भारतीय मानक
Indian Standard

IS 16614 (Part 2) : 2022

दो-टोपी वाले एल ई डी रैखिक लैंप

भाग 2 कार्यकारिता अपेक्षाएं

Double-Capped LED Linear Lamps

Part 2 Performance Requirements

ICS 29.140.99

भारतीय मानक ब्यूरो
BUREAU OF INDIAN STANDARDS
मानक भवन, 9 बहादुरशाह ज़फर मार्ग, नई दिल्ली 110002 –
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI-110002
www.bis.gov.in www.standardsbis.in

July 2022 **Price Group 10**

Lamps and Related Equipment Sectional Committee, ETD 23

FOREWORD

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

Double-capped fluorescent lamps are installed in big volume in office lighting, street lighting, industrial lighting and for several other applications. Double-capped LED linear lamps are considered as a possible replacement for double capped tubular fluorescent lamps having caps of type G5 or G13. It is envisaged that transition from fluorescent technology to LED technology would provide many environmental advantages, including being energy efficient, producing zero toxic elements and having a longer life span.

This standard specifies the requirements and method of test to be followed for determining the performance and life, including method of sampling and conditions of compliance for double capped LED linear (Tubular) lamps used in new luminaire and also as a retrofit replacing double capped tubular fluorescent lamps having the same cap dimensions as of LED linear lamp provided that the retrofit LED linear lamp complies with the safety requirement specified in IS 16614 (Part 1).

This standard covers double-capped LED linear lamps with cap G5 and G13 only.

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

Part 1 Safety Specifications

While preparing this standard, considerable assistance has been taken from the following standards and technical specifications:

a) IS 16102 (Part 2) : 2017 ‘Self Ballasted LED Lamps for General Lighting Purposes Part 2 Performance Requirements’
b) International Energy Agency’s (IEA) SSL Annex 4E for LED linear lamps
c) US Energy Star Program for LED Lamps

The composition of the technical committee responsible for formulation of this standard is given in Annex C.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis shall be rounded off in accordance with IS 2 : 2022 ‘Rules for rounding off numerical values (*second revision*)’. 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
DOUBLE-CAPPED LED LINEAR LAMPS

PART 2 PERFORMANCE REQUIREMENTS

1 SCOPE

This standard (Part 2) specifies the performance requirements, together with the test methods and conditions, required to show compliance of double-capped LED linear retrofit and conversion lamps, with G5 and G13 caps suitable for use in luminaires and also intended for replacing fluorescent lamps with the same caps, having:

a) a rated power up to 40 W;
b) rated a.c. voltage of up to 250 V at 50 Hz or a rated d.c. voltage of up to 250 V;
c) nominal lengths from 300 mm to 1 500 mm.

NOTES

1 Double-capped LED Linear lamp(s) are commonly known as LED tube light(s).

2 Where in this standard the term 'LED Lamp(s)' is used, it is understood to stand for 'double-capped LED Linear lamp(s)', except where it is obviously assigned to other types of LED lamps.

3 LED Lamps supplied with external controlgear are covered under the scope of this standard provided that the controlgear meets the requirements of relevant Indian standard i.e. IS 15885 (Part 2/Sec 13).

4 The manufacturer or responsible vendor shall provide recommended controlgear for testing purposes. Failure of the LED Lamp and/or controlgear shall be considered as the failure of the LED lamp together with the controlgear.

The requirements specified in this standard are applicable for LED lamps for domestic and similar general lighting services. Additional requirements may apply for LED lamps intended for use in other applications.

The requirements of this standard relate to type and acceptance testing.

This standard covers LED Lamps that intentionally produce white light, based on inorganic LEDs. This standard does not cover LED Lamps that intentionally produce tinted or coloured light nor does it cover OLEDs.

This standard specifies test requirements for a maximum rated life (declared) of up to 50 000 h. The verification of manufacturer's life time claims beyond rated life of 50 000 h cannot be made in a sufficiently confident way, because projecting test data further in time is not available.

It can be expected that 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 50°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:

a) Lamps shall be tested under claimed different conditions; and
b) Lamps shall start and operate satisfactorily under claimed different conditions; and
c) Lamps shall meet the performance claims under the claimed different conditions, which may differ from the general conditions for measurement specified in **A-1**.

