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Responsible committee: CPL/34/1 Electric Light Sources including Caps and Holders

Interested committees:

Title: BS EN IEC 63554 LED lamps – Safety requirements

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Introduction

This draft standard is based on national and international discussions. Your comments on this draft are invited and will assist in the preparation of the consequent standard.

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Template for comments and secretariat observations

Date: xx/xx/20xx	Document: ISO/DIS xxxx
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1	2	(3)	4	5	(6)	7
MB	Clause No./ Subclause No./Annex (e.g. 3.1)	Paragraph/Figure/ Table/Note	Type of comment	Commend (justification for change) by the MB	Proposed change by the MB	Secretariat observations on each comment submitted
	3.1	Definition 1	ed	Definition is ambiguous and needs clarifying.	Amend to read '...so that the mains connector to which no connection...'	
	6.4	Paragraph 2	te	The use of the UV photometer as an alternative cannot be supported as serious problems have been encountered in its use in the UK.	Delete reference to UV photometer.	



COMMITTEE DRAFT FOR VOTE (CDV)

PROJECT NUMBER: IEC 63554 ED1	
DATE OF CIRCULATION: 2024-04-19	CLOSING DATE FOR VOTING: 2024-07-12
SUPERSEDES DOCUMENTS: 34A/2386/NP, 34A/2392/RVN	

IEC SC 34A : ELECTRIC LIGHT SOURCES	
SECRETARIAT: United Kingdom	SECRETARY: Mr Petar Luzajic
OF INTEREST TO THE FOLLOWING COMMITTEES: TC 34,SC 34B,SC 34C,SC 34D	PROPOSED HORIZONTAL STANDARD: ☐ Other TC/SCs are requested to indicate their interest, if any, in this CDV to the secretary.
FUNCTIONS CONCERNED: ☐ EMC ☐ ENVIRONMENT ☐ QUALITY ASSURANCE ☒ SAFETY	
☒ SUBMITTED FOR CENELEC PARALLEL VOTING Attention IEC-CENELEC parallel voting The attention of IEC National Committees, members of CENELEC, is drawn to the fact that this Committee Draft for Vote (CDV) is submitted for parallel voting. The CENELEC members are invited to vote through the CENELEC online voting system.	☐ NOT SUBMITTED FOR CENELEC PARALLEL VOTING

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TITLE:
LED lamps – Safety requirements

PROPOSED STABILITY DATE: 2028

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Introduction for National Committees (Not part of the proposal)

The document serving as the basis for this CDV was prepared by SC 34A/WG 4 through document 34A/WG4(HTA)031A taking into account document 34A/WG4(HTA)030 and the previously circulated documents 34A/2322/CD, 34A/2352/CC and 34A/2383/INF.

END OF CDV INTRODUCTION FOR NATIONAL COMMITTEES.

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

LED LAMPS – SAFETY REQUIREMENTS

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- IEC 63XXX has been prepared by subcommittee 34A: Electric light sources, of IEC technical committee 34: Lighting. It is an International Standard.
- This first edition cancels and replaces IEC 62560:2011, IEC 62560:2011/AMD1:2015, IEC 62838:2015, IEC 62931:2017 and IEC 62776:2014. This edition constitutes a technical revision.
- This edition includes the following significant technical changes with respect to the documents it cancels and replaces:
- a) combination of the contents of IEC 62560, IEC 62838, IEC 62931 and IEC 62776 into a single stand-alone document;
 - b) introduction of:
 - 1) "Particular requirements for single-capped LEDni lamps";
 - 2) "Particular requirements for double-capped LEDi lamps" and
 - 3) "Particular requirements for double-capped LEDni lamps" as new parts of the document;
 - 4) "Particular requirement for single-capped LED lamps designed to retrofit fluorescent lamps".

471 The text of this International Standard is based on the following documents:

Draft	Report on voting
34A/XX/FDIS	34A/XX/RVD

472
473 Full information on the voting for its approval can be found in the report on voting indicated in
474 the above table.

475 The language used for the development of this International Standard is English.

476 This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in
477 accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available
478 at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are
479 described in greater detail at www.iec.ch/standardsdev/publications.

480 NOTE In this document, the following print type is used:

481 – compliance statements: *in italic type*.

482 The committee has decided that the contents of this document will remain unchanged until the
483 stability date indicated on the IEC website under webstore.iec.ch in the data related to the
484 specific document. At this date, the document will be

- 485 • reconfirmed,
- 486 • withdrawn,
- 487 • replaced by a revised edition, or
- 488 • amended.

489

IMPORTANT – The "colour inside" logo on the cover page of this document indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

490

491

INTRODUCTION

Since the introduction of safety standards for LED lamps, a majority of the requirements within these standards are similar, but not always written using the same wording. Many of those requirements can be specified as being applicable to all types of LED lamps. This document provides this set of general requirements, safety requirements and tests in the main text that are basically applicable for all LED lamps. Annexes H to P specify additionally for each particular type of LED lamp the specific requirements relevant to that type of LED lamp, which are more concise and clearer due to this format.

This document is not considered a specification for any arbitrary type of LED lamp, but the provisions in the main text are only applicable in combination with one particular type of LED lamp, to the extent determined by the applicable Annex H to P.

This document replaces the following safety standards, and the table below shows which annexes of this document apply to the superseded standard references:

- IEC 62560:2011 and IEC 62560:2011/AMD1:2015;
- IEC 62838:2015;
- IEC 62931:2017;
- IEC 62776:2014.

Applicable Annexes for the superseded standard references

IEC 63XXX:20XX Edition 1	Replaced IEC standards	Notes
Annex H	IEC 62560:2015 - Self-ballasted LED-lamps for general lighting services by voltage > 50 V – Safety specifications	
Annex I	IEC 62838:2015 Edition 1.0 - LEDsi lamps for general lighting services with supply voltages not exceeding 50 V a.c. r.m.s. or 120 V ripple free d.c. – Safety specifications	
Annex J	Particular requirement for single-capped LEDi lamps	New requirements, not included in a replaced document
Annex K	Particular requirements for double-capped LEDi lamps	New requirements, not included in a replaced document
Annex M	Particular requirements for double-capped LEDni lamps	New requirements, not included in a replaced document
Annex N	IEC 62931:2017 Edition 1.0 - GX16t-5 capped tubular led lamp – Safety specifications	
Annex O	IEC 62776:2014 Edition 1.0 - Double-capped LED lamps designed to retrofit linear fluorescent lamps – Safety specifications	
Annex P	Particular requirement for single-capped LED lamps designed to retrofit fluorescent lamps	New requirements, not included in a replaced document

LED LAMPS – SAFETY REQUIREMENTS

1 Scope

This document specifies safety requirements for LED lamps for operation at supply of a DC supply of up to 1 500 V or an AC supply up to 1 000 V. This document does not include requirements for performance characteristics of LED light sources.

