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INTERNATIONAL STANDARD

Lamps, light sources and LED packages for road vehicles – Performance requirements

colour inside

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LAMPS, LIGHT SOURCES AND LED PACKAGES FOR ROAD VEHICLES – PERFORMANCE REQUIREMENTS

FOREWORD

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International Standard IEC 60810 has been prepared by subcommittee 34A: Lamps, of IEC technical committee 34: Lamps and related equipment.

This fifth edition cancels and replaces the fourth edition published in 2014 and Amendment 1:2017. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

a) update and clarification of the title and scope;
b) introduction of new LED light sources;
c) introduction of requirements for LED light sources;
d) introduction of guidelines on LED package robustness validation for LED packages.

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

FDIS	Report on voting
34A/2021/FDIS	34A/2033/RVD

Full information on the voting for the approval of this International Standard can be found in the report on voting indicated in the above table.

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

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

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

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LAMPS, LIGHT SOURCES AND LED PACKAGES FOR ROAD VEHICLES – PERFORMANCE REQUIREMENTS

1 Scope

This document is applicable to ~~lamps (~~filament lamps, discharge lamps, LED light sources~~)~~ and LED packages to be used in road vehicles, i.e. in headlamps, fog-lamps, signalling lamps and interior lighting. It is especially applicable to those lamps and light sources which are listed in IEC 60809.~~ However, the standard may also be used for other lamps falling under the scope of this standard.~~

It specifies requirements and test methods for the measurement of performance characteristics such as lamp life, luminous flux maintenance, torsion strength, glass bulb strength and resistance to vibration and shock. Moreover, information on temperature limits, maximum lamp outlines and maximum tolerable voltage surges is given as guidance for lighting and electrical equipment design.

For some of the requirements given in this document, reference is made to data given in tables. For lamps not listed in such tables, the relevant data are supplied by the lamp manufacturer or responsible vendor.

The performance requirements are additional to the basic requirements specified in IEC 60809. They are, however, not intended to be used by authorities for legal type-approval purposes.

NOTE 1 In the various vocabularies and standards, different terms are used for "incandescent lamp" (IEC 60050-845:1987, 845-07-04) and "discharge lamp" (IEC 60050-845:1987, 845-07-17). In this document, "filament lamp" and "discharge lamp" are used. However, where only “lamp” is written both types are meant, unless the context clearly shows that it applies to one type only.

NOTE 2 This document does not apply to luminaires.

NOTE 3 In this document, the term LED light source is used, in other standards the term LED lamps can be used to describe similar products.

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. For undated references, the latest edition of the referenced document (including any amendments) applies.

~~IEC 60050 (all parts), *International Electrotechnical Vocabulary* (available at <http://www.electropedia.org/)~~

IEC 60050-845, *International Electrotechnical Vocabulary – Part 845: Lighting* (available at http://www.electropedia.org)

IEC 60061-1, *Lamp caps and holders together with gauges for the control of interchangeability and safety – Part 1: Lamp caps*

~~IEC 60068-2-6:1995, *Environmental testing – Part 2-6: Tests – Test Fc: Vibration (sinusoidal)*~~

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

IEC 60068-2-43, *Environmental testing – Part 2-43: Tests – Test Kd: Hydrogen sulphide test for contacts and connections*

IEC 60068-2-58, *Environmental testing – Part 2-58: Tests – Test Td: Test methods for solderability, resistance to dissolution of metallization and to soldering heat of surface mounting devices (SMD)*

IEC 60068-2-60, *Environmental testing – Part 2-60: Tests – Test Ke: Flowing mixed gas corrosion test*

~~IEC 60410:1973, *Sampling plans and procedures for inspection by attributes*~~

IEC 60809:2014, *Lamps for road vehicles – Dimensional, electrical and luminous requirements*

CISPR 25, *Vehicles, boats and internal combustion engines – Radio disturbance characteristics – Limits and methods of measurement for the protection of on-board receivers*

ISO 7637-2:2011, *Road vehicles – Electrical disturbances from conduction and coupling – Part 2: Electrical transient conduction along supply lines only*

ISO 10605, *Road vehicles – Test methods for electrical disturbances from electrostatic discharge*

United Nations Vehicle Regulations – 1958 Agreement, *Agreement concerning the adoption of uniform technical prescriptions for wheeled vehicles, equipment and parts which can be fitted and/or be used on wheeled vehicles and the conditions for reciprocal recognition of approvals granted on the basis of these prescriptions*
(available at www.unece.org/trans/main/wp29/wp29regs.html)[1]

Addendum 36: Regulation No. 37, *Uniform provisions concerning the approval of filament lamps for use in approved lamp units of power-driven vehicles and of their trailers*

~~Addendum 37: Regulation No. 38, *Uniform provisions concerning the approval of rear fog lamps for power-driven vehicles and their trailers*~~

Addendum 47: Regulation No 48, *Uniform provisions concerning the approval of vehicles with regard to the installation of lighting and light-signalling devices*

Addendum 100: Regulation No. 101, *Uniform provisions concerning the approval of passenger cars powered by an internal combustion engine only, or powered by a hybrid electric power train with regard to the measurement of the emission of carbon dioxide and fuel consumption and/or the measurement of electric energy consumption and electric range, and of categories M1 and N1 vehicles powered by an electric power train only with regard to the measurement of electric energy consumption and electric range*

Addendum 122: Regulation No. 123, *Uniform provisions concerning the approval of adaptive front-lighting systems (AFS) for motor vehicles*

Addendum 127: Regulation No. 128, *Uniform provisions concerning the approval of light emitting diode (LED) light sources for use in approved lamp units on power-driven*

~~JESD22-A100D, *Cycled temperature humidity bias life test*~~

JESD22-A101C, *Steady-state temperature humidity bias life test*

~~JESD22-A104D~~ JESD22-A104E, *Temperature cycling*

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1 Also known as The 1958 Agreement. In the text of this document the regulations under this agreement are referred to as, for example, UN Regulation 37 or R37.

JESD22-A105C, *Power and temperature cycling*

JESD22-A106B, *Thermal shock*

JESD22-A108D, *Temperature, bias, and operating life*

JESD22-A113F, *Preconditioning of plastic surface mount devices prior to reliability testing*

JESD22-A115C, *Electrostatic discharge (ESD) sensitivity testing machine model (MM)*

JESD22-B101B, *External visual*

JESD22-B103B, *Vibration, variable frequency*

JESD22-B110B, *Mechanical shock*

JESD22-B106D, *Resistance to solder shock for through-hole mounted devices*

JESD22-B116:1998, *Wire Bond Shear Test Method*

JESD51-50:2012-04, *Overview of methodologies for the thermal measurement of single- and multi-chip, single- and multi-pnjunction light-emitting diodes (LEDs)*

JESD51-51:2012-04, *Implementation of the electrical test method for the measurement of real thermal resistance and impedance of light-emitting diodes with exposed cooling surface*

JESD51-52:2012-04, *Guidelines for combining CIE 127-2007 total flux measurements with thermal measurements of leds with exposed cooling surface*

JESD51-53:2012-05, *Terms, definitions and units glossary for LED thermal testing*

ANSI/IPC/ECA J-STD-002C, *Solderability tests for component leads, terminations, lugs, terminals and wires*

ANSI/ESDA/JEDEC JS-001-2012, *Joint JEDEC/ESDA standard for electrostatic discharge sensitivity testing human body model (HBM) – component level*

MIL-STD-883E:2015, *Visual Inspection Criteria*

ZVEI "*Guideline for Customer Notifications of Product and/or Process Changes (PCN) of Electronic Components specified for Automotive Applications*" 4th revised Edition, October 2016, Rev. 3

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60050-845 and IEC 60809, and the following 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
life
total time (expressed in hours) during which a lamp has been operated before it becomes useless

Note 1 to entry: For filament lamps, it is considered to be so according to one of the following criteria:

a) the end of life is the time when the filament fails;

b) the life of a dual-filament lamp is the time until either filament fails, if the lamp is tested in a switching cycle involving alternative operation of both filaments.

3.2
characteristic life
T
T_c
constant of the Weibull distribution indicating the time up to which 63,2 % of a number of tested lamps of the same type have ended their individual lives

3.3
life B_3
constant of the Weibull distribution indicating the time during which 3 % of a number of the tested lamps of the same type have reached the end of their individual lives

3.4
luminous flux maintenance
ratio of the luminous flux of a lamp at a given time in its life to its initial luminous flux, the lamp being operated under specific conditions

EXAMPLE 1 L_{70} is the time in hours to 70 % luminous flux maintenance.

EXAMPLE 2 L_{50} is the time in hours to 50 % luminous flux maintenance.

3.5
initial luminous flux
luminous flux of a lamp measured after ~~the ageing specified in Annex C of IEC 60809:2014, for filament lamps or in Annex D of this standard for discharge lamps or in Annex I of this standard for LED light sources~~ specified ageing

Note 1 to entry: The ageing is specified in Annex C of IEC 60809:2014 for filament lamps or in Annex D of this document for discharge lamps or in Annex I of this document for LED light sources.

3.6
rated value
value of a characteristic specified for operation of a lamp at test voltage and/or other specified conditions

3.7
pinch temperature limit
maximum admissible pinch temperature to ensure satisfactory lamp performance in service

3.8
solder temperature limit
maximum admissible solder temperature to ensure satisfactory lamp performance in service

3.9
maximum lamp outline
contour limiting the space to be reserved for the lamp in the relevant equipment

3.10
heavy-duty lamp
lamp which shall comply with the heavy-duty test conditions specified in Table B.2 of IEC 60810 in addition to the requirements specified in IEC 60809

Note 1 to entry: A lamp is declared as heavy-duty by the manufacturer or responsible vendor.

3.11
life B_{10}
constant of the Weibull distribution indicating the time during which 10 % of a number of the tested lamps of the same type have reached the end of their individual lives

3.12
LED package
solid state device embodying a p-n junction, emitting optical radiation when excited by an electric current

Note 1 to entry: Examples are shown in Figure 1.

Note 2 to entry: In UN terminology the term "LED" is used with the same definition.

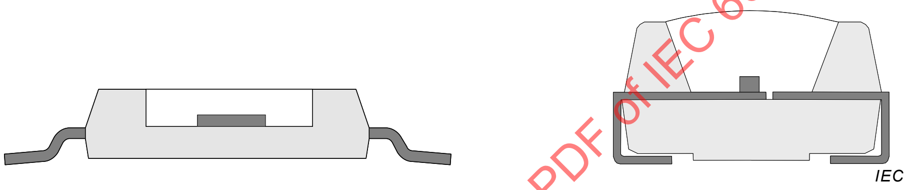


Figure 1 – Examples of LED packages

3.13
LED light source
light source where the visible radiation is emitted from one or more LED(s)

Note 1 to entry: An LED light source may or may not require an additional electronic controlgear and may or may not require additional provisions for thermal management.

3.13.1
LED module
LED light source which can only be replaced with the use of mechanical tools

Note 1 to entry: LED modules are generally considered as components for use in trades, professions or industries and are generally not intended for sale to the general public.

Note 2 to entry: Examples are shown in Figures 2 and 3.

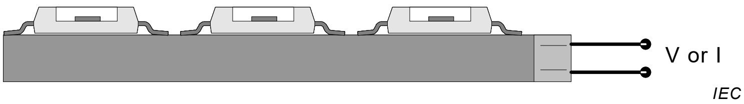


Figure 2 – Example of an LED module without integrated heatsink

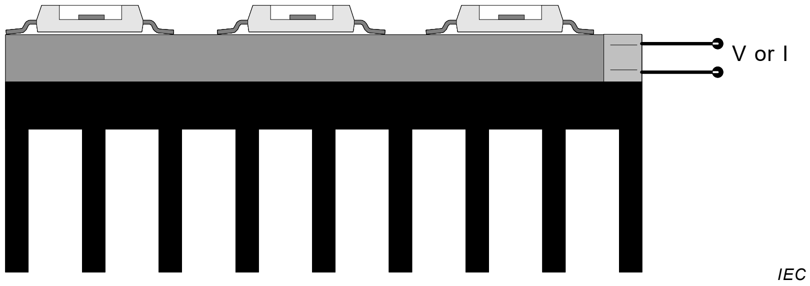


Figure 3 – Example of an LED module with integrated heatsink

3.13.2
replaceable LED light source
LED light source which can be easily replaced without the use of special tools

Note 1 to entry: Replaceable LED light sources are usually intended for sale to the general public as a replacement part.

Note 2 to entry: An example is shown in Figure 4.

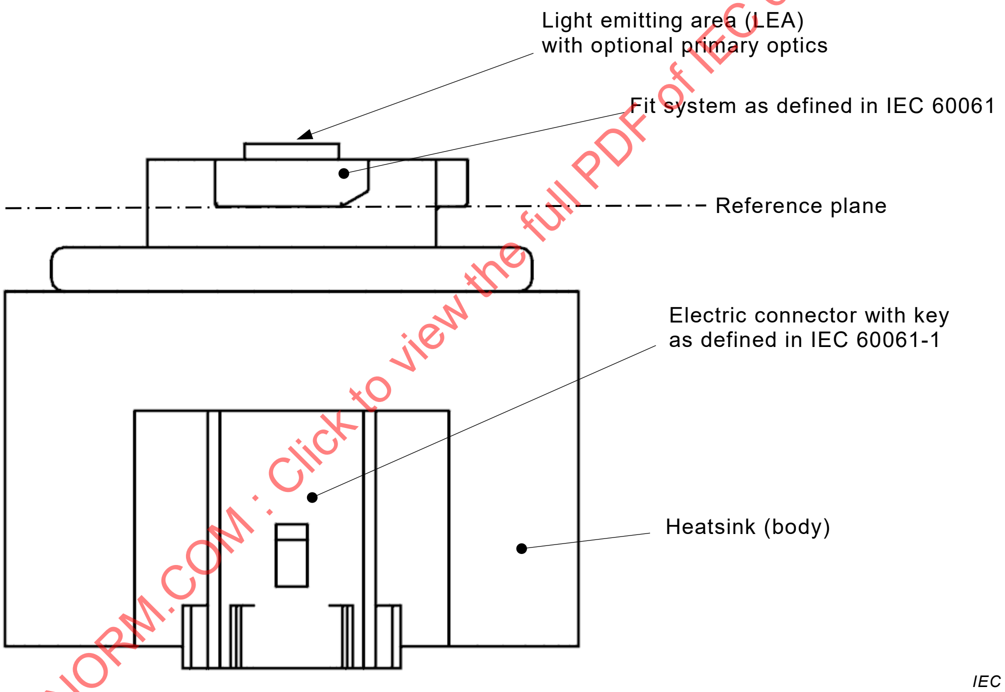


Figure 4 – Example of a replaceable LED light source

3.13.3
non-replaceable LED light source
LED light source which cannot be removed from the device or luminaire

Note 1 to entry: Non-replaceable LED light sources are usually intended as components for integration into the luminaire or device by manufacturers. They are designed and intended to be indivisible parts of a lighting or light signalling device, or of parts or modules or units of such devices.

Note 2 to entry: An example is shown in Figure 5.

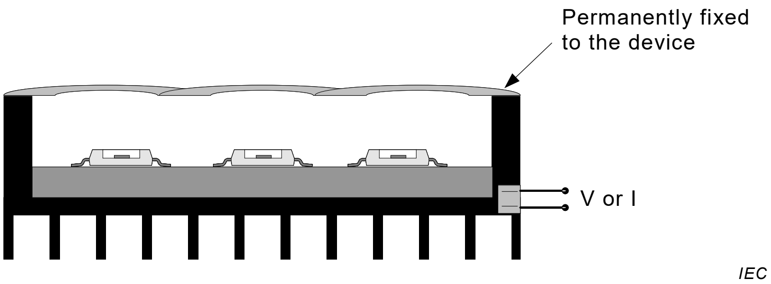


Figure 5 – Example of a non-replaceable LED light source

3.14
T_p ~~of a LED light source~~
temperature at a specified location on the surface of the LED light source (T_p-point) that can be measured during operation of the light source and that can be correlated to the temperature of the p-n junction of the LED

Note 1 to entry: The T_p point is generally specified by the manufacturer of the LED light source or by its datasheet.

3.15
electronic light source controlgear
one or more component(s) between supply and light source to control voltage and/or electrical current of the light source

3.16
case temperature
T_s
temperature of the thermocouple attachment point on the LED package as defined by the manufacturer of the package

4 Requirements and test conditions for filament lamps

4.1 Basic function and interchangeability

Filament lamps shall comply with IEC 60809.

4.2 Torsion strength

The cap shall be strong and firmly secured to the bulb.

Compliance is checked before and after the life test by submitting the filament lamp to the following torque values:

- filament lamps with bayonet caps
  - with 9 mm shell diameter: 0,3 Nm;
  - with 15 mm shell diameter: 1,5 Nm;
  - with 20 mm shell diameter: 3,0 Nm;
- filament lamps with screw caps
  - with 10 mm shell diameter: 0,8 Nm.

NOTE The torque values given above are all under consideration.

The torque shall not be applied suddenly but shall be increased progressively from 0 to the specified amount.

Values are based on a non-compliance level of 1 %.

4.3 Characteristic life ~~T~~ T_c

The life ~~T~~ T_c measured on a test quantity of at least 20 filament lamps shall be at least 96 % of the rated value, given in Table 3.

Compliance is checked by life tests as ~~prescribed~~ specified in Annex A.

4.4 Life B_3

The life B_3 shall not be less than the rated value given in Table 3.

Compliance is checked by life tests as ~~prescribed~~ specified in Annex A.

The number of filament lamps failing before the required time shall not exceed the values in Table 1.

Table 1 – Conditions of compliance for life B_3

Number of filament lamps tested	Acceptance number
23 to 35	2
36 to 48	3
49 to 60	4
61 to 74	5
75 to 92	6

4.5 Luminous flux maintenance

The luminous flux maintenance shall be not less than the rated value given in Table 4. This value is based on a non-compliance level of 10 %.

4.6 Resistance to vibration and shock

In the event of service life being influenced by vibration or shock, the test methods and schedules detailed in Annex B shall be used to assess the performance.

The filament lamps are deemed to have satisfactorily completed the wideband or narrowband random vibration test as described in Annex B, if they continue to function during and after the test.

The number of filament lamps failing one of the tests shall not exceed the values in Table 2 (values are based on an acceptance quality limit (AQL) of 4 %).

Table 2 – Conditions of compliance for the vibration test

Number of filament lamps tested	Acceptance number
14 to 20	2
21 to 32	3
33 to 41	4
42 to 50	5
51 to 65	6

4.7 Glass-bulb strength

In the event of bulbs being impaired by mechanical handling for their assembly in equipment, the test methods and schedules defined in Annex C shall be used to assess the performance. The bulbs shall withstand the specified compression strength.

5 Filament lamp data

Rated life and luminous flux-maintenance values for road vehicle filament lamps are tested under the conditions ~~prescribed~~ specified in Annex A.

Tables 3 and 4 provide rated life and luminous flux maintenance values for continuous operation.

Table 3 – Rated life values for continuous operation

Filament lamp data sheet number		Type	12 V			24 V		
IEC 60809[a]	UN[b]	Category	Test V	B_3/h	T_c/h	Test V	B_3/h	T_c/h
Lamps for front lighting applications								
2310	R37-H1	H1	13,2	150	400	28,0	90	250
2320	-	H2	13,2	90	250	28,0	90	250
2330	R37-H3	H3	13,2	150	400	28,0	90	250
2120	R37-H4	H4 (HB/LB)	13,2	125/250	250/500	28,0	100/200	200/400
2315	R37-H7	H7	13,2	300	500	28,0	200	400
2365	R37-H8	H8, H8B	13,2	400	800			
2370	R37-H9	H9, H9B	13,2	250	500			
2375	R37-H10	H10	13,2	800	1 600			
2380	R37-H11	H11, H11B	13,2	350	600	28,0	300	600
2385	R37-H12	H12	13,2	480	970			
-	R37-H13	H13,H13A (HB/LB)	13,2	170/1 200	350/2 500			
-	R37-H15	H15 (HB/DRL)	13,2	250/2 000	500/4 000	28,0	200/1 500	400/3 000
-	R37-H16	H16, H16B	13,2	500	1 000			
-	R37-H17	H17	13,2	100/~~350~~ 200	200/~~700~~ 400			
-	R37-H18	H18	13,2	300	500			
-	R37-H19	H19 (HB/LB)	13,2	125/250	250/500			
-	R37-H20	H20	13,2	100	200			
3430	R37-H27W	H27W/1 H27W/2	13,5	90	190			
2325	R37-HB3	HB3/ HB3A	13,2	250	500			
2335	R37-HB4	HB4/ HB4A	13,2	850	1 700			
2420	R37-HIR2	HIR2	13,2	300	600			
2130	R37-HS1	HS1 (HB/LB)	13,2	~~150~~ 75/150	~~300~~ 150/300			
2340	R37-HS2	HS2	13,2	100	250			
~~-~~	~~R37-P24W~~	~~PSX24W~~	~~13,2~~	~~1000~~	~~2000~~			
~~-~~	~~R37-P24W~~	~~PX24W~~	~~13,2~~	~~1000~~	~~2000~~			
-	R37-PSX26W	PSX26W	13,2	1 000	2 000			
2110	R37-R2	R2 (HB / LB)	13,2	30/60	90/160			
2150	R37-S1/S2	S2	13,2	~~100~~ 50/100	~~200~~ 100/200			
Lamps for signalling applications								
		C5W	13,5	350	750	28,0	120	350
3410	R37-H6W	H6W, HY6W	13,5	350	700			
-	R37-H10W	H10W/1	13,5	150	400			
-	R37-H10W	HY10W/1	13,5	300	600			
3420	R37-H21W	H21W	13,5	200	400	28,0	90	180

Filament lamp data sheet number		Type	12 V			24 V		
IEC 60809[a]	UN[b]	Category	Test V	B_3/h	T_c/h	Test V	B_3/h	T_c/h
-	R37-HY21W	HY21W	13,5	200	400	28,0	90	180
-	R37-P13W	P13W	13,5	4 000	8 000			
-	R37-P19W	P19W	13,5	1 000	2 000			
3310	R37-P21W	P21W	13,5	120	320	28,0	60	160
3120	R37-P21/4W	P21/4W	13,5	60/600	160/1 600	28,0	60/600	160/1 600
3110	R37-P21/5W	P21/5W	13,5	60/600	160/1 600	28,0	60/600	160/1 600
-	R37-P24W	P24W	13,5	750	1500			
3315	R37-P27W	P27W	13,5	550	1320			
-	R37-P27/7W	P27/7W	13,5	550/3 690	1 320/8 820			
-	R37-PR21W	PR21W	13,5	120	320	28,0	60	160
~~-~~	~~R37-PR21/4W~~	~~PR21/4W~~	~~13,5~~	~~60/600~~	~~160/ 1600~~			
-	R37-PR21/5W	PR21/5W	13,5	60/600	160/1 600			
~~-~~	~~R37-P27/7W~~	~~PR27/7W~~	~~13,5~~	~~550/3600~~	~~1300/8000~~			
-	R37-P19W	PSY19W	13,5	1 200	2 400			
-	R37-P24W	PSY24W	13,5	1 000	2 000			
-	R37-P19W	PY19W	13,5	1 200	2 400			
3311	R37-PY21W	PY21W	13,5	120	320	28,0	60	160
-	R37-P24W	PY24W	13,5	1 000	2 000			
3141	R37-PY27/7W	PY27/7W	13,5	550/3 600	1 300/8 000			
3320	R37-R5W	R5W	13,5	100	300	28,0	80	225
3330	R37-R10W	R10W	13,5	100	300	28,0	80	225
-	R37-R10W	RY10W	13,5	100	300			
3340	R37-T4W	T4W	13,5	300	750	28,0	120	350
4310	R37-W3W	W3W	13,5	500	1 500	28,0	400	1 100
4320	R37-W5W	W5W	13,5	200	500	28,0	120	350
4340	R37-W16W	W16W	13,5	250	700			
4321	R37-W5W	WY5W	13,5	200	500			

Filament lamp data sheet number		Type	12 V			24 V		
IEC 60809[a]	**UN**[b]	**Category**	**Test V**	B_3/h	T_c/h	**Test V**	B_3/h	T_c/h
4120	R37-C21W	C21W	13,5	40	110			
-	R37-WY16W	WY16W	13,5	250	700			
-	R37-W21W	W21W	13,5	120	320			
-	R37-W21/5W	W21/5W	13,5	60/600	160/1 600			
-	R37-WY21W	WY21W	13,5	120	320			
-	R37-W15/5W	W15/5W	13,5	120/600	320/1 600			
-	R37-W10W	W10W	13,5	100	300			
-	R37-WY10W	WY10W	13,5	100	300			

The values indicated are minimum requirements. Depending on some particular customers' specifications, different values may be obtained, i.e. shorter life/higher luminous flux or longer life/lower luminous flux. This shall be negotiated between filament lamp manufacturers and their customers.

If there is no direct contact between the customer and supplier, the information on deviation from recommended life time data shall be given on the package and/or in publicly available technical documentation.

[a] If a UN sheet number is referenced, the IEC sheet number refers to a data sheet withdrawn with IEC 60809:1995/AMD5:2012 and is given for information only.

[b] The number in front of the dash indicates the number of the UN regulation.

Table 4 – Rated luminous flux-maintenance values for continuous operation

Filament lamp data sheet number		Type	12 V			24 V		
IEC 60809[e]	UN[f]	Category	Test V	Luminous flux maintenance		Test V	Luminous flux maintenance	
				h	%		h	%
Lamps for front lighting applications								
2110	R37-R2	R2	13,2	55[c] 110[d]	85 70	28,0 28,0	55[c] 110[d]	85 70
2120	R37-H4	H4	13,2	110[c] 225[d]	85 85	 28,0	110[c] 225[d]	85 85
2125	-	H6	14,0	75[c] 150[d]	85 80	–	–	–
2305		H5	14,0	75	85	–	–	–
2310	R37-H1	H1	13,2	170	90	28,0	170	90
2320		H2	13,2	170	90	28,0	170	90
2330	R37-H3	H3	13,2	170	90	28,0	170	90
3110	R37-P21/5W	P21/5W	13,5	110[a] 750[b]	70 70	28,0	110[a] 750[b]	70 70
3120	R37-P21/4W	P21/4W	13,5	110[a]750[b]	70 70	28,0	Under consideration	Under consideration
3310	R37-P21W	P21W	13,5	110	70	28,0	110	70
3320	R37-R5W	R5W	13,5	150	70	28,0	150	70
3330	R37-R10W	R10W	13,5	150	70	28,0	150	70
3340	R37-T4W	T4W	13,5	225	70	28,0	225	70
4110	R37-C5W	C5W	13,5	225	60	28,0	225	60
4120	R37-C21W	C21W	13,5	75	60	–	–	–
4310	R37-W3W	W3W	13,5	750	60	28,0	750	60
4320	R37-W5W	W5W	13,5	225	60	28,0	225	60

The values indicated are minimum requirements. Depending on some particular customers' specifications, different values may be obtained, i.e. shorter life/higher luminous flux or longer life/lower luminous flux. This shall be negotiated between filament lamp manufacturers and their customers.

Luminous flux-maintenance values for extended operation times are under consideration.

[a] High-wattage filament.

[b] Low-wattage filament.

[c] Main or upper beam filament.

[d] Dipped or lower beam filament.

[e] If a UN sheet number is referenced, the IEC sheet number refers to a data sheet withdrawn with IEC 60809:1995/AMD5:2012 and is given for information only.

[f] The number in front of the dash indicates the number of the UN regulation.

6 Requirements and test conditions for discharge lamps

6.1 Basic function and interchangeability

Discharge lamps shall comply with the technical requirements of IEC 60809.

6.2 Mechanical strength

6.2.1 Bulb-to-cap connection

The bulb shall be strongly secured to the cap. Compliance is checked by means of the bulb deflection test conducted in accordance with Annex E.

6.2.2 Cable-to-cap connection (if any*)*

If the cable has a fixed connection to the cap, it shall withstand a pulling force of 60 N. The force shall be applied in the direction of the (straight) cable.

6.3 Characteristic life ~~T~~ T_c

The life ~~T~~ T_c measured on a test quantity of at least 20 lamps shall be not less than the value declared by the manufacturer, which shall be at least 3 000 h. Compliance is checked by tests as ~~prescribed~~ specified in Annex D.

6.4 Life B_3

The life B_3 measured on a test quantity of at least 20 lamps shall be not less than the value declared by the manufacturer, which shall be at least 1 500 h. Compliance is checked by tests as ~~prescribed~~ specified in Annex D.

6.5 Luminous flux maintenance

The luminous flux maintenance shall be at least 60 % of the initial luminous flux. Compliance is checked by tests as ~~prescribed~~ specified in Annex D.

Values are based on a non-compliance level of 10 %.

6.6 Resistance to vibration and shock

In the event of service life being influenced by vibration and shock, the test methods and schedules in Annex B shall be used to assess the performance.

The discharge lamps are deemed to have satisfactorily completed the wideband or narrowband random vibration test as described in Annex B, if they continue to function during and after the test. Moreover, the position of the electrodes shall comply with the dimensional requirements as ~~prescribed~~ specified in the relevant standard.

Values are based on a non-compliance level of 4 %.

Precautions should be taken to avoid potential hazards due to high voltages, UV radiation and risk of bulb breakage during starting, run-up and operation of some discharge lamp types.

6.7 Discharge lamps with integrated starting device

The total weight of the lamp shall not exceed 75 g. Information for ballast design is given in Annex G.

6.8 Discharge lamps with integrated starting device and integrated ballast

The total weight of the lamp shall not exceed 120 g.

The centre of gravity of lamps using IEC cap PK32d shall be positioned within the shape of a cylinder as indicated by the shaded areas in Figure 6.

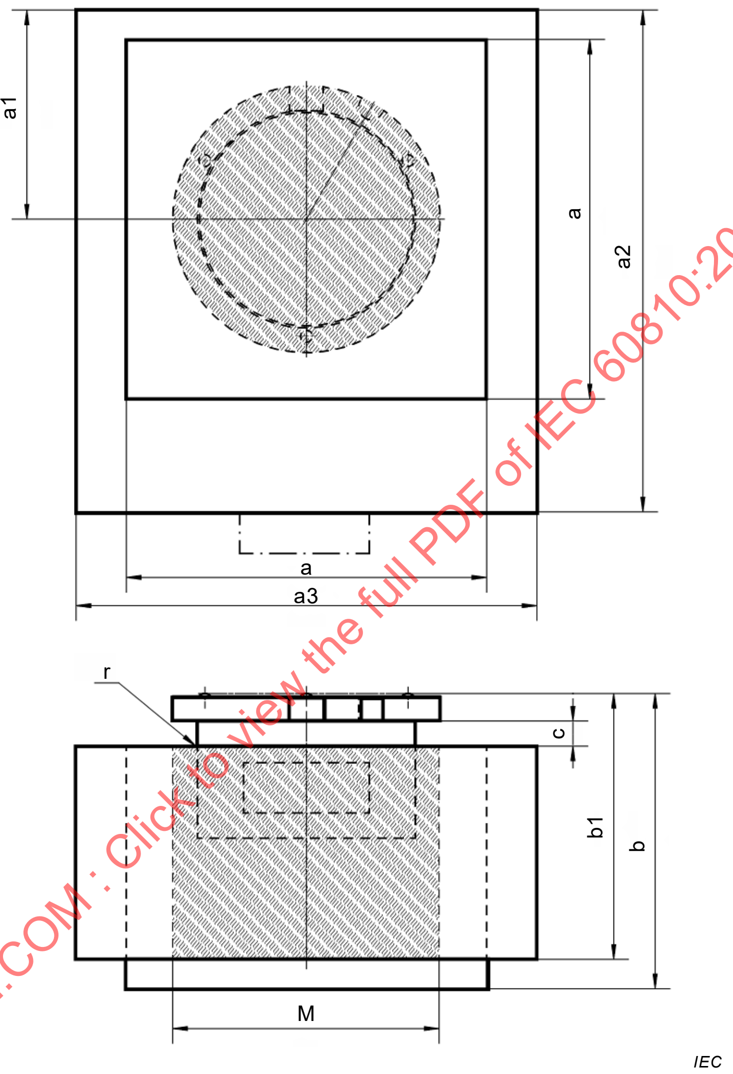


Figure 6 – Position of the centre of gravity (shaded areas)

7 Requirements and test conditions for LED light sources

7.1 Basic function and interchangeability

LED light sources shall:

- be so designed as to be and to remain in good working order when in normal use;
- exhibit no fault in design or manufacture;
- exhibit no scores or spots on their optical surfaces which might impair their efficiency and their optical performance.