2 REFERENCES

The standards listed below contain provisions which, through reference in this text, constitute provisions of this standard. 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 the standards listed below:

IS No.	*Title*
1885 (Part 16/Sec 1) : 1968	Electrotechnical vocabulary Part 16 Lighting Section 1 General aspects
2418 (Part 2) : 2018	Tubular Fluorescent Lamps for General Lighting Service Part 2 Performance Requirements (Second Revision)
6873 (Part 5) : 2019	Limits and Methods of Measurement of Radio Disturbance Characteristics Part 5 Electrical Lighting and similar Equipment (Third Revision)
9000 (Part 14/Sec 2) : 1988	Basic environmental testing procedures for electronic and electrical items Part 14 Test N: Change of temperature Section 2 Test Nb: Change of temperature (Temperature Cycling) with specified rate of change - One Chamber Method (First Revision)
IS 10322 (Part 1) : 2014	Luminaires Part 1 General Requirements and Tests (First Revision)
14700 (Part 3/Sec 2) : 2018	Electromagnetic compatibility Part 3 Limits Sec 2 Limits for harmonic current emissions
IS 15885 (Part 2/Sec 13) : 2012	Safety of lamp controlgear Part 2 Particular requirements Section 13 d.c. or a.c. Supplied Electronic Controlgear for LED Modules
16101 : 2012	General Lighting - LEDs and LED Modules - Terms and Definitions
IS 16102 (Part 2) : 2017	Self-Ballasted LED Lamps for General Lighting Services Part 2 Performance Requirements (First Revision)
16103 (Part 2) : 2012	LED modules for general lighting Part 2 Performance requirements
16106 : 2012	Method of Electrical and Photometric Measurements of Solid-State Lighting (LED) Products
16614 (Part 1) : 2018	Double-Capped LED Linear Lamps Part 1 Safety Specification
IS/IEC TR 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), IS 16101, IS 16102 (Part 2) and IS 16614 (Part 1) 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 are specified in this standard, or assigned by the manufacturer or responsible vendor.

3.2 Test Voltage — Voltage at which tests are carried out.

NOTE — Specification of test voltage is made in **A-2**.

3.3 Lumen Maintenance (of an 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 percent.

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.

3.4 Initial Value — Photometric, colorimetric and electrical characteristics at the end of the ageing period and stabilisation time.

3.5 Maintained Value — Photometric, colorimetric and electrical characteristics at an operational time, including stabilisation time

NOTE — The operational time is stated in **7.1**.

3.6 Life (of an Individual LED Lamp) L_x — Length of time during which an LED lamp provides at least claimed percentage of the initial luminous flux, under standard conditions.

NOTES

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

2 Any built-in electronic controlgear, however, may show a sudden end of life failure. The definition **3.6** implies that an LED lamp giving no light at all, due to an electronic failure, has actually reached end of life, since it no longer complies with the minimum luminous flux level as declared by the manufacturer or responsible vendor.

3.7 Rated Lamp Life — Length of time during which a population of LED lamps provides at least the claim for luminous flux percentage *x* and less or equal the claim for failure fraction percentage *y*, as declared by the manufacturer or responsible vendor.

NOTES

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

2 Note 1 and 2 of **3.6** 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 F_{10} and/or F_{50}.

3.9 Stabilisation 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 at stable thermal conditions.

3.10 Ageing — Preconditioning period of the LED lamps before initial values are taken.

3.11 LED Lamp Efficacy — Quotient of the luminous flux emitted by the power consumed by the LED lamp.

NOTE — Efficacy is expressed in lm/W.

3.12 t_{LED}-point — Designated location of the point where to measure the performance temperature t_{LED} at the surface of the LED package.

3.13 Family — Group of LED lamps that have same design characteristics, distinguished by common features of materials, components, and/or method of processing.

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

4 GENERAL REQUIREMENTS ON TESTS

The LED lamps for which compliance with this standard is claimed shall comply with the safety requirements specified in IS 16614 (Part 1). For measurement of lamp characteristics, *see* Annex A.

Other general test conditions are described in **7.1**.

5 MARKING

5.1 General Requirements for Marking

In addition to the marking specified in IS 16614 (Part 1), LED lamps shall be clearly and indelibly marked with the information specified in Table 1.

Compliance shall be checked according to **5.3** of IS 16614 (Part 1).

NOTE — The LED Lamp supplied without controlgear shall also be marked with the input voltage, current and wattage.

5.2 Places of Marking

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

5.3 BIS Certification Marking

The LED lamps conforming to the requirements of this standard may be certified as per the conformity assessment schemes under the provisions of the *Bureau of Indian Standards Act*, 2016 and the Rules and Regulations framed thereunder, and the LED lamps may be marked with the Standard Mark.

6 DIMENSIONS

The LED lamp dimensions and compliance checking shall be in accordance with **6.3** of IS 16614 (Part 1).