NOTE LED light sources as defined in IEC 60050-845:2020, 845-27-053 can take the form of an LED module or an LED lamp. LED lamp is defined in IEC 60050-845:2020, 845-27-054.

This document does not apply to:

- LED packages;
- LED light sources for automotive lighting;
- OLED light sources;

This document is only applicable to the product categories listed in Table 1.

Table 1 – LED lamps in scope of this document

Shape	Controlgear integration	Caps	Rated voltage limits (if lower than 1 500 V DC or 1 000 V AC)	Rated power	Annex for particular requirements
Single-capped	LEDi (non-SELV, voltage source)	B15d, B22d, E11, E12, E14, E17, E26, E27, GU10, GZ10, GX53, E39, E40	AC > 50 V and ≤ 250 V		Annex H
	LEDsi (SELV, voltage source)	G4, GU4, GU5.3, GX5.3, G6.35, GY4, GY6.35, GU7, G53	AC ≤ 50 V or Ripple free DC voltage ≤ 120 V	≤ 60 W	Annex I
	LEDni (SELV, current source)	GUZ5.3-1, GUZ5.3-2, GH36d-1, GH36d-2, GH36d-3, GH36d-4, GH36d-5, GH36d-6, GH36d-7, GH36d-8	Ripple free DC voltage ≤ 120 V	≤ 60 W	Annex J
Double-capped	LEDi (non-SELV, voltage source)	GJ6.6t, GJ6.6d-1, GR6d-10, GR6d-11, GR6d-12, GR6d-13, GR6d-14, GR6d-15	50 V < V AC ≤ 382 V	≤ 65 W	Annex K
	LEDsi				Annex L (not currently within scope of this document)
	LEDni (SELV, current source)	GJ6.6d-2-x, GR6d-1, GR6d-2, GR6d-3, GR6d-4, GR6d-5	Ripple free DC current ≤ 1,4 A	≤ 70 W	Annex M
	LEDni (non-SELV, current source)	GX16t-5	Ripple free DC voltage ≤ 190 V	≤ 70 W	Annex N
Double-capped LED lamps designed to retrofit linear fluorescent lamps		G13, G5	AC ≤ 250 V	≤ 125 W	Annex O
Single-capped LED lamps designed to retrofit fluorescent lamps		2G11	AC ≤ 250 V	≤ 125 W	Annex P

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies.

- 531 For undated references, the latest edition of the referenced document (including any
532 amendments) applies.
- 533 IEC 60061-1, *Lamp caps and holders together with gauges for the control of interchangeability*
534 *and safety – Part 1: Lamp caps* (available at <http://std.iec.ch/iec60061>)
- 535 IEC 60061-2, *Lamp caps and holders together with gauges for the control of interchangeability*
536 *and safety – Part 2: Lampholders* (available at <http://std.iec.ch/iec60061>)
- 537 IEC 60061-3, *Lamp caps and holders together with gauges for the control of interchangeability*
538 *and safety – Part 3: Gauges* (available at <http://std.iec.ch/iec60061>)
- 539 IEC 60061-4, *Lamp caps and holders together with gauges for the control of interchangeability*
540 *and safety – Part 4: Guidelines and general information* (available at <http://std.iec.ch/iec60061>)
- 541 IEC 60081:1997, *Double-capped fluorescent lamps – Performance specifications*
542 IEC 60081:1997/AMD1:2000
- 543 IEC 60155:1993, *Glow-starters for fluorescent lamps*
- 544 IEC 60360:1998, *Standard method of measurement of lamp cap temperature rise*
- 545 IEC 60364-7-715:2011, *Low voltage electrical installations – Part 7-715: Requirements for*
546 *special installations or locations – Extra-low-voltage lighting installations*
- 547 IEC 60384-14, *Fixed capacitors for use in electronic equipment – Part 14: Sectional*
548 *specification – Fixed capacitors for electromagnetic interference suppression and connection*
549 *to the supply mains*
- 550 IEC 60417, *Graphical symbols for use on equipment* (available from: [http://www.graphical-](http://www.graphical-symbols.info/equipment)
551 [symbols.info/equipment](http://www.graphical-symbols.info/equipment))
- 552 IEC 60598 (all parts), *Luminaires*
- 553 IEC 60598-1:2020, *Luminaires – Part 1: General requirements and tests*
- 554 IEC 60695-2-10, *Fire hazard testing – Part 2-10: Glowing/hot-wire based test methods – Glow-*
555 *wire apparatus and common test procedure*
- 556 IEC 60695-2-11:2014, *Fire hazard testing – Part 2-11: Glowing/hot-wire based test methods –*
557 *Glow-wire flammability test method for end products (GWEPT)*
- 558 IEC 60901:1996, *Single-capped fluorescent lamps – Performance specifications*
559 IEC 60901:1996/AMD6:2014
- 560 IEC 60921:2004, *Ballasts for tubular fluorescent lamps – Performance requirements*
561 IEC 60921:2004/AMD1:2006
- 562 IEC 60990:2016, *Methods of measurement of touch current and protective conductor current*
- 563 IEC 61032:1997, *Protection of persons and equipment by enclosures – Probes for verification*
- 564 IEC 61347-1:202X, *Controlgear for electric light sources – Safety, Part 1: General requirements*
- 565 IEC 61347-2-8:2000, *Lamp controlgear – Part 2-8: Particular requirements for ballasts for*
566 *fluorescent lamps*
567 IEC 61347-2-8:2000/AMD1:2006
- 568 IEC 61195:1999, *Double-capped fluorescent lamps – Safety specifications*
569 IEC 61195:1999/AMD1:2012
570 IEC 61195:1999/AMD2:2014
- 571 IEC 62471-7:2023, *Photobiological safety of lamps and lamp systems*
- 572 ISO 4046-4:2016, *Paper, board, pulp and related terms – Vocabulary – Part 4: Paper and board*
573 *grades and converted products*

ISO 7089:2000, *Plain washers – Normal series – Product grade A*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at <http://www.electropedia.org/>
- ISO Online browsing platform: available at <http://www.iso.org/obp>

3.1 ultraviolet hazard efficacy of luminous radiation

$K_{S,v}$
quotient of an ultraviolet hazard quantity by the corresponding photometric quantity

Note 1 to entry: Ultraviolet hazard efficacy of luminous radiation is expressed in mW / klm.