Replaceable LED light sources shall be equipped with caps complying with IEC 60061-1. The cap shall be strong and firmly secured to the rest of the LED light source.

To ascertain whether LED light sources ~~conform to these~~ comply with the requirements above, a visual inspection, a dimension check and, where necessary, a trial fitting shall be carried out.

LED light sources shall comply with the technical requirements of IEC 60809.

In the case of LED light sources with more than one function, each function shall be tested separately, unless specified differently.

If an electronic light source controlgear (ECG) is needed to operate the LED light source, the test shall be performed with an appropriate ECG.

7.2 UV radiation

The UV-radiation of the LED light source shall be determined according to 5.9 of IEC 60809:2014. If $k_{UV} \leq 10^{-5}$ W/lm the light source is of the low-UV type.

7.3 Luminous flux and colour maintenance

The luminous flux maintenance value L_{70} and the colour maintenance shall be measured on a test quantity of at least 20 LED light sources according to the procedure given in Annex I.

For very small production batches, a test quantity less than 20 may be acceptable.

The manufacturer shall declare and determine the ~~L_{70}-T_c and~~ $L_{70}B_{10}$ values.

The measured values shall be not less than the value declared by the manufacturer.

For LED light sources which were approved under the corresponding UN Regulation 128, the $L_{70}B_{10}$ values shall be not less than those specified in Table 5.

Table 5 – Minimum $L_{70}B_{10}$ values for ~~standardised~~ replaceable LED light sources

Category according to UN R 128	Minimum $L_{70}B_{10}$ h
LR1	2 200 ~~a~~ mi 1 000 ~~b~~ ma
LW2	4 000
LR3A, LR3B	1 000
LR4A, LR4B	2 200 mi 1 000 ma
LR5A, LR5B	1 000
LW3A, LW3B	2 200
LW5A, LW5B	4 000
LY3A, LY3B	500 fl
LY5A, LY5B	500 fl

Key

~~a low power function~~

~~b high power function~~

mi minor function

ma major function

fl tested in flashing mode, i.e. ON/OFF ratio of 1:1

NOTE In the case of pulse width modulation (PWM) operation, it can be expected that the $L_{70}B_{10}$ value is higher (depending on duty cycle).

Table 6 shows typical "on"-time values for the different functions per 100 000 km, for information.

Table 6 – Typical "on"-times for the different functions per 100 000 km drive distance, based on an average speed of 33,6 km/h [a]

Intended application	Typical "on" times in hours per 100 000 km drive distance
Rear registration plate lamp	1 100 [b]
Direction indicator lamp	250
Front and rear position lamp	1 100 [b]
Stop lamp	500
End-outline marker lamp	1 100
Reversing lamp	50
Rear fog lamp	50
Daytime running lamp (DRL)	2 000
Side marker lamp	1 100 [b]
Cornering lamp	100
Low beam lamp (passing beam)	1 000
High beam lamp (driving beam)	100 [c]
Front fog lamp	100

[a] The average driving speed is based on the composition of driving cycles defined in UN R101.

[b] In case these light sources are intended for vehicles where these functions are also switched on together with the DRL function, then the value of 3 100 shall be used.

[c] In case these light sources are intended for vehicles which use the 'adaptive driving beam' function of UN R123, then the value of 200 shall be used.

If the specific requirements of the intended use are known for the LED light source, these should be taken into account.

Compliance is checked by the tests ~~prescribed~~ specified in Annex I.

Values are based on a non-compliance level of 10 %.

An example of LED light source life-time data is given in Table 7.

Table 7 – Example of product data

Type	Intended use	$L_{70}B_{10}$	~~L_{70}, T_c~~
MD0815	Stop lamp	1 500 h	~~2 500 h~~

7.4 Resistance to vibration and shock

In the event of service life being influenced by vibration and shock, the test methods and schedules in Annex B shall be used to assess the performance.

The light sources are deemed to have satisfactorily completed the wideband or narrowband random vibration test as described in Annex B, if they continue to function during and after the test.

Values are based on a non-compliance level of 4 %.

7.5 Electromagnetic compatibility

Replaceable LED light sources shall be classified according to CISPR 25.

7.6 Powered thermal cycling test

This test is intended to determine the ability of the LED light source to withstand changes of ambient temperatures.

LED light sources shall be tested according to test condition “Nb” of IEC 60068-2-14, under the following conditions (see Figure 7):

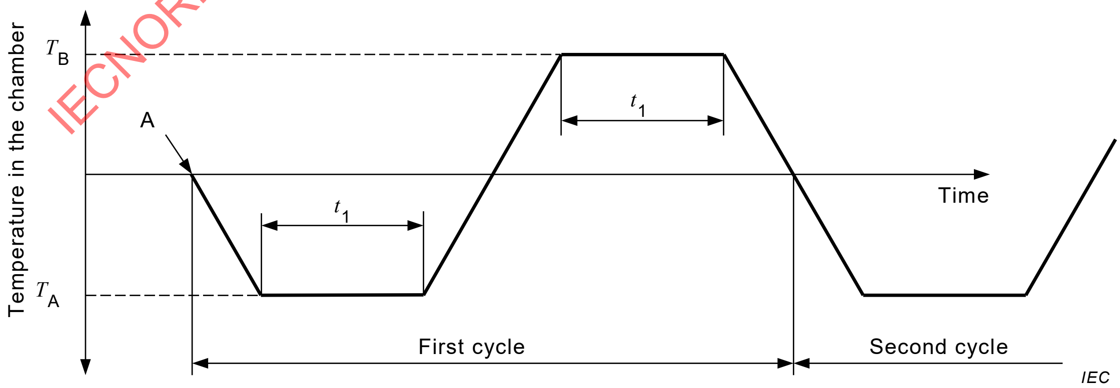
- rate of change of temperature is 3 K/min;
- the exposure time t_1 shall be a minimum of 2 h;
- the number of cycles shall be 15;
- the test shall be performed on a minimum of 20 LED light sources;
- during the testing, the LED light source shall be continuously switched on and off in 5 min intervals (5 min on, 5 min off, 5 min on, etc.);
- the test voltage shall be chosen according to Clause I.2 of this document;
- temperatures T_A and T_B shall be chosen according to the classes defined in Table 8.

Table 8 – Temperature classes for the powered thermal cycling test

	Lower temperature T_A	Higher temperature T_B
Class A	–40 °C	+60 °C
Class B	–40 °C	+85 °C
Class C	–40 °C	+105 °C

For LED light sources that require an external light source controlgear, the light source controlgear may also be subjected to this test.

LED light sources that require additional provisions for thermal management shall be tested with these provisions in place. A description of the thermal management design shall be included in the test report.



Key

A start of first cycle

Figure 7 – Extract from IEC 60068-2-14 Test Nb, showing the temperature cycle profile

After the powered thermal cycling test, the electrical and photometrical performance of the LED light source shall be tested.

The LED light sources are deemed to have satisfactorily completed the test if they continue to function after the test and if the photometrical and electrical performance is within the specifications provided by the manufacturer.

Values are based on a non-compliance level of 10 %.

7.7 Mass

The total mass of the LED light source shall not exceed the value given in Table 9 or, where not given, the value in the system information on cap sheets specified in IEC 60061-1.

Table 9 – Maximum mass for LED light sources

LED light source category	Cap	Mass g
LR1	PGJ21	60
LW2	PGJY50	50
LR3, LR4, LR5, LW3, LW5, LY3, LY5	PGJ18.5	35

7.8 Typical circuits for LED light sources

7.8.1 General

The purpose of 7.8 is to show typical electrical circuits for LED light sources.

7.8.2 Typical circuits for LR3, LR5, LY3, LY5, LW3 and LW5 LED light sources

A typical electrical circuit for LR3, LR5, LY3, LY5, LW3, and LW5 light source contains

- one or more LED dies/packages and an electronic driver,
- an electronic protection,
- an optional resistor to ensure a minimum current for special application requirements,

as shown in Figure 8.

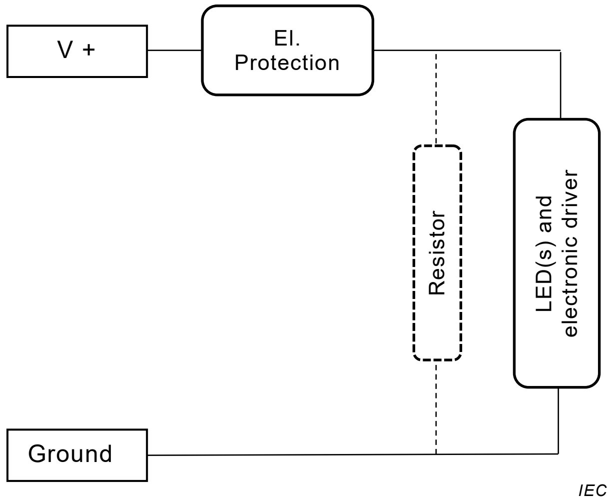


Figure 8 – Typical electrical circuit for an LR3, LR5, LY3, LY5, LW3 and LW5 LED light source

7.8.3 Typical circuits for LR4 LED light sources

A typical electrical circuit for LR4 light source contains

- two electrical strings (with common ground),
- for each string one or more LED dies/packages and an electronic driver,
- for each string an electronic protection,
- a resistor to ensure a minimum current of 10 mA in the “major function” string

as shown in Figure 9.

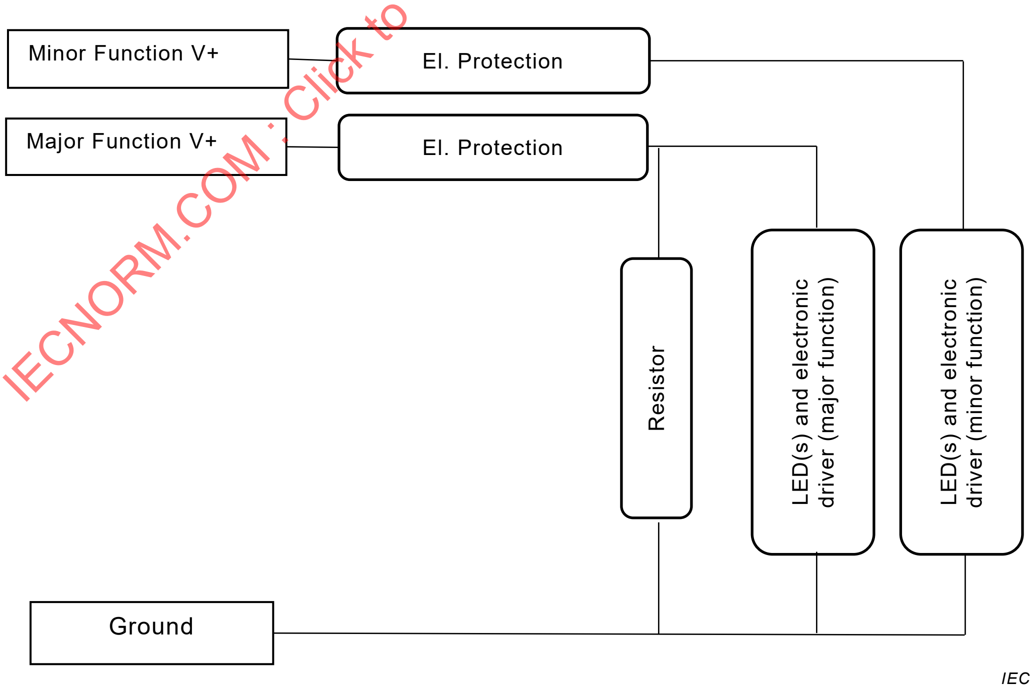


Figure 9 – Typical electrical circuit for an LR4 LED light source

7.9 Maximum power consumption

For the LED light sources listed in Table 10, the maximum power consumption at test voltages of 9 V DC, 13,5 V DC and 16 V DC shall not exceed the values given in Table 10.

Table 10 – Maximum power consumption

	Test voltage		
	9 V DC	**13,5 V DC**	**16 V DC**
LR3	3,5 W	3,5 W	5 W
LR4 (minor/major function)	1,0 W / 3,5 W	1,0 W / 3,5 W	1,5 W / 5 W
LR5	3,5 W	3,5 W	5 W
LW3	5 W	5 W	10 W
LY3 [a]	5 W	5 W	10 W
LW5	8 W	8 W	10 W
LY5 [a]	8 W	8 W	12 W

NOTE The values given in Table 10 for maximum power at 13,5V DC are taken from UN R128.

[a] During the ON state, tested in flashing mode, i.e. ON/OFF ratio of 1:1.

7.10 Overvoltage test

The purpose of this test is to evaluate the performance of the LED light source under stress due to overvoltage. The test shall be conducted on a test quantity of at least 20 LED light sources with the following test conditions:

- for a 12 V-light source: test voltage: 26 V;
- for a 24 V-light-source: test voltage: 52 V;
- ambient temperature: 23 °C ± 5 °C;
- duration 60 s.

The light sources are deemed to have satisfactorily completed the test, if after the test

- the luminous flux has not changed by more than 20 % compared to the initial value;
- the chromaticity values (cx, cy) remain within the colour boundaries;
- the electrical current has not changed by more than 10 % compared to the initial value.

Values are based on a non-compliance level of 10 %.

7.11 Reverse voltage test

The purpose of this test is to evaluate the performance of the LED light source under stress due to reverse voltage. The test shall be conducted on a test quantity of at least 20 LED light sources with the following test conditions:

- for a 12 V-light source: test voltage: 14 V DC with reverse polarity;
- for a 24 V-light-source: test voltage: 28 V DC with reverse polarity;
- ambient temperature: 23 °C ± 5 °C
- duration 60 s.

The light sources are deemed to have satisfactorily completed the test, if after the test

- the luminous flux has not changed by more than 20 % compared to the initial value;

- the chromaticity values (cx, cy) remain within the colour boundaries;
- the electrical current has not changed by more than 10 % compared to the initial value.

Values are based on a non-compliance level of 10 %.

7.12 Transient voltage test (field decay)

The purpose of this test is to evaluate the performance of the LED light source under stress due to transient voltage (field decay). The test shall be conducted on a test quantity of at least 20 LED light sources with the following test conditions:

- conditions: see Figure 10 and Table 11 (see also ISO 7637-2, pulse 1),
- test pulse severity level III;
- minimum 500 pulses;
- pulse repetition ≥ 0,5 s.

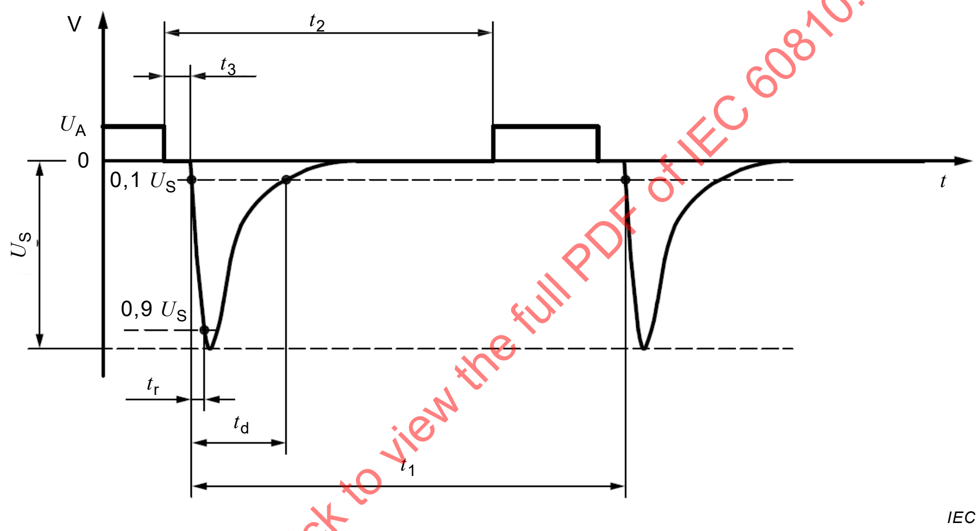


Figure 10 – Profile of pulse 1 from ISO 7637-2

Table 11 – Test parameters for pulse 1 from ISO 7637-2

Parameters	Nominal 12 V system	Nominal 24 V system
U_s	-75 V to -150 V	-300 V to -600 V
R_i	10 Ω	50 Ω
t_d	2 ms	1 ms
t_r	$\left(1\,^{0}_{-0,5}\right)$ µs	$\left(3\,^{0}_{-1,5}\right)$ µs
t_1 [a]	≥ 0,5 s	
t_2	200 ms	
t_3 [b]	< 100 µs	

[a] t_1 shall be chosen such that it is the minimum time for the DUT to be correctly initialized before the application of the next pulse and shall be ≥ 0,5 s.

[b] t_3 is the smallest possible time necessary between the disconnection of the supply source and the application of the pulse.

The light sources are deemed to have satisfactorily completed the test, if after the test

- the luminous flux has not changed by more than 20 % compared to the initial value;
- the chromaticity values (cx, cy) remain within the colour boundaries;
- the electrical current has not changed by more than 10 % compared to the initial value.

Values are based on a non-compliance level of 10 %.

7.13 Transient voltage test (load dump)

The purpose of this test is to evaluate the performance of the LED light source under stress due to transient voltage (load dump). The test shall be conducted on a test quantity of at least 20 LED light sources with the following test conditions:

- conditions: see Figure 11 and Table 12 (see also ISO 7637-2, pulse 2a);
- test pulse severity level III;
- minimum 500 pulses;
- pulse repetition ≥ 0,2 s.

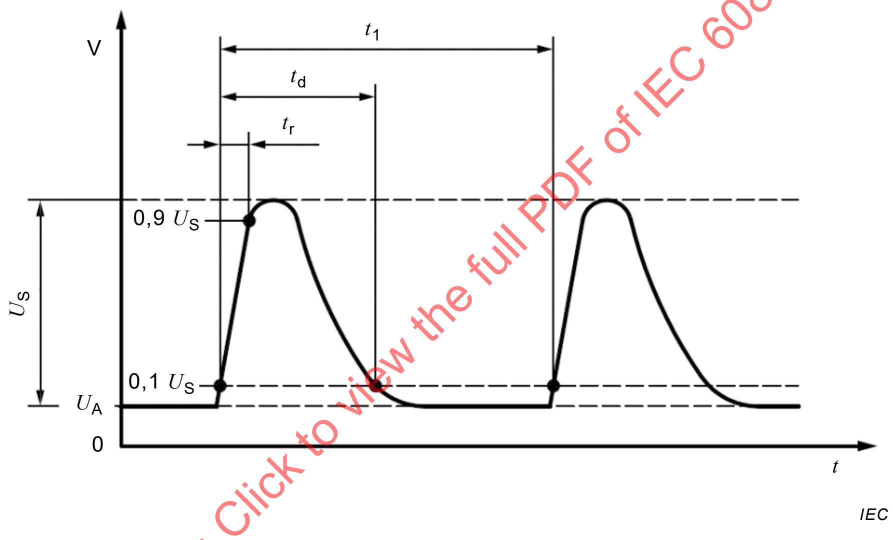


Figure 11 – Profile of pulse 2a from ISO 7637-2

Table 12 – Test parameters for pulse 2a from ISO 7637-2

Parameters	Nominal 12 V and 24 V system
U_s	+37 V to + 112 V
R_i	2 Ω
t_d	0,05 ms
t_r	$\left(1\,^{0}_{-0,5}\right)$ µs
t_1 [a]	0,2 s to 5 s
[a] The repetition time t_1 can be short depending on the switching. The use of a short repetition time reduces the test time.	

The light sources are deemed to have satisfactorily completed the test, if after the test

- the luminous flux has not changed by more than 20 % compared to the initial value;
- the chromaticity values (cx, cy) remain within the colour boundaries;
- the electrical current has not changed by more than 10 % compared to the initial value.

Values are based on a non-compliance level of 10 %.

7.14 Electrostatic discharge test (ESD)

The purpose of this test is to evaluate the performance of the LED light source under stress due to electrostatic discharge at the terminals of the LED light source and at the housing. The test and classification shall be conducted according to ISO 10605 on a test quantity of at least 20 LED light sources. Details of the testing and applied criteria, for example severity level, shall be reported.

7.15 Pulsed operating life (PLT) test

The purpose of this test is to evaluate the performance of the LED light source under stress due to pulsed operation.

- duration 1 000 h;
- peak voltage 13,5 V;
- $T_{ambient}$ = 23 °C ± 5 °C;
- pulse width 100 µs, duty cycle 3 %. This corresponds to a frequency of 300 Hz.

The light sources are deemed to have satisfactorily completed the test, if after the test

- the luminous flux has not changed after 100 h by more than 10 % compared to the initial value;
- the luminous flux has not changed after 1 000 h by more than 20 % compared to the initial value;
- the chromaticity values (cx, cy) remain within the colour boundaries:
- the electrical current has not changed by more than 10 % compared to the initial value.

Values are based on a non-compliance level of 10 %.

8 Requirements and test conditions for LED packages

8.1 LED package stress test qualification

Clause 8[2] defines minimum stress test driven qualification requirements and references test conditions for qualification of LED packages.

The purpose of this document is to determine that a LED package is capable of passing the specified stress tests and thus can be expected to give a certain level of quality/reliability in automotive lighting applications.

"Stress test qualification" according to this document is defined as successful completion of the test requirements outlined in this document.

Subclause 8.6 defines a set of qualification tests that shall be considered for new LED package qualifications. In the case of requalification associated with a design or process change, a limited set of qualification tests may be considered, see Annex L.

Where appropriate, family qualifications ~~can~~ may be done, a rationale should be given by the supplier.

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2 The approach on LED package stress test qualification as described in this document is derived from a similar approach developed by the Automotive Electronics Council (AEC – Q101: Stress test qualification for automotive grade discrete semiconductors).

~~Examples for families:~~

- ~~same chip technology in different LED packages;~~
- ~~same phosphor systems in different LED packages.~~

The family may be classified by following major key characteristics of LED packages.

This is not recommended to transfer results, in case of different

- package material (e.g. pre-mold, ceramic, epoxy) and design, or
- casting material (e.g. silicone, epoxy)/lens/window, or
- conversion (e.g. layer transfer, volume conversion), or
- interconnect die bond (e.g. glued, bonded)/wire bond, or
- chip technology (e.g. AlInGaP, AlInGaN, AlInGaAs, sapphire, regardless of colour).

Any deviation from this recommendation shall be documented.

Transfer of results is possible, in case of different

- phosphor CCT (same or better performance) or
- chip size/number of chips in LED package (same or smaller current density, scalable).

LED packages having the same key characteristics may be released by family qualifications.

This document makes reference to other IEC standards or standards from other organizations (e.g. JEDEC). Where relevant, further details on the test definitions can be found in these documents. Test conditions in this document may deviate from test conditions in the reference documents (e.g. PTMCL condition 2). In such a case, further definitions in the reference document shall still be applied as appropriate.

The results of LED package testing may be reported by using the communication sheet as specified in Annex K.

A guideline on LED package robustness validation is given in Annex M.

8.2 Test samples

8.2.1 Lot requirements

Unless specified otherwise in 8.6, a total of minimum 78 LED packages taken from three different batches of 26 each shall be used for each test. For family qualification, the three different batches shall be considered to represent the whole variety of the qualification family.

The sample size may be reduced due to technical problems or experimental limitations to a minimum of 3 x 5 LED packages. The reason(s) for sample size reduction shall be provided with the report.

8.2.2 Production requirements

All qualification LED packages shall be produced on tooling and processes at the manufacturing site that will be used to support LED package deliveries at projected production volumes.

8.2.3 Pre- and post-stress test requirements

Electrical and photometric values (forward voltage, luminous flux or radiant power and/or intensity, colour parameter) shall be measured at the nominal test conditions as defined in the product specification before and after stress testing (see also 8.6.1).

NOTE A simple light/no light test is under consideration for testing at different temperatures.

All LED packages used for qualification shall meet the product specification parameters measured at the nominal test conditions before stress testing.

8.2.4 Assembly of LED packages on test boards

LED packages may need to be assembled on test boards. An appropriate choice of test board, interconnect material and process shall be made by the manufacturer. The choice of test board, interconnect material and process shall be documented for each individual test in the test report.

8.2.5 Moisture pre-conditioning (MP)

Moisture preconditioning is applicable to surface mountable devices designed for reflow soldering. All qualification LED packages used for the following tests:

- 8.6.4 TMCL,
- 8.6.5 WHTOL,
- 8.6.6 PTMCL, and
- 8.6.14 RSH-reflow

shall be subject to moisture preconditioning according to JESD22-A113F. The initial electrical and photometrical test according to 8.6.1 shall be executed after the moisture pre-conditioning.

8.2.6 Thermal resistance (TR) test

The thermal resistance shall be tested according to JESD51-50, JESD51-51, JESD51-52 and JESD51-53; the resulting $R_{\mathrm{th,electr}}$ and the optical power radiation of the LED package for the calculation of "$R_{\mathrm{th,real}}$" should be recorded and the $R_{\mathrm{th,electr}}$ (typical) and the $R_{\mathrm{th,electr}}$ (maximum) shall be reported (reporting should be done in the communication sheet according to Annex K).

8.3 Definition of failure criteria

A LED package shall be considered to have failed if any of the following criteria applies.

- Forward voltage V_{f} at the nominal drive current I_{f} deviates by more than ±10 % of the initial value.
- Radiant power or luminous flux or intensity at the nominal drive current I_{f} deviates by more than
  - ±20 % of the initial value, or
  - ±30 % of the initial value

where these options of ±20 % or ±30 % are at the choice of the manufacturer.

  - A deviation of ±50 % of the initial value may be acceptable for some interior lighting applications (e.g. LED packages for instrument clusters).

- Colour coordinates x,y at the nominal drive current I_{f} of white LED deviate by more than ±0,01 from the initial value. The permitted deviation for saturated colour LEDs is under consideration. A deviation of ±0,02 of the initial value may be acceptable for some interior lighting.

- The LED package exhibits externally visible physical damage attributable to the environmental test (e.g. delamination). However, if the cause of failure is agreed (by the manufacturer and the user) to be due to mishandling or ESD, the failure shall be discounted, but reported as part of the data submission. A microscope with a magnification in a range of 40X to 50X shall be used.

Failures in the interconnect to the test board or in the test board that are not related to a LED package failure shall be discounted, but reported as part of the data submission.

8.4 Choice between test conditions

A manufacturer shall select a specific luminous flux maintenance class according to 8.3 prior to the qualification testing. The appropriate pass/fail criteria shall be applicable.

Furthermore, the manufacturer shall choose between different classes of test conditions where applicable (e.g. TMCL cycle condition 1 to 4 in 8.6.4). The test condition shall be documented in the test report.

In general, it may be assumed that passing the harsher test conditions implies that the more relaxed conditions would also be passed (e.g. passing TMCL condition 3 implies that TMCL conditions 1 and 2 would also be passed).

8.5 Criteria for passing qualification/requalification

All LED packages under test shall pass the tests, otherwise the LED package or LED package family is considered to have failed.

LED packages that have failed the acceptance criteria of tests required by this document require the supplier to satisfactorily determine root cause and corrective action to assure the user that the failure mechanism is understood and contained and the corrective and preventive actions are confirmed to be effective by repeating the applicable qualification test(s) successfully.

8.6 Qualification test ~~definition~~

8.6.1 Pre- and post- electrical and photometric test

All LED packages shall be tested at nominal drive current according to the following requirements of the appropriate LED package specification (manufacturer's datasheet) prior to and after the following tests except for 8.6.2 and 8.6.10:

- luminous flux or radiant power or intensity (whichever is appropriate);
- forward voltage;
- colour coordinates or dominant or peak wave length (whichever is appropriate).

NOTE The choice between dominant and peak wavelength is under consideration.

In addition, the forward voltage at the minimum (or lower) and maximum drive current shall be recorded.

8.6.2 Pre- and post- external visual (EV) test

The construction, marking and workmanship of the LED package shall be inspected according to JESD22-B101B prior to and after the following tests except for 8.6.10.

8.6.3 High temperature operating life (HTOL) test

The purpose of this test is to evaluate the performance of the LED package under stress due to high temperature operation. The test shall be conducted according to JESD22-A108D; the following test conditions apply:

- Duration 1 000 h.
- ~~If no derating is required, the testing shall be doneat:~~
  - ~~T_s = 85 °C with the maximum drive current, and~~
  - ~~at the max. specified T_s with the corresponding maximum rated drive current.~~
- ~~If derating is required, the testing shall be done:~~
  - ~~with the maximum drive current at the corresponding max. rated T_s, and~~
  - ~~at the max. specified T_s with the corresponding maximum rated drive current.~~
- the testing shall be done:
  - at the maximum specified drive current with the corresponding maximum rated T_s, and
  - at the maximum specified T_s with the corresponding maximum rated drive current.

8.6.4 Temperature cycling (TMCL) test

The purpose of this test is to evaluate the performance of the LED package under stress due to temperature cycles without operation of the LED. The LED package shall be tested according to ~~JESD 22-A104D~~ JESD22-A104E; the following test conditions apply:

- duration 1 000 cycles;
- soak mode 4 (minimum soak time 15 min).

The following minimum and maximum temperatures for T_s shall be chosen by the manufacturer:

- TMCL condition 1: $T_{s,min}$ = –40 °C; $T_{s,max}$ = 85 °C;
- TMCL condition 2: $T_{s,min}$ = –40 °C; $T_{s,max}$ = 100 °C;
- TMCL condition 3: $T_{s,min}$ = –40 °C; $T_{s,max}$ = 110 °C;
- TMCL condition 4: $T_{s,min}$ = –40 °C; $T_{s,max}$ = 125 °C;
- TMCL condition 5: $T_{s,min}$ = –40 °C; $T_{s,max}$ = 150 °C .

The TMCL condition closest to the manufacturer's operating temperature range according to the appropriate LED package specification (manufacturer's datasheet) shall be chosen unless the manufacturer wishes to test compliance with a more severe cycle condition. The choice of the TMCL cycle condition and the transfer time shall be reported.