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

Compliance is checked by inspection.

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

Sl no.	Requirement	Product	Packaging	Product datasheets, leaflets or website
(1)	(2)	(3)	(4)	(5)
i)	Rated luminous flux (lm)	**x**	**x**	**x**
ii)	Rated Correlated Colour Temperature (CCT)	**x**	**x**	**x**
iii)	Beam angle (for directional lamps only)	**x**	**x**	**x**
iv)	Photometric Code	**-**	**x**	**x**
v)	Rated life (*h*) and the related lumen maintenance (*x*)	**x**	**x**	**x**
vi)	Failure fraction (F_y), corresponding to the rated life	**-**	**x**	**x**
vii)	Peak intensity (cd) (for directional lamps only)	**-**	**x**	**x**
viii)	Rated Colour Rendering Index (CRI)	**-**	**x**	**x**
ix)	Ageing time (*h*), if different to 0 h	**-**	**x**	**x**
x)	Rated efficacy (lm/W)	**x**	**x**	**x**
xi)	Dimensions	**-**	**x**	**x**
xii)	Power Factor	**x**	**x**	**x**

Key: '**x**' = required, '**–**' = not required

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

7 TEST CONDITIONS

7.1 General Test Conditions

Testing duration shall be 6 000 h.

Additional LED lamps within the same family (*see* **3.13**) may be subjected to decreased testing duration (*see* **7.2**). For identification of a family *see* Table 2, for details on sample sizes for family testing *see* Table 11.

For LED lamps using LED modules where compliance with IS 16103 (Part 2) has been proven, the test duration of 6 000 h is not required, provided that the LED module operates in its temperature and current limits as tested according to IS 16103 (Part 2). The data for chromaticity and lumen maintenance at 6 000 h from IS 16103 (Part 2) test report, shall be taken and used to fulfill the maintained value requirements of **10.1** and **11.2** respectively.

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/Table 11. LED Lamps used in endurance tests shall not be used in other tests.

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

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

7.2 Creation of LED Lamp Families to reduce test effort

7.2.1 *General*

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

7.2.2 *Variations within a Family*

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

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

Table 2 Variations allowed within a Family
(*Clause* 7.2.2)

Sl No.	Part characteristics where variations are allowed (*see* NOTE 2)	Conditions for Acceptance
(1)	(2)	(3)
i)	Housing/chassis, heat sink/ heat management	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* NOTE 1)
ii)	Optics (*see* NOTE 1)	The test results showing the effect of optical material change shall be documented in the manufacturer's technical file.
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.
iv)	Controlgear	t_{LED} remains at the same or at a lower value, if the rated life time is the same or higher than the baseline product, as indicated and specified by the manufacturer or responsible vendor. A statistical failure rate calculation based on an MTBF (mean time between failures) calculation by the manufacturer shall show equal or lower failure rate of the electronic control gear.

NOTES

1 Optics include for instance secondary optics (lenses), reflectors, trims and gaskets and their interconnections. The results relate to changes in luminous flux, peak luminous intensity, luminous intensity distribution, beam angle, shift in colour co-ordinates, shift in CCT (*see* **10.1**) and shift in colour rendering index (CRI) (*see* **10.2**).

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

7.2.3 *Compliance testing of Family Members*

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

a) Chromaticity co-ordinates
b) Colour rendering index
c) Lumen maintenance
d) Result of operational high temperature stress test

Documentation of data shall be made available to the testing laboratory from the manufacturer's technical file.

Compliance:

For all of the tested units in a sample, the measured values of an LED Lamp (the initial and maintained value) shall not vary beyond the values indicated by the manufacturer or responsible vendor. The measured values shall be of the same category or code as the provided values or better. 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 ELECTRICAL CHARACTERISTICS

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 value by more than 7.5 percent.

8.2 Power Factor

The measured power factor for each individual LED lamp of the sample shall not be less than 0.9.

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**.

8.3.1 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 3; 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* 8.3.1)

Sl No.	Harmonic order *n*	Maximum permissible harmonic current per watt mA/W	Maximum permissible harmonic current 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)	$3.85/n$	$0.15\frac{15}{n}$

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.

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 4 Disturbance voltage limits at mains terminals
(*Clause* 8.4.1)

Sl. No.	Frequency Range	Limits[a] dB (μV)	
		Quasi-Peak	Average
(1)	(2)	(3)	(4)
i)	9 kHz – 50 kHz	110	-
ii)	50 kHz – 150 kHz	90 – 80[b]	-
iii)	150 kHz – 0.5 MHz	66 – 56[b]	56 to 46[b]
iv)	0.5 MHz – 5.0 MHz	56	46
v)	5.0 MHz – 30 MHz	60	50

[a] At the transition frequency, the lower limit applies.
[b] The limit decreases linearly with the logarithm of the frequency in the ranges 50 kHz to 150 kHz and 150 kHz to 0.5 MHz.