Note 2 to entry: The ultraviolet hazard efficacy of luminous radiation is obtained by weighting the spectral power distribution of the lamp or LED module with the UV hazard function $S_{UV}(\lambda)$. Information about the relevant UV hazard function is given in IEC 62471:2006. It only relates to possible hazards regarding UV exposure of human beings. It does not deal with the possible influence of optical radiation on materials, such as mechanical damage or discoloration.

3.2 LED light source

electric light source based on LED technology

Note 1 to entry: An LED light source can take the form of an LED module or an LED lamp.

[SOURCE: IEC 60050-845:2020, 845-27-053]

3.3 integrated LED lamp LEDi lamp

LED lamp, incorporating controlgear and any additional elements necessary for stable operation of the light source, designed for direct connection to the supply voltage

[SOURCE: IEC 60050-845:2020, 845-27-055]

3.4 semi-integrated LED lamp LEDsi lamp

LED lamp that carries the control unit of the controlgear, and is operated by the separated power supply of the controlgear

Note 1 to entry: The term control unit is specified in IEC 60050-845-28-057.

[SOURCE: IEC 60050-845:2020, 845-27-056]

3.5 non-integrated LED lamp LEDni lamp

LED lamp that needs a separate controlgear to operate

[SOURCE: IEC 60050-845:2020, 845-27-057]

3.6 retrofit LED lamp

LED lamp designed as a replacement for a lamp of different technology without requiring internal modification of the luminaire

Note 1 to entry: A retrofit LED lamp can also be used in new luminaires designed for the LED lamp.

Note 2 to entry: The replacement of a glow starter according to IEC 60155:1993 with LED replacement starter having the same dimensions and fit, for the correct functioning of the double-capped LED lamp is not considered as a modification to the luminaire.

3.7**conversion LED lamp**

LED lamp designed as a replacement for a lamp of different technology with modification of the luminaire

Note 1 to entry: A conversion LED lamp can also be used in new luminaires designed for the LED lamp.

3.8**rated value**

<of light sources > value of a quantity, used for specification purposes, declared by the manufacturer or responsible vendor and established under standard test conditions

Note 1 to entry: To express the "rated value" of a particular quantity, the term "value" is replaced by the quantity name; for example, rated power, rated voltage, rated current, and rated temperature.

Note 2 to entry: The standard test conditions are given in this document.

[SOURCE: IEC 60050-845:2020, 845-27-100 modified – "...the relevant standard" in note to entry 2 replaced by "...this document"]

3.9**cap temperature rise** Δt_s

surface temperature rise above ambient temperature of the lamp cap under operating conditions

Note 1 to entry: The standard method for Edison screw cap or bayonet cap is specified in IEC 60360:1998.

3.10**type test**

test or series of tests for the purpose of checking compliance of the design of a given product with the requirements of the relevant standard

3.11**type test sample**

sample consisting of one or more similar units being representative of the production and submitted by the manufacturer or responsible vendor for the purpose of the type test

3.12 **t_c -point**

<of an LED lamp requiring an external heatsink> designated location of the point where to measure the t_c -temperatures at the surface of the LED lamp

3.13 **t_c -temperature**

<of an LED lamp requiring an external heatsink> temperature at the t_c -point, related to the safety of the LED lamp

3.14**maximum operating temperature** $t_{c \text{ rated}}$

<of an LED lamp requiring an external heatsink> maximum operating temperature to which the rated safety characteristics are declared by the manufacturer or responsible vendor

3.15**thermal power** P_d

power to be transferred from an LED lamp to the luminaire by means of heat conduction

Note 1 to entry: Thermal power is expressed in Watt (W).

Note 2 to entry: P_d is below the rated power of an LED lamp.

Note 3 to entry: For LED lamps which do not require heat conduction to the luminaire, P_d is equal to zero.

3.16**mains**

AC or DC power distribution system that supplies operating power to electrical equipment

672 Note 1 to entry: Mains include public or private utilities and, unless otherwise specified in this document, equivalent
673 sources such as motor-driven generators and uninterruptible power supplies.

674 **3.17**

675 **interrupted DC voltage**

676 voltage changing periodically between a DC level and zero

677 Note 1 to entry: In interrupted DC voltage waveforms, the duration of the signal at the DC level can vary within one
678 period.

679 **3.18**

680 **live part**

681 conductive part intended to be energized under normal operating conditions, including the
682 neutral conductor and mid-point conductor, but excluding the PEN conductor, PEM conductor
683 and PEL conductor

684 Note 1 to entry: PEN conductor, PEM conductor and PEL conductor are defined in IEC 60050-195:2021, 195-02-12,
685 195-02-13 and 195-02-14.

686 Note 2 to entry: This concept does not necessarily imply a risk of electric shock.

687 [SOURCE: IEC 60050-195:2021, 195-02-19, modified – Note 1 and Note 2 to entry added]

688 **3.19**

689 **hazardous-live-part**

690 live part that, under certain conditions, can give a harmful electric shock

691 [SOURCE: IEC 60050-195:2021, 195-06-05, modified – Note 1 to entry removed]

692 **3.20**

693 **LED replacement starter**

694 device that can replace a starter in a luminaire comprising fluorescent lamps in order to enable
695 proper operation of LED lamps in such a luminaire

696 **3.21**

697 **pulse width modulation control**

698 **PWM control**

699 pulse control in which the pulse width or frequency or both are modulated within each
700 fundamental period to produce a certain output waveform

701 [SOURCE: IEC 60050-551:1998, 551-16-30]

702 **3.22**

703 **working voltage**

704 highest RMS voltage across any insulation at any rated electrical supply conditions, transients
705 being neglected, under normal and under abnormal conditions

706 Note 1 to entry: The rated electrical supply conditions can be the rated voltage, the rated current or a rated supply
707 range.

708 **3.23**

709 **extra-low voltage**

710 **ELV**

711 voltage which does not exceed 50 V AC or 120 V ripple-free DC between conductors or between
712 any conductor and earth

713 Note 1 to entry: Ripple-free is conventionally defined as an RMS ripple voltage of not more than 10 % of the DC
714 component.