8.6.5 Wet high temperature operating life (WHTOL) test

The purpose of this test is to evaluate the performance of the LED package under stress due to temperature and humidity during steady state operation. The LED package shall be tested according to JESD22-A101C; the following test conditions apply:

- duration 1 000 h;
- T_s = 85 °C;
- 85 % RH;
- power cycle 30 min on/30 min off.

The tests shall be performed at the corresponding minimum and maximum rated drive current (i.e. rating at T_s = 85 °C).

8.6.6 Power temperature cycling (PTMCL) test

The purpose of this test is to evaluate the performance of the LED package under stress due to temperature cycles during operation of the LED package. The LED package shall be tested according to JESD22-A105C; the following test conditions apply:

- duration 1 000 temperature cycles;
- power cycle 5 min on/5 min off operated at the corresponding maximum rated drive current.

The manufacturer shall select one of the following test types:

- PTMCL condition 1: T_s –40 °C to 85 °C, (test condition A according to JESD22-A105C);
- PTMCL condition 2: T_s –40 °C to ~~105~~ 100 °C, (transition and dwell time according to test condition A of JESD22-A105C);
- PTMCL condition 3: T_s –40 °C to 125 °C, (test condition B according to JESD22-A105C).

The PTMCL condition closest to the manufacturer’s operating temperature range according to the appropriate LED package specification (manufacturer's datasheet) shall be chosen unless the manufacturer wishes to test compliance with a more severe cycle condition. The choice of the PTMCL condition shall be reported.

8.6.7 Electrostatic discharge, human body model (ESD-HBM) test

The purpose of this test is to evaluate the performance of the LED package under stress due to electrostatic discharge using the human body model. The LED package shall be tested according to ANSI/ESDA/JEDEC JS-001-2012.

8.6.8 Electrostatic discharge, machine model (ESD-MM) test

The purpose of this test is to evaluate the performance of the LED package under stress due to electrostatic discharge using the machine model. The LED package shall be tested according to JESD22-A115C.

8.6.9 Destructive physical analysis (DPA) test

The purpose of this test is to evaluate the capability of the device’s internal materials, design, and workmanship to withstand forces induced by various stresses induced during environmental testing.

Perform DPA according to Annex J on random samples of good units after completion of the PTMCL test, WHTOL test, H2S and FMGC test (two samples per lot). The post electrical and photometrical test of these samples shall be executed before the destructive physical analysis.

8.6.10 Physical dimensions (PD) test

Verify physical dimensions according to LED package mechanical drawings of the LED package manufacturer.

8.6.11 Vibrations variable frequency (VVF) test

The purpose of this test is to evaluate the performance of the LED package under stress due to mechanical vibrations with variable frequency. The LED package shall be tested according to JESD22-B103B.

Use a constant displacement of 1,5 mm (double amplitude) over the range of 20 Hz to 100 Hz and a 200 m/s^2 constant peak acceleration over the range of 100 Hz to 2 kHz.

8.6.12 Mechanical shock (MS) test

The purpose of this test is to evaluate the performance of the LED package under stress due to mechanical shock. The LED package shall be tested according to JESD22-B110B:

- 15 000 m/s^2 for 0,5 ms;
- five shocks in each direction, three orientations (+ and – $x/y/z$ direction, i.e. 30 shocks).

~~This test is not applicable if wire bonds are casted.~~

8.6.13 Resistance to soldering heat (RSH-TTW) test

The purpose of the TTW ("through the wave") test is to evaluate the performance of the LED package under stress due to soldering heat. The LED package shall be tested according to JESD22-B106D.

This test only applies to LED packages that are declared to be solderable by wave soldering by the manufacturer.

8.6.14 Resistance to soldering heat (RSH-reflow) test

The purpose of this test is to evaluate the performance of the LED package under stress due to soldering heat. The LED package shall be tested according to JESD22-A113F; alternative: ANSI/IPC/ECA J-STD-002C.

Reflow soldering shall be tested three times at 260 °C. Testing according to 8.6.1 shall be carried out before and after each reflow.

This test applies only to LED packages that are specified for reflow soldering.

8.6.15 Solderability (SO) test

~~Details for this test are under consideration.~~

The purpose of this test is to determine the solderability of lead free solder alloys applicable for surface mounted (SMD) LED packages. The LED packages shall be tested according to IEC 60068-2-58.

Sample size: 3 x 10.

8.6.16 Thermal shock (TMSK) test

The purpose of this test is to evaluate the performance of the LED package under stress due to thermal shock. The LED package shall be tested according to JESD22-A106B. The following conditions shall apply:

- duration 1 000 cycles;
- TMSK cycle condition 1: $T_{s,min}$ = –40 °C; $T_{s,max}$ = 85 °C;
- ~~TMSK cycle condition 2: $T_{s,min}$ = –40 °C; $T_{s,max}$ = 125 °C;~~
- TMSK cycle condition 2: $T_{s,min}$ = –40 °C; $T_{s,max}$ = 100 °C;
- TMSK cycle condition 3: $T_{s,min}$ = –40 °C; $T_{s,max}$ = 125 °C;
- liquid to liquid.

The cycle condition closest to the manufacturer's operating temperature range according to the appropriate LED package specification (manufacturer's datasheet) shall be chosen unless the manufacturer wishes to test compliance with a more severe cycle condition. The choice of the TMSK cycle condition shall be reported.

8.6.17 Hydrogen sulphide (H_2S) test

The resistance to hydrogen sulphide shall be tested according to IEC 60068-2-43; the following test conditions apply:

- air temperature 40 °C;
- 90 % RH;
- H_2S concentration: ~~10×10^{-6} to~~ 15×10^{-6};
- duration 336 h.

8.6.18 Pulsed operating life (PLT) test

The purpose of this test is to evaluate the performance of the LED package under stress due to pulsed operation. The LED package shall be tested according to JESD22-A108D.

- duration 1 000 h;
- T_s = 55 °C;
- pulse width 100 µs, duty cycle 3 %.

For interior lighting applications the test may be performed at T_s = 25 °C.

The LED package shall be operated at the corresponding maximum rated drive current.

8.6.19 Dew (DEW) test

The purpose of this test is to evaluate the performance of the LED ~~package~~ under stress due to dew deposition. ~~The LED package shall be tested according to JESD 22-A100D.~~ The following conditions shall be applied to the LED package.

~~The LED package shall be cycled from 30 °C to 65 °C. 65 °C shall be maintained for 4 h to 8 h before reducing the temperature to 30 °C. This cycle shall continue for 1 008 h, with relative humidity maintained between 90 % to 98 % in the test chamber.~~

~~No bias shall be applied during this test.~~

The LED package shall be cycled from 10 °C to 80 °C and from 50 % RH to 100 % RH with each cycle of t_{cycle} = 6,5 h, see Figure 12 and detailed description below.

1) When the LED package is initially placed in the chamber, over a 15 min time period the temperature is dropped from 20 °C to 10 °C, and the humidity is raised from 50 % RH to between 50 % to 100 % RH.
2) Hold the LED package for 60 min at 10 °C to ensure it has reached the starting temperature for bedewing. During the first 30 min, the humidity is raised to between 90 % to 100 % RH. During the next 30 min, the humidity is raised to between 95 % to 100 % RH. Now switch over from air condition control to chamber control.
3) Temperature is raised gradually from 10 °C to 70 °C over a 3 h period with heating rate of 20 °C/h, with humidity held between 95 % to 100 % RH . During this time the LED packages are turned on only every 30 min for 2 min with current density of not more than 0,05 A/mm^2, low enough not to heat the LED packages beyond condensation. Except for these 2 min every 30 min, the LED packages shall be turned off.
4) Temperature is raised to 80 °C within a further 30 min. The humidity shall be held between 95 % to 100 % RH.
5) Temperature is decreased to 75 °C and is held for 30 min. The humidity is undefined and uncontrolled during this time. Start of the drying after reaching 75 °C air temperature.

6) Temperature is decreased from 75 °C to 20 °C within 75 min. The humidity is undefined and uncontrolled during this time. This is the end of the first cycle and the DUT shall be dry (RH < 50 %).

7) Each additional cycle starts at step 1 and continues to step 6.

The test is continuous except for where interim measurements are required. Electrical measurements shall be performed not sooner than one hour after removing the LED packages from the stress chamber. For interim readouts, the LED packages shall be returned to stress within four hours after removing them from the stress chamber.

Duration: Typical duration is 10 cycles.

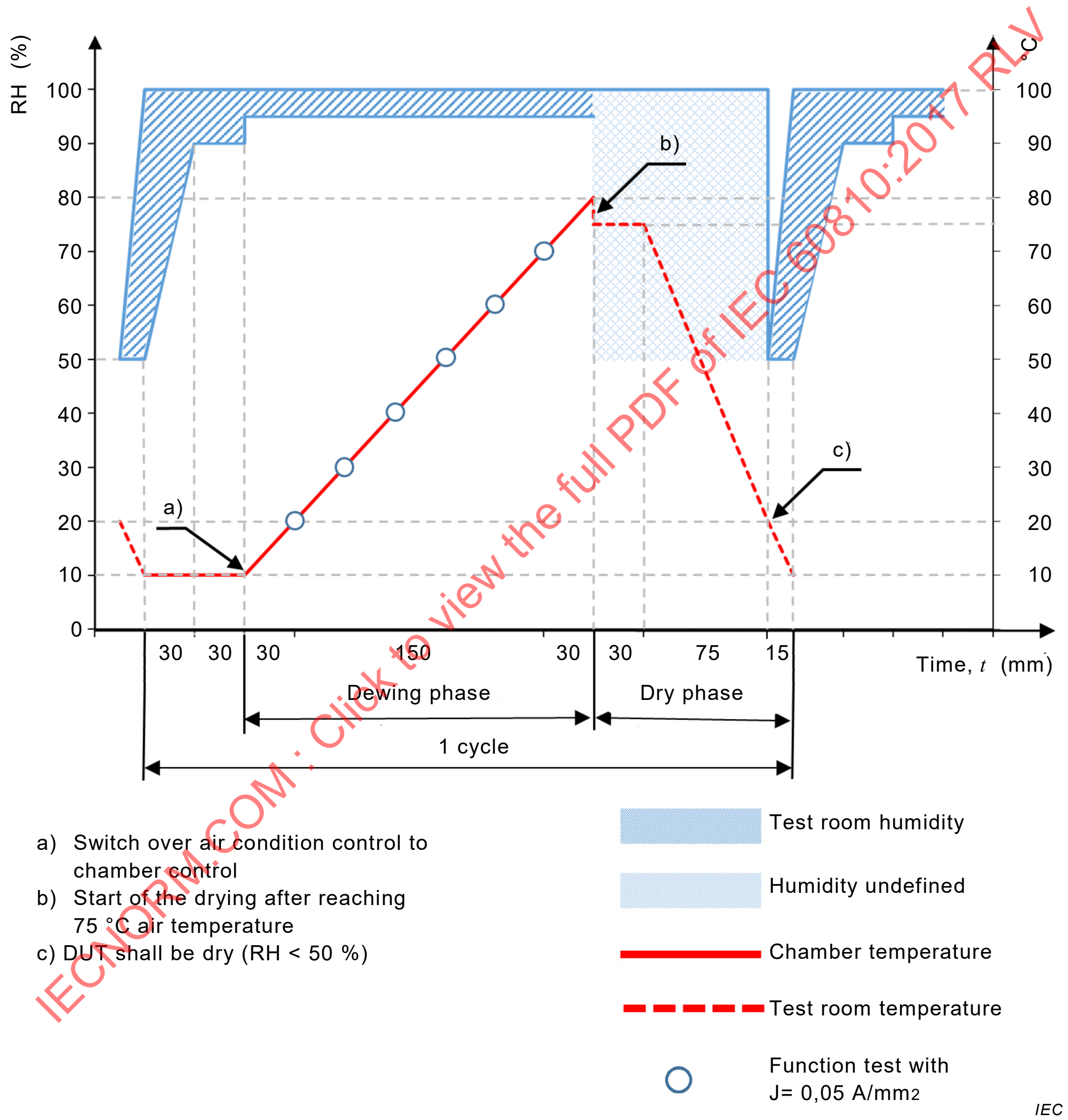


Figure 12 – Temperature–humidity characteristics for the DEW test

8.6.20 Flowing mixed gas corrosion (FMGC) test

The resistance to corrosive gas atmosphere shall be tested according to IEC 60068-2-60; the following test conditions apply:

- test method 4;
- air temperature 25 °C;
- 75 % RH;

- H_2S concentration: 10 × 10^{-9};
  NO_2 concentration: 200 × 10^{-9};
  Cl_2 concentration: 10 × 10^{-9};
  SO_2 concentration: 200 × 10^{-9};
- duration 500 h.

8.6.21 Wire bond pull test (WBP)

The purpose of this test is to measure the wire bond strength of the LED package. This test may be applicable to all versions of available wire bond techniques used for LED packages. The wire bond strength test shall be performed according to MIL-STD 883E. The wire bond strength C_{pk} value shall be > 1,67 and shall be reported separately. See ISO 3534-2 for the definition of the C_{pk} value.

A post-stress test evaluation of wire bond strength is not recommended, since the LED packages are typically encapsulated and the de-capsulation process could influence the result of wire bond strength evaluation. A minimum sample size of 3 x 5 is recommended.

8.6.22 Bond shear test (BS)

The purpose of this test is to determine the strength of the interface between ball bond and die bonding surface, or an wedge/stich bond and a die or package bonding surface. The bond shear test shall be performed according to JESD22-B116. The bond shear C_{pk} value shall be > 1,67 and shall be reported separately. See ISO 3534-2 for the definition of the C_{pk} value.

A post-stress test evaluation of wire bond shear is not recommended, since the LED packages are typically encapsulated and the de-capsulation process could influence the result of wire bond shear evaluation. A minimum sample size of 3 x 5 is recommended.

8.6.23 Die shear test (DS)

The purpose of this test is to determine the quality of the interface between the semiconductor die and package bonding surface. The die shear shall be performed according to MIL-STD 883E. The die shear C_{pk} value shall be > 1,67 and shall be reported separately. See ISO 3534-2 for the definition of the C_{pk} value.

A post-stress test evaluation of the die shear is not recommended, since the LED packages are typically encapsulated and the de-capsulation process could influence the result of die shear evaluation. A minimum sample size of 3 x 5 is recommended.

Annex A
(normative)

Life test conditions for filament lamps

A.1 Ageing

Filament lamps shall be aged at their test voltage for approximately 1 h. For dual-filament lamps, each filament shall be aged separately. Filament lamps which fail during the ageing period shall be omitted from the test results.

A.2 Test voltage

Measurements shall be carried out at the test voltage specified in Clause 5 which shall be a stable DC or AC voltage with a frequency between 40 Hz and 60 Hz.

In the case of non-replaceable filament lamps (defined in IEC 60809), the filament lamp shall be operated at the test voltage specified in the relevant data sheet. In case an electronic regulator is used, such as pulse width modulation (PWM), this non-replaceable filament lamp should be operated in such a way that it does not negatively affect the lifetime of the filament lamp.

NOTE The test voltage is deemed to be stable when the momentary fluctuations do not exceed 1 % and the deviation of the average over the test period does not exceed 0,5 % of the specified value.

A.3 Operating position and operating conditions

Filament lamps shall be operated on a vibration-free test rack with both lamp axis and filament(s) horizontal. In the special case of double-filament lamps which include a shield, this shall be under the dipped or lower-beam filament (H-H line horizontal). In the case of filament lamps with an axial filament, the longer filament support shall be positioned above the filament.

The lamps shall be tested under normal ambient temperature conditions; assumption is 25 °C ± 10 °C.

A.4 Switching cycle

A.4.1 Single-filament lamps

A.4.1.1 Filament lamps for continuous operation

Filament lamps shall be switched off twice daily for periods of not less than 15 min, such periods not being considered as part of the life.

A.4.1.2 Filament lamps for intermittent operation

Filament lamps for intermittent operation as used in stop-lamps and flashing direction indicators shall be operated in the following switching cycle:

- 15 s on for intermittent (flashing) operation;
- 15 s off;
- flashing frequency: 90/min;
- on/off ratio 1:1.

The whole flashing operation time is considered as life.

A.4.2 Dual-filament lamps for headlamps

The filaments shall be operated alternately according to the following cycle and starting with the lower beam filament:

- dipped or lower-beam filament: 15 h on/45 min off;
- main or upper-beam filament: 7,5 h on/45 min off.

The end of the life is determined by failure of either filament.

The off periods are not considered as part of the life.

NOTE The life of the lower-beam filament represents two-thirds of the total life, the life of the upper-beam filament one-third.

A.4.3 Dual-filament lamps for light signalling equipment

A.4.3.1 General

Life testing shall be carried out for each filament separately. Life testing of the low-wattage filament shall be carried out on filament lamps other than those used for life testing of the high-wattage filament.

A.4.3.2 Filaments for continuous operation

The switching cycle shall be as specified in A.4.1.1.

A.4.3.3 Filaments for intermittent operation

The switching cycle shall be as specified in A.4.1.2.

A.5 Luminous flux and colour maintenance

Tests may be interrupted for determination of the luminous flux and colour maintenance.

Annex B
(normative)

Vibration tests

B.1 General

These tests are designed to ensure that lamps satisfactorily completing this schedule will not be adversely affected by shock and vibration in normal service.

Two levels of test are specified which are referred to as "standard test" and "heavy-duty test" and the appropriate level shall be selected for the intended vehicle usage.

The acceleration levels and frequency spectra used in these tests are based on extensive investigations into the characteristics experienced at lamp mounting positions on a wide range of vehicles and in normal service conditions.

Although the standard test relates to normal vehicle service conditions, investigations have shown that the more arduous conditions given by heavy goods vehicles require lamps of a greater mechanical strength.

Within the constraints of dimensional and photometric specifications, the ultimate strength of an incandescent lamp is limited by the properties of the filament material. These restrict the mechanical stress to which a lamp can be subjected.

Higher vibration levels may impair the performance of lamps.

Two tests methods are specified:

a) a wideband random vibration test (WBR);
b) a narrowband random vibration test (NBR).

The WBR test is the preferred one, as simulation of service conditions can be achieved most accurately by the use of WBR equipment. However, studies have indicated that a relationship exists between WBR and NBR vibrations. For the purpose of this document, both tests are equal for testing motor vehicle lamps to vibration resistance.

Analysis of vibration measurements, taken under transient conditions such as door, boot and bonnet closures, shows compatibility with the significant features of both the WBR and NBR test programmes.

The generally accepted requirements of a fatigue life of 10^7 reversals are encompassed by the schedule in IEC 60068-2-6.

Measurements of vibration and shock characteristics in service reveal frequencies of up to 20 000 Hz.

A vibration level is expressed as acceleration spectral density (ASD). It is the spectral density of an acceleration variable and is given in units of acceleration squared per unit frequency.

ASD spectrum defines the way ASD varies within the frequency range.

The ASD levels at frequencies above 1 000 Hz are, however, so low as to be insignificant, as the resonant frequencies of the critical construction features of most automobile lamps fall within the range of 200 Hz to 800 Hz. This, together with problems in the design of fixtures suitable for operation at frequencies above this level, has led to the adoption of 1 000 Hz as the maximum limit for the test schedules (excluding half bandwidth).

B.2 Test conditions

B.2.1 General

Figure B.1 details the preferred arrangement of equipment for the testing of lamps of WBR or NBR tests.

In order to be assured of reliable and reproducible test results, the following procedures should be followed.

B.2.2 Mounting (see IEC 60068-2-47)

The lamp caps shall be fastened rigidly to the work holders on the vibration head. This may be achieved by clamping, soldering or embedding. Electrical connection to the lamps shall be made by the use of soldered wires or other means such that electrical connection is ensured during the whole test.

On tests including higher frequencies, it is essential that fixtures are designed in such a way that the propagation path (the distance between lamp and moving coil) is always shorter than the one-quarter wavelength of the velocity of sound in the fixture material.

B.2.3 Measuring points

A measuring point is the position at which measurements are made to ensure that the test requirements are met. The measuring point shall be on the fixture as close as possible to the position at which the lamp is held and the detector shall be rigidly connected to it.

If several lamps are mounted on a single fixture, the measuring point may be related to the fixture generally rather than the lamp fixing points.

The resonant frequency of the fully loaded fixture shall always be higher than the maximum test frequency.

B.2.4 Control point

The signal from the transducer mounted at the measuring point shall be used as a means of maintaining the specified vibration characteristics.

B.2.5 Conditioning

Filament lamps shall be aged for 30 min at test voltage as given in the relevant data sheets of IEC 60809 or in the relevant data sheets of non-replaceable filament lamps. No ageing period is required for discharge lamps, but lamps which fail before starting a vibration test shall be omitted from the test results.

B.2.6 Axis of vibration

Field measurements on vehicles have shown that automobile lamps are usually subjected to greater stresses in the vertical plane than in either of the horizontal planes. It is therefore recommended that a vertical direction of excitation be used for testing with the principal lamp axis and filament(s) horizontal.

B.2.7 WBR test – Basic motion

The basic motion of the control point on the test fixture (see Figure B.1) shall be rectilinear and of a stochastic nature with a normal (Gaussian) distribution of instantaneous acceleration values. Peak values are limited to three times the r.m.s. value as determined by the ASD profile and its frequency range (i.e. "3σ-clipping"). Experience has shown that a peak factor set to 2,3 at the exciter corresponds to a 3 σ test signal at the control point because of filtering by the vibrator (see ISO 5344).

B.3 Test conditions

B.3.1 General

The test voltage for filament lamps shall be in accordance with IEC 60809 or with the specification in the relevant data sheets of non-replaceable filament lamps. For discharge lamps, the conditions of Clause D.2 apply.

The specific vibration test conditions are given as follows (see Tables B.1, B.2, B.3 and B.4):

Table B.1 – Vibration test on motor vehicle lamps – Test conditions

Narrowband random vibration test	Standard test conditions	Table B.2
	Heavy-duty test conditions	Table B.3
Wideband random vibration test	Standard test conditions	Table B.4

B.3.2 Narrowband random vibration tests

Table B.2 – Vibration test on motor vehicle lamps – Standard test conditions (narrowband)

Narrowband random vibration test	
1 Frequency range	30 Hz to 1 050 Hz
2 Bandwidth	100 Hz
3 Sweep range	80 Hz to 1 000 Hz
4 Sweep rate	1 octave/min
5 Sweep duration (full cycle)	7,3 min
6 ASD spectrum	0,12 g^2/Hz (= 3,5 g eff.) from 80 Hz to 150 Hz 0,014 g^2/Hz (= 1,2 g eff.) from 150 Hz to 1 000 Hz
7 Tolerance of the acceleration values	±1 dB
8 Test duration	20 h
9 Switching cycle	20 min lit to 10 min unlit
10 Compressor speed	10 dB/s

Table B.3 – Vibration test on motor vehicle lamps – Heavy-duty test conditions

Narrowband random vibration test	
1 Frequency range	30 Hz to 1 050 Hz
2 Bandwidth	100 Hz
3 Sweep range	80 Hz to 1 000 Hz
4 Sweep rate	1 octave/min
5 Sweep duration (full cycle)	7,3 min
6 ASD spectrum	0,36 g^2/Hz (= 6,0 g eff.) from 80 Hz to 150 Hz 0,09 g^2/Hz (= 3,0 g eff.) from 150 Hz to 1 000 Hz
7 Tolerance of the acceleration values	±1 dB
8 Test duration	20 h
9 Switching cycle	10 min lit to 10 min unlit
10 Compressor speed	10 dB/s

B.3.3 Wideband random vibration tests

Test requirements are given in Table B.4 for standard service.

Requirements for heavy-duty service are under consideration.

Table B.4 – Vibration test on motor vehicle lamps – Standard test conditions (wideband)

Wideband random vibration test		
1 Frequency range	12 Hz to 1 002 Hz	
2 ASD spectrum	Hz	g^2/Hz
a)	12	0,01
a)	12 to 24	0,01 to 0,15
a)	24 to 54	0,15
	54 to 1 002	0,15 to 0,008 2
3 Total r.m.s. acceleration level	5,4 g ± 1 dB	
4 Tolerance of the true ASD values	±3 dB	
5 Switching cycle	20 min lit to 10 min unlit	
6 Test duration	20 h	
NOTE 1 The acceleration level increases logarithmically with the logarithm of the frequency in the range 12 Hz to 24 Hz (12 dB/octave) and it decreases in the range 54 Hz to 1 002 Hz (–3 dB/octave). Outside the specified frequency range, the ASD level has to decrease with gradients as steep as possible. NOTE 2 All data are provisional.		

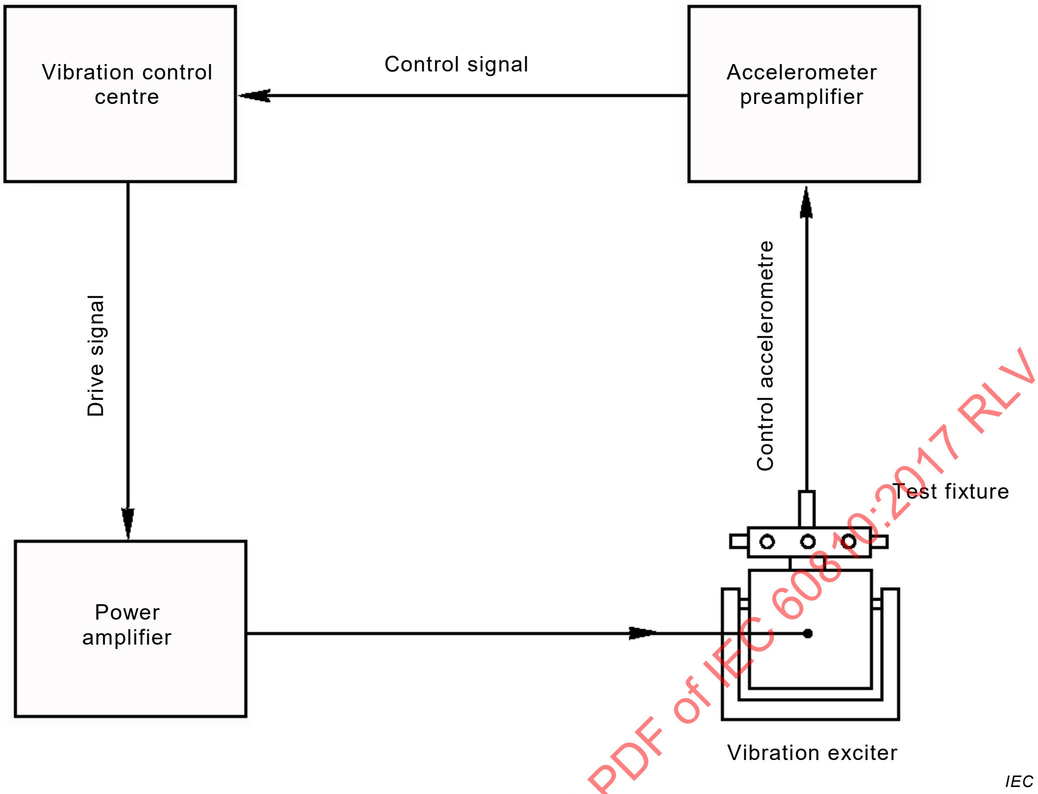


Figure B.1 – Recommended equipment layout for vibration testing

Annex C
(normative)

Glass-bulb strength test

C.1 General

If required, the test specified in Annex C shall be used to determine the glass-bulb strength of certain road vehicle filament lamps.

This test is necessary for these filament lamps because mechanical handling is utilized for their assembly in equipment.

C.2 Test equipment and procedure

C.2.1 Principle of the test equipment

See Figure C.1.

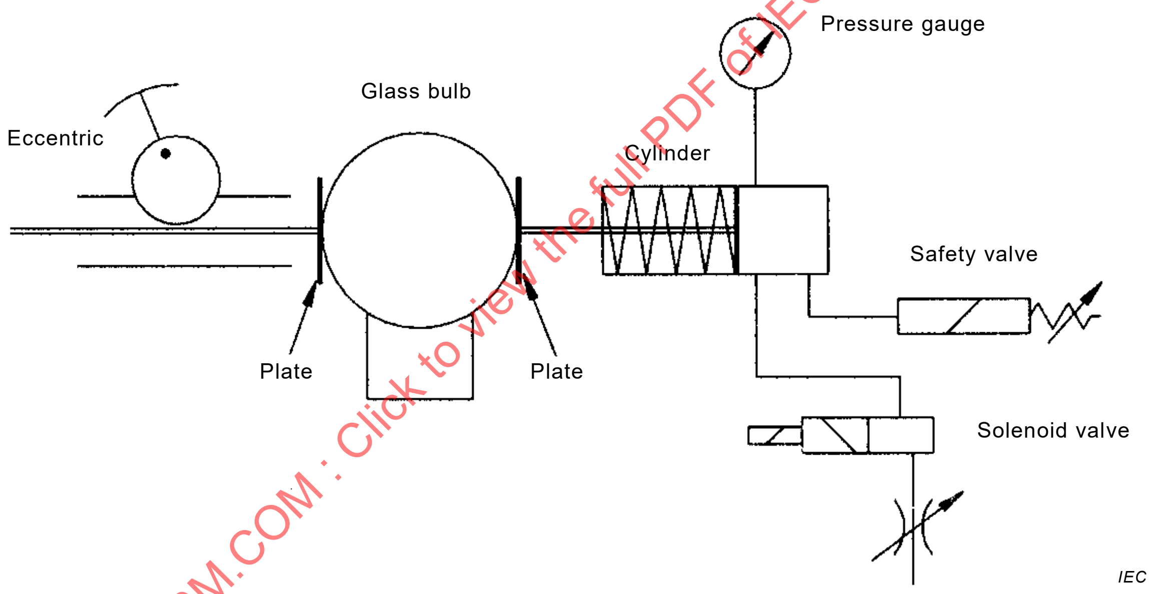


Figure C.1 – Diagrammatic sketch of the principle of the test equipment

The test apparatus consists mainly of

- a pneumatic cylinder applying the necessary force;
- two plates transmitting the force onto the test sample;
- a measuring apparatus indicating the applied force.

C.2.2 Test conditions

This apparatus shall test bulbs with a maximum diameter of 50 mm. The bulb shall be tested with a slowly increasing compressive force. In no case shall bulbs be exposed to a shock load.

The increase of force from 0 N to 200 N shall be in 4 s to 5 s during which period the force increases approximately in a linear manner.

It shall be possible to limit the maximum force of the apparatus to 200 N by a compression safety valve. The apparatus shall incorporate a suitable protective screen to prevent injury from glass fragments in the event of a bulb failure during the test.

C.2.3 Requirements for plates

Each plate shall have a plane smooth surface with a diameter of approximately 20 mm and shall be of hardened tool steel. The hardness of the plates shall lie between 55 Rockwell and 60 Rockwell (HRC).

C.3 Requirements

The compression strength of the bulb shall not fall below the values stated in Table C.1 taking an AQL of 1 % as a basis.

Table C.1 – Compression strength

Category	Minimum glass-bulb strength N
P21/5W	40
P21W	40
P27/7W	40
P27W	40
PR21/5W	40
PR21W	40
PY21W	40
PY27/7W	40
R10W	40
R2	40
R5W	40
RR10W	40
RR5W	40
RY10W	40
T4W	40
W10W	40
W15/5W	40
W2.3W	40
W21/5W	40
W21W	40
W3W	40
W5W	40
WP21W	40
WR5W	40
WT21/5W	40
WT21W	40
WTY21/5W	40
WTY21W	40
WY10W	40
WY16W	40
WY21W	40
WY5W	40

C.4 Evaluation

C.4.1 General

One of the following procedures shall be applied.