Table 5 Radiated disturbance limits
(*Clause* 8.4.2)

Sl No.	Frequency range	Quasi-peak limits for loop diameter dB (μA)		
		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[a]	81 – 51[a]	75 – 45[a]
iii)	150 kHz – 3 MHz	58 – 22[a]	51 – 15[a]	45 – 9[a]
iv)	3.0 MHz – 30 MHz	22	15 – 16[b]	9 – 12[b]

[a] Decreasing linearly with the logarithm of the frequency.
[b] Increasing linearly with the logarithm of the frequency.

9 PHOTOMETRIC CHARACTERISTICS

9.1 Luminous Flux

Rated luminous flux of the lamps shall be declared by the manufacturer or responsible vendor.

Luminous flux is measured according to Annex A.

Compliance:

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

The average initial luminous flux of the LED lamps in the measured sample shall not be less than the rated luminous flux by more than 7.5 percent.

9.2 Luminous intensity distribution, peak intensity and beam angle

9.2.1 *General*

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

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 the following subclauses, are to take into account the manufacturing tolerances.

9.2.3 *Luminous Intensity Distribution*

The initial distribution of luminous intensity shall not vary ± 5 percent with that declared by the manufacturer.

Compliance is checked according to Annex A.

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.

Compliance is checked according to 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.

Compliance is checked according to Annex A.

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

9.3 Luminous Efficacy

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

The manufacturer or responsible vendor shall declare the rated efficacy value (lm/watt) and the corresponding efficacy level as per Table 6.

Compliance:

The LED lamps shall comply with the minimum lumen per watt requirement of the rated efficacy level.

Table 6 Efficacy Levels
(*Clause* 9.3)

Sl No.	Efficacy Level	(lm/watt) Min
(1)	(2)	(3)
i)	1	100
ii)	2	120
iii)	3	140

NOTE — Efficacy of directional lamps can be classified with a luminous flux defined in a 120° (π sr) cone or 90° (0.6 π sr) cone, *see* **A-3.3**.

10 COLORIMETRIC CHARACTERISTICS

10.1 Rated Colour and Colour Variation Code

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, F 6500

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

Table 7 Colour
(*Clause* 10.1)

Sl No.	Rated Colour	CCT (K)	Chromaticity Co-ordinates	
			X	Y
(1)	(2)	(3)	(4)	(5)
i)	F 6500	6 400	0.313	0.337
ii)	F 5700	5 700	0.329	0.342
iii)	F 5000	5 000	0.346	0.359
iv)	F 4000	4 040	0.380	0.380
v)	F 3500	3 450	0.409	0.394
vi)	F 3000	2 940	0.440	0.403
vii)	F 2700	2 720	0.463	0.420

NOTE — The letters in the rated colour stand for F = Values from IS 2418 (Part 2) Annex C

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

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.

Compliance:

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

For all of the tested units in a sample, the measured chromaticity co-ordinate values of an LED lamp (the initial value and maintained value) shall not move beyond the chromaticity co-ordinate tolerance category as indicated by the manufacturer or responsible vendor (*see* Table 1). The measured values shall be of the same category as the rated values or better. The sample units for the chromaticity coordinate measurement shall be selected from four different batches.

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

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

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

Sl No.	Size of MacAdam ellipse (centred at the chromaticity co-ordinate at the corresponding rated colour)	Colour variation code	
		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 and conversion LED lamps for which it is important that the chromaticity corresponds as much as possible to the lamps to be replaced. Tolerance areas are based on the ellipses defined by MacAdam, as normally applied for (compact) fluorescent lamps and other discharge lamps.

10.2 Colour Rendering Index (CRI)

The rated CRI declared by the manufacturer or responsible vendor shall not be less than 80.

The initial CRI shall be measured in accordance with **A-3.7**.

Compliance:

For all tested units in a sample, the measured initial CRI values shall not be lower than 3 points from the rated CRI value (*see* Table 1).