715 Note 2 to entry: Extra-low voltage (ELV) is part of the low-voltage (LV) band, See Clause 4.2 and Table 1 of
716 IEC 61140:2016.

717 **3.24**

718 **SELV circuit**

719 electric circuit in which the voltage cannot exceed the value of extra-low voltage:

720 – under normal conditions and

721 – under single fault conditions, including earth faults in other electric circuits

722 Note 1 to entry: SELV is the abbreviation for safety extra-low voltage.

723 [SOURCE: IEC 61140:2016, 3.26.1. Modified “system” replaced by “circuit”]

3.25**PELV circuit**

electric circuit in which the voltage cannot exceed the value of extra-low voltage:

– under normal conditions and

– under single fault conditions, except earth faults in other electric circuits

Note 1 to entry: PELV is the abbreviation for protective extra-low voltage.

[SOURCE: IEC 61140:2016, 3.26.2. Modified “system” replaced by “circuit”]

3.26**FELV circuit**

electrical circuit in which the voltage cannot exceed the value of ELV used for functional purposes and having simple separation from LV

Note 1 to entry: FELV is the abbreviation for functional extra-low voltage.

Note 2 to entry: An FELV circuit does not fulfil the requirements for SELV circuits (or PELV circuits).

Note 3 to entry: An FELV circuit is not safe to touch and may be connected to protective earth.

[SOURCE: IEC 60669-2-5, 3.204]

4 Classification**4.1 General**

LED lamps are classified, according to the level of controlgear integration, as:

– integrated LED lamps, LEDi;

– semi-integrated LED lamps, LEDsi;

– non-integrated LED lamps, LEDni.

4.2 Classification and specific requirements for each product category

Particular requirements for product categories according to Table 1 are specified in the listed Annexes.

5 General requirements

LED lamps shall be so designed and constructed that, for their intended use, they cause no danger to the user or surroundings.

Parts of LED lamps providing hazard protection, as covered by this document, shall not become loose during normal operation and handling.

Requirements, tests and compliances are provided in this document to reduce the risk of harm to a tolerable level under normal operating conditions, abnormal operating conditions and single fault conditions.

Where the terms “voltage” and “current” are used, they imply the RMS values unless otherwise stated.

Annex B and Annex C provide information for luminaire design and information for controlgear design, respectively.

6 General conditions for tests**6.1 General****6.1.1 Type test**

Tests according to this document are type tests.

NOTE The requirements and tolerances specified in this document are related to testing of a type test sample submitted by the manufacturer for that purpose. Compliance of type test samples does not ensure compliance of the whole production of a manufacturer with this document. Conformity of production is the responsibility of the manufacturer and routine tests and quality insurance in addition to the type test can be necessary.

6.1.2 Test samples

Tests shall be carried out with type test samples.

770 NOTE 1 For example, damage to marking as a result of the marking test has no impact on electrical testing, thus
771 the lamp is still considered to be representative of production for other tests.

772 Unless otherwise specified, the type test shall be carried out on one sample consisting of one
773 or more sample items submitted for the purpose of the type test.

774 In general, all tests shall be carried out on each type of the LED lamp. Where there is a range
775 of similar LED lamps for testing, samples representing the most onerous case within the range
776 shall be selected as relevant to the test criteria and agreed with the manufacturer.

777 NOTE 2 As an example, it is not necessary to carry out overload condition tests separately on LED lamps of one
778 type having different colour temperatures.

779 Factory-sealed LED lamps shall not be opened for any tests unless otherwise required in this
780 document.

781 If required in this document, tests shall be performed using sample items specially prepared in
782 agreement with the manufacturer or responsible vendor.

783 **6.1.3 Compliance by inspection of relevant data**

784 Where in this document compliance of materials, components or subassemblies is checked by
785 inspection or by testing of properties, compliance may be confirmed by reviewing any relevant
786 data or previous test results that are available.

787 **6.2 Default test conditions**

788 **6.2.1 General**

789 Unless otherwise specified in this document, the tests shall be conducted under the most
790 onerous operating conditions within the specified operating range. It can be necessary to
791 request information about the most onerous test conditions from the manufacturer. In addition
792 to 6.2.2 and 6.2.3 the following parameters shall be taken into account:

- 793 – operating mode, including loading by external connected equipment;
- 794 – control settings;
- 795 – position of movable parts;
- 796 – operating position.

797 **6.2.2 Electrical supply conditions**

798 **6.2.2.1 General**

799 Where the terms "voltage" and "current" are used without modifiers, they imply the RMS values.
800 The supply voltage, current and frequency shall be stabilized within ± 1 % of the specified test
801 value.

802 **6.2.2.2 LED lamps supplied by voltage sources**

803 LED lamps supplied by voltage sources usually comprise means to adjust their operating
804 current so that they can be supplied by a voltage source that, ideally, has no impedance.

805 EXAMPLE Mains driven LED lamps.

806 In case of a single rated voltage, tests shall be carried out at the most onerous boundary of the
807 90 % to 110 % range around that rated voltage.

808 In case of a rated voltage range, tests shall be carried out at the minimum voltage of that range
809 -10 % or at the maximum value of that range +10 %, whichever is the most onerous.

810 In case of alternative rated voltages or voltage ranges, tests shall be carried out separately for
811 each rated voltage or voltage range.

812 For AC rated LED lamps, tests shall be carried out at the most onerous rated frequency.

813 For LED lamps rated for both AC and DC, each test shall be carried out with the most onerous
814 voltage source condition.

815 The peak-to-peak ripple of the DC test voltage shall not exceed 10 % of the average value of
816 the test voltage.

Where LED lamps are intended for use from a battery supply, a DC power source may supply the LED lamp under test, provided that the source impedance is equivalent to that of a battery.

NOTE A non-inductive capacitor of appropriate rated voltage and with a capacitance of at least 50 μF , connected across the supply terminals of the units under test normally provides a source impedance simulating that of a battery.

6.2.2.3 LED lamps supplied by current sources

LED lamps supplied by current sources usually do not comprise means to adjust their operating current, the operating voltage of such LED lamps results from the operating current.

EXAMPLE Non-integrated LED lamp (LEDni lamp).

Tests shall be carried out at the rated maximum current +10 %.

The peak-to-peak ripple of the DC test current shall not exceed 10 % of the average value of the test current.

6.2.3 Ambient test conditions

Tests shall be carried out at an ambient temperature within the range of 20 °C to 30 °C unless otherwise specified.