C.4.2 Assessment based on attributes

Set the test apparatus at the minimum force specified in Table C.1. A first sample is selected randomly from the batch, the number selected being determined by the batch size (see Table C.2). The number of bulbs failing are compared with the acceptance and rejection numbers. If there is no decision, a second sample is tested in accordance with Table C.2.

Table C.2 – Inspection by attributes – Double sampling plan

Batch size	Sample	Accept	Reject
1 201 to 3 200	1st sample $n1$ = 80	1	4
	2nd sample $n2$ = 80	4	5
3 201 to 10 000	1st sample $n1$ = 125	2	5
	2nd sample $n2$ = 125	6	7
10 001 to 35 000	1st sample $n1$ = 200	3	7
	2nd sample $n2$ = 200	8	9
35 001 to 150 000	1st sample $n1$ = 315	5	9
	2nd sample $n2$ = 315	12	13
If a second sample has to be taken, the number of filament lamps failing in the combined sample is compared with the acceptance and rejection numbers in the corresponding line.			

This random test, based on attributes, corresponds ~~with IEC 60410~~ to the tests given in ISO 2859-1.

C.4.3 Assessment based on variables

The size of the sample (selected randomly) is determined by the batch size as shown in Table C.3.

Each filament lamp is tested until it fails and the value at which this occurs is recorded.

The result is assessed as follows.

The lower quality statistic (Q_L) is calculated using the equation:

$$Q_L = \frac{\overline{X} - 40}{S}$$

where

$\overline{X}$ is the mean value of all the results in the sample;

S is the standard deviation:

$$S = \sqrt{\frac{\sum_{i=1}^{i=n} (X_i - \overline{X})^2}{n-1}}$$

where

X_i is the value of individual results;

n is the number of results.

The test is passed if: $Q_L \geq K$

where

K is the acceptability constant determined from Table C.3.

Table C.3 – Inspection by variables – "S" method of assessment

Batch size			Sample size	Acceptability constant K
1 201	to	3 200	15	1,79
3 201	to	10 000	20	1,82
10 001	to	35 000	25	1,85
35 001	to	150 000	35	1,89

NOTE 1 The statistical basis of this method assumes that the distribution of results is normal, or nearly so.

NOTE 2 Tests for normality can be made by the use of probability paper plots in accordance with ISO 2854.

NOTE 3 This test, based on variables, corresponds to the tests given in ISO 3951.

Annex D
(normative)

Life and luminous flux maintenance test conditions for discharge lamps

D.1 Ageing

No ageing period is required, but lamps which fail before starting the life test shall be omitted from the test results.

For lamps subject to the luminous flux maintenance test, the initial luminous flux shall be measured after 10 on/off switching cycles as ~~prescribed~~ specified in Clause D.4.

D.2 Test circuit and test voltage

Discharge lamps shall be tested with the ballast submitted by the lamp manufacturer and, preferably, designed to operate the lamp in a nominal 12 V system. The test voltage to the ballast shall be 13,5 V. The power supply to the ballast shall be sufficient to secure the high-current flow.

D.3 Burning position and operating conditions

Discharge lamps shall be operated in free air with an ambient temperature of 25 °C ± 5 °C. The burning position shall be horizontal within 10°, with the lead wire down.

Precautions should be taken to avoid potential hazards due to high voltages, UV radiation and risk of bulb breakage during starting, run-up and operation of some discharge lamp types.

D.4 Switching cycle

One on/off switching cycle is built up of the following 10 on/off periods (see Table D.1):

Table D.1 – On/off switching cycle

Period	On min	Off min
1	20	0,2
2	8	5
3	5	3
4	3	3
5	2	3
6	1	3
7	0,5	3
8	0,3	0,3
9	20	4,7
10	20	15

The total duration of one on/off switching cycle is 120 min, during which the lamp is switched on for 79,8 min and switched off for 40,2 min. The time during which the lamp is switched off is not considered as part of the life.

For discharge lamps with two defined power modes, a power switching cycle according to Table D.2 shall be applied in addition.

One power switching cycle has a total duration of 113 min. The power switching cycle is superimposed onto the on/off switching cycle of Table D.1.

Figure D.1 show the superposition of the two switching cycles.

NOTE The power switching cycle duration of 113 min is chosen to avoid synchronicity with the 120 min of the on/off cycle. Over the total test duration this results in a percentage of 71 % in low power operation (e. g. low beam) and 29 % high power operation (e. g. high beam).

Table D.2 – Power switching cycle

Period	Power mode	Time min
A	High power	3
B	Low power	20
C	High power	10
D	Low power	20
E	High power	10
F	Low power	20
G	High power	10
H	Low power	20

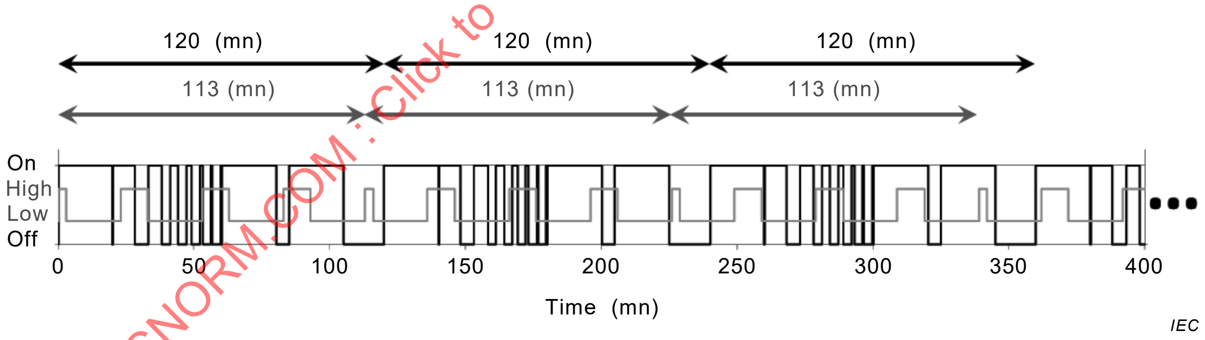


Figure D.1 – Superposition of on/off switching and power switching cycle

Life tests may be interrupted for the purpose of the luminous flux maintenance test.

For discharge lamps with two defined power modes, an additional fast power switching cycle according to Table D.3 shall be performed on 10 lamps. The test consists of 10 steps “5 s low – 2 s high” and 10 steps “20 s low – 10 s high” These 20 steps are repeated until 50 000 operations are reached. A maximum of one lamp may fail the test (no light emitted).

Table D.3 – Fast power switching cycle

Operations	Steps	Power mode	Time s
1	1	Low power	5
2	2	High power	2
3	3	Low power	5
4	4	High power	2
5	5	Low power	5
6	6	High power	2
7	7	Low power	5
8	8	High power	2
9	9	Low power	5
10	10	High power	2
11	11	Low power	20
12	12	High power	10
13	13	Low power	20
14	14	High power	10
15	15	Low power	20
16	16	High power	10
17	17	Low power	20
18	18	High power	10
19	19	Low power	20
20	20	High power	10
21	1	Low power	5
22	2	High power	2
….	….	…	…
50 000	20	High power	10

D.5 Luminous flux maintenance

The luminous flux maintenance is measured after the lamp has been operated 75 % of the characteristic life as declared by the manufacturer.

Annex E
(normative)

Bulb deflection test

E.1 General

If required, the test specified in Annex E shall be used to determine the strength of the bulb-to-cap connection of discharge lamps.

E.2 Test set-up and procedure

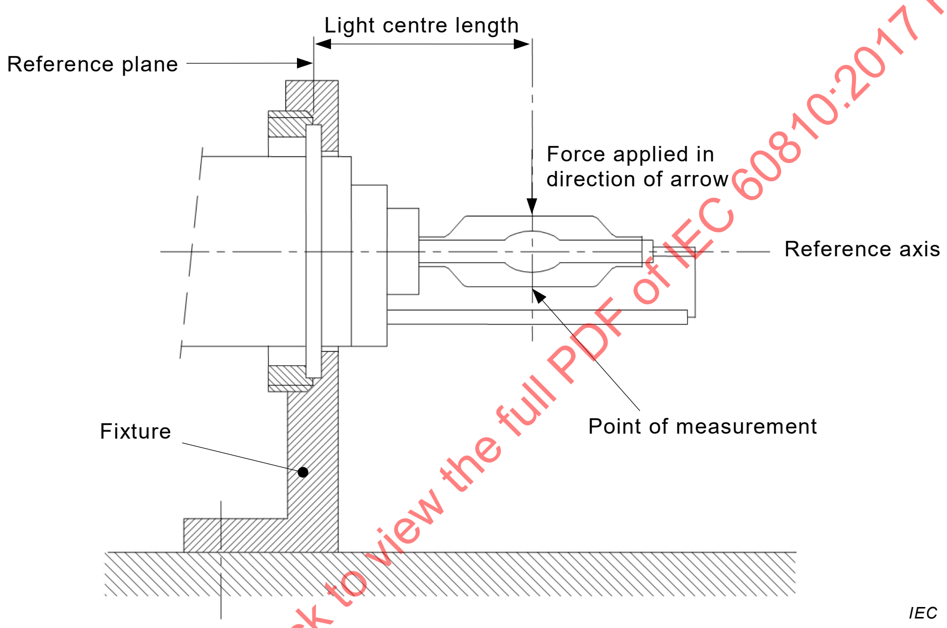


Figure E.1 – Sketch of the test set-up

The lamp shall be rigidly and horizontally mounted in the fixture (see Figure E.1), with the reference notch in the up position. A force of 18 N is applied on the glass bulb

- at a distance from the reference plane equal to the light centre length of the lamp;
- perpendicular to the reference axis;
- using a rod with a hard rubber tip with a minimum spherical radius of 1 mm;
- four times, spaced 90° apart, starting in the vertical direction.

NOTE The spacing of 90° is approximate, depending on the position of the outer supply wire.

The force shall be gradually increased from 0 N to 18 N.

The bulb deflection shall be measured at the glass surface 180° opposite to the force application.

A different lamp shall be used for each force application at 0°, 90°, 180° and 270°.

E.3 Requirement

The deflection shall not exceed 0,13 mm in the direction of the force applied.

Annex F
(informative)

Guidance on equipment design

F.1 Pinch temperature limit

Headlamps, fog-lamps and signalling lamps should be so designed that in operation the pinch temperature of halogen lamps does not exceed 400 °C.

Specially prepared filament lamps are required for the pinch temperature test and reference should be made to the filament lamp supplier.

NOTE For pinch temperature measuring method, see IEC 60682.

F.2 Solder temperature limit

Headlamps, fog-lamps and signalling lamps should be so designed that in operation the solder temperature of filament lamps does not exceed the following limits:

- ~~290~~ 180 °C for single-filament lamps;
- ~~270~~ 180 °C for double-filament lamps.

F.3 Maximum filament lamp outline

Maximum filament lamp outline is provided as guidance for designers of lighting equipment and is based on a maximum sized filament lamp inclusive of bulb-to-cap eccentricity and tilt. Observance of these requirements in the equipment design will ensure mechanical acceptance of filament lamps complying with IEC 60809. Details are given in Figures F.2 to F.5.

F.4 Maximum surge voltage

Maximum surge voltage values are provided as guidance for designers of electrical equipment. They are specified as maximum tolerable duration as a function of the height of voltage surge.

This does not imply that values shorter than the specified ones have a negligible effect on filament lamp performance, but only that a higher voltage or duration in any case harm the filament lamp and should be avoided. Values in graphical form are given in Figure F.1.

F.5 Recommended instructions for use and handling of halogen filament lamps

It is recommended that the following points be included in any instructions for use if supplied with halogen filament lamps covered by this document. Symbols as shown in Annex H (Clauses H.2 to H.5) may be used in addition or as an alternative to text information.

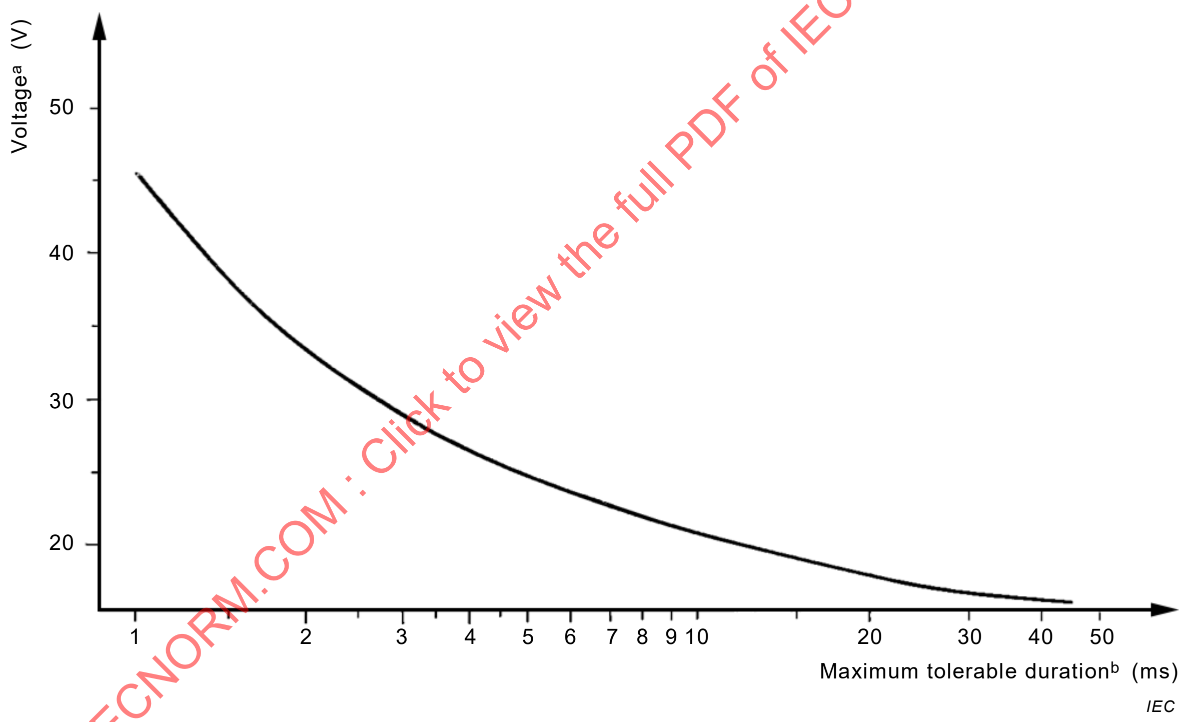
- Halogen filament lamps operate at high bulb temperatures and care should be taken to avoid touching the bulb in any circumstances.
- If filament lamps with quartz bulb are touched, they should be cleaned before use with a lint-free cloth moistened with methylated spirit.
- Filament lamps with scratched or otherwise damaged bulbs should not be used.

NOTE In some instances filament lamp manufacturers give information that the filament lamp contains gas under pressure and recommend protective measures when handling it.

F.6 Recommended instructions for use and handling of discharge lamps

It is recommended that the following points are included in any instructions for use if supplied with discharge lamps covered by this document. Symbols as shown in Annex H (Clauses H.2 to H.10) may be used in addition or as an alternative to text information.

- Care should be taken to avoid touching the bulb in any circumstances. The use of protective gloves and eye protection is advised. If the bulb is touched, it should be cleaned before use with a lint-free cloth moistened with methylated spirit. Lamps with scratched bulbs should not be used.
- Discharge lamps operate with a suitable ballast which produces very high voltage when switching and during operation. During operation, the bulb of the discharge lamp emits UV-radiation. In order to avoid any safety risk or impairment of health, the discharge lamps should only be used in closed headlamps.
- Discharge lamps operate at high temperatures. Before handling, the lamp should be left to cool down for an appropriate time and the supply voltage to the ballast should be disconnected.



[a] Voltage surges are superimposed on a stabilized voltage of 14,5 V after a burning period of at least 30 s. The voltage shown on the graph above is the sum of the stabilized 14,5 V and the voltage surge.

[b] If this maximum tolerable duration is exceeded, a certain percentage of filament lamps will fail immediately. The resulting influence on the non-failing filament lamps is being studied.

NOTE Data for 24 V filament lamps are under consideration. Further details of the surge are under consideration.

Figure F.1 – Voltage surges for 12 V filament lamps – Maximum tolerable duration for a voltage surge as a function of its height

Dimensions in millimetres

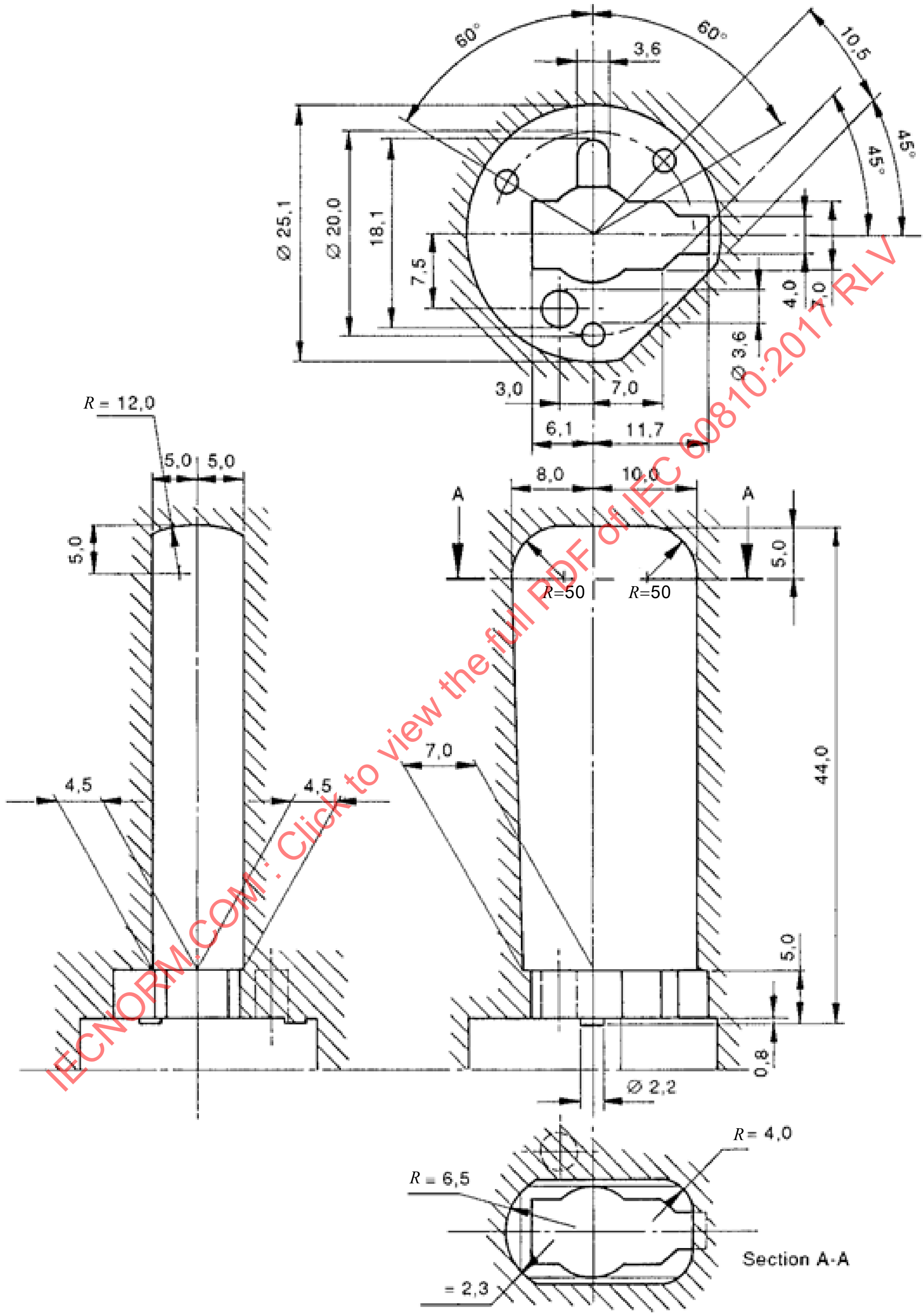
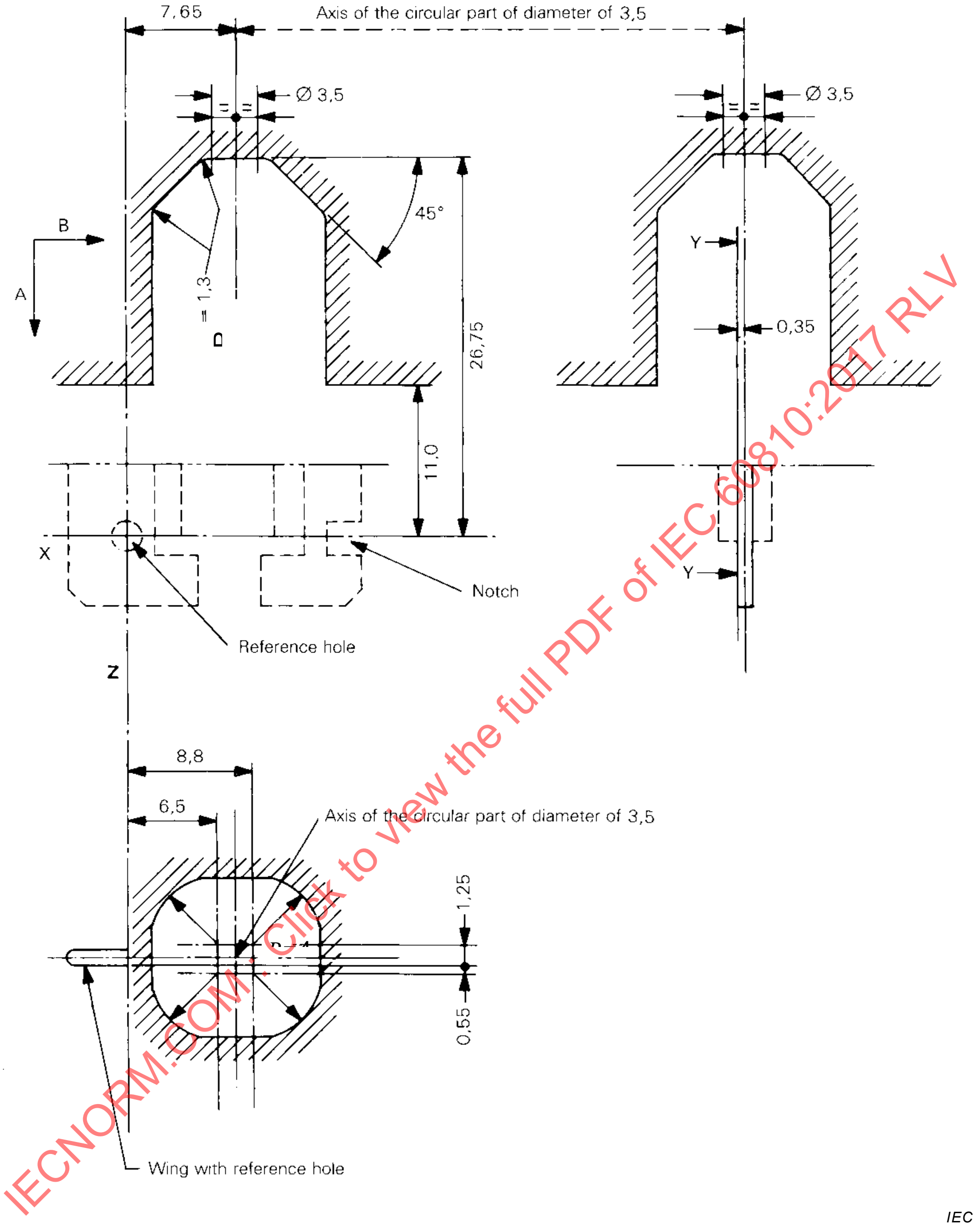


Figure F.2 – Maximum filament lamp outlines H1

Dimensions in millimetres



Key

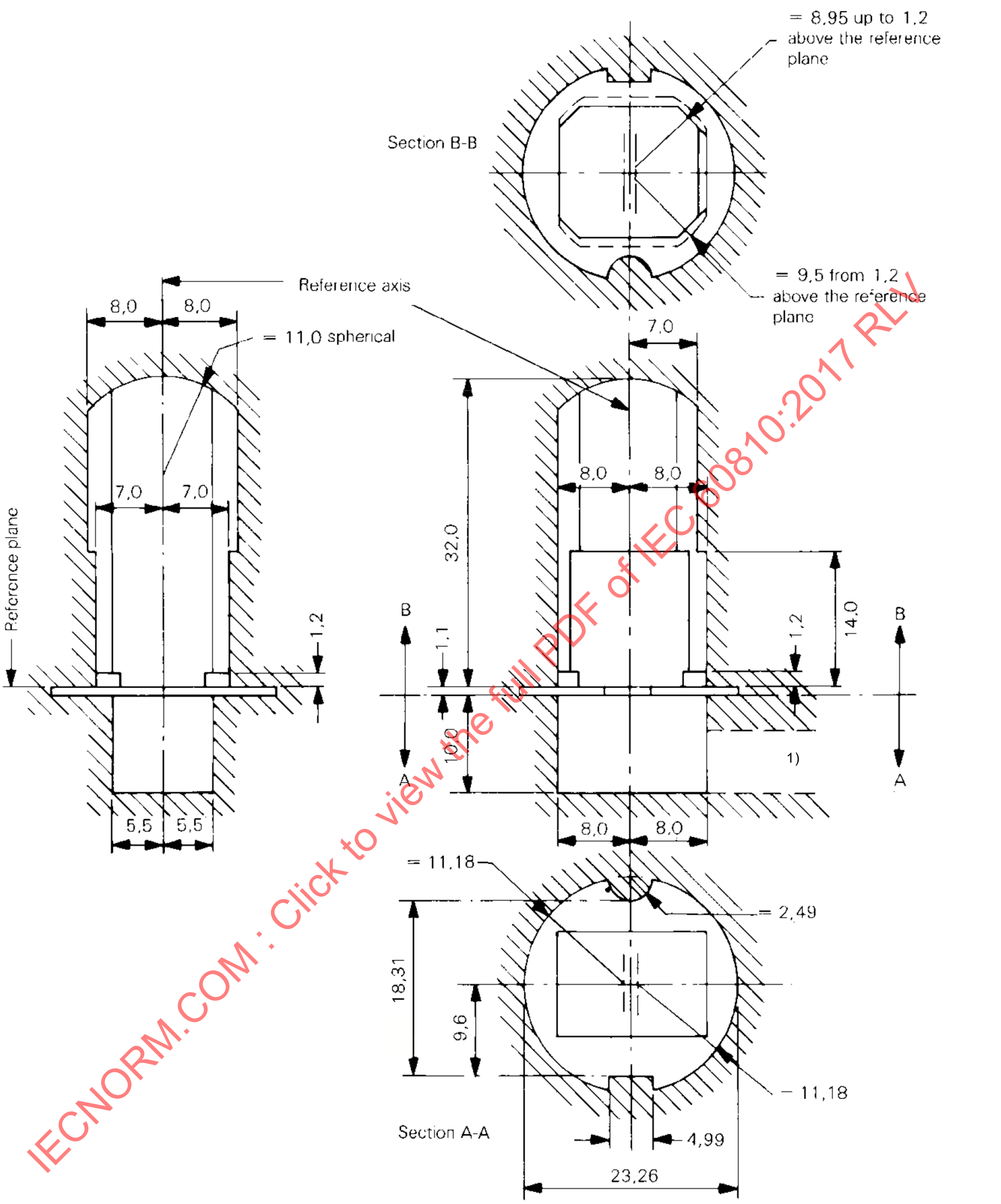
X Reference axis common to the reference hole and the notch

Z Reference plane containing reference axis of the hole and perpendicular to X axis

Y Supporting plane of the wings

Figure F.3 – Maximum filament lamp outlines H2

Dimensions in millimetres



1 Maximum lamp outline for the passage of the insulated cable and connector tab.

Figure F.1 – Maximum filament lamp outlines H3

Dimensions in millimetres

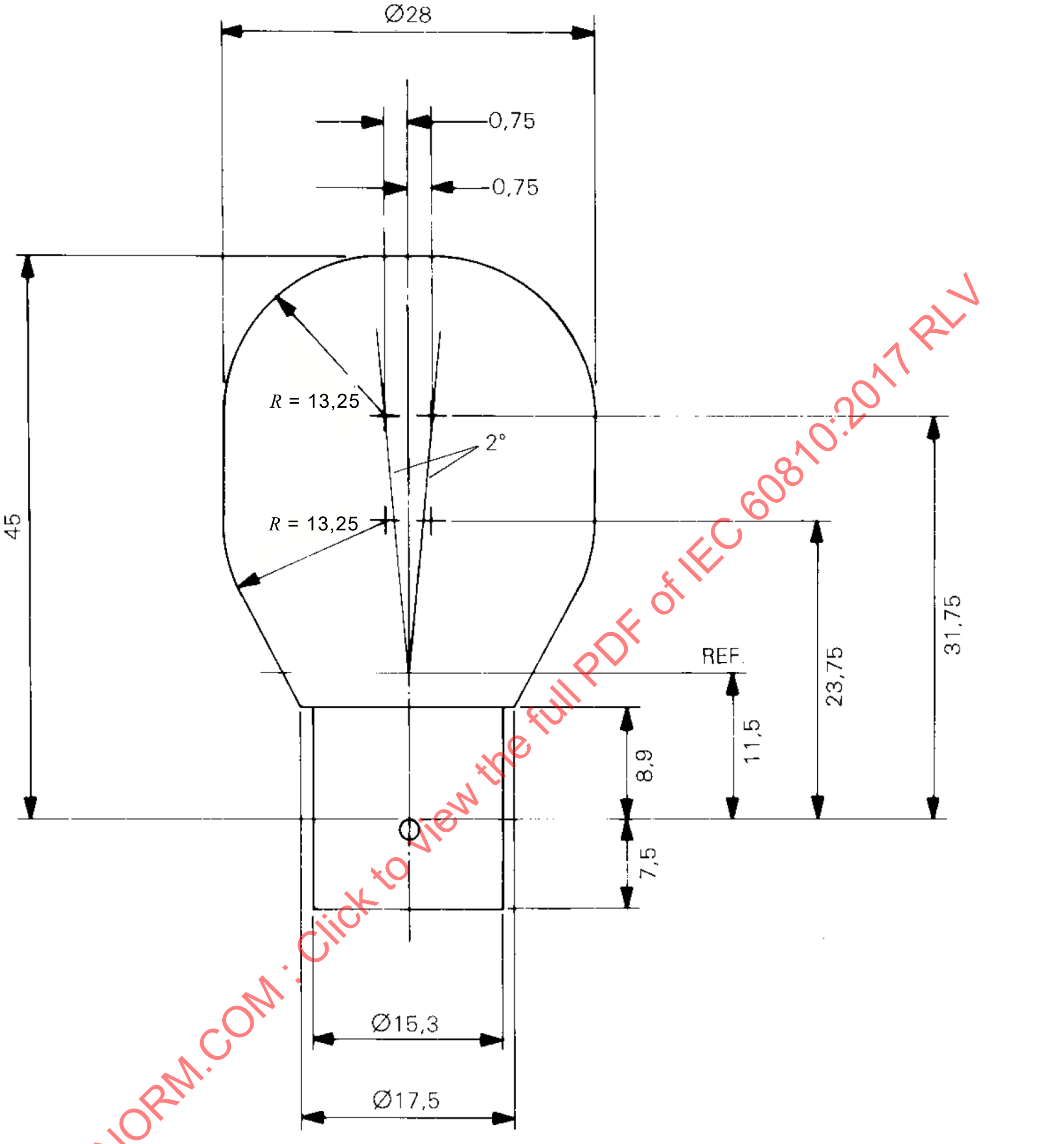


Figure F.5 – Maximum filament lamp outlines P21W, PY21W, P21/4W and P21/5W

Annex G
(informative)

~~Information for~~ Ballast design

Discharge lamps with integrated starting device may make use of a spark gap to generate the high-voltage starting pulse. The ballast should provide an open-circuit voltage as follows (see Table G.1).