11 LAMP LIFE

11.1 General

Life of an LED lamp (as defined in **3.6**) is the combined effect of

a) gradual light output degradation, mostly caused by material degradation (*see* **11.2**) and
b) abrupt light output degradation, mostly caused by electrical components failure (*see* **11.3,** endurance tests as an indication for reliability and life)

For ensuring life of LED lamps, both gradual light output degradation and abrupt light output degradation shall be checked by measuring lumen reduction over life at L_{70} (*see* **11.2**) and carrying out endurance tests (*see* **11.3**) respectively.

The rated life of the LED lamps shall be at least 25 000 h.

The fraction of tested lamps of a sample (F_y) that may fail to comply with the requirements of the tests under **11.2** and **11.3** are defined in **3.3** and **3.8**.

All tested units shall be operational at all applicable lumen maintenance measurement points designated in **11.2**.

11.2 Luminous Flux Maintenance

The lumen maintenance figure may vary depending on the application of the LED lamp. This standard specifies a value of 70 percent of the initial luminous flux as the end of life criteria for the applications covered under the scope of this standard that is, L_{70} .

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 the test results at 6 000 h to determine the expected lumen maintenance 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.

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** that is, 6 000 h. The measurement of luminous flux shall be repeated at 1 000 h intervals for a total equal to an operational time of 6 000 h. The measured luminous flux value shall be expressed as maintained value which is equal to the percentage of the initial value.

NOTES

1 The measurement of lumen output values at 1 000 h intervals will give additional insight as to the reliability of the measured values.

2 In case during testing, the maintained value of luminous flux at any 1 000 h interval falls below the maintained value at 6 000 h (as specified in Table 9), the test shall be discontinued and the lamps shall be deemed to have failed the test for lumen maintenance.

Compliance at 6 000 h test duration:

LED Lamp shall maintain minimum percentage of initial luminous flux after completion of the 6 000 h test duration as per Table 9 below:

Table 9 Minimum Lumen Maintenance After Test Duration
(*Clause* 11.2)

Sl No.	**Maximum Life Claim (hours to L_{70})**	**Minimum Lumen Maintenance After Test Duration (6 000 h) (percent)**
(1)	(2)	(3)
i)	25 000	91.8
ii)	30 000	93.1
iii)	35 000	94.1
iv)	40 000	94.8
v)	45 000	95.4
vi)	50 000	95.8

Given a sample of '*n*' pieces (individuals) of LED lamps according to Table 9 being subjected to 6 000 h, it is deemed to having passed the test, if at the end of the test, the number of failed units is smaller or equal to the number claimed by the manufacturer. This standard gives the following guide for calculation:

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 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*

Lamps shall be subjected to the following tests specified in **11.3.2** to **11.3.4**.

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

11.3.2 *Temperature Cycling Tests*

The temperature cycling test shall be conducted according to IS 9000 (Part 14/Sec 2) with specified rate of change as below:

The lamp is placed in a test chamber in which the temperature is varied from −10°C to +50°C over a period of 4 h and for a test duration of 250 cycles (1 000 h in total). The 4 h period of each cycle consists of 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 lamp is switched on at test voltage for 34 min and 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, then:

a) the lamps shall be tested under claimed extended condition,
b) the lamps shall start and operate satisfactorily under claimed extended conditions, and
c) lamps shall meet all performance claims for operation under claimed extended conditions, which may differ from the performance claims under the general conditions for measurement specified in Annex A.

Compliance:

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

NOTES

1 The switching period of 68 min is chosen to get a phase shift between temperature and switching period.
2 Requirements for bending of tube are under consideration.

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

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

11.3.3 *Supply Switching Test*

At test voltage, the lamp shall be switched on and off for 30 s each. The cycling shall be repeated for a number equal to half the rated life in hours (for example, 20 000 cycles if the rated life is 40 000 h).

The temperature requirements of Clause **A-1** shall apply.

NOTE — Purpose of this test is to check the endurance of the built-in electronic components.

Compliance:

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

11.3.4 *Operational high temperature stress 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 K (see last paragraph and the note) above the maximum specified operating temperature, if declared by the manufacturer and over an operational time of 1 000 h. If there is no declared value, then the test shall be performed at 60°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 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 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 41 lamps are required for baseline product and 20 samples for each family product for type test.

Table 10 Sample Size for Type Tests
(*Clauses* 13 *and* 14.1)

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[a]	t_{LED} point	1 unit for each test[b]	Not applicable	Not applicable
ii)	9.2.3	Luminous intensity distribution		Not applicable	Not applicable
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)	9.2	Luminous Efficacy		4	
xiii)	10.1	Chromaticity tolerance (initial and maintained)		4	
xiv)	10.2	Colour Rendering Index (initial)		2	
xv)	11.2	Lumen maintenance		0 or 2[c]	
xvi)	11.3.2	Temperature cycling, energised	5	1	2
xvii)	11.3.3	Supply voltage switching	5	1	
xviii)	11.3.4	Operational high temperature stress test	5	1	

[a] t_{LED} point to be tested and recorded. Measurement of t_{LED} point is only for reference purpose for family compliance testing.