7 Marking

7.1 Marking on the LED lamps

Lamps shall be legibly and durably marked with the following:

- a) Mark of origin (trademark, the manufacturer's name or the name of the responsible vendor).
- b) Rated power.

7.2 Marking on the packing or in the instructions

For LED lamps not suitable for water contact (see Clause 10.6), the information in Figure 1 (IEC 60417-6179-1:2014-10) or a written cautionary notice such as 'Use in Dry Locations only' shall be given on the packaging, immediate lamp wrapping (or container) or in the accompanying information. The height of the graphical symbol shall be at least 5 mm.



(IEC 60417-6179-1:2014-10)

Figure 1 – Lamp not suitable for water contact

7.3 Durability and legibility of marking

Compliance with 7.1 and 7.2 is checked by the following:

Presence and legibility of the marking by visual inspection.

The durability of the marking is checked by trying to remove it by rubbing lightly for 15 s with a piece of cloth soaked with water. The marking on the LED lamp shall be legible after the test.

8 Electrical safety

8.1 General

To reduce the likelihood of painful effects and injury due to electric current passing through the human body, LED lamps shall be provided with the protection means as specified in Clause 8.

8.2 Electrical connections

Electrical connections, except the electrical connection between caps and holders, shall be so designed that contact pressure is not transmitted through insulating material other than ceramic pure mica or other material with characteristics which are at least equivalent, unless there is

sufficient resilience in the metallic parts to compensate for any possible shrinkage of the insulating material.

NOTE Caps and holders are specified in IEC 60061 series.

Compliance is checked by inspection.

8.3 Protection against electric shock

8.3.1 Construction

8.3.1.1 General

Parts providing protection against accidental contact with hazardous-live-part shall have adequate mechanical strength and shall not work loose in normal use. It shall not be possible to remove them without the use of a tool.

Compliance is checked by inspection and by 10.3.

Non-impregnated fibrous materials shall not be used as insulation.

NOTE 1 Examples of fibrous materials are wood, cotton, silk, or paper.

Wax and similar impregnators shall not be used, unless suitably restrained from migration.

NOTE 2 Insulating material is considered impregnated if the space between the fibres of the material is substantially filled with a suitable insulating coating (i.e., epoxy resin, varnish, etc.).

If impregnated fibrous materials are used, these shall withstand the glow-wire test.

Compliance is checked by inspection and by the additional glow-wire test according to 9.1.2.2 applied to the fibrous material at 550 °C.

8.3.1.2 SELV or PELV circuits

SELV and PELV circuits shall be insulated from all circuits other than SELV or PELV, excluding FELV, by double or reinforced insulation. Insulation shall be based upon the working voltage across the insulation respectively upon a working voltage equal to the highest voltage in any of the circuits.

SELV and PELV circuits shall be insulated from FELV circuits by supplementary insulation (based upon a working voltage equal to the mains supply voltage).

SELV and PELV circuits shall be insulated from other SELV circuits by basic insulation (based upon a working voltage equal to the highest voltage in any of the circuits).

Any SELV or PELV circuit shall be insulated from accessible conductive parts by basic insulation based upon a working voltage equal to the highest SELV or PELV voltage in the circuit.

NOTE The above requirement does not exclude the connection of the PELV-circuits to earth for functional purposes.

Compliance is checked by inspection and by 8.4 and 8.5.

8.3.1.3 FELV circuits

FELV circuits shall be insulated from the mains supply by at least basic insulation (based upon a working voltage equal to the mains supply voltage).

It is not required that FELV circuits shall be insulated from other FELV circuits except for functional purpose.

Compliance is checked by inspection and by 8.4 and 8.5.

8.3.1.4 Bridging of insulation by resistors

Parts separated by insulation may be bridged by resistors. For basic and supplementary insulation, they may consist of one single resistor. For double or reinforced insulation, they shall consist of at least two separate resistors of the same rated resistance, connected in series, each one rated for the total working voltage.

Bridging resistors shall comply with the requirements of G.10 of IEC 62368-1:2023.

8.3.1.5 Bridging of insulation by capacitors

Parts separated by insulation may be bridged by Y capacitors according to the Table 2. When according to Table 2 at least two separate capacitors are required, they shall be of the same rated capacitance, connected in series, each one rated for the total working voltage.

Y1, Y2 and Y4 capacitors shall comply with IEC 60384-14.

Table 2 – Required number and type of Y capacitors

Mains supply voltage ^a	Bridged insulation	Capacitor type	Required number of capacitors
$U \leq 150 \text{ V}$	B or S	Y4	1
$U \leq 150 \text{ V}$	B or S	Y2	1
$U \leq 150 \text{ V}$	B or S	Y1	1
$U \leq 150 \text{ V}$	D or R	Y4	2
$U \leq 150 \text{ V}$	D or R	Y2	2
$U \leq 150 \text{ V}$	D or R	Y1	1
$150 \text{ V} < U \leq 300 \text{ V}$	B or S	Y2	1
$150 \text{ V} < U \leq 300 \text{ V}$	B or S	Y1	1
$150 \text{ V} < U \leq 300 \text{ V}$	D or R	Y2	2
$150 \text{ V} < U \leq 300 \text{ V}$	D or R	Y1	1
$300 \text{ V} < U \leq 500 \text{ V}$	B or S	Y2	1
$300 \text{ V} < U \leq 500 \text{ V}$	B or S	Y1	1
$300 \text{ V} < U \leq 500 \text{ V}$	D or R	Y2	2
$300 \text{ V} < U \leq 500 \text{ V}$	D or R	Y1	1

Key:
 B basic insulation
 S supplementary insulation
 D double insulation
 R reinforced insulation

^a In case of capacitors connected between live parts of circuits insulated from the mains and accessible parts, the voltage to be considered is the working voltage as indicated in Clause 7.

8.3.1.6 LED lamps

LED lamps shall be so constructed that the following parts of the lamp or lamp cap shall not be accessible when installed in a lampholder according to the relevant IEC lampholder data sheet:

- external conductive parts insulated only by basic insulation from hazardous-live-parts;
- hazardous-live-parts.

Compliance is checked with tests according to 8.3.2 and with additional tests for specific lamp caps according to particular requirements for each category of LED lamp as indicated in Table 1.

8.3.1.7 Metal core printed circuits boards (MCPCBs)

The insulation properties of printed circuit boards over a metallic substrate (metal core printed circuit boards – MCPCBs) shall only be considered as a single level of insulation (basic or supplementary).