Table G.1 – Open circuit voltage

Open- circuit voltage (r.m.s.)	V	min.	360
		max.	600

Annex H
(informative)

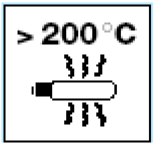
Symbols

H.1 General

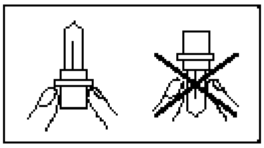
Annex H ~~concerns~~ lists the symbols referred to in Clauses F.5 and F.6.

The height of graphical symbols shall not be less than 5 mm, and for letters, not less than 2 mm.

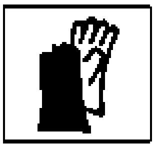
H.2 Symbol indicating that lamps operate at high temperatures



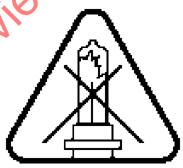
H.3 Symbol indicating that care should be taken to avoid touching the bulb



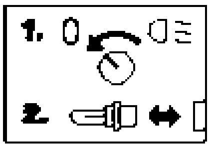
H.4 Symbol indicating that the use of protective gloves is advised



H.5 Symbol indicating that lamps with scratched or otherwise damaged bulbs should not be used



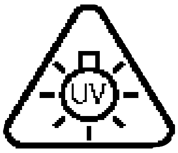
H.6 Symbol indicating that before handling, the lamp shall be switched off



H.7 Symbol indicating that the use of eye protection is advised

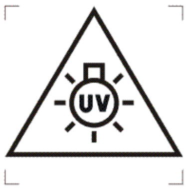
H.8 Symbol indicating that during operation, the lamp emits UV-radiation

H.8.1



The symbol in H.8.2 should be used for new products. It is under consideration to remove the symbol in H.8.1 in a future revision of this document.

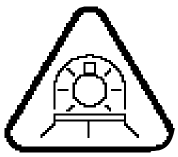
H.8.2



IEC 60417-6040:2010-08

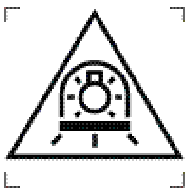
H.9 Symbol indicating that the lamp shall be operated only in a luminaire with a protective shield

H.9.1



The symbol in H.9.2 should be used for new products. It is under consideration to remove symbol in H.9.1 in a future revision of this document.

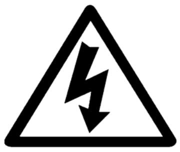
H.9.2



IEC 60417-6071:2011-09

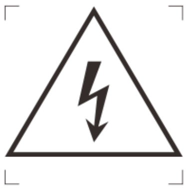
H.10 Symbol indicating dangerous voltage

H.10.1



The symbol in H.10.2 should be used for new products. It is under consideration to remove the symbol in H.10.1 in a future revision of this document.

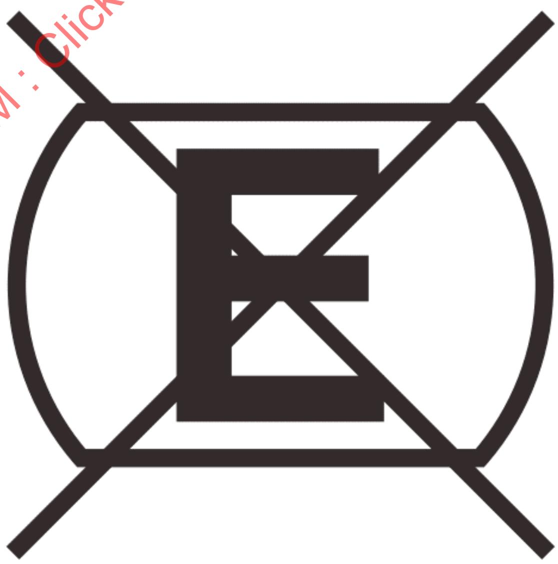
H.10.2



IEC 60417-6042:2010-11

H.11 Pictogram for instruction "Non-ECE"

The pictogram for instruction according to Figure H.1 indicates: “This product is not intended for use in applications where a light source approved (E-marked) to a UN regulation (R37, R99 and R128) is required."



IEC 60417-6362:2016-04

Figure H.1 – Pictogram for instruction "Non-ECE"

H.12 Pictogram for instruction "Interior lighting only"

The pictogram for instruction according to Figure H.2 indicates: "This product is for vehicle interior lighting only".

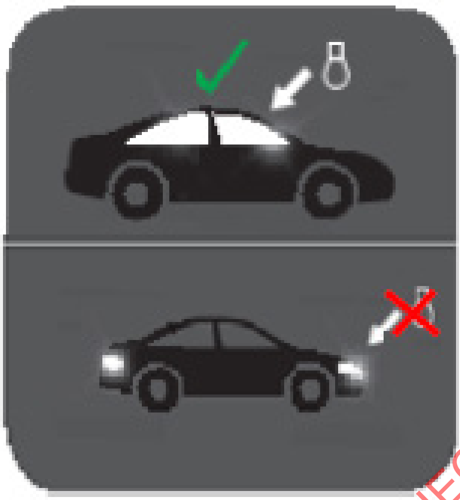


Figure H.2 – Pictogram for instruction "Interior lighting only"

Annex I
(normative)

Luminous flux maintenance test conditions for LED light sources

I.1 Ageing

LED light sources shall be aged at their test voltage for 48 h under the operating conditions specified in I.3. LED light sources which fail during the ageing period shall be omitted from the test results.

I.2 Test voltage

~~Measurements~~ Tests shall be carried out at a test voltage of:

- ~~6,75 V for products intended for a 6 V board voltage;~~
- 13,5 V for signal light sources and 13,2 V for front lighting light sources, for products intended for a 12 V board voltage;
- 28 V for products intended for a 24 V board voltage.

The applied voltage shall be a stable direct current.

If the LED light source is intended to be operated by an electronic light source controlgear, the test voltage shall be applied to the input terminals of the controlgear. In this case, the output of the electronic light source controlgear, for example voltage, electrical current, power, operating mode shall be described in the test report.

NOTE The test voltage is deemed to be stable when the momentary fluctuations do not exceed 1 % and the deviation of the average over the test period does not exceed 0,5 % of the specified value.

I.3 Operating conditions

I.3.1 Test rack

LED light sources shall be operated on a vibration-free test rack.

I.3.2 LED light sources with integrated thermal management

LED light sources with integrated thermal management shall be installed in a chamber with the following characteristics:

- well-mixed air, but no excessive forced convection across the light source;
- ambient air temperature in the chamber: 25 °C ± 10 °C.

I.3.3 LED light sources with external thermal management

LED light sources, for which the thermal management is intended to be achieved in conjunction with the luminaire/device or a separate thermal management component, shall be operated at the specified base temperature T_p. The base temperature T_p shall be included in the test report and shall be part of the luminous flux maintenance declaration by the manufacturer.

NOTE Control of the T_p temperature during testing can be achieved by active or passive methods for example a heat-sink, a heat-sink combined with a cooling fan or a Peltier-cooling-element.

Examples of possible product data are given in Table I.1.

Table I.1 – Examples of possible product data

Type	$L_{70}T_{c}$ h	$L_{70}B_{10}$ h
Product designation at T_{p} = 100 °C	2 500	1 500
Product designation at T_{p} = 70 °C	3 500	2 500

I.4 Switching cycle

I.4.1 Single-function LED light sources

I.4.1.1 LED light sources for continuous operation

LED light sources shall be switched off twice daily for periods of not less than 15 min, such periods not being considered as part of the life.

I.4.1.2 LED light sources for intermittent operation

LED light sources for intermittent operation as used in direction indicators shall be operated in the following switching cycle:

- 115 min continuous on or flashing, as appropriate;
- 5 min off;
- flashing frequency: 90/min; on/off ratio 1:1.

The whole flashing operation time is considered as life.

I.4.2 Dual-function LED light sources for headlamps

The functions shall be operated alternately according to the following cycle and starting with the lower beam function:

- passing-beam function: 15 h on/45 min off;
- driving-beam function: 7,5 h on/45 min off.

The lifetime values for the light source are determined by the lower performing of the two functions.

The off periods are not considered as part of the life.

NOTE The operation of the passing-beam function represents two-thirds of the total life, the operation of the driving-beam function one-third.

I.4.3 Multiple-function LED light sources for light signalling equipment

Luminous flux maintenance testing may be carried out either for each function separately, or with all functions operated simultaneously or with the functions operated alternately.

In the case of an alternate operation, each function shall be operated with a minimum on-period of 10 h.

If different operating conditions (e.g. dimming) are used for the same LED light source in order to fulfil different functions, luminous flux maintenance testing may be carried out at the most onerous conditions.

For LED light sources for continuous operation, the switching cycle shall be as specified in I.4.1.1.

For LED light sources for intermittent operation, the switching cycle shall be as specified in I.4.1.2.

I.5 Luminous flux maintenance measurements

Tests may be interrupted for the determination of the luminous flux maintenance.

Luminous flux maintenance measurements should be carried out at regular intervals, at a ~~minimum~~ maximum time interval of 1 000 h.

For the measurement of the luminous flux, an integrating method shall be used. The LED light source shall be operated in a dry and still atmosphere at an ambient temperature of 23 °C ± 5 °C.

LED light sources, for which the thermal management is intended to be achieved by additional provisions, shall be operated at the specified performance temperature T_p.

Measurements shall be carried out when photometric stability has occurred.

The moment at which the photometry is stable is defined as the point in time at which the variation of the photometric value is less than 3 % within any 15 min period.

I.6 Colour measurement

The colour of the emitted light shall be measured, using an integrating method, at the same time as the luminous flux maintenance measurements and under the same conditions as specified in I.5.

The colour shall be expressed in CIE-coordinates and shall remain within the respective colour boundaries as given in 4.4.1 of IEC 60809:2014 (for colour specification, see also UN Regulation R48~~, Subclause 2.28~~ Revision 12:2014, 2.29).

If the colour of the emitted light has shifted outside the respective colour specification, the light source shall be considered to have failed and the luminous flux maintenance test shall be stopped.

If the colour of the emitted light is produced by a combination of light source radiation and secondary optics, all colour measurements shall be carried out with secondary optics.

In this case, the optical properties of the secondary optics shall be described in the test report.

Annex J
(normative)

Destructive physical analysis for LED packages

J.1 Description

The purpose of this examination is to determine the capability of a LED package's internal materials, design, and workmanship to withstand forces induced by various stresses induced during environmental testing.

J.2 Equipment

The following equipment is required:

a) optical microscope having magnification capability of up to 50X;
b) de-capsulation equipment.

J.3 Procedure

The following procedure shall be followed:

a) LED packages selected for this test shall have successfully completed environmental testing as ~~defined in 8.6.4 or 8.6.5 (TMCL test and WHTOL test)~~ listed in 8.6.9. (PTMCL test, WHTOL test, H2S and FMGC test).
b) The LED packages shall be opened or de-capsulated in order to expose the internal die/substrate and determine the extent of any mechanical damage. An additional cross sectional cut through chip interconnect (chip/glue/leadframe) may be performed for the validation of corrosion stability. The cross sectional cut shall be done after the LED package is de-capsulated. The process used to de-capsulate the LED package shall ensure that it does not cause degradation of the leads and bonds. The internal die or substrate shall be completely exposed and free of packaging material.
c) The LED packages shall be examined under a magnification of up to 50X to the criteria listed in J.4.
d) Failed LED packages shall be analysed to determine the cause of the failure. A failure analysis report documenting this analysis shall be prepared on all failures. If the analysis shows that the failure was caused by the package opening process, the test shall be repeated on a second group of LED packages.

J.4 Failure criteria

LED packages shall be considered to have failed if they exhibit any of the following:

a) visible evidence of non-conforming to the LED packages' certificate of design, construction and qualification;
b) visible evidence of corrosion, contamination, delamination or metallization voids;
c) visible evidence of die/substrate cracks or defects;
d) visible evidence of wire, die, or termination bond defects;
e) visible evidence of dendrite growth or electromigration.

Annex K
(informative)

Communication sheet LED package testing

SUBJECT: LED package stress test qualification according to IEC 60810

DEVICE:		**Report No.:**	
Family package:		**Date:**	

Key product data: [Reference to applicable product specification sheet]

nominal drive current I_f

minimum drive current I_f

maximum drive current I_f

mininum operating temperature $T_{s,\ min}$

maximum operating temperature $T_{s,\ max}$

$R_{th,electr.}$ (typical) and $R_{th,electr.}$ (maximum)

TEST PERFORMED	CONDITION	DURATION/ TEST REPEATS	SAMPLE SIZE	FAILURES		
				Electrical	Photometrical	Visual
8.6.3 High temperature operating life (HTOL) *JESD22-A108D*	T_S = __°C I_F = __ mA T_S = __°C I_F = __ mA	1 000 h	3 x 26			
8.6.4 Temperature cycling (TMCL) ~~*JESD22-A104D*~~ *JESD22-A104E*	Preconditioning: JEDEC level __ TMCL condition _ -__°C/+___°C __min each extreme Transfer time __ s	1 000 cycles	3 x 26			
8.6.5 Wet high temperature operating life – minimum rated drive current (WHTOL) *JESD22-A101C*	Preconditioning: JEDEC Level __ T_S = 85°C, RH= 85 %; I_F = __ mA $t_{on\ /\ off}$ = 30 min	1 000 h	3 x 26			
8.6.6 Power temperature cycling (PTMCL) *JESD22-A105C*	Preconditioning: JEDEC level __ PTMCL condition _: -__/+___°C I_F = __ mA $t_{on\ /\ off}$ = 5 min	1 000 h	3 x 26			

TEST PERFORMED	**CONDITION**	**DURATION/ TEST REPEATS**	**SAMPLE SIZE**	**FAILURES**		
				Electrical	Photometrical	Visual
8.6.7 Electrostatic discharge (ESD-HBM) *JS-001-2012*	Human body model 8 000 V		3 x 26			
8.6.8 Electrostatic discharge (ESD-MM) *JESD22-A115C*	Machine model 400 V		3 x 26			
8.6.10 Physical dimension (PD)	According to data sheet		3 x 26			
8.6.11 Vibrations variable frequency (VVF) *JESD22-B103B*	**Constant displacement:** 1,5 mm (20 Hz to 100 Hz) **Peak acceleration:** 200 m/s^2 (100 Hz to 2 000 Hz) Duration one cycle: ≥ 4 min Cycles per axis: 4 Number of axes: 3 (X;Y;Z)	1x	3 x 26			
8.6.12 Mechanical shock (MS) *JESD22-B110B*	**Shock type:** Half sinus **Max. acceleration:** 1 500 g **Shock duration:** 0,5 ms **Number of shocks:** 5 in each direction **Number of directions:** 6 (±X, ±Y, ±Z) → 30 shocks total	1x	3 x 26			
8.6.13 Resistance to soldering heat (RSH-TTW) *JESD22-B106D*	TTW-soldering	3x	3 x 26			
8.6.14 Resistance to soldering heat (RSH-reflow) *JESD22-A113F*	Reflow soldering 260 °C	3x	3 x 26			
8.6.15 Solderability (SO) *IEC ~~60068-2-20~~ 60068-2-58*	~~Wetting 245 °C, 3 s Dewetting 260 °C, 10 s~~ Process temperature group __	1x	~~1x11~~ 3 x 10			
8.6.16 Thermal shock (TMSK) *JESD22-A106B*	TMSK condition _: -__°C/+___°C (liquid-to-liquid)	1 000 cycles	3 x 26			
8.6.17 Hydrogen sulphide (H2S) *IEC 60068-2-43*	T_A = 40 °C RH = 90 % 10 – 15 × 10^{-6} H_2S	336 h	3 x 26			
8.6.18 Pulsed operating life (PLT) *JESD22-A108D*	T_S = 55 °C I_F = __ mA t = 100 µs; D = 3 %	1 000 h	3 x 26			

TEST PERFORMED	CONDITION	DURATION/ TEST REPEATS	SAMPLE SIZE	FAILURES		
				Electrical	Photometrical	Visual
8.6.19 Dew test (DEW) ~~*JESD22-A100C*~~	$T_{A\,min}$ = 30 °C – 65 °C Time at 65 °C __h RH = 90 % to 98 %;	1 008 h	3 x 26			
8.6.20 Flow mixed gas corrosion (FMGC) *IEC 60068-2-60*	Test method 4 T_A = 25 °C RH = 75 %	500 h	3 x 26			

TEST PERFORMED	SAMPLE SIZE	C_{pk} VALUE
8.6.21 Wire bond pull test (WBP) *MIL-STD 883E*		
8.6.22 Bond shear test (BS) *JEDEC STD22-B116*		
8.6.23 Die shear test (DS) *MIL-STD 883E*		

<u>Failure criteria:</u>

Electrical: V_f (I_f (nominal) = __ mA) >__ V; ±10 % from initial value

Photometrical:

- Radiant power/luminous flux: I_v (I_f (nominal) = __ mA) absolute limit: ± __% max.
- Colour coordinates: x (I_f (nominal) = __ mA) < 0,01

  y (I_f (nominal) = __ mA) < 0,01

Visual: e.g. broken or damaged package or leads

Conclusion: **The tested devices fulfil the reliability requirements.**

Annex L
(normative)

Re-testing matrix for LED packages testing

~~Table L.1 specifies retesting requirements for product/process changes~~

~~NOTE Table L.1 was developed based on the ZVEI document.~~

~~**Table L.1 – Retesting matrix**~~

Legend:

X = Test is recommended
C = Test is recommended based on LED type and risk assesement
na = not applicable for this change

* This test only applies to LED packages that are declared to be solderable by wave soldering by the manufacturer
**This test applies only to LED packages that are specified for reflow soldering

Category	Subcategory	Type of Change	8.6.3 High Temperature Operating Life (HTOL)	8.6.4 Temperature Cycling (TMCL)	8.6.5 Wet High Temperature Operating Life (WHOTL)	8.6.6 Power Temperature Cycling (PTMCL)	8.6.7 Electrostatic Discharge Human Body Model (ESD-HBM)	8.6.8 Electrostatic Discharge Machine Model (ESD-MM)	8.6.10 Physical Dimensions (PD) of LED package	8.6.11 Vibrations Variable Frequency (VVF)	8.6.12 Mechanical Shock (MS)	8.6.13 Resistance to Soldering Heat (RSH-TTW) *	8.6.14 Resistance to Soldering Heat (RSH-reflow) **	8.6.15 Solderability (SO)	8.6.16 Thermal Shock (TMSK)	8.6.17 Hydrogen Sulphide (H_2S)	8.6.18 Pulsed Operating Life (PLT)	8.6.19 DEW Test (DEW)	8.6.20 Flow Mixed Gas Corrosion (FMGC)
Design		Design changes in active elements	X	na	X	X	X	X	na	na	na	na	na	na	na	na	X	X	na
Design		Design changes in routing	X	X	X	X	na	na	na	na	na	X	X	na	X	X	X	X	X
Design		LED package	X	X	X	X	na	na	X	X	X	X	X	X	X	X	C	X	X
		LED Chip size / shrink	X	X	X	X	X	X	na	na	na	X	X	na	na	na	X	na	na
Process – Wafer Production	New Material	Wafer substrate material	X	C	C	X	C	C	na	na	na	X	X	na	C	C	X	C	C
Process – Wafer Production	New Material	Wafer diameter	X	na	X	na	C	C	na	na	na	X	X	na	na	na	X	na	na
~~Process – Wafer Production~~	~~New Material~~	~~Final wafer thickness~~	~~X~~	~~X~~	~~na~~	~~X~~	~~C~~	~~C~~	~~na~~	~~na~~	~~na~~	~~na~~	~~na~~	~~na~~	~~na~~	~~na~~	~~X~~	~~na~~	~~na~~
Process – Wafer Production	New Material	Electrical active doping / implantation element	X	na	C	na	C	C	na	na	na	na	na	na	na	na	X	na	na
Process – Wafer Production	New Material	Oxide / dielectrics	X	na	X	X	C	C	na	na	na	na	na	na	na	na	X	C	na
Process – Wafer Production	New Material	Metallization (chip frontside)	X	X	X	X	C	C	na	na	na	na	na	na	X	X	X	X	X
Process – Wafer Production	New Material	Metallization (chip backside)	X	X	X	X	C	C	na	na	na	X	X	na	X	X	X	X	X
Process – Wafer Production	New Material	Passivation / die coating	X	X	X	C	C	C	na	na	na	na	na	na	na	C	na	C	C
Process – Wafer Production		Change in process technique	C	C	C	C	na	na	na	na	na	na	na	na	C	C	C	C	C
Process – Wafer Production		Change of material supplier with impact on agreed specifications	X	na	na	X	na	na	na	na	na	X	X	na	na	na	X	na	na
Process – Assembly	New Material	Package	C	X	C	C	na	na	X	C	C	X	X	na	C	C	na	C	C
Process – Assembly	New Material	Leadframe base material	na	X	X	C	na	na	na	na	na	X	X	X	C	X	na	C	X
Process – Assembly	New Material	Leadframe finsihing material	na	X	X	X	na	na	na	na	na	X	X	X	C	X	na	C	X
Process – Assembly	New Material	Die attach material	X	X	X	X	na	na	na	C	C	X	X	na	C	X	na	C	X
Process – Assembly	New Material	Bond wire material	X	X	C	X	na	na	na	C	C	X	X	na	C	C	X	na	C
Process – Assembly	New Material	LED package susbtrate (BGA)	C	X	X	C	na	na	na	na	na	X	X	X	C	X	na	C	X
Process – Assembly	New Material	Phosphor material / architecure	X	C	X	X	na	na	na	C	C	X	X	na	C	C	na	C	C
Process – Assembly	New Material	Mould compund, encapsulation / sealing material	X	X	X	C	na	na	na	na	na	X	X	X	C	X	na	C	X
Process – Assembly		Change in process technique (e.g. die attach, bonding, plating, ...)	X	X	X	C	na	na	na	C	C	C	C	na	C	C	C	C	C
Process – Assembly		Change of material supplier with impact on agreed specifications	X	X	X	C	na	na	na	na	na	X	X	C	C	C	na	C	C
Logistics / Capacity / Testing	Equipment	Production from a new equipment / tool uses a different technology	C	X	C	C	na	na	na	na	na	X	X	C	C	na	na	na	na
Logistics / Capacity / Testing	Equipment	Production from a new equipment / tool uses same basic technology	na	C	C	C	na	na	na	na	na	na	na	C	C	na	na	na	na
Logistics / Capacity / Testing	Equipment	Change in the final testing equipment type use of a different technology	na	na	na	C	X	X	na	na	na	na	na	C	na	na	C	na	na
Logistics / Capacity / Testing	Process flow	Move of all or part of wafer fab to a different and not previously released location/ site / subcontractor	X	X	X	C	X	X	na	na	na	X	X	na	C	na	X	na	na
Logistics / Capacity / Testing	Process flow	Move of all or part of assembly to a different and not previously released location/ site / subcontractor	X	X	X	C	C	C	C	C	C	X	X	C	C	X	na	C	C

For product and/or process changes the ZVEI Guideline "Guideline for Customer Notifications of Product and/or Process Changes (PCN) of Electronic Components specified for Automotive Applications" including the DeltaQualificationMatrix (DeQuMa) shall be applied.

Annex M
(informative)

Guidelines for LED packages robustness validation

M.1 General

Annex M[3] gives guidance on a robustness validation procedure for LED packages.

The purpose of these guidelines is to show procedures that can give relevant information on the degradation of LED packages under over-stress conditions, and to give guidance on using this information in combination with acceleration models to predict the degradation behaviour and the time-to-failure under typical application conditions. During the testing, the stress level is increased beyond the specification limit of the LED package until significant degradation is observed. The failures over time under over-stress conditions are recorded. In addition, the degradation modes are investigated by using a non-destructive and destructive physical analysis (DPA). By combining the measured failure rates for each degradation mode under over-stress conditions with relevant acceleration models, information can be obtained on the expected degradation over time under use conditions in automotive lighting applications.

NOTE It is not possible to develop acceleration models for all over-stress conditions, for example when no significant degradation is observed.

“Robustness testing”, according to this document, is defined as over-stress testing beyond the product specification limits until significant degradation is observed.

“Moderate overstress testing”, according to this document, is defined as the subset of this information that can be combined with models to make predictions about the lifetimes and failure rates under real application conditions within the product specification limits.

Figure M.1 shows the basic over-stress testing concept for two stress parameters.

3 The procedure of robustness validation is derived from a similar approach developed by the ZVEI (Requirements and test conditions for LED packages, November 2012, Revision 1.9)

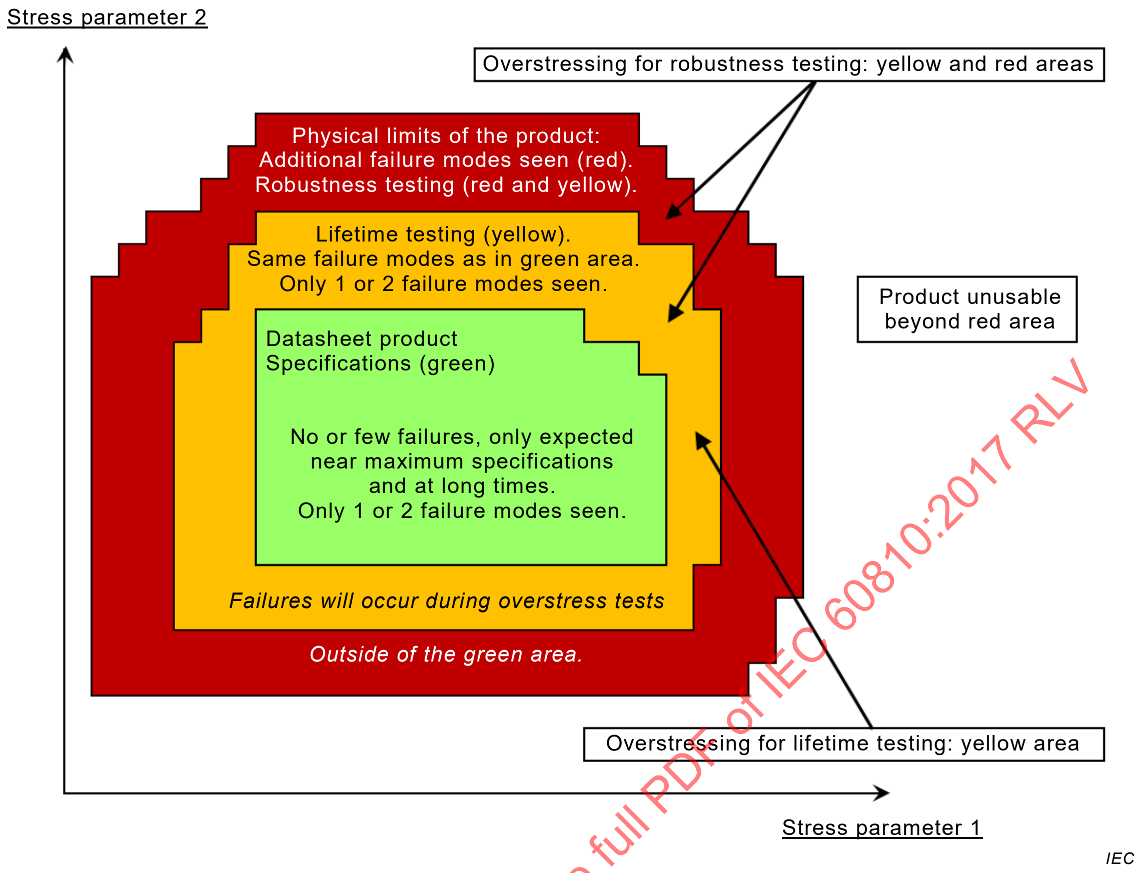


Figure M.1 – Concept of over-stress testing for two stress parameters

The "moderate overstress testing" parametric area (yellow) is such that the degradation modes observed are the same ones as seen in the "product specification" area, and/or are relevant to operation immediately beyond it.

Beyond the "moderate overstress testing" parametric area (red and beyond), new degradation modes are observed, and special considerations need to be taken so that acceleration models and the lifetime estimates are still representative of the automotive use conditions within or near the boundaries of the product specification.

Figure M.2 shows a flow diagram for the robustness validation process.

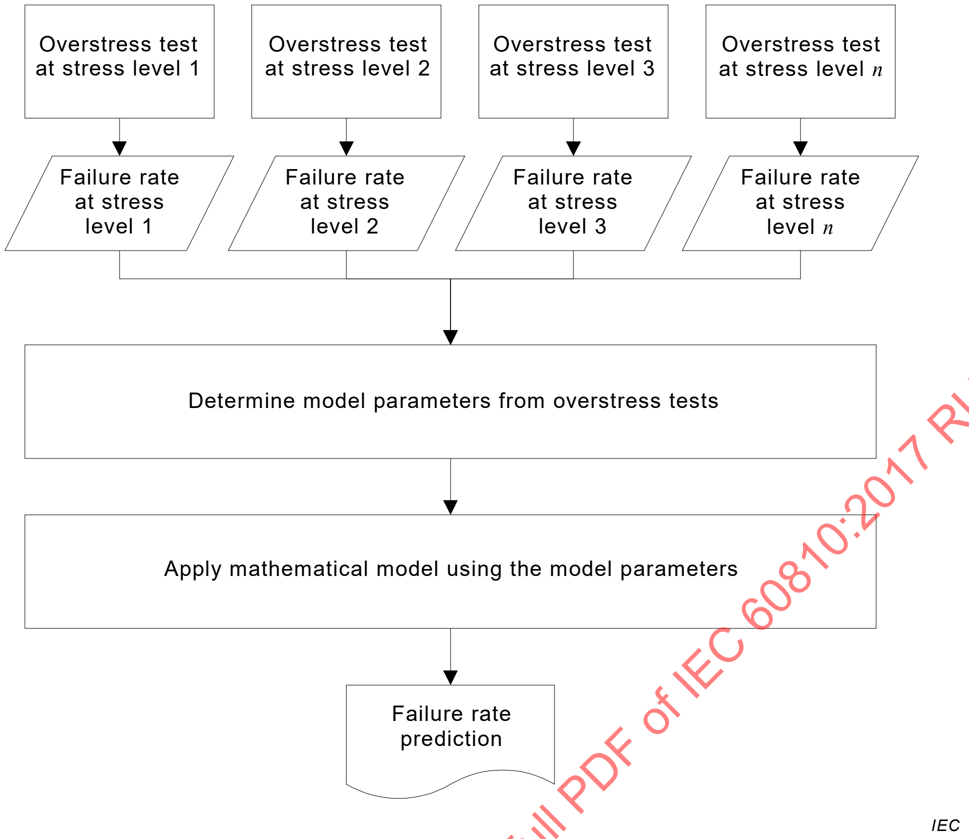


Figure M.2 – Flow diagram for the robustness validation process

Clause M.5 defines a set of over-stress tests that should be considered for robustness validations for new LED packages.