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

[c] The failures in lumen maintenance test is related to failure function (F_{10}/F_{50}) as defined in **11.2**.

Table 11 Sample Size for testing of Family
(*Clauses* 13 *and* 14.1)

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[a]	t_{LED} point	1 unit for each test[b]	Not applicable	Not applicable
ii)	9.2.3	Luminous intensity distribution		Not applicable	Not applicable
iii)	8.3	Harmonics		0	0
iv)	8.4	Emission of radio frequency disturbance		0	
v)	5	Marking	5 units for all tests	0	1
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 5 units for all tests	1	2
xi)	9.1	Luminous flux		1	
xii)	9.2	Luminous Efficacy		1	
xiii)	10.1	Chromaticity tolerance (initial and maintained)		1	
xiv)	10.2	Colour Rendering Index (initial)		1	
xv)	11.2	Lumen maintenance		1	
xvi)	11.3.2	Temperature cycling, energised	3	1	1
xvii)	11.3.3	Supply voltage switching	3	1	
xviii)	11.3.4	Operational high temperature stress test	3	1	

[a] t_{LED} point to be tested and recorded. Measurement of t_{LED} point is only for reference purpose for family compliance testing.

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

[c] The failures in lumen maintenance test is related to failure function (F_{10}/F_{50}) as defined in **11.2**.

13.2 Acceptance tests

The method of selection of lamps is given in **16** of IS 16614 (Part 1). The minimum sampling size for acceptance tests and acceptance criteria shall be as given in Table 12.

Table 12 Sample Size for Acceptance Tests[a]

(*Clause* 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	5 units for all tests[b]	0	1
ii)	6	Dimensions		1	
iii)	8.2	Power factor		1	
iv)	8.1	Lamp power	Same 10 units for all tests	2	3
v)	9.1	Luminous flux		2	
vi)	9.3	Luminous Efficacy		2	
vii)	10.1	Chromaticity tolerance (initial)		2	
viii)	10.2	Colour rendering index (initial)		2	

[a]Acceptance tests are defined in **14.2**.

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

14 TESTS

14.1 Type Tests

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

a) Marking (*see* **5**)
b) Dimension (*see* **6**)

c) Lamp power (*see* **8.1**)
d) Power factor (*see* **8.2**)
e) Harmonics (*see* **8.3**)
f) Emission of radio frequency disturbances (*see* **8.4**)
g) Luminous flux (*see* **9.1**)
h) Luminous intensity distribution (*see* **9.2.3**)
j) Peak intensity value (*see* **9.2.4**)
k) Beam angle value (*see* **9.2.5**)
m) Luminous Efficacy (*see* **9.3**)
n) Colour chromaticity and Colour rendering index (CRI) (*see* **10.1** and **10.2**)
p) Life (*see* **11**)

14.2 Acceptance Tests

The following shall constitute the acceptance tests:

a) Marking (*see* **5**)
b) Dimension (*see* **6**)
c) Lamp power (*see* **8.1**)
d) Power factor (*see* **8.2**)
e) Luminous flux (*see* **9.1**)
f) Efficacy (*see* **9.3**)
g) Colour chromaticity and Colour rendering index (CRI) (*see* **10.1** and **10.2**)

ANNEX A
(NORMATIVE)
METHOD OF MEASURING LAMP CHARACTERISTICS

A-1 GENERAL

Unless otherwise specified, all measurements shall be made in a draught-free room at a temperature of 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.For general conditions of measurement IS 16106 applies.

Measurement results shall be expressed for steady state operation of the lamps at rated test conditions.

For stabilization before measurements 7 of IS 16106 applies.

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 exhibits 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.

   NOTE — Normally the observed stabilisation process is a slow decrease in luminous flux or luminous intensity until thermal stability. However due to the electronics, fluctuations can still occur near thermal stability and stabilisation criteria not met.

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.

Temperature cycling test (**11.3.2**) and accelerated operational life tests (**11.3.4**) shall be conducted in the temperature specified in **11.3.2** and **11.3.4** respectively, with a tolerance of (+0˚C, −5˚C).

A-2 TEST VOLTAGE AND TEST FREQUENCY

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 frequency shall be 50 Hz and test voltage shall be as defined in **A-2.2**.