NOTE At the time of publication of this document, there was insufficient evidence for the formulation of requirements that would allow MCPCBs to qualify for double or reinforced insulation.

8.3.2 Tests for accessibility of hazardous-live-parts

The accessibility of hazardous-live-parts is checked by inspection and by a manual test using the test finger as shown in IEC 61032:1997 Figure 2 (Test probe B) with a force of 10 N. The test finger shall be applied in all possible positions. To check the accessibility of conductive parts, it is recommended to use a lamp to indicate a contact and that the voltage is not less than 40 V.

For testing, any movable conductive material shall be placed in the most onerous position without using a tool. Covers that are designed to be removed by hand shall be removed for the test.

8.3.3 Requirements for accessible parts

8.3.3.1 General

LED lamps shall comply with 8.3.3.3 or 8.3.3.4 as applicable.

For LED lamps requiring external controlgear providing insulation between the mains supply and the LED lamps, the measurement of touch current from accessible conductive parts of the LED lamp to earth or ground is not required.

NOTE In this case, the touch current depends exclusively on the construction of the controlgear.

8.3.3.2 Touch voltage and touch current limits

The touch voltage limits, reduced touch voltage limits and touch current limits to be applied are according to Table 3, Table 4 and Table 5.

Table 3 – Touch voltage limits

Waveform Type	Working voltage (V)	Working peak voltage (V)
AC	25	35,4
DC	60	70
interrupted DC ($f < 10$ Hz or $f > 200$ Hz)	-	70
interrupted DC ($10 \text{ Hz} \leq f \leq 200 \text{ Hz}$)	-	25
NOTE Limits are based on IEC 60364-4-41:2005.		

Table 4 – Reduced touch voltage limits

Waveform Type	Working voltage (V)	Working peak voltage (V)
AC	12 V	16,9
DC	30 V	35
interrupted DC ($f < 10$ Hz or $f > 200$ Hz)	-	35
interrupted DC ($10 \text{ Hz} \leq f \leq 200 \text{ Hz}$)	-	12
NOTE 1 Limits are based on IEC 60364-4-41:2005.		
NOTE 2 For background information on PELV limits refer to IEC TR 61319.		

Table 5 – Touch current limits

Waveform type	Max. current (mA)
AC	0,7 (peak)
DC	2,0
interrupted DC ($f < 10$ Hz or $f > 200$ Hz)	0,7 (peak)
interrupted DC ($10 \text{ Hz} \leq f \leq 200 \text{ Hz}$)	0,41 (peak)
NOTE 1 Limits for AC and DC are based on IEC 61140:2016.	
NOTE 2 Limits for interrupted DC are based on KOUWENHOVEN, W.B. <i>et al</i> , <i>Electric Shock Effects of Frequency</i> (1936)	

8.3.3.3 LED lamps specified only for operation with SELV power supplies

For LED lamps with voltages exceeding the voltage limits specified in Table 3 between any accessible conductive parts, the touch current between all pairs of accessible conductive parts shall not exceed the touch current limits as specified in Table 5.

LED lamps which are not suitable for water contact and with touch voltages between any accessible conductive parts not exceeding the voltage limits specified in Table 3 are deemed to comply with the touch current limits as specified in Table 5 without testing.

NOTE Lamps not marked according to 7.2 are considered suitable for water contact.

LED lamps which are suitable for water contact and with touch voltages between any accessible conductive parts not exceeding the voltage limits specified in Table 4 are deemed to comply with the touch current limits as specified in Table 5 without testing.

Compliance is checked by measuring the touch voltages using a measuring circuit consisting of a non-inductive resistance of 50 kΩ and the touch current according to Annex A.

8.3.3.4 LED lamps specified to be operated with power supplies other than SELV

The touch current between all pairs of accessible conductive parts and accessible conductive parts and earth shall not exceed the touch current limits as specified in 8.3.3.1.

LED lamps which are not suitable for water contact and with touch voltages between any accessible conductive parts and accessible conductive parts and earth not exceeding the voltage limits specified in Table 3 are deemed to comply with the touch current limits as specified in Table 5 without testing.

LED lamps which are suitable for water contact and with touch voltages between any accessible conductive parts and accessible conductive parts and earth not exceeding the voltage limits specified in Table 4 are deemed to comply with the touch current limits as specified in Table 5 without testing.

Compliance is checked by measuring the touch voltages using a measuring circuit consisting of a non-inductive resistance of 50 kΩ and the touch current according to Annex A.

8.3.3.5 Limitation of the touch current in case of failure of one means of protection

The LED lamp shall remain safe in case of failure of one means of protection.

NOTE 1 To reduce the risk of an electric shock when touching a conductive part of the LED lamp, two independent means of protection are required according to IEC 61140. A means of protection can be for example basic insulation provided by a creepage distance and/or clearance, supplementary insulation provided by a creepage distance and/or clearance and/or a provision for connection to protective earth as required by this document.

LED lamps using the following constructions are deemed to comply with the requirement:

- where accessible conductive parts are connected to protective earth;
- for built-in components when one means of protection is provided by the final product;
- in case the protection is provided by reinforced insulation;
- where the failure of basic or supplementary insulation does not connect two conductive parts.

LED lamps using other constructions are tested by disabling each of the two means of protection in turn.

NOTE 2 For example, the basic isolation can be bridged to disable this (basic isolation) means of protection.

Disconnection of the protective earth is not necessary because the current to protective earth is already limited, see 8.6.2.

The touch current shall not exceed:

- for AC and interrupted DC ($f < 10$ Hz; $f > 200$ Hz): 3,5 mA;
- for DC: 10 mA (non-interrupted DC only);
- interrupted DC 2 mA (frequencies between 10 Hz and 200 Hz).

Compliance is checked by measuring the touch current according to Annex A.

8.3.4 Requirements for SELV circuits and PELV circuits

The voltage in any SELV circuit or PELV circuit shall not exceed the limits for ELV.

Touch voltages in SELV circuits shall not exceed the limits given in Table 3. Touch voltages in PELV circuits shall not exceed the limits given in Table 4.

For SELV and PELV circuits within the lamp, the value of the leakage current coming from any other circuit (including circuits connected to mains) shall not exceed the limits as specified in 8.3.3.1.

Compliance is checked by measuring the voltage and touch current according to Annex A.