Clause M.7 gives relevant mathematical models.

Where appropriate, family robustness validation may be done and a rationale should be given by the supplier. For family definition, see 8.1.

For product and/or process changes the ZVEI Guideline including the DeltaQualificationMatrix (DeQuMa) "Guideline for Customer Notifications of Product and/or Process Changes (PCN) of Electronic Components specified for Automotive Applications" should be applied.

This document makes reference to other IEC standards or standards from other organizations (e.g. JEDEC). Where relevant, further details on the test definitions can be found in these documents. Test conditions in this document may deviate from test conditions in the reference documents. In such a case, further definitions in the reference document should still be applied as appropriate.

M.2 Test samples

M.2.1 Lot requirements

Unless specified otherwise, a minimum of 30 LED packages taken from three different batches of 10 each should be used for each test and for each over-stress condition. For family qualification, the three different batches should be considered to represent the whole variety of the qualification family.

The sample size may be reduced due to capacity constraints or experimental limitations. The reason(s) for sample size reduction should be provided with the report.

M.2.2 Production requirements

All LED packages should be produced on tooling and processes at the manufacturing site that will be used to support LED package deliveries at projected production volumes. Alternatively, laboratory samples from the latest phase of development may be used; this should be documented in the test report.

M.2.3 Pre- and post-stress test requirements

Electrical and photometric values (forward voltage, luminous flux or radiant power and/or intensity, colour parameter) should be measured before and after stress testing (see also M.5.1).

NOTE A simple light/no light test is under consideration for testing at different temperatures.

Where possible, the LED packages used for the robustness validation should meet the product specification parameters measured at the nominal test conditions before over-stress testing.

M.2.4 Assembly of LED packages on test boards

LED packages may need to be assembled on test boards. An appropriate choice of test board, interconnect material and process should be made by the manufacturer. The choice of test board, interconnect material and process should be documented for each individual test in the test report.

M.3 Definition of end-of-test criteria

The LED manufacturer should define end-of-test criteria and report these with a justification. Typical testing time is 1 500 h to 2 000 h. Testing beyond 3 000 h is not recommended. In case of physical damage, this should be documented by means of DPA.

M.4 Test sequence of over-stress testing

For each over-stress test, tests should be carried out at different stress levels. Each stress test should be carried out on separate samples. One stress level should be inside (or on the border of) the product specification, i.e. it should be the same as for the qualification test; then the stress level should be increased step-by-step beyond the product specification.

It is recommended to choose at least three over-stress levels per stress parameter within the “moderate-overstress testing” (yellow) area (see Figure M.1). For robustness validation, additional stress levels may be chosen within the “robustness testing” (yellow and red areas), until at least 30 % of the tested parts have failed the criteria or a typical testing time of 1 500 h to 2 000 h is reached.

Table M.1 shows an over-stress matrix for two stress parameters in the case where no knowledge on the potential degradation mechanism exists. In that case, it is recommended to evaluate this comprehensive test matrix to study end of life versus stress level. If experience with potential degradation mechanism of this LED family exists, only a subset of tests is required.

Table M.1 – Typical over-stress matrix for two stress parameters

	Stress 2 →				
Stress 1 ↓	Stress 2 level 1 (inside specification)	Over-stress 2 level 2	Over-stress 2 level 3	Over-stress 2 level 4	Over-stress 2 level *n*
Stress 1 level 1 (inside specification)	0				
Over-stress 1 level 2		1	1	1	
Over-stress 1 level 3		1	1	1	2
Over-stress 1 level 4		1	1	1	2
Over-stress 1 level *n*			2	2	2

Key

"0" (green) = no failures (within the green "product specification" area in Figure M.1).

"1" (yellow) = some failures (within the yellow "moderate overstress testing" area in Figure M.1), investigating relevant degradation modes for acceleration of application use conditions.

"2" (red) = significant failures (red area, near or beyond physical limit of the product in Figure M.1), investigating the physical boundaries in more detail.

M.5 Over-stress test definition

M.5.1 Pre- and post-electrical and photometric test

All LED packages should be tested at nominal or maximum or stress drive current according to the following requirements of the appropriate LED package specification (manufacturer's datasheet) prior to and after the following tests:

- luminous flux or radiant power or intensity (whichever is appropriate);
- forward voltage;
- colour coordinates x,y or dominant wavelength λ_d or peak wave length λ_p (whichever is appropriate).

In addition, the forward voltage at the minimum (or lower) current should be recorded.

The nominal drive current should be defined by the LED package supplier; typically this is the drive current used for LED binning.

M.5.2 Pre- and post-external visual (EV) test

The construction, marking and workmanship of the LED package should be inspected according to JESD22-B101B prior to and after the following tests.

M.5.3 High temperature operating life (HTOL) and low temperature operating life (LTOL) tests

The purpose of this test is to evaluate the performance of the LED package under stress due to high temperature operation. The test should be conducted according to JESD22-A108D; the following test conditions apply:

- typical duration 2 000 h;
- over-stress parameters: T_j, I_f.

As part of the robustness investigation, the following HTOL over-stress conditions should be tested for a minimum of 1 500 h:

- $T_j = T_{j,max} + 15$ K for high-power (≥ 1W rated power) LED packages
- $T_j = T_{j,max} + 30$ K for mid-power (< 1W rated power) LED packages
- $I_f = 125$ % $I_{f,max}$ mA for high-power (≥ 1 W rated power) LED packages
- $I_f = 150$ % $I_{f,max}$ mA for mid-power (< 1 W rated power) LED packages
- 78 LED packages taken from three different batches (production lot) of 26 each should be used.
- For all surface mount solder reflowable: preconditioning according to JESD22-A113F followed by three Pb-Free reflow solder cycles. Reflow cycles should be completed between 15 min and 4 h after preconditioning is completed.

As part of the robustness investigation, the following LTOL over-stress condition should be tested for a minimum of 1 500 h:

- $T_{ambient}$ = -40 °C
- $I_f = 125$ % $I_{f,max}$ mA for high-hower (≥ 1 W rated power) LED packages
- $I_f = 150$ % $I_{f,max}$ mA for mid-power (< 1 W rated power) LED packages
- 78 LED packages taken from three different batches (production lot) of 26 each should be used.
- For all surface mount solder reflowable: preconditioning according to JESD22-A113F followed by three Pb-Free reflow solder cycles. Reflow cycles should be completed between 15 min and 4 h after preconditioning is completed.

M.5.4 Temperature cycling (TMCL) test

The purpose of this test is to evaluate the performance of the LED package under stress due to temperature cycles without operation of the LED. The LED package should be tested according to JESD22-A104E; the following test conditions apply:

- Typical duration: 1 000 cycles.
- Recommendation: soak mode 4, with soak time 15 min and transfer time 15 min.
- $T_{s,max}$ and $T_{s,min}$ combinations are listed in Table 1 of JESD22-A104E. Other $T_{s,max}$ and $T_{s,min}$ combinations than the ones specified in Table 1 of JESD22-A104E (test conditions A to N) may be considered.
- Over-stress parameters: $T_{s,max}$, $T_{s,min}$, transfer rate.

The choice of the TMCL cycle condition and the transfer time should be reported.

M.5.5 Wet high temperature operating life (WHTOL) test

The purpose of this test is to evaluate the performance of the LED package under stress due to temperature and humidity. The LED package should be tested according to JESD22-A101C. The following test conditions apply:

- Typical duration: 2 000 h.
- The LED should be operated either continuously DC or with a power cycle of 30 min on/30 min off (power duty factor = 50 %).
- Other currents, chamber temperatures, and chamber relative humidities (RH) or moisture contents (MC)[4], with or without a power cycle, may be chosen to develop WHTOL models. All other test provisions should be in accordance with JESD22-A101C.

[4] Absolute humidity absorbed by the LED package.

- Efforts should be made to estimate the relative humidty (RH) and/or moisture content (MC) values near the LED during the power-on and during the power-off cycles.
- The tests should be performed at the minimum and maximum rated drive currents corresponding to the T_j of the LED during the power-on operation.
- Over-stress parameters: $RH_{chamber}$ or $MC_{chamber}$, I_f, $T_{chamber}$, power duty factor.

As part of the robustness investigation, the following over-stress conditions should be tested for a minimum of 1 500 h:

- 85 °C / 85 % RH ambient
- I_f = 125 % $I_{f,max}$ mA for high-power (≥ 1W rated power) LED packages
- I_f = 150 % $I_{f,max}$ mA for mid-power (< 1W rated power) LED packages
- 78 LED packages taken from three different batches (production lot) of 26 each should be used.
- For all surface mount solder reflowable: preconditioning according to JESD22-A113F followed by three Pb-Free reflow solder cycles. Reflow cycles should be completed between 15 min and 4 h after preconditioning is completed.

M.5.6 Power temperature cycling (PTMCL) test

The purpose of this test is to evaluate the performance of the LED package under stress due to temperature cycles during operation of the LED package. The LED package should be tested according to JESD22-A105C; the following test conditions apply:

- Typical duration: 1 000 temperature cycles.
- Power cycle 5 min on/5 min off operated at the corresponding maximum rated drive current.
- Other $T_{s,max}$ than the ones specified in Table 1 of JESD22-A105C (test conditions A and B) may be chosen.
- Over-stress parameters: $T_{s,min}$, $T_{s,max}$, I_f, transition time, dwell time.
- $T_{j,min}$ and $T_{j,max}$ should be reported for both on and off cycles.

As part of the robustness investigation, the following over-stress conditions should be tested for 1 500 temperature cycles:

- $T_{s,min}$ = -40 °C; $T_{s,max}$ = 125 °C
- 10 min dwell, 20 min transfer (1 h cycle)
- 2 min on/2 min off
- I_f = 130 % $I_{f,max}$ mA for high-power (≥ 1W rated power) LED packages
- I_f = 150 % $I_{f,max}$ mA for mid-power (< 1W rated power) LED packages
- 78 LED packages taken from three different batches (production lot) of 26 each should be used.
- For all surface mount solder reflowable: preconditioning according to JESD22-A113F followed by three Pb-Free reflow solder cycles. Reflow cycles should be completed between 15 min and 4 h after preconditioning is completed.

M.5.7 Thermal shock (TMSK) test

The purpose of this test is to evaluate the performance of the LED package under stress due to thermal shock. The LED package should be tested according to JESD22-A106B (or IEC 60068-2-14). The following conditions should apply:

- typical duration: 1 000 cycles;
- over-stress parameters: $T_{s,min}$, $T_{s,max}$;

- one (or both) of the options below should be chosen:
- Option 1: liquid to liquid. Other $T_{s,max}$ and $T_{s,min}$ combinations than the ones specified in Table 1 of JESD22-A106B (test conditions A to D) may be chosen,
- Option 2: air to air. Other $T_{s,max}$ and $T_{s,min}$ combinations may be chosen. A typical air-to-air test test condition is: $T_{s,max}$ = 125 °C, $T_{s,min}$ = -40 °C, soak time 30 min, transfer time 10 s.

As part of the robustness investigation, the following over-stress conditions should be tested for 3 000 cycles:

- $T_{s,min}$: -55 °C; $T_{s,max}$: 150 °C
- 10 s transfer
- Dwell time 15 min
- 78 LED packages taken from three different batches (production lot) of 26 each should be used.
- For all surface mount solder reflowable: preconditioning according to JESD22-A113F followed by three Pb-Free reflow solder cycles. Reflow cycles should be completed between 15 min and 4 h after preconditioning is completed.

M.6 Destructive physical analysis (DPA) test

The purpose of this test is to evaluate the degradation mechanisms induced by the stresses during environmental over-stress testing.

The DPA analysis is used to identify the degradation mechanism and to determine if the degradation mode is application related or not (see also Figure M. 1).

Guidance for DPA is given in Annex J. DPA should be performed on random samples of failed units after completion of the over-stress tests (minimum two samples). The post electrical and photometrical test of these samples should be executed before the destructive physical analysis.

M.7 Projection models

The following models are available to calculate the acceleration factors, see Table M.2.

NOTE The formulae in Clause M.7 assume X-stress > X-use (where X = T, I_f or ES, RH or MC, T_{max}-T_{min}, cycle time), and are written consistently such that a + sign is always in front of power and exponential exponents.

The models shall always use the corresponding T_j (the LED junction temperature, in K) to calculate the LED's optical and electrical properties. Modelling of solder joints or of package mechanical properties shall use T_c or T_s (in K) instead.

Table M.2 – Acceleration models

Stress test	Model	Acceleration factor equation
HTOL	Arrhenius and (inverse) power law	$AF = (\frac{If\ stress}{If\ use})^{+n} \times e^{+\frac{Ea}{k}(\frac{1}{Tuse} - \frac{1}{Tstress})}$
HTOL Note: NOTE 1 $n \neq 0$ when photo-thermal and electro-chemical effects are present, which is very often the case. $n = 0$ when these effects are not significant, and for storage tests (where $I_f = 0$).		
TMCL, TMSK	Coffin-Manson	$AF = (\frac{T_{max} - T_{min}\lvert stress}{T_{max} - T_{min}\lvert use})^{+q}$
	Norris-Landzberg	$AF = (\frac{Cycle\ Time_{stress}}{Cycle\ Time_{use}})^{+p} \times (\frac{T_{max} - T_{\min stress}}{T_{max} - T_{\min use}})^{+q} \times e^{+\frac{Ea}{k}(\frac{1}{Tmax\ use} - \frac{1}{Tmax\ stress})}$
	Engelmaier	$AF = (\frac{DeltaD_{use}}{DeltaD_{stress}})^{+\frac{1}{c}}$ DeltaD = range of angular shear after total joint stress relaxation
WHTOL	Peck	No photo-thermal or electrical effects (applies to wet storage): $AF = (\frac{RH_{stress}}{RH_{use}})^{+r}$ or
		$AF = (\frac{MC_{stress}}{MC_{use}})^{+r}$ See Notes 3 and 5
WHTOL	Peck including current	Same T_j for use and stress: $AF = (\frac{RH_{stress}}{RH_{use}})^{+r} \times (\frac{I_{f,stress}}{I_{f,use}})^{+n}$ See Notes 2 and 3
WHTOL	Peck including current and T_j	T_j use ≠ T_j stress: $AF = (\frac{MC_{stress}}{MC_{use}})^{+m} \times (\frac{I_{f,stress}}{I_{f,use}})^{+n} \times e^{+\frac{Ea}{k}(\frac{1}{T\ use} - \frac{1}{T\ stress})}$ See Notes 3 and 4
WHTOL	Peck-Eyring including current and temperature	RH or MC use ≠ RH or MC stress: $AF = (\frac{I_{f\ stress}}{I_{f\ use}})^{+n} \times e^{+B(\frac{1}{MC\ use} - \frac{1}{MC\ stress})} \times e^{+\frac{Ea}{k}(\frac{1}{T\ use} - \frac{1}{T\ stress})}$ See Note 5

WHTOL Notes: NOTE 2 Electrical exponent $n \neq 0$ when photo-thermal and electro-chemical effects are present, which is very often the case. $n = 0$ when these effects are not significant, and for storage tests (where $I_f = 0$), and for some corrosion tests. NOTE 3 Peck and Peck – Non-thermal formulae are only valid for RH comparisons at about the same T_j (i.e., roughly comparable saturation vapour pressures near the LED), and for high (> 50 %) RH values. At low RH, Peck either does not hold, or holds for r values of a magnitude much smaller than at high RH, so that low RH to high RH comparisons are not well described by Peck. (RH = relative humidity = partial vapour pressure/saturation vapour pressure). NOTE 4 The simultaneous effect of temperature and humidity is often accounted for. For T_j stress different from T_j use, RH-stress corresponds to a very different moisture content (vapour density, closely approximated by partial vapour pressure) than RH use for the same RH. The moisture content is abbreviated above as MC. By using MC instead of RH, the formula can then include the Arrhenius temperature acceleration. NOTE 5 For cases when one wants to compare very different RH or MC conditions, it is better to use an exponential behaviour for humidity, through the use of the temperature-humidity variation of the Eyring relationship, rather than through a(n) (inverse) power law, since as outlined above the value of its exponent r changes dramatically over the range of interest.		
PTMCL	Combination of models	NOTE 6 Model under consideration.
Electrical only	(Inverse) power law	$AF = (\frac{I_{f\ stress}}{I_{f\ use}})^{+n}$ or $AF = (\frac{ES_{\text{stress}}}{ES_{use}})^{+n}$
orThermal only	Arrhenius	$AF = e^{+\frac{Ea}{k}(\frac{1}{T\ use}-\frac{1}{T\ stress})}$ (applies to dry storage or constant current, E_a may depend on current density)
Low-frequency power cycling	Power law	Wherever appropriate for pulsed and power cycling tests of low frequency (power-on pulsed lengths > 1 s to -10 s and/or cycle frequencies < 0,1 Hz to -1 Hz), multiply any of the expressions above by: $AF = (\frac{Duty\ Factor_{stress}}{Duty\ factor_{use}})^{+d}$

Some guidelines for the use of acceleration models include the following.

- Acceleration models useful for lifetime estimates and relevant to customer use conditions should be generated from data where the same degradation modes as the ones occurring in the field are observed ("moderate overstress testing" or yellow zone). Generally, accelerated tests are used to obtain information about one particular, relatively simple degradation mechanism (or corresponding degradation method). If there is more than one degradation mode, it is possible that the different degradation mechanisms will be accelerated at different rates. Then, unless this is accounted for in the modelling and analysis, estimates could be seriously incorrect when extrapolating to lower use-levels of the accelerating variables.
- Accelerating variables should be chosen to correspond with variables that cause actual degradation.
- Previous attempts to obtain acceleration parameters can turn to be similar to the ones of interest. With controlled changes in the principal components, the acceleration parameters will not change significantly. Only one verification test is required to prove identical acceleration parameters.
- Accelerated tests should be designed, as much as possible, to minimize the amount of extrapolation required. High levels of accelerating variables can cause extraneous degradation modes that would never occur at use-levels of the accelerating variables. If

extraneous degradation is not recognized and properly handled, this can lead to seriously incorrect conclusions. Also, the relationship may not be accurate enough over a wide range of acceleration.

- Accelerated test programmes should be planned and conducted by experts knowledgeable about the product and its use environment, the physical, chemical or mechanical aspects of the degradation mode, and the statistical aspects of the design and analysis of reliability experiments.

Bibliography

IEC 60068-2-6, *Environmental testing – Part 2-6: Tests – Test Fc: Vibration (sinusoidal)*

IEC 60068-2-20, *Environmental testing – Part 2-20: Tests – Test T: Test methods for solderability and resistance to soldering heat of devices with leads*

IEC 60068-2-47, *Environmental testing – Part 2-47: Test – Mounting of specimens for vibration, impact and similar dynamic tests*

IEC 60417, *Graphical symbols for use on equipment* (available at http://www.graphical-symbols.info/equipment)

IEC 60682:1980, *Standard method of measuring the pinch temperature of quartz-tungsten-halogen lamps*

IEC 60809:199[5], *Lamps for road vehicles – Dimensional, electrical and luminous requirements*
IEC 60809:1995/AMD5:2012

ISO 2854:1976, *Statistical interpretation of data – Techniques of estimation and tests relating to means and variances*

ISO 2859-1:1999, *Sampling procedures for inspection by attributes – Part 1: Sampling schemes indexed by acceptance quality limit (AQL) for lot-by-lot inspection*

ISO 3534-2, *Statistics – Vocabulary and symbols – Part 2: Applied statistics*

ISO 3951:1989[6], *Sampling procedures and charts for inspection by variables for percent nonconforming*

ISO 5344, *Electrodynamic vibration generating systems – Performance characteristics*

AEC – Q101 Rev C 2005-06, *Stress test qualification for automotive grade discrete semiconductors*

ICNIRP, *Guidelines on Limits of Exposure to Ultraviolet Radiation of Wavelengths Between 180 nm and 400 nm (Incoherent Optical Radiation). Health Physics 87 (2): 171-186; 2004*

United Nations Vehicle Regulations – 1958 Agreement, *Agreement concerning the adoption of uniform technical prescriptions for wheeled vehicles, equipment and parts which can be fitted and/or be used on wheeled vehicles and the conditions for reciprocal recognition of approvals granted on the basis of these prescriptions* (available at www.unece.org/trans/main/wp29/wp29regs.html)

Addendum 98: UN Regulation No. 99, *Uniform provisions concerning the approval of gas-discharge light sources for use in approved gas-discharge lamp units of power-driven vehicles*

5 Withdrawn.

6 Withdrawn.

~~ZVEI, *Guideline for Customer Notifications of Product and /or Process Changes (PCN) of Electronic Components for Automotive Market; 2013*~~

IEC 60810

Edition 5.0 2017-09

INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

Lamps, light sources and LED packages for road vehicles – Performance requirements

Lampes, sources lumineuses et LED encapsulées pour véhicules routiers – Exigences de performances

IEC 60810:2017-09(en-fr)

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

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LAMPS, LIGHT SOURCES AND LED PACKAGES FOR ROAD VEHICLES – PERFORMANCE REQUIREMENTS

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
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International Standard IEC 60810 has been prepared by subcommittee 34A: Lamps, of IEC technical committee 34: Lamps and related equipment.

This fifth edition cancels and replaces the fourth edition published in 2014 and Amendment 1:2017. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

a) update and clarification of the title and scope;
b) introduction of new LED light sources;
c) introduction of requirements for LED light sources;
d) introduction of guidelines on LED package robustness validation for LED packages.

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

FDIS	Report on voting
34A/2021/FDIS	34A/2033/RVD

Full information on the voting for the approval of this International Standard can be found in the report on voting indicated in the above table.

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

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

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

IMPORTANT – The 'colour inside' logo on the cover page of this publication 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.

LAMPS, LIGHT SOURCES AND LED PACKAGES FOR ROAD VEHICLES – PERFORMANCE REQUIREMENTS

1 Scope

This document is applicable to filament lamps, discharge lamps, LED light sources and LED packages to be used in road vehicles, i.e. in headlamps, fog-lamps, signalling lamps and interior lighting. It is especially applicable to those lamps and light sources which are listed in IEC 60809.

It specifies requirements and test methods for the measurement of performance characteristics such as lamp life, luminous flux maintenance, torsion strength, glass bulb strength and resistance to vibration and shock. Moreover, information on temperature limits, maximum lamp outlines and maximum tolerable voltage surges is given as guidance for lighting and electrical equipment design.

For some of the requirements given in this document, reference is made to data given in tables. For lamps not listed in such tables, the relevant data are supplied by the lamp manufacturer or responsible vendor.

The performance requirements are additional to the basic requirements specified in IEC 60809. They are, however, not intended to be used by authorities for legal type-approval purposes.

NOTE 1 In the various vocabularies and standards, different terms are used for "incandescent lamp" (IEC 60050-845:1987, 845-07-04) and "discharge lamp" (IEC 60050-845:1987, 845-07-17). In this document, "filament lamp" and "discharge lamp" are used. However, where only “lamp” is written both types are meant, unless the context clearly shows that it applies to one type only.

NOTE 2 This document does not apply to luminaires.

NOTE 3 In this document, the term LED light source is used, in other standards the term LED lamps can be used to describe similar products.

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. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60050-845, *International Electrotechnical Vocabulary – Part 845: Lighting* (available at http://www.electropedia.org)

IEC 60061-1, *Lamp caps and holders together with gauges for the control of interchangeability and safety – Part 1: Lamp caps*

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

IEC 60068-2-43, *Environmental testing – Part 2-43: Tests – Test Kd: Hydrogen sulphide test for contacts and connections*

IEC 60068-2-58, *Environmental testing – Part 2-58: Tests – Test Td: Test methods for solderability, resistance to dissolution of metallization and to soldering heat of surface mounting devices (SMD)*

IEC 60068-2-60, *Environmental testing – Part 2-60: Tests – Test Ke: Flowing mixed gas corrosion test*

IEC 60809:2014, *Lamps for road vehicles – Dimensional, electrical and luminous requirements*

CISPR 25, *Vehicles, boats and internal combustion engines – Radio disturbance characteristics – Limits and methods of measurement for the protection of on-board receivers*

ISO 7637-2:2011, *Road vehicles – Electrical disturbances from conduction and coupling – Part 2: Electrical transient conduction along supply lines only*

ISO 10605, *Road vehicles – Test methods for electrical disturbances from electrostatic discharge*

United Nations Vehicle Regulations – 1958 Agreement, *Agreement concerning the adoption of uniform technical prescriptions for wheeled vehicles, equipment and parts which can be fitted and/or be used on wheeled vehicles and the conditions for reciprocal recognition of approvals granted on the basis of these prescriptions*
(available at www.unece.org/trans/main/wp29/wp29regs.html)[1]

Addendum 36: Regulation No. 37, *Uniform provisions concerning the approval of filament lamps for use in approved lamp units of power-driven vehicles and of their trailers*

Addendum 47: Regulation No 48, *Uniform provisions concerning the approval of vehicles with regard to the installation of lighting and light-signalling devices*

Addendum 100: Regulation No. 101, *Uniform provisions concerning the approval of passenger cars powered by an internal combustion engine only, or powered by a hybrid electric power train with regard to the measurement of the emission of carbon dioxide and fuel consumption and/or the measurement of electric energy consumption and electric range, and of categories M1 and N1 vehicles powered by an electric power train only with regard to the measurement of electric energy consumption and electric range*

Addendum 122: Regulation No. 123, *Uniform provisions concerning the approval of adaptive front-lighting systems (AFS) for motor vehicles*

Addendum 127: Regulation No. 128, *Uniform provisions concerning the approval of light emitting diode (LED) light sources for use in approved lamp units on power-driven*

JESD22-A101C, *Steady-state temperature humidity bias life test*

JESD22-A104E, *Temperature cycling*

JESD22-A105C, *Power and temperature cycling*

JESD22-A106B, *Thermal shock*

JESD22-A108D, *Temperature, bias, and operating life*

JESD22-A113F, *Preconditioning of plastic surface mount devices prior to reliability testing*

JESD22-A115C, *Electrostatic discharge (ESD) sensitivity testing machine model (MM)*

JESD22-B101B, *External visual*

JESD22-B103B, *Vibration, variable frequency*

[1] Also known as The 1958 Agreement. In the text of this document the regulations under this agreement are referred to as, for example, UN Regulation 37 or R37.

JESD22-B110B, *Mechanical shock*

JESD22-B106D, *Resistance to solder shock for through-hole mounted devices*

JESD22-B116:1998, *Wire Bond Shear Test Method*

JESD51-50:2012-04, *Overview of methodologies for the thermal measurement of single- and multi-chip, single- and multi-pnjunction light-emitting diodes (LEDs)*

JESD51-51:2012-04, *Implementation of the electrical test method for the measurement of real thermal resistance and impedance of light-emitting diodes with exposed cooling surface*

JESD51-52:2012-04, *Guidelines for combining CIE 127-2007 total flux measurements with thermal measurements of leds with exposed cooling surface*

JESD51-53:2012-05, *Terms, definitions and units glossary for LED thermal testing*

ANSI/IPC/ECA J-STD-002C, *Solderability tests for component leads, terminations, lugs, terminals and wires*

ANSI/ESDA/JEDEC JS-001-2012, *Joint JEDEC/ESDA standard for electrostatic discharge sensitivity testing human body model (HBM) – component level*

MIL-STD-883E:2015, *Visual Inspection Criteria*

ZVEI "*Guideline for Customer Notifications of Product and/or Process Changes (PCN) of Electronic Components specified for Automotive Applications*" 4th revised Edition, October 2016, Rev. 3

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60050-845 and IEC 60809, and the following 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
life
total time (expressed in hours) during which a lamp has been operated before it becomes useless

Note 1 to entry: For filament lamps, it is considered to be so according to one of the following criteria:

a) the end of life is the time when the filament fails;

b) the life of a dual-filament lamp is the time until either filament fails, if the lamp is tested in a switching cycle involving alternative operation of both filaments.

3.2
characteristic life
T
T_c
constant of the Weibull distribution indicating the time up to which 63,2 % of a number of tested lamps of the same type have ended their individual lives

3.3
life B_3
constant of the Weibull distribution indicating the time during which 3 % of a number of the tested lamps of the same type have reached the end of their individual lives

3.4
luminous flux maintenance
ratio of the luminous flux of a lamp at a given time in its life to its initial luminous flux, the lamp being operated under specific conditions

EXAMPLE 1 L_{70} is the time in hours to 70 % luminous flux maintenance.

EXAMPLE 2 L_{50} is the time in hours to 50 % luminous flux maintenance.

3.5
initial luminous flux
luminous flux of a lamp measured after specified ageing

Note 1 to entry: The ageing is specified in Annex C of IEC 60809:2014 for filament lamps or in Annex D of this document for discharge lamps or in Annex I of this document for LED light sources.

3.6
rated value
value of a characteristic specified for operation of a lamp at test voltage and/or other specified conditions

3.7
pinch temperature limit
maximum admissible pinch temperature to ensure satisfactory lamp performance in service

3.8
solder temperature limit
maximum admissible solder temperature to ensure satisfactory lamp performance in service

3.9
maximum lamp outline
contour limiting the space to be reserved for the lamp in the relevant equipment

3.10
heavy-duty lamp
lamp which shall comply with the heavy-duty test conditions specified in Table B.2 of IEC 60810 in addition to the requirements specified in IEC 60809

Note 1 to entry: A lamp is declared as heavy-duty by the manufacturer or responsible vendor.

3.11
life B_{10}
constant of the Weibull distribution indicating the time during which 10 % of a number of the tested lamps of the same type have reached the end of their individual lives

3.12
LED package
solid state device embodying a p-n junction, emitting optical radiation when excited by an electric current

Note 1 to entry: Examples are shown in Figure 1.

Note 2 to entry: In UN terminology the term "LED" is used with the same definition.

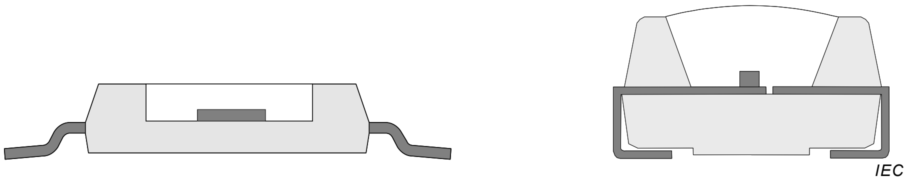


Figure 1 – Examples of LED packages

3.13
LED light source
light source where the visible radiation is emitted from one or more LED(s)

Note 1 to entry: An LED light source may or may not require an additional electronic controlgear and may or may not require additional provisions for thermal management.

3.13.1
LED module
LED light source which can only be replaced with the use of mechanical tools

Note 1 to entry: LED modules are generally considered as components for use in trades, professions or industries and are generally not intended for sale to the general public.

Note 2 to entry: Examples are shown in Figures 2 and 3.