A-2.2 Relation of Rated Voltage to Test Voltage

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

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

Sl No.	Rated Voltage	U_{test} (V)
(1)	(2)	(3)
i)	240 V	240
ii)	220-240 V	230

A-2.3 Tests

A-2.3.1 *Initial tests*

For the purpose of this standard, initial tests are defined as in Table 14.

A-2.3.2 *Lifetime Tests and Endurance Tests*

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

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

Sl No.	Clause or subclause	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	Chromaticity tolerance (initial)
ix)	10.1	Correlated colour temperature (initial)
x)	10.2	Colour rendering index (initial)

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

Sl No.	Clause or subclause	Test
(1)	(2)	(3)
i)	10.1	Chromaticity tolerance (maintained)
ii)	10.1	Correlated colour temperature (maintained)
iii)	11.2	Lumen maintenance
iv)	11.3.2	Temp. cycling, energised
v)	11.3.3	Supply voltage switching
vi)	11.3.4	Operational high temperature stress test

A-2.4 Requirements

The test voltage shall be the rated voltage or the midpoint 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 define an ageing period of up to 1 000 h.

A-3.3 Luminous flux

The initial and maintained luminous flux shall be measured after stabilisation of the LED lamp.
In case of directional lamps the luminous flux shall be measured in a solid angle of 120° (π sr).

NOTE — Measurement of luminous flux shall be made in accordance to IS 16106.

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 TR 61341.

A-3.5 Peak intensity

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

A-3.6 Beam angle

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

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

A-3.7 Colour rendering

Measurement of colour rendering index shall be made in accordance to IS 16106.

A-3.8 Chromaticity co-ordinate values

Chromaticity co-ordinates shall be in accordance with the values given in Annex C 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

(NORMATIVE)
EXPLANATION OF THE PHOTOMETRIC CODE

Example of photometric code like 830/359, meaning:

8	3	0	/	3	5	9

(Explanation of the number from left to right)
- '8', rated CRI of, for example, 87
- '30', rated CCT of 3 000 K
- '3', initial spread of chromaticity co-ordinates within a 3-step MacAdam ellipse
- '5', maintained spread of chromaticity co-ordinates at an operational test duration as stated in **7.1** within a 5-step MacAdam ellipse
- '9', lumen maintenance code at an operational time as stated in **7.1**

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

CRI = 80 to 89 → code 8
CRI = 90 to ≥ 99 → code 9
The highest value is 9.

ANNEX C

(*Foreword*)

COMMITTEE COMPOSITION

Lamps and Related Equipment Sectional Committee, ETD 23

Organization	*Representative (s)*
In Personal Capacity	SHRIMATI RANJANA MEHROTRA (***Chairperson***)
Airports Authority of India	SHRI SHALENDERA KUMAR SHRI N. B. GOEL (*Alternate*)
Bajaj Electricals Limited	SHRI SATISH SATYARTHI SHRI HRISHIKESH TA (*Alternate*)
Binay Opto Electronics Private Limited	SHRI VINEET K. ROHATGI SHRI RAJEEV ROHATGI (*Alternate*)
Bureau of Energy Efficiency	SHRI KAMRAN SHAIK SHRIMATI P. SAMAL (*Alternate I*) SHRIMATI ANJU R. SINGH (*Alternate II*)
Central Electricity Authority	SHRIMATI SHIVANI SHARMA SHRIMATI VANDANA SINGHAL (*Alternate*)
Central Power Research Institute	SHRI R. SUDHIR KUMAR SHRI N. RAJKUMAR (*Alternate*)
Central Public Works Department	SHRI J. M. PASWAN SHRI CHAITANYA KUMAR VERMA (*Alternate*)
Consumers Association, Pallakad	SHRI A. D. P. A. SURENDRAN SHRI R. C. MATHEW (*Alternate*)
Crompton Greaves	SHRIMATI UMA LANKA
CSIR - National Physical Laboratory	DR PARAG SHARMA SHRI V. K. JAISWAL (*Alternate*)
Delhi Metro Rail Corporation Limited	MD. PERVEZ ALAM KHAN SHRI AMIT RASTOGI (*Alternate*)
Development Commissioner Micro-Small and Medium Enterprises	SHRI MANOJ KHUNEKAR SHRI DATTA A. POTDUKHE (*Alternate*)
Directorate General Factory Advice Service and Labour Institutes	SHRI H. M. BHANDARI SHRI B. N. JHA (*Alternate*)
Electric Lamp and Component Manufacturers Association of India	SHRI SHYAM SUJAN SHRI AMAL SENGUPTA (*Alternate*)