8.3.5 Capacitor discharge requirements

Where a capacitor voltage becomes accessible upon disconnection of an LED lamp from the electrical supply, the accessible voltage shall comply with Table 6.

The accessible voltage limits in Table 6 apply from disconnection after:

- 1 s for LED lamps that can be removed with a single action or
- 5 s for LED lamps that can only be removed with multiple action or
- 60 s for LED lamps where a tool is required for disconnection.

The measurement is made with an instrument having an input impedance consisting of a resistance of $100\text{ M}\Omega \pm 5\text{ M}\Omega$ in parallel with an input capacitance of 25 pF or less.

The disconnection (start of discharge time) is done at the moment when the capacitor of the LED lamp that provides the accessible voltage is charged to its peak voltage.

The listed capacities in Table 6 represent the maximum value (rated value of the capacitor including specified tolerance).

Table 6 – Voltage limits for a charged capacitor

C nF	limits A U_{peak} V
300 or greater	60
170	75
91	100
61	125
41	150
28	200
18	250
12	350
8,0	500
4,0	1 000
1,6	2 500
0,8	5 000
0,4	10 000
0,2	20 000
0,133 or less	30 000
NOTE The values for limits A are calculated by dividing the values from Table A.2 of IEC TS 61201:2007, by two (2).	

8.4 Electric strength

8.4.1 General

LED lamps shall have adequate electric strength between circuits, and between circuits and the housing of the LED lamp.

8.4.2 Humidity conditioning

Place the LED lamp under test in the most unfavourable position of normal use, in a humidity cabinet containing air with a relative humidity maintained between 91 % and 95 %. The temperature of the air at all places where samples can be located shall be maintained within ± 1 °C of any convenient value t between 20 °C and 30 °C.

Before being placed in the humidity cabinet, bring the sample to a temperature between t and $(t + 4)$ °C. Keep the sample in the cabinet for 48 h prior to any test.

NOTE In most cases, the sample can be brought to the specified temperature between t and $(t + 4)$ °C by keeping it in a room at this temperature for at least 4 h before the humidity treatment.

8.4.3 Electric strength test

8.4.3.1 Preparation of devices

- Accessible surfaces of insulating material are covered with metal foil. The metal foil shall be positioned to make contact with surfaces which can be touched by the standard test finger. The metal foil is so placed that no flashover occurs at the edges of the insulation.
- Supply connections shall be electrically connected together.
- Any output connections shall be electrically connected together.
- Any terminals of a control port shall be electrically connected together.
- Any internal connections or components between terminal(s) and any earth terminal(s) shall be removed for this test.

8.4.3.2 Test procedure

Testing shall be carried out in the humidity cabinet.

The high-voltage source shall be capable of providing at least 200 mA, with the output terminals short-circuited, after the output voltage has been adjusted to the appropriate test voltage.

The overcurrent relay of the test equipment shall trip when the output terminals of the test equipment are short-circuited but shall not trip when the output current is less than 100 mA.

NOTE Equipment according to IEC 61180 is considered to fulfil this requirement.

The value of the test voltage applied shall be measured with an accuracy of ± 3 %. A voltage of substantially sine-wave form, with a frequency of 50 Hz or 60 Hz and the value specified in Table 7, shall be applied for 1 min across the parts as specified in 8.4.1.

Initially, no more than half the prescribed voltage shall be applied, it is then raised gradually to the full value.

Where double insulation is used, the voltage applied to the double insulation does not overstress the basic insulation or the supplementary insulation. In case of doubt, each insulation shall be tested individually.

In the case of a lamp where it is not possible to remove coupling capacitors, leading to an incorrect result in an AC test, an alternative electric strength test with a DC test voltage may be applied according to the following parameters and procedure:

- The DC test voltage shall be substantially free of ripple. This requirement is fulfilled if the peak values of the voltage do not deviate from the average value by more than 3 %. The average value of the DC test voltage shall be equal to the peak value of the AC test voltage as required in Table 7.
- The DC test voltage shall be raised uniformly from 0 V to the value specified above within 5 s and held at that value for 1 min.

Compliance:

LED lamps shall withstand the test voltage in Table 7. No flashover or breakdown which trips the overcurrent relay shall occur during the test.

1066

Table 7 – Electric strength test voltage

Working voltage U	Insulation	Test voltage V (AC RMS)
Up to and including 50V AC or 120 V ripple free DC	Basic insulation	500
Above 50 V AC or 120 V ripple free DC up to and including 1 000 V AC or 1 500 V DC	Basic or supplementary insulation	$2 U + 1\,000$
	Double or reinforced insulation	$4 U + 2\,000$

1067 8.5 Creepage distances, clearances and distances through insulation

1068 The requirements of IEC 61347-1:202X, Clause 13 apply, in conjunction with the following
1069 specific requirements.

1070 The minimum creepage distance between contact pins and conductive parts (if any) of the cap
1071 shall be in accordance with the requirements in IEC 60061-4, sheet 7007-6.

1072 If enamel forms the insulation of a wire and withstands the voltage test prescribed in Clause 13
1073 of IEC 60317-0-1:2013, it is considered as contributing 1 mm to the insulation distances.

1074 The most onerous position shall be identified with the circuit diagram information in agreement
1075 with the manufacturer or responsible vendor.

1076 The measurement shall be conducted by opening the LED lamp, if applicable.

1077 *Compliance is checked by measurement.*

1078 8.6 Earthing**1079 8.6.1 General**

1080 The requirements specified in IEC 61347-1:202X, Clause 8 apply.

1081 Self-tapping screws may be used to provide earth continuity if it is not necessary to disturb the
1082 connection in normal use and is provided with a suitable means of locking.

1083 8.6.2 Protective conductor current

1084 The current that flows in the protective conductor shall not exceed 2,0 mA and is checked
1085 according to Annex A.

1086 8.7 Insertion orientation

1087 LED lamps that can be inserted into a lampholder(s) in more than one orientation shall not
1088 impair safety when inserted in any orientation.