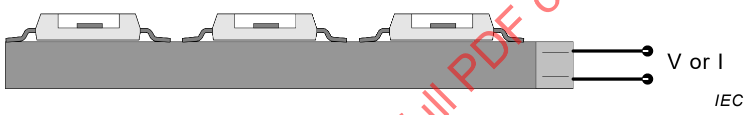


Figure 2 – Example of an LED module without integrated heatsink

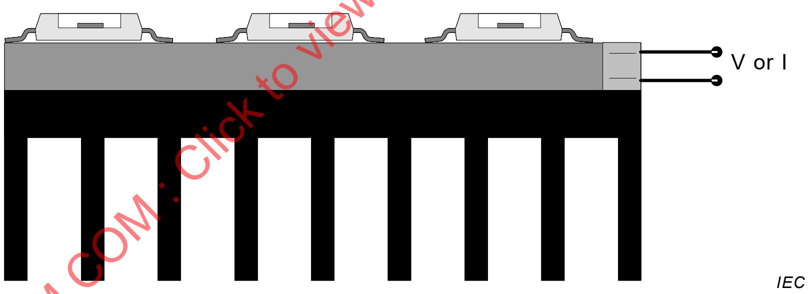


Figure 3 – Example of an LED module with integrated heatsink

3.13.2
replaceable LED light source
LED light source which can be easily replaced without the use of special tools

Note 1 to entry: Replaceable LED light sources are usually intended for sale to the general public as a replacement part.

Note 2 to entry: An example is shown in Figure 4.

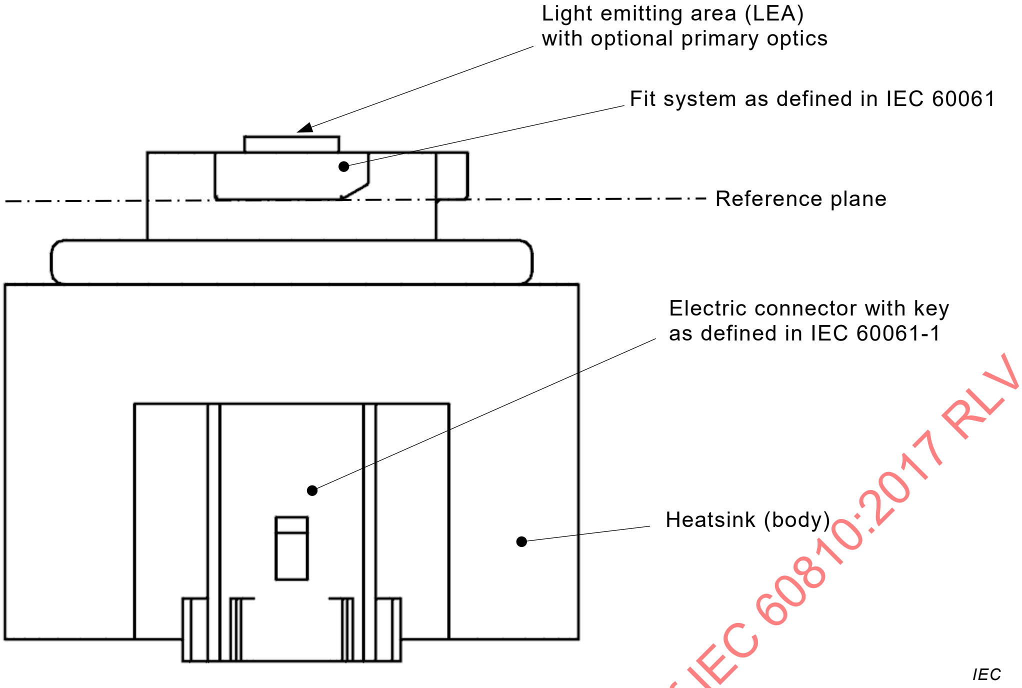


Figure 4 – Example of a replaceable LED light source

3.13.3
non-replaceable LED light source
LED light source which cannot be removed from the device or luminaire

Note 1 to entry: Non-replaceable LED light sources are usually intended as components for integration into the luminaire or device by manufacturers. They are designed and intended to be indivisible parts of a lighting or light signalling device, or of parts or modules or units of such devices.

Note 2 to entry: An example is shown in Figure 5.

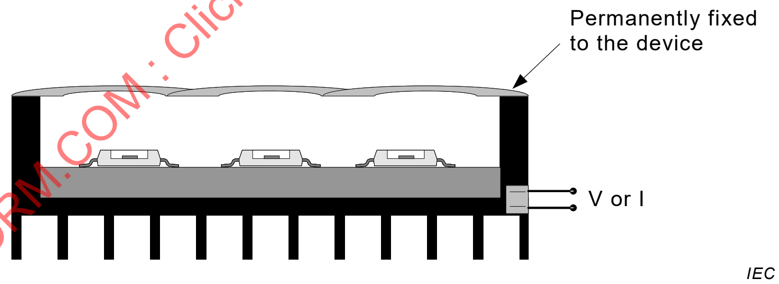


Figure 5 – Example of a non-replaceable LED light source

3.14
T_p
temperature at a specified location on the surface of the LED light source (T_p-point) that can be measured during operation of the light source and that can be correlated to the temperature of the p-n junction of the LED

Note 1 to entry: The T_p point is generally specified by the manufacturer of the LED light source or by its datasheet.

3.15
electronic light source controlgear
one or more component(s) between supply and light source to control voltage and/or electrical current of the light source

3.16
case temperature
T_s
temperature of the thermocouple attachment point on the LED package as defined by the manufacturer of the package

4 Requirements and test conditions for filament lamps

4.1 Basic function and interchangeability

Filament lamps shall comply with IEC 60809.

4.2 Torsion strength

The cap shall be strong and firmly secured to the bulb.

Compliance is checked before and after the life test by submitting the filament lamp to the following torque values:

- filament lamps with bayonet caps
  – with 9 mm shell diameter: 0,3 Nm;
  – with 15 mm shell diameter: 1,5 Nm;
  – with 20 mm shell diameter: 3,0 Nm;
- filament lamps with screw caps
  – with 10 mm shell diameter: 0,8 Nm.

NOTE The torque values given above are all under consideration.

The torque shall not be applied suddenly but shall be increased progressively from 0 to the specified amount.

Values are based on a non-compliance level of 1 %.

4.3 Characteristic life T_c

The life T_c measured on a test quantity of at least 20 filament lamps shall be at least 96 % of the rated value, given in Table 3.

Compliance is checked by life tests as specified in Annex A.

4.4 Life B_3

The life B_3 shall not be less than the rated value given in Table 3.

Compliance is checked by life tests as specified in Annex A.

The number of filament lamps failing before the required time shall not exceed the values in Table 1.

Table 1 – Conditions of compliance for life B_3

Number of filament lamps tested	Acceptance number
23 to 35	2
36 to 48	3
49 to 60	4
61 to 74	5
75 to 92	6

4.5 Luminous flux maintenance

The luminous flux maintenance shall be not less than the rated value given in Table 4. This value is based on a non-compliance level of 10 %.

4.6 Resistance to vibration and shock

In the event of service life being influenced by vibration or shock, the test methods and schedules detailed in Annex B shall be used to assess the performance.

The filament lamps are deemed to have satisfactorily completed the wideband or narrowband random vibration test as described in Annex B, if they continue to function during and after the test.

The number of filament lamps failing one of the tests shall not exceed the values in Table 2 (values are based on an acceptance quality limit (AQL) of 4 %).

Table 2 – Conditions of compliance for the vibration test

Number of filament lamps tested	Acceptance number
14 to 20	2
21 to 32	3
33 to 41	4
42 to 50	5
51 to 65	6

4.7 Glass-bulb strength

In the event of bulbs being impaired by mechanical handling for their assembly in equipment, the test methods and schedules defined in Annex C shall be used to assess the performance. The bulbs shall withstand the specified compression strength.

5 Filament lamp data

Rated life and luminous flux-maintenance values for road vehicle filament lamps are tested under the conditions specified in Annex A.

Tables 3 and 4 provide rated life and luminous flux maintenance values for continuous operation.

Table 3 – Rated life values for continuous operation

Filament lamp data sheet number		Type	12 V			24 V		
IEC 60809[a]	**UN[b]**	**Category**	**Test V**	B_3/h	T_c/h	**Test V**	B_3/h	T_c/h
Lamps for front lighting applications								
2310	R37-H1	H1	13,2	150	400	28,0	90	250
2320	-	H2	13,2	90	250	28,0	90	250
2330	R37-H3	H3	13,2	150	400	28,0	90	250
2120	R37-H4	H4 (HB/LB)	13,2	125/250	250/500	28,0	100/200	200/400
2315	R37-H7	H7	13,2	300	500	28,0	200	400
2365	R37-H8	H8, H8B	13,2	400	800			
2370	R37-H9	H9, H9B	13,2	250	500			
2375	R37-H10	H10	13,2	800	1 600			
2380	R37-H11	H11, H11B	13,2	350	600	28,0	300	600
2385	R37-H12	H12	13,2	480	970			
-	R37-H13	H13,H13A (HB/LB)	13,2	170/1 200	350/2 500			
-	R37-H15	H15 (HB/DRL)	13,2	250/2 000	500/4 000	28,0	200/1 500	400/3 000
-	R37-H16	H16, H16B	13,2	500	1 000			
-	R37-H17	H17	13,2	100/200	200/400			
-	R37-H18	H18	13,2	300	500			
-	R37-H19	H19 (HB/LB)	13,2	125/250	250/500			
-	R37-H20	H20	13,2	100	200			
3430	R37-H27W	H27W/1 H27W/2	13,5	90	190			
2325	R37-HB3	HB3/ HB3A	13,2	250	500			
2335	R37-HB4	HB4/ HB4A	13,2	850	1 700			
2420	R37-HIR2	HIR2	13,2	300	600			
2130	R37-HS1	HS1 (HB/LB)	13,2	75/150	150/300			
2340	R37-HS2	HS2	13,2	100	250			
-	R37-PSX26W	PSX26W	13,2	1 000	2 000			
2110	R37-R2	R2 (HB / LB)	13,2	30/60	90/160			
2150	R37-S1/S2	S2	13,2	50/100	100/200			
Lamps for signalling applications								
		C5W	13,5	350	750	28,0	120	350
3410	R37-H6W	H6W, HY6W	13,5	350	700			
-	R37-H10W	H10W/1	13,5	150	400			
-	R37-H10W	HY10W/1	13,5	300	600			
3420	R37-H21W	H21W	13,5	200	400	28,0	90	180

Filament lamp data sheet number		Type	12 V			24 V		
IEC 60809[a]	**UN[b]**	**Category**	**Test V**	B_3/h	T_c/h	**Test V**	B_3/h	T_c/h
-	R37-HY21W	HY21W	13,5	200	400	28,0	90	180
-	R37-P13W	P13W	13,5	4 000	8 000			
-	R37-P19W	P19W	13,5	1 000	2 000			
3310	R37-P21W	P21W	13,5	120	320	28,0	60	160
3120	R37-P21/4W	P21/4W	13,5	60/600	160/1 600	28,0	60/600	160/1 600
3110	R37-P21/5W	P21/5W	13,5	60/600	160/1 600	28,0	60/600	160/1 600
-	R37-P24W	P24W	13,5	750	1500			
3315	R37-P27W	P27W	13,5	550	1320			
-	R37-P27/7W	P27/7W	13,5	550/3 690	1 320/8 820			
-	R37-PR21W	PR21W	13,5	120	320	28,0	60	160
-	R37-PR21/5W	PR21/5W	13,5	60/600	160/1 600			
-	R37-P19W	PSY19W	13,5	1 200	2 400			
-	R37-P24W	PSY24W	13,5	1 000	2 000			
-	R37-P19W	PY19W	13,5	1 200	2 400			
3311	R37-PY21W	PY21W	13,5	120	320	28,0	60	160
-	R37-P24W	PY24W	13,5	1 000	2 000			
3141	R37-PY27/7W	PY27/7W	13,5	550/3 600	1 300/8 000			
3320	R37-R5W	R5W	13,5	100	300	28,0	80	225
3330	R37-R10W	R10W	13,5	100	300	28,0	80	225
-	R37-R10W	RY10W	13,5	100	300			
3340	R37-T4W	T4W	13,5	300	750	28,0	120	350
4310	R37-W3W	W3W	13,5	500	1 500	28,0	400	1 100
4320	R37-W5W	W5W	13,5	200	500	28,0	120	350
4340	R37-W16W	W16W	13,5	250	700			
4321	R37-W5W	WY5W	13,5	200	500			
4120	R37-C21W	C21W	13,5	40	110			

Filament lamp data sheet number		Type	12 V			24 V		
IEC 60809[a]	UN[b]	Category	Test V	B_3/h	T_c/h	Test V	B_3/h	T_c/h
-	R37-WY16W	WY16W	13,5	250	700			
-	R37-W21W	W21W	13,5	120	320			
-	R37-W21/5W	W21/5W	13,5	60/600	160/1 600			
-	R37-WY21W	WY21W	13,5	120	320			
-	R37-W15/5W	W15/5W	13,5	120/600	320/1 600			
-	R37-W10W	W10W	13,5	100	300			
-	R37-WY10W	WY10W	13,5	100	300			

The values indicated are minimum requirements. Depending on some particular customers' specifications, different values may be obtained, i.e. shorter life/higher luminous flux or longer life/lower luminous flux. This shall be negotiated between filament lamp manufacturers and their customers.

If there is no direct contact between the customer and supplier, the information on deviation from recommended life time data shall be given on the package and/or in publicly available technical documentation.

[a] If a UN sheet number is referenced, the IEC sheet number refers to a data sheet withdrawn with IEC 60809:1995/AMD5:2012 and is given for information only.

[b] The number in front of the dash indicates the number of the UN regulation.

Table 4 – Rated luminous flux-maintenance values for continuous operation

Filament lamp data sheet number		Type	12 V			24 V		
IEC 60809[e]	UN[f]	Category	Test V	Luminous flux maintenance		Test V	Luminous flux maintenance	
				h	%		h	%
Lamps for front lighting applications								
2110	R37-R2	R2	13,2	55[c] 110[d]	85 70	28,0 28,0	55[c] 110[d]	85 70
2120	R37-H4	H4	13,2	110[c] 225[d]	85 85	 28,0	110[c] 225[d]	85 85
2125	-	H6	14,0	75[c] 150[d]	85 80	–	–	–
2305		H5	14,0	75	85	–	–	–
2310	R37-H1	H1	13,2	170	90	28,0	170	90
2320		H2	13,2	170	90	28,0	170	90
2330	R37-H3	H3	13,2	170	90	28,0	170	90
3110	R37-P21/5W	P21/5W	13,5	110[a] 750[b]	70 70	28,0	110[a] 750[b]	70 70
3120	R37-P21/4W	P21/4W	13,5	110[a]750[b]	70 70	28,0	Under consideration	Under consideration
3310	R37-P21W	P21W	13,5	110	70	28,0	110	70
3320	R37-R5W	R5W	13,5	150	70	28,0	150	70
3330	R37-R10W	R10W	13,5	150	70	28,0	150	70
3340	R37-T4W	T4W	13,5	225	70	28,0	225	70
4110	R37-C5W	C5W	13,5	225	60	28,0	225	60
4120	R37-C21W	C21W	13,5	75	60	–	–	–
4310	R37-W3W	W3W	13,5	750	60	28,0	750	60
4320	R37-W5W	W5W	13,5	225	60	28,0	225	60

The values indicated are minimum requirements. Depending on some particular customers' specifications, different values may be obtained, i.e. shorter life/higher luminous flux or longer life/lower luminous flux. This shall be negotiated between filament lamp manufacturers and their customers.

Luminous flux-maintenance values for extended operation times are under consideration.

[a] High-wattage filament.

[b] Low-wattage filament.

[c] Main or upper beam filament.

[d] Dipped or lower beam filament.

[e] If a UN sheet number is referenced, the IEC sheet number refers to a data sheet withdrawn with IEC 60809:1995/AMD5:2012 and is given for information only.

[f] The number in front of the dash indicates the number of the UN regulation.

6 Requirements and test conditions for discharge lamps

6.1 Basic function and interchangeability

Discharge lamps shall comply with the technical requirements of IEC 60809.

6.2 Mechanical strength

6.2.1 Bulb-to-cap connection

The bulb shall be strongly secured to the cap. Compliance is checked by means of the bulb deflection test conducted in accordance with Annex E.

6.2.2 Cable-to-cap connection (if any*)*

If the cable has a fixed connection to the cap, it shall withstand a pulling force of 60 N. The force shall be applied in the direction of the (straight) cable.

6.3 Characteristic life T_c

The life T_c measured on a test quantity of at least 20 lamps shall be not less than the value declared by the manufacturer, which shall be at least 3 000 h. Compliance is checked by tests as specified in Annex D.

6.4 Life B_3

The life B_3 measured on a test quantity of at least 20 lamps shall be not less than the value declared by the manufacturer, which shall be at least 1 500 h. Compliance is checked by tests as specified in Annex D.

6.5 Luminous flux maintenance

The luminous flux maintenance shall be at least 60 % of the initial luminous flux. Compliance is checked by tests as specified in Annex D.

Values are based on a non-compliance level of 10 %.

6.6 Resistance to vibration and shock

In the event of service life being influenced by vibration and shock, the test methods and schedules in Annex B shall be used to assess the performance.

The discharge lamps are deemed to have satisfactorily completed the wideband or narrowband random vibration test as described in Annex B, if they continue to function during and after the test. Moreover, the position of the electrodes shall comply with the dimensional requirements as specified in the relevant standard.

Values are based on a non-compliance level of 4 %.

Precautions should be taken to avoid potential hazards due to high voltages, UV radiation and risk of bulb breakage during starting, run-up and operation of some discharge lamp types.

6.7 Discharge lamps with integrated starting device

The total weight of the lamp shall not exceed 75 g. Information for ballast design is given in Annex G.

6.8 Discharge lamps with integrated starting device and integrated ballast

The total weight of the lamp shall not exceed 120 g.

The centre of gravity of lamps using IEC cap PK32d shall be positioned within the shape of a cylinder as indicated by the shaded areas in Figure 6.

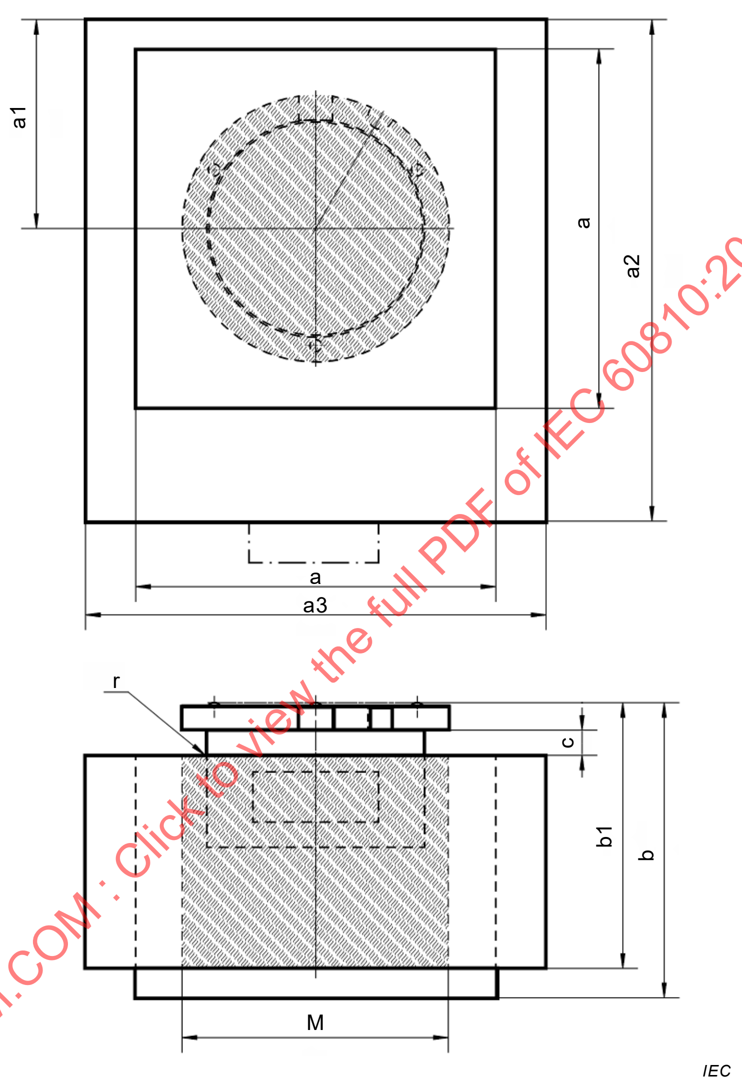


Figure 6 – Position of the centre of gravity (shaded areas)

7 Requirements and test conditions for LED light sources

7.1 Basic function and interchangeability

LED light sources shall:

- be so designed as to be and to remain in good working order when in normal use;
- exhibit no fault in design or manufacture;
- exhibit no scores or spots on their optical surfaces which might impair their efficiency and their optical performance.

Replaceable LED light sources shall be equipped with caps complying with IEC 60061-1. The cap shall be strong and firmly secured to the rest of the LED light source.

To ascertain whether LED light sources comply with the requirements above, a visual inspection, a dimension check and, where necessary, a trial fitting shall be carried out.

LED light sources shall comply with the technical requirements of IEC 60809.

In the case of LED light sources with more than one function, each function shall be tested separately, unless specified differently.

If an electronic light source controlgear (ECG) is needed to operate the LED light source, the test shall be performed with an appropriate ECG.

7.2 UV radiation

The UV-radiation of the LED light source shall be determined according to 5.9 of IEC 60809:2014. If $k_{UV} \leq 10^{-5}$ W/lm the light source is of the low-UV type.

7.3 Luminous flux and colour maintenance

The luminous flux maintenance value L_{70} and the colour maintenance shall be measured on a test quantity of at least 20 LED light sources according to the procedure given in Annex I.

For very small production batches, a test quantity less than 20 may be acceptable.

The manufacturer shall declare and determine the $L_{70}B_{10}$ values.

The measured values shall be not less than the value declared by the manufacturer.

For LED light sources which were approved under the corresponding UN Regulation 128, the $L_{70}B_{10}$ values shall be not less than those specified in Table 5.

Table 5 – Minimum $L_{70}B_{10}$ values for replaceable LED light sources

Category according to UN R 128	Minimum $L_{70}B_{10}$ h
LR1	2 200 [mi] 1 000 [ma]
LW2	4 000
LR3A, LR3B	1 000
LR4A, LR4B	2 200 [mi] 1 000 [ma]
LR5A, LR5B	1 000
LW3A, LW3B	2 200
LW5A, LW5B	4 000
LY3A, LY3B	500 [fl]
LY5A, LY5B	500 [fl]

Key

[mi] minor function

[ma] major function

[fl] tested in flashing mode, i.e. ON/OFF ratio of 1:1

NOTE In the case of pulse width modulation (PWM) operation, it can be expected that the $L_{70}B_{10}$ value is higher (depending on duty cycle).

Table 6 shows typical “on”-time values for the different functions per 100 000 km, for information.

Table 6 – Typical "on"-times for the different functions per 100 000 km drive distance, based on an average speed of 33,6 km/h [a]

Intended application	Typical "on" times in hours per 100 000 km drive distance
Rear registration plate lamp	1 100 [b]
Direction indicator lamp	250
Front and rear position lamp	1 100 [b]
Stop lamp	500
End-outline marker lamp	1 100
Reversing lamp	50
Rear fog lamp	50
Daytime running lamp (DRL)	2 000
Side marker lamp	1 100 [b]
Cornering lamp	100
Low beam lamp (passing beam)	1 000
High beam lamp (driving beam)	100 [c]
Front fog lamp	100

[a] The average driving speed is based on the composition of driving cycles defined in UN R101.

[b] In case these light sources are intended for vehicles where these functions are also switched on together with the DRL function, then the value of 3 100 shall be used.

[c] In case these light sources are intended for vehicles which use the 'adaptive driving beam' function of UN R123, then the value of 200 shall be used.

If the specific requirements of the intended use are known for the LED light source, these should be taken into account.

Compliance is checked by the tests specified in Annex I.

Values are based on a non-compliance level of 10 %.

An example of LED light source life-time data is given in Table 7.

Table 7 – Example of product data

Type	Intended use	$L_{70}B_{10}$
MD0815	Stop lamp	1 500 h

7.4 Resistance to vibration and shock

In the event of service life being influenced by vibration and shock, the test methods and schedules in Annex B shall be used to assess the performance.

The light sources are deemed to have satisfactorily completed the wideband or narrowband random vibration test as described in Annex B, if they continue to function during and after the test.

Values are based on a non-compliance level of 4 %.

7.5 Electromagnetic compatibility

Replaceable LED light sources shall be classified according to CISPR 25.

7.6 Powered thermal cycling test

This test is intended to determine the ability of the LED light source to withstand changes of ambient temperatures.

LED light sources shall be tested according to test condition "Nb" of IEC 60068-2-14, under the following conditions (see Figure 7):

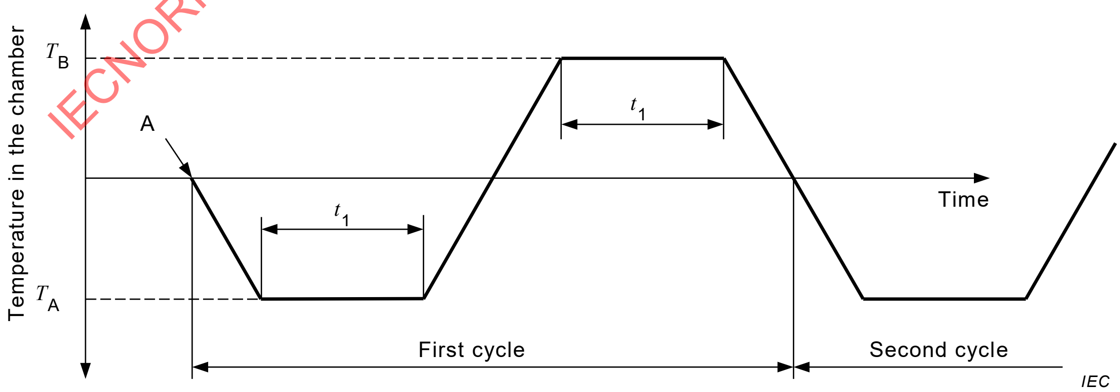
- rate of change of temperature is 3 K/min;
- the exposure time t_1 shall be a minimum of 2 h;
- the number of cycles shall be 15;
- the test shall be performed on a minimum of 20 LED light sources;
- during the testing, the LED light source shall be continuously switched on and off in 5 min intervals (5 min on, 5 min off, 5 min on, etc.);
- the test voltage shall be chosen according to Clause I.2 of this document;
- temperatures T_A and T_B shall be chosen according to the classes defined in Table 8.

Table 8 – Temperature classes for the powered thermal cycling test

	Lower temperature T_A	Higher temperature T_B
Class A	–40 °C	+60 °C
Class B	–40 °C	+85 °C
Class C	–40 °C	+105 °C

For LED light sources that require an external light source controlgear, the light source controlgear may also be subjected to this test.

LED light sources that require additional provisions for thermal management shall be tested with these provisions in place. A description of the thermal management design shall be included in the test report.



Key

A start of first cycle

Figure 7 – Extract from IEC 60068-2-14 Test Nb, showing the temperature cycle profile

After the powered thermal cycling test, the electrical and photometrical performance of the LED light source shall be tested.

The LED light sources are deemed to have satisfactorily completed the test if they continue to function after the test and if the photometrical and electrical performance is within the specifications provided by the manufacturer.

Values are based on a non-compliance level of 10 %.

7.7 Mass

The total mass of the LED light source shall not exceed the value given in Table 9 or, where not given, the value in the system information on cap sheets specified in IEC 60061-1.

Table 9 – Maximum mass for LED light sources

LED light source category	Cap	Mass g
LR1	PGJ21	60
LW2	PGJY50	50
LR3, LR4, LR5, LW3, LW5, LY3, LY5	PGJ18.5	35

7.8 Typical circuits for LED light sources

7.8.1 General

The purpose of 7.8 is to show typical electrical circuits for LED light sources.

7.8.2 Typical circuits for LR3, LR5, LY3, LY5, LW3 and LW5 LED light sources

A typical electrical circuit for LR3, LR5, LY3, LY5, LW3, and LW5 light source contains

- one or more LED dies/packages and an electronic driver,
- an electronic protection,
- an optional resistor to ensure a minimum current for special application requirements,

as shown in Figure 8.

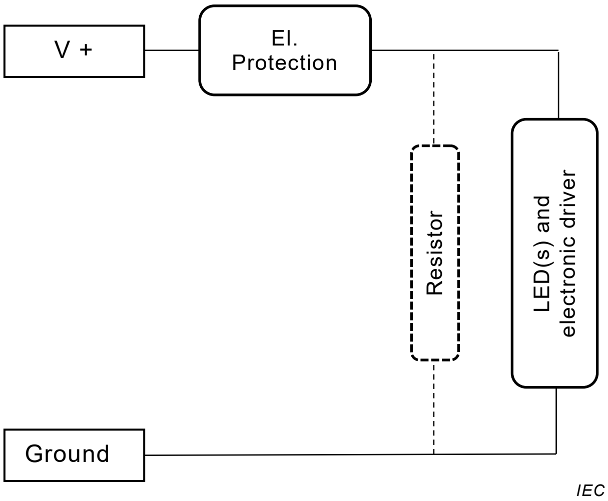


Figure 8 – Typical electrical circuit for an LR3, LR5, LY3, LY5, LW3 and LW5 LED light source

7.8.3 Typical circuits for LR4 LED light sources

A typical electrical circuit for LR4 light source contains

- two electrical strings (with common ground),
- for each string one or more LED dies/packages and an electronic driver,
- for each string an electronic protection,
- a resistor to ensure a minimum current of 10 mA in the “major function” string

as shown in Figure 9.

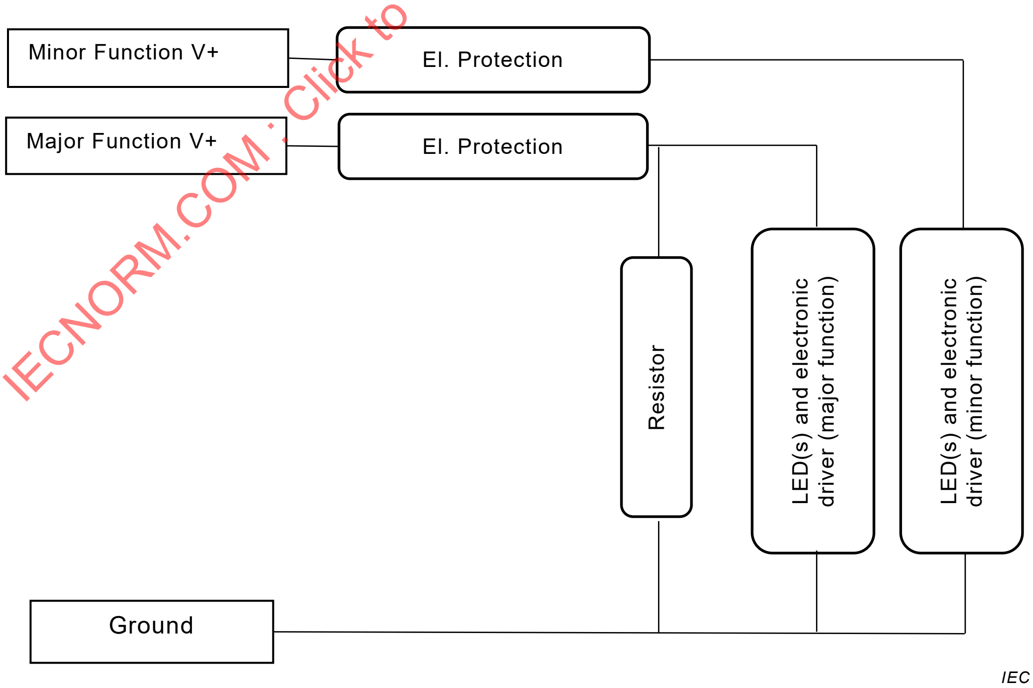


Figure 9 – Typical electrical circuit for an LR4 LED light source

7.9 Maximum power consumption

For the LED light sources listed in Table 10, the maximum power consumption at test voltages of 9 V DC, 13,5 V DC and 16 V DC shall not exceed the values given in Table 10.