Electrical Research and Development Association	DR VINOD GUPTA SHRI N. L. PATEL (*Alternate*)
Energy Efficiency Services Limited	SHRI ANIL KUMAR CHOUDHARY SHRI ASHISH MALVIYA (*Alternate I*) SHRI MUKESH KUMAR RAY (*Alternate II*)
EON Electric Limited	SHRI V. P. MAHENDRU SHRI SHARMA VISHAL (*Alternate*)
Halonix Technologies Private Limited	SHRI RAJEEV CHHABRA SHRI MUKHESH CHATURVEDI (*Alternate*)
Indian Society of Lighting Engineers	SHRI P. K. SOOD DR RAJAT SUBHRA MANDAL (*Alternate*)
International Centre of Automotive Technology	SHRI KUNWAR GIRISH SINGH SHRI AKASH BISWAS (*Alternate*)
Jadavpur University	DR SASWATI MAZUMDAR DR B. ROY (*Alternate*)
Ledvance India Private Limited	SHRI AMAR S. ADHIKARI SHRI VISHAL BHARDWAJ (*Alternate*)
Ministry of Defence	SHRI ARVIND KUMAR
Ministry of Electronics and Information Technology	SHRIMATI ASHA NANGIA SHRI BHARAT KUMAR YADAV (*Alternate*)
MLS India Private Limited	SHRI KRISHAN SUJAN
NTPC Limited	SHRI BHABANISANKAR JENA SHRI F. RAHMAN (*Alternate*)
Signify Innovations India Limited	SHRI NITISH POONIA SHRI MURLI OMPRAKSAH TOSHNIWAL (*Alternate*)
Surya Roshni Limited	SHRI AMIT TYAGI SHRI TAPAN KUMAR BANDYOPADHYAY (*Alternate*)
The Brihan Mumbai Electricity Supply and Transport	SHRI A.R. TALEGAONKAR SHRI N. N. SAMUAL (*Alternate*)
The Energy and Resources Institute	SHRI ARVIND SHARMA
UL India Private Limited	SHRI SATISH KUMAR SHRI GAUTAM BRAHMBHATT (*Alternate I*) SHRI HARI OM (*Alternate II*)
Voluntary Organization in Interest of Consumer Education (Voice)	SHRI H. WADHWA SHRI K. C. CHAUDHARY (*Alternate*)

Expert In Personal Capacity	SHRI P. K. MUKHERJEE
BIS Directorate General	SHRIMATI PRITI BHATNAGAR, SCIENTIST 'F' and HEAD (ETD) [REPRESENTING DIRECTOR GENERAL (*Ex-officio*)]

Member Secretary
SHRI SHYAM KUMAR
SCIENTIST 'C'/DEPUTY DIRECTOR (ETD), BIS

Bureau of Indian Standards

BIS is a statutory institution established under the *Bureau of Indian Standards Act*, 2016 to promote harmonious development of the activities of standardization, marking and quality certification of goods and attending to connected matters in the country.

Review of Indian Standards

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 website- www.bis.gov.in or www.standardsbis.in.

This Indian Standard has been developed from Doc No.: ETD 23 (17898).

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.gov.in

Regional Offices:		*Telephones*
Central:	601/A Konnectus Tower-I, 6th Floor DMRC Building, Bhavbhuti Marg, New Delhi 110 002	2323 7617
Eastern:	8th Floor, Plot No. 7/7 & 7/8, CP Block, Sector V Salt Lake, Kolata 700091	236 7012, 2320 9474
Northern:	Plot No. 4A, Sector 27-B, Madhya Marg Chandigarh 160 019	265 0206, 265 0290
Southern:	C I T Campus, IV Cross Road, Taramani Chennai 600 113	2254 1442, 2254 1216
Western:	Plot No. E-9, Road No. 8, MIDC, Andheri (East) Mumbai 400 093	28218093

Branches: AHMEDABAD, BENGALURU, BHOPAL, BHUBANESHWAR, CHANDIGARH, CHENNAI, COIMBATORE, DEHRADUN, DELHI, FARIDABAD, GHAZIABAD, GUWAHATI, HIMACHAL PRADESH, HUBLI, HYDERABAD, JAIPUR, JAMMU & KASHMIR, JAMSHEDPUR, KOCHI, KOLKATA, LUCKNOW, MADURAI, MUMBAI, NAGPUR, NOIDA, PANIPAT, PATNA, PUNE, RAIPUR, RAJKOT, SURAT, VISHAKHAPATNAM.

Publication Unit, BIS, New Delhi, India