1089 NOTE The use of polarised connectors or lampholders prevents incorrect orientation.

1090 *Compliance is checked by the following test:*

1091 *The LED lamp is inserted or connected in all possible orientations and operated for 1 h.*

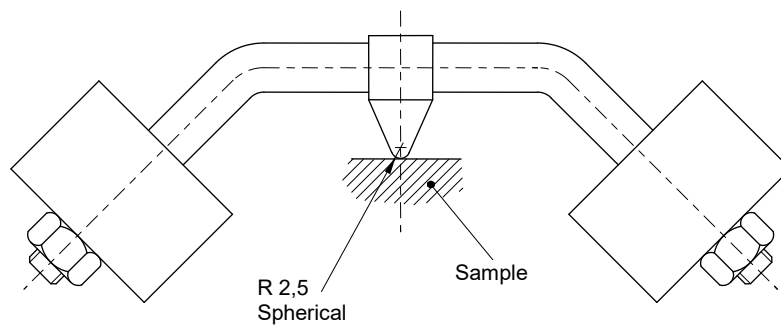
1092 *The LED lamp shall not emit flames, emit molten material, produce flammable gases and*
1093 *hazardous-live-parts shall not become accessible according to 8.3.2.*

1094 9 Thermal safety**1095 9.1 Resistance to heat and fire****1096 9.1.1 Resistance to heat**

1097 Parts of insulating material providing protection against electric shock, and parts of insulating
1098 material retaining live parts in position shall be sufficiently resistant to heat.

1099 *Compliance is checked by subjecting parts other than ceramic parts to a ball-pressure test by*
1100 *means of the apparatus shown in Figure 2.*

1101



IEC 494/08

Dimensions in millimetres

[SOURCE: IEC 60598-1:2020, Figure 10]

Figure 2 – Ball-pressure test apparatus

For LED lamps, the test is made in a heating cabinet at a temperature of $(25 \pm 5) ^\circ\text{C}$ in excess of the operating temperature of the relevant part according to cap temperature rise clause for each category of LED lamp, with a minimum of $125 ^\circ\text{C}$ for parts retaining live parts in position and $75 ^\circ\text{C}$ for other parts.

The surface of the part to be tested is placed in the horizontal position and a steel ball of 5 mm diameter pressed against this surface with a force of 20 N.

The surface where the ball presses should not bend, if necessary the surface shall be supported. For this purpose, if the test cannot be made on the complete specimen, a suitable part may be cut from it.

The specimen shall be at least 2,5 mm thick, but if such a thickness is not available on the specimen, then two or more pieces are placed together.

After 1 h, the ball is removed from the specimen, which is then immersed for 10 s in cold water for cooling down to approximately room temperature. The diameter of the impression is measured, and shall not exceed 2 mm.

In the event of curved surfaces, the shorter axis is measured if the indent is elliptical.

9.1.2 Resistance to flame and ignition

9.1.2.1 General

External parts of insulating material providing protection against electric shock and parts of insulating material retaining current-carrying parts in position shall be sufficiently resistant to flame and ignition or fire.

For materials other than ceramic, compliance is checked by the tests of 9.1.2.2 or 9.1.2.3, as appropriate. For PCBs, 9.1.2.4 applies instead.

9.1.2.2 Glow-wire test

External parts of insulating material providing protection against electric shock shall be subjected for 30 s to the glow-wire test in accordance with IEC 60695-2-11:2021, subject to the following details:

- the test specimen shall be a complete LED lamp;
- the test temperature of the tip of the glow-wire shall be $650 ^\circ\text{C}$.

Flames or glowing combustion of the LED lamp shall extinguish within 30 s after removal of the glow-wire and the single layer of wrapping tissue on the wooden board according to IEC 60695-2-10:2021, 4.4, placed underneath the controlgear shall not ignite.

NOTE 1 This corresponds to (compliance) criterion b) of IEC 60695-2-11:2021, Clause 10.

NOTE 2 IEC 60695-2-11:2021, Clause 12 has been fully considered when preparing this section; no additional or deviating specifications other than those listed above have been identified to be applicable.

9.1.2.3 Needle-flame test

Parts of insulating material retaining live parts in position shall be subjected to the needle-flame test in accordance with IEC 60695-11-5:2016, subject to the following details:

- the test specimen shall be a complete LED lamp. If it is necessary to take away parts of the LED lamp to perform the test, ensure that the test conditions are not significantly different from those occurring in normal use;
- the test flame is applied to the centre of the surface to be tested;
- the duration of application is 10 s;
- the duration of burning shall not exceed 30 s after removal of the test flame, and any burning drop from the sample shall not ignite the underlying parts as required by IEC 60695-11-5:2016.

9.1.2.4 Printed circuit boards

Printed circuit boards are tested in accordance with IEC 61189-2:2006, 8.6 and the relevant parts of the IEC 61249-2 series.

Any self-sustaining flame shall extinguish within 30 s of removal of the gas flame and any flaming drops shall not ignite the tissue paper specified.

9.2 Heat management**9.2.1 General**

Subclause 9.2 is applicable to LED lamps where a heat conducting thermal interface to the luminaire is required for keeping the temperature below $t_{c \text{ rated}}$.

LED lamps shall not impair safety when operated under poor heat-conduction conditions when tested according to 9.2.3.

9.2.2 Thermal interface material

For the purpose of heat-transfer from the LED lamp to the luminaire, the use of thermal interface material can be necessary. Any thermal interface material shall be delivered within the LED lamp packaging.

9.2.3 Testing**9.2.3.1 Test set-up**

The LED lamp shall be installed in its connecting device with a spacer used to create a gap between the thermal interface and heat sink. This spacer shall be placed as close to the edge of the thermal interface as the construction allows. The spacer shall be a rigid plastic washer according to ISO 7089:2000, size M5, 10 mm in diameter, 1,0 mm thick. See Figure 3.

The connecting device shall provide or be attached to a heat sink. The heat sink shall be such that, when the LED lamp is inserted without a washer and operated under normal conditions until thermally stabilized in an ambient temperature, t_a , according to 6.2.3, the temperature measured at the t_c -point is not smaller than $(t_{c \text{ rated}} - 5)^\circ\text{C}$ and not greater than $t_{c \text{ rated}}$. Thermal stabilization occurs when the temperature change rate is less than 5°C/h .

If the M5 washer is too thick to allow the LED lamp to engage and be energized by the lampholder, the next smaller metric washer size (M4, M3,5, M3, M2,5, M2 and M1,6) shall be tried sequentially. The largest of these washers that allows the LED lamp to engage and be energized from the lampholder shall be used as the spacer for the test.

If even the smallest washer according to ISO 7089:2000 cannot be inserted with the LED lamp being energized the test shall be considered as passed.

A layer of wrapping tissue according to ISO 4046-4:2016, 4.215 shall be spread out horizontally 200 mm $\pm$ 5 mm below the sample.