/IEC TR61341.

A-3.5 Peak Intensity

The peak intensity shall be measured in accordance with IS/IEC TR61341.

A-3.6 Beam Angle

The beam angle shall be measured in accordance with IS/IEC TR61341.

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 with IS 16106.

A-3.8 Chromaticity Co-ordinate Values

Chromaticity co-ordinates shall be in accordance with the values given in Annex B of IS 2418 (Part 2).

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.

ANNEX B

(*Clauses* 5.2, 10 *and* 11.2)

EXPLANATION OF THE PHOTOMETRIC CODE

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

8	3	0	/	3	5	9

CRI of for example 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 percent of rated life (within a maximum duration of 6 000 h) within a 5-step MacAdam ellipse

Code of lumen maintenance at 25 percent of rated lamp life (with a maximum duration of 6 000 h); in this example: ≥ 90 percent of the 0 h value.

The colour rendering value is expressed as one figure which is

obtained by using the intervals as mentioned below:

CRI = 70 to 79 → code 7
CRI = 80 to 89 → code 8
CRI = ≥ 90 → code 9
The highest value is 9

Bureau of Indian Standards

BIS is a statutory institution established under the *Bureau of Indian Standards Act*, 1986 to promote harmonious development of the activities of standardization, marking and quality certification of goods and attending to connected matters in the country.

Copyright

Review of Indian Standards

Amendments are issued to standards as the need arises on the basis of comments. Standards are also reviewed periodically; a standard along with amendments is reaffirmed when such review indicates that no changes are needed; if the review indicates that changes are needed, it is taken up for revision. Users of Indian Standards should ascertain that they are in possession of the latest amendments or edition by referring to the latest issue of 'BIS Catalogue' and 'Standards : Monthly Additions'.

This Indian Standard has been developed from Doc No.: ETD 23 (6910).

Amendments Issued Since Publication

Amend No.	Date of Issue	Text Affected

BUREAU OF INDIAN STANDARDS

Headquarters:

Manak Bhavan, 9 Bahadur Shah Zafar Marg, New Delhi 110002
Telephones : 2323 0131, 2323 3375, 2323 9402 *Website*: www.bis.org.in

Regional Offices: *Telephones*

Central : Manak Bhavan, 9 Bahadur Shah Zafar Marg, NEW DELHI 110002 — 2323 7617, 2323 3841

Eastern : 1/14 C.I.T. Scheme VII M, V. I. P. Road, Kankurgachi, KOLKATA 700054 — 2337 8499, 2337 8561, 2337 8626, 2337 9120

Northern : Plot No. 4-A, Sector 27-B, Madhya Marg, CHANDIGARH 160019 — 26 50206, 265 0290

Southern : C.I.T. Campus, IV Cross Road, CHENNAI 600113 — 2254 1216, 2254 1442, 2254 2519, 2254 2315

Western : Manakalaya, E9 MIDC, Marol, Andheri (East), MUMBAI 400093 — 2832 9295, 2832 7858, 2832 7891, 2832 7892

Branches: AHMEDABAD. BENGALURU. BHOPAL. BHUBANESHWAR. COIMBATORE. DEHRADUN. DURGAPUR. FARIDABAD. GHAZIABAD. GUWAHATI. HYDERABAD. JAIPUR. JAMMU. JAMSHEDPUR. KOCHI. LUCKNOW. NAGPUR. PARWANOO. PATNA. PUNE. RAIPUR. RAJKOT. VISAKHAPATNAM.

Published by BIS, New Delhi