Table 10 – Maximum power consumption

	Test voltage		
	9 V DC	**13,5 V DC**	**16 V DC**
LR3	3,5 W	3,5 W	5 W
LR4 (minor/major function)	1,0 W / 3,5 W	1,0 W / 3,5 W	1,5 W / 5 W
LR5	3,5 W	3,5 W	5 W
LW3	5 W	5 W	10 W
LY3 [a]	5 W	5 W	10 W
LW5	8 W	8 W	10 W
LY5 [a]	8 W	8 W	12 W

NOTE The values given in Table 10 for maximum power at 13,5V DC are taken from UN R128.

[a] During the ON state, tested in flashing mode, i.e. ON/OFF ratio of 1:1.

7.10 Overvoltage test

The purpose of this test is to evaluate the performance of the LED light source under stress due to overvoltage. The test shall be conducted on a test quantity of at least 20 LED light sources with the following test conditions:

- for a 12 V-light source: test voltage: 26 V;
- for a 24 V-light-source: test voltage: 52 V;
- ambient temperature: 23 °C ± 5 °C;
- duration 60 s.

The light sources are deemed to have satisfactorily completed the test, if after the test

- the luminous flux has not changed by more than 20 % compared to the initial value;
- the chromaticity values (cx, cy) remain within the colour boundaries;
- the electrical current has not changed by more than 10 % compared to the initial value.

Values are based on a non-compliance level of 10 %.

7.11 Reverse voltage test

The purpose of this test is to evaluate the performance of the LED light source under stress due to reverse voltage. The test shall be conducted on a test quantity of at least 20 LED light sources with the following test conditions:

- for a 12 V-light source: test voltage: 14 V DC with reverse polarity;
- for a 24 V-light-source: test voltage: 28 V DC with reverse polarity;
- ambient temperature: 23 °C ± 5 °C
- duration 60 s.

The light sources are deemed to have satisfactorily completed the test, if after the test

- the luminous flux has not changed by more than 20 % compared to the initial value;

- the chromaticity values (cx, cy) remain within the colour boundaries;
- the electrical current has not changed by more than 10 % compared to the initial value.

Values are based on a non-compliance level of 10 %.

7.12 Transient voltage test (field decay)

The purpose of this test is to evaluate the performance of the LED light source under stress due to transient voltage (field decay). The test shall be conducted on a test quantity of at least 20 LED light sources with the following test conditions:

- conditions: see Figure 10 and Table 11 (see also ISO 7637-2, pulse 1),
- test pulse severity level III;
- minimum 500 pulses;
- pulse repetition ≥ 0,5 s.

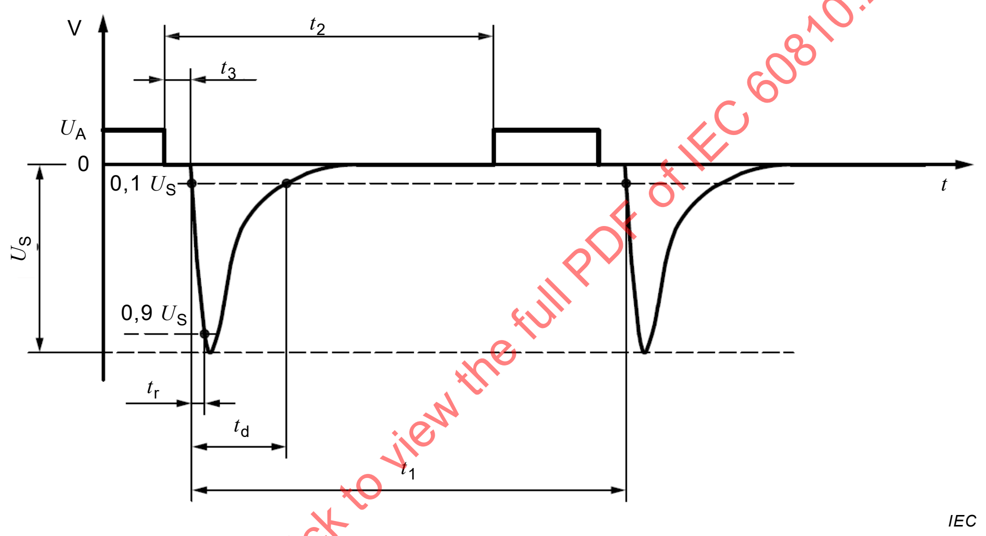


Figure 10 – Profile of pulse 1 from ISO 7637-2

Table 11 – Test parameters for pulse 1 from ISO 7637-2

Parameters	Nominal 12 V system	Nominal 24 V system
U_s	-75 V to -150 V	-300 V to -600 V
R_i	10 Ω	50 Ω
t_d	2 ms	1 ms
t_r	$\left(1^{\ 0}_{-0,5}\right)$ µs	$\left(3^{\ 0}_{-1,5}\right)$ µs
t_1 [a]	≥ 0,5 s	
t_2	200 ms	
t_3 [b]	< 100 µs	

[a] t_1 shall be chosen such that it is the minimum time for the DUT to be correctly initialized before the application of the next pulse and shall be ≥ 0,5 s.

[b] t_3 is the smallest possible time necessary between the disconnection of the supply source and the application of the pulse.

The light sources are deemed to have satisfactorily completed the test, if after the test

- the luminous flux has not changed by more than 20 % compared to the initial value;
- the chromaticity values (cx, cy) remain within the colour boundaries;
- the electrical current has not changed by more than 10 % compared to the initial value.

Values are based on a non-compliance level of 10 %.

7.13 Transient voltage test (load dump)

The purpose of this test is to evaluate the performance of the LED light source under stress due to transient voltage (load dump). The test shall be conducted on a test quantity of at least 20 LED light sources with the following test conditions:

- conditions: see Figure 11 and Table 12 (see also ISO 7637-2, pulse 2a);
- test pulse severity level III;
- minimum 500 pulses;
- pulse repetition ≥ 0,2 s.

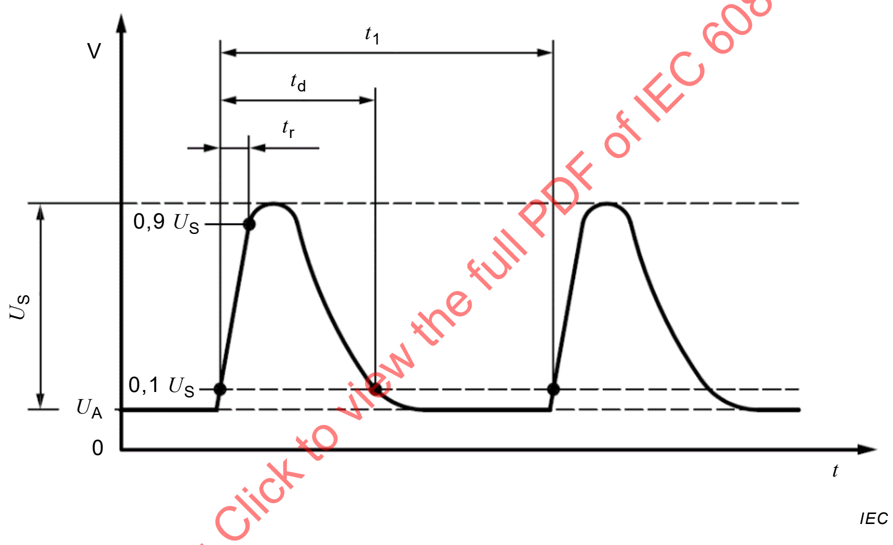


Figure 11 – Profile of pulse 2a from ISO 7637-2

Table 12 – Test parameters for pulse 2a from ISO 7637-2

Parameters	Nominal 12 V and 24 V system
U_s	+37 V to + 112 V
R_i	2 Ω
t_d	0,05 ms
t_r	$\left(1^{\ 0}_{-0,5}\right)$ µs
t_1[a]	0,2 s to 5 s

[a] The repetition time t_1 can be short depending on the switching. The use of a short repetition time reduces the test time.

The light sources are deemed to have satisfactorily completed the test, if after the test

- the luminous flux has not changed by more than 20 % compared to the initial value;
- the chromaticity values (cx, cy) remain within the colour boundaries;
- the electrical current has not changed by more than 10 % compared to the initial value.

Values are based on a non-compliance level of 10 %.

7.14 Electrostatic discharge test (ESD)

The purpose of this test is to evaluate the performance of the LED light source under stress due to electrostatic discharge at the terminals of the LED light source and at the housing. The test and classification shall be conducted according to ISO 10605 on a test quantity of at least 20 LED light sources. Details of the testing and applied criteria, for example severity level, shall be reported.

7.15 Pulsed operating life (PLT) test

The purpose of this test is to evaluate the performance of the LED light source under stress due to pulsed operation.

- duration 1 000 h;
- peak voltage 13,5 V;
- T_{ambient} = 23 °C ± 5 °C;
- pulse width 100 µs, duty cycle 3 %. This corresponds to a frequency of 300 Hz.

The light sources are deemed to have satisfactorily completed the test, if after the test

- the luminous flux has not changed after 100 h by more than 10 % compared to the initial value;
- the luminous flux has not changed after 1 000 h by more than 20 % compared to the initial value;
- the chromaticity values (cx, cy) remain within the colour boundaries:
- the electrical current has not changed by more than 10 % compared to the initial value.

Values are based on a non-compliance level of 10 %.

8 Requirements and test conditions for LED packages

8.1 LED package stress test qualification

Clause 8[2] defines minimum stress test driven qualification requirements and references test conditions for qualification of LED packages.

The purpose of this document is to determine that a LED package is capable of passing the specified stress tests and thus can be expected to give a certain level of quality/reliability in automotive lighting applications.

"Stress test qualification" according to this document is defined as successful completion of the test requirements outlined in this document.

Subclause 8.6 defines a set of qualification tests that shall be considered for new LED package qualifications. In the case of requalification associated with a design or process change, a limited set of qualification tests may be considered, see Annex L.

Where appropriate, family qualifications may be done, a rationale should be given by the supplier.

[2] The approach on LED package stress test qualification as described in this document is derived from a similar approach developed by the Automotive Electronics Council (AEC – Q101: Stress test qualification for automotive grade discrete semiconductors).

The family may be classified by following major key characteristics of LED packages.

This is not recommended to transfer results, in case of different

- package material (e.g. pre-mold, ceramic, epoxy) and design, or
- casting material (e.g. silicone, epoxy)/lens/window, or
- conversion (e.g. layer transfer, volume conversion), or
- interconnect die bond (e.g. glued, bonded)/wire bond, or
- chip technology (e.g. AlInGaP, AlInGaN, AlInGaAs, sapphire, regardless of colour).

Any deviation from this recommendation shall be documented.

Transfer of results is possible, in case of different

- phosphor CCT (same or better performance) or
- chip size/number of chips in LED package (same or smaller current density, scalable).

LED packages having the same key characteristics may be released by family qualifications.

This document makes reference to other IEC standards or standards from other organizations (e.g. JEDEC). Where relevant, further details on the test definitions can be found in these documents. Test conditions in this document may deviate from test conditions in the reference documents (e.g. PTMCL condition 2). In such a case, further definitions in the reference document shall still be applied as appropriate.

The results of LED package testing may be reported by using the communication sheet as specified in Annex K.

A guideline on LED package robustness validation is given in Annex M.

8.2 Test samples

8.2.1 Lot requirements

Unless specified otherwise in 8.6, a total of minimum 78 LED packages taken from three different batches of 26 each shall be used for each test. For family qualification, the three different batches shall be considered to represent the whole variety of the qualification family.

The sample size may be reduced due to technical problems or experimental limitations to a minimum of 3 x 5 LED packages. The reason(s) for sample size reduction shall be provided with the report.

8.2.2 Production requirements

All qualification LED packages shall be produced on tooling and processes at the manufacturing site that will be used to support LED package deliveries at projected production volumes.

8.2.3 Pre- and post-stress test requirements

Electrical and photometric values (forward voltage, luminous flux or radiant power and/or intensity, colour parameter) shall be measured at the nominal test conditions as defined in the product specification before and after stress testing (see also 8.6.1).

NOTE A simple light/no light test is under consideration for testing at different temperatures.

All LED packages used for qualification shall meet the product specification parameters measured at the nominal test conditions before stress testing.

8.2.4 Assembly of LED packages on test boards

LED packages may need to be assembled on test boards. An appropriate choice of test board, interconnect material and process shall be made by the manufacturer. The choice of test board, interconnect material and process shall be documented for each individual test in the test report.

8.2.5 Moisture pre-conditioning (MP)

Moisture preconditioning is applicable to surface mountable devices designed for reflow soldering. All qualification LED packages used for the following tests:

- 8.6.4 TMCL,
- 8.6.5 WHTOL,
- 8.6.6 PTMCL, and
- 8.6.14 RSH-reflow

shall be subject to moisture preconditioning according to JESD22-A113F. The initial electrical and photometrical test according to 8.6.1 shall be executed after the moisture pre-conditioning.

8.2.6 Thermal resistance (TR) test

The thermal resistance shall be tested according to JESD51-50, JESD51-51, JESD51-52 and JESD51-53; the resulting $R_{\text{th electr}}$ and the optical power radiation of the LED package for the calculation of "$R_{\text{th,real}}$" should be recorded and the $R_{\text{th,electr}}$ (typical) and the $R_{\text{th,electr}}$ (maximum) shall be reported (reporting should be done in the communication sheet according to Annex K).

8.3 Definition of failure criteria

A LED package shall be considered to have failed if any of the following criteria applies.

- Forward voltage V_f at the nominal drive current I_f deviates by more than ±10 % of the initial value.
- Radiant power or luminous flux or intensity at the nominal drive current I_f deviates by more than
  - ±20 % of the initial value, or
  - ±30 % of the initial value

where these options of ±20 % or ±30 % are at the choice of the manufacturer.

  - A deviation of ±50 % of the initial value may be acceptable for some interior lighting applications (e.g. LED packages for instrument clusters).

- Colour coordinates x,y at the nominal drive current I_f of white LED deviate by more than ±0,01 from the initial value. The permitted deviation for saturated colour LEDs is under consideration. A deviation of ±0,02 of the initial value may be acceptable for some interior lighting.
- The LED package exhibits externally visible physical damage attributable to the environmental test (e.g. delamination). However, if the cause of failure is agreed (by the manufacturer and the user) to be due to mishandling or ESD, the failure shall be discounted, but reported as part of the data submission. A microscope with a magnification in a range of 40X to 50X shall be used.

Failures in the interconnect to the test board or in the test board that are not related to a LED package failure shall be discounted, but reported as part of the data submission.

8.4 Choice between test conditions

A manufacturer shall select a specific luminous flux maintenance class according to 8.3 prior to the qualification testing. The appropriate pass/fail criteria shall be applicable.

Furthermore, the manufacturer shall choose between different classes of test conditions where applicable (e.g. TMCL cycle condition 1 to 4 in 8.6.4). The test condition shall be documented in the test report.

In general, it may be assumed that passing the harsher test conditions implies that the more relaxed conditions would also be passed (e.g. passing TMCL condition 3 implies that TMCL conditions 1 and 2 would also be passed).

8.5 Criteria for passing qualification/requalification

All LED packages under test shall pass the tests, otherwise the LED package or LED package family is considered to have failed.

LED packages that have failed the acceptance criteria of tests required by this document require the supplier to satisfactorily determine root cause and corrective action to assure the user that the failure mechanism is understood and contained and the corrective and preventive actions are confirmed to be effective by repeating the applicable qualification test(s) successfully.

8.6 Qualification test

8.6.1 Pre- and post- electrical and photometric test

All LED packages shall be tested at nominal drive current according to the following requirements of the appropriate LED package specification (manufacturer's datasheet) prior to and after the following tests except for 8.6.2 and 8.6.10:

- luminous flux or radiant power or intensity (whichever is appropriate);
- forward voltage;
- colour coordinates or dominant or peak wave length (whichever is appropriate).

NOTE The choice between dominant and peak wavelength is under consideration.

In addition, the forward voltage at the minimum (or lower) and maximum drive current shall be recorded.

8.6.2 Pre- and post- external visual (EV) test

The construction, marking and workmanship of the LED package shall be inspected according to JESD22-B101B prior to and after the following tests except for 8.6.10.

8.6.3 High temperature operating life (HTOL) test

The purpose of this test is to evaluate the performance of the LED package under stress due to high temperature operation. The test shall be conducted according to JESD22-A108D; the following test conditions apply:

- Duration 1 000 h.
- the testing shall be done:
  - at the maximum specified drive current with the corresponding maximum rated T_s, and

– at the maximum specified T_s with the corresponding maximum rated drive current.

8.6.4 Temperature cycling (TMCL) test

The purpose of this test is to evaluate the performance of the LED package under stress due to temperature cycles without operation of the LED. The LED package shall be tested according to JESD22-A104E; the following test conditions apply:

- duration 1 000 cycles;
- soak mode 4 (minimum soak time 15 min).

The following minimum and maximum temperatures for T_s shall be chosen by the manufacturer:

- TMCL condition 1: $T_{s,min}$ = –40 °C; $T_{s,max}$ = 85 °C;
- TMCL condition 2: $T_{s,min}$ = –40 °C; $T_{s,max}$ = 100 °C;
- TMCL condition 3: $T_{s,min}$ = –40 °C; $T_{s,max}$ = 110 °C;
- TMCL condition 4: $T_{s,min}$ = –40 °C; $T_{s,max}$ = 125 °C;
- TMCL condition 5: $T_{s,min}$ = –40 °C; $T_{s,max}$ = 150 °C .

The TMCL condition closest to the manufacturer's operating temperature range according to the appropriate LED package specification (manufacturer's datasheet) shall be chosen unless the manufacturer wishes to test compliance with a more severe cycle condition. The choice of the TMCL cycle condition and the transfer time shall be reported.

8.6.5 Wet high temperature operating life (WHTOL) test

The purpose of this test is to evaluate the performance of the LED package under stress due to temperature and humidity during steady state operation. The LED package shall be tested according to JESD22-A101C; the following test conditions apply:

- duration 1 000 h;
- T_s = 85 °C;
- 85 % RH;
- power cycle 30 min on/30 min off.

The tests shall be performed at the corresponding minimum and maximum rated drive current (i.e. rating at T_s = 85 °C).

8.6.6 Power temperature cycling (PTMCL) test

The purpose of this test is to evaluate the performance of the LED package under stress due to temperature cycles during operation of the LED package. The LED package shall be tested according to JESD22-A105C; the following test conditions apply:

- duration 1 000 temperature cycles;
- power cycle 5 min on/5 min off operated at the corresponding maximum rated drive current.

The manufacturer shall select one of the following test types:

- PTMCL condition 1: T_s –40 °C to 85 °C, (test condition A according to JESD22-A105C);
- PTMCL condition 2: T_s –40 °C to 100 °C, (transition and dwell time according to test condition A of JESD22-A105C);
- PTMCL condition 3: T_s –40 °C to 125 °C, (test condition B according to JESD22-A105C).

The PTMCL condition closest to the manufacturer's operating temperature range according to the appropriate LED package specification (manufacturer's datasheet) shall be chosen unless the manufacturer wishes to test compliance with a more severe cycle condition. The choice of the PTMCL condition shall be reported.

8.6.7 Electrostatic discharge, human body model (ESD-HBM) test

The purpose of this test is to evaluate the performance of the LED package under stress due to electrostatic discharge using the human body model. The LED package shall be tested according to ANSI/ESDA/JEDEC JS-001-2012.

8.6.8 Electrostatic discharge, machine model (ESD-MM) test

The purpose of this test is to evaluate the performance of the LED package under stress due to electrostatic discharge using the machine model. The LED package shall be tested according to JESD22-A115C.

8.6.9 Destructive physical analysis (DPA) test

The purpose of this test is to evaluate the capability of the device's internal materials, design, and workmanship to withstand forces induced by various stresses induced during environmental testing.

Perform DPA according to Annex J on random samples of good units after completion of the PTMCL test, WHTOL test, H2S and FMGC test (two samples per lot). The post electrical and photometrical test of these samples shall be executed before the destructive physical analysis.

8.6.10 Physical dimensions (PD) test

Verify physical dimensions according to LED package mechanical drawings of the LED package manufacturer.

8.6.11 Vibrations variable frequency (VVF) test

The purpose of this test is to evaluate the performance of the LED package under stress due to mechanical vibrations with variable frequency. The LED package shall be tested according to JESD22-B103B.

Use a constant displacement of 1,5 mm (double amplitude) over the range of 20 Hz to 100 Hz and a 200 m/s^2 constant peak acceleration over the range of 100 Hz to 2 kHz.

8.6.12 Mechanical shock (MS) test

The purpose of this test is to evaluate the performance of the LED package under stress due to mechanical shock. The LED package shall be tested according to JESD22-B110B:

- 15 000 m/s^2 for 0,5 ms;
- five shocks in each direction, three orientations (+ and – $x/y/z$ direction, i.e. 30 shocks).

8.6.13 Resistance to soldering heat (RSH-TTW) test

The purpose of the TTW ("through the wave") test is to evaluate the performance of the LED package under stress due to soldering heat. The LED package shall be tested according to JESD22-B106D.

This test only applies to LED packages that are declared to be solderable by wave soldering by the manufacturer.

8.6.14 Resistance to soldering heat (RSH-reflow) test

The purpose of this test is to evaluate the performance of the LED package under stress due to soldering heat. The LED package shall be tested according to JESD22-A113F; alternative: ANSI/IPC/ECA J-STD-002C.

Reflow soldering shall be tested three times at 260 °C. Testing according to 8.6.1 shall be carried out before and after each reflow.

This test applies only to LED packages that are specified for reflow soldering.

8.6.15 Solderability (SO) test

The purpose of this test is to determine the solderability of lead free solder alloys applicable for surface mounted (SMD) LED packages. The LED packages shall be tested according to IEC 60068-2-58.

Sample size: 3 x 10.

8.6.16 Thermal shock (TMSK) test

The purpose of this test is to evaluate the performance of the LED package under stress due to thermal shock. The LED package shall be tested according to JESD22-A106B. The following conditions shall apply:

- duration 1 000 cycles;
- TMSK cycle condition 1: $T_{s,min}$ = –40 °C; $T_{s,max}$ = 85 °C;
- TMSK cycle condition 2: $T_{s,min}$ = –40 °C; $T_{s,max}$ = 100 °C;
- TMSK cycle condition 3: $T_{s,min}$ = –40 °C; $T_{s,max}$ = 125 °C;
- liquid to liquid.

The cycle condition closest to the manufacturer's operating temperature range according to the appropriate LED package specification (manufacturer's datasheet) shall be chosen unless the manufacturer wishes to test compliance with a more severe cycle condition. The choice of the TMSK cycle condition shall be reported.

8.6.17 Hydrogen sulphide (H_2S) test

The resistance to hydrogen sulphide shall be tested according to IEC 60068-2-43; the following test conditions apply:

- air temperature 40 °C;
- 90 % RH;
- H_2S concentration: 15×10^{-6};
- duration 336 h.

8.6.18 Pulsed operating life (PLT) test

The purpose of this test is to evaluate the performance of the LED package under stress due to pulsed operation. The LED package shall be tested according to JESD22-A108D.

- duration 1 000 h;
- T_s = 55 °C;
- pulse width 100 µs, duty cycle 3 %.

For interior lighting applications the test may be performed at T_s = 25 °C.

The LED package shall be operated at the corresponding maximum rated drive current.

8.6.19 Dew (DEW) test

The purpose of this test is to evaluate the performance of the LED under stress due to dew deposition. The following conditions shall be applied to the LED package.

The LED package shall be cycled from 10 °C to 80 °C and from 50 % RH to 100 % RH with each cycle of t_{cycle} = 6,5 h, see Figure 12 and detailed description below.

1) When the LED package is initially placed in the chamber, over a 15 min time period the temperature is dropped from 20 °C to 10 °C, and the humidity is raised from 50 % RH to between 50 % to 100 % RH.
2) Hold the LED package for 60 min at 10 °C to ensure it has reached the starting temperature for bedewing. During the first 30 min, the humidity is raised to between 90 % to 100 % RH. During the next 30 min, the humidity is raised to between 95 % to 100 % RH. Now switch over from air condition control to chamber control.
3) Temperature is raised gradually from 10 °C to 70 °C over a 3 h period with heating rate of 20 °C/h, with humidity held between 95 % to 100 % RH . During this time the LED packages are turned on only every 30 min for 2 min with current density of not more than 0,05 A/mm^2, low enough not to heat the LED packages beyond condensation. Except for these 2 min every 30 min, the LED packages shall be turned off.
4) Temperature is raised to 80 °C within a further 30 min. The humidity shall be held between 95 % to 100 % RH.
5) Temperature is decreased to 75 °C and is held for 30 min. The humidity is undefined and uncontrolled during this time. Start of the drying after reaching 75 °C air temperature.
6) Temperature is decreased from 75 °C to 20 °C within 75 min. The humidity is undefined and uncontrolled during this time. This is the end of the first cycle and the DUT shall be dry (RH < 50 %).
7) Each additional cycle starts at step 1 and continues to step 6.

The test is continuous except for where interim measurements are required. Electrical measurements shall be performed not sooner than one hour after removing the LED packages from the stress chamber. For interim readouts, the LED packages shall be returned to stress within four hours after removing them from the stress chamber.

Duration: Typical duration is 10 cycles.

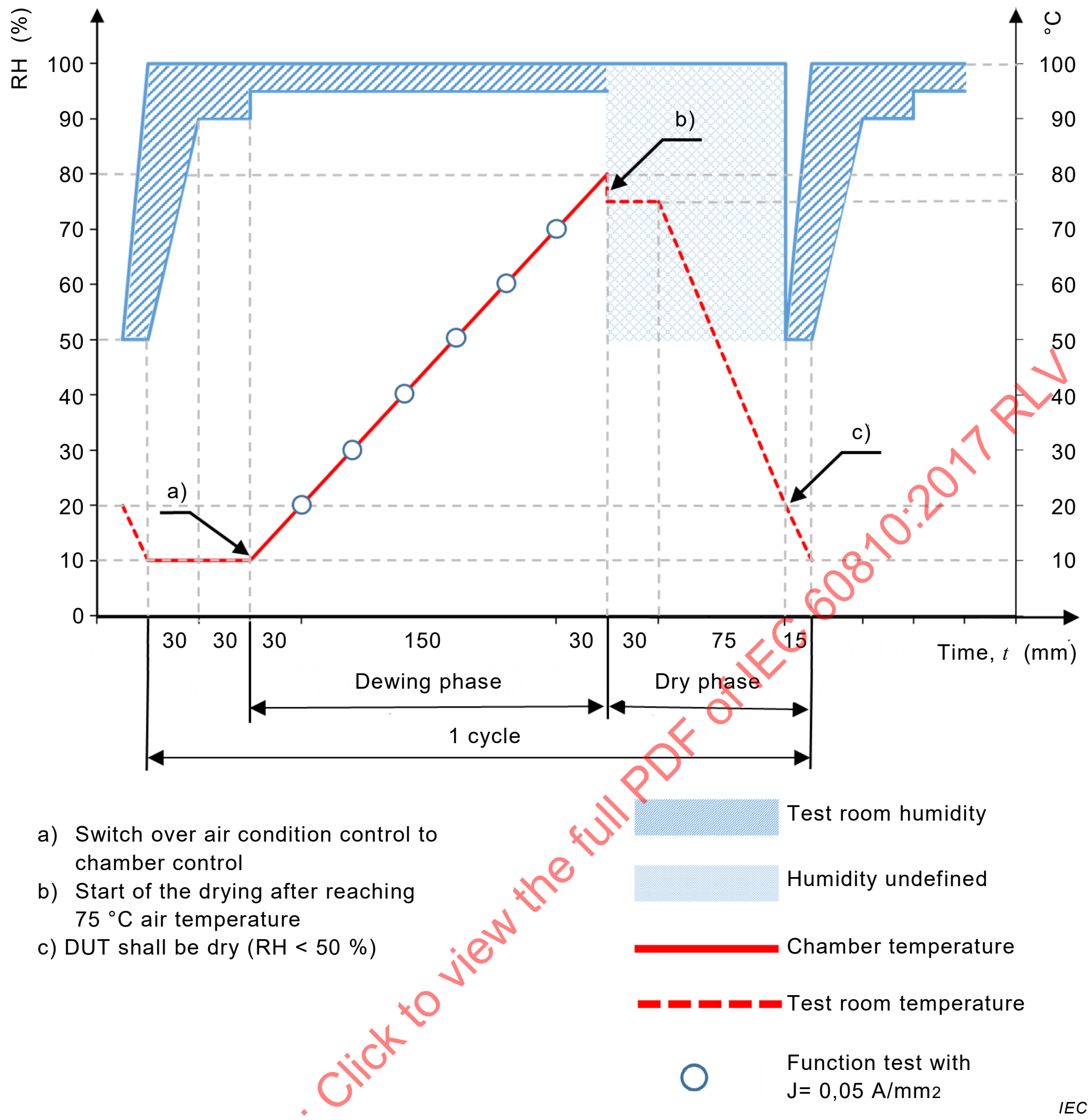


Figure 12 – Temperature–humidity characteristics for the DEW test

8.6.20 Flowing mixed gas corrosion (FMGC) test

The resistance to corrosive gas atmosphere shall be tested according to IEC 60068-2-60; the following test conditions apply:

- test method 4;
- air temperature 25 °C;
- 75 % RH;
- H_2S concentration: 10 × 10^{-9};
  NO_2 concentration: 200 × 10^{-9};
  Cl_2 concentration: 10 × 10^{-9};
  SO_2 concentration: 200 × 10^{-9};
- duration 500 h.

8.6.21 Wire bond pull test (WBP)

The purpose of this test is to measure the wire bond strength of the LED package. This test may be applicable to all versions of available wire bond techniques used for LED packages.

The wire bond strength test shall be performed according to MIL-STD 883E. The wire bond strength C_{pk} value shall be > 1,67 and shall be reported separately. See ISO 3534-2 for the definition of the C_{pk} value.

A post-stress test evaluation of wire bond strength is not recommended, since the LED packages are typically encapsulated and the de-capsulation process could influence the result of wire bond strength evaluation. A minimum sample size of 3 x 5 is recommended.

8.6.22 Bond shear test (BS)

The purpose of this test is to determine the strength of the interface between ball bond and die bonding surface, or an wedge/stich bond and a die or package bonding surface. The bond shear test shall be performed according to JESD22-B116. The bond shear C_{pk} value shall be > 1,67 and shall be reported separately. See ISO 3534-2 for the definition of the C_{pk} value.

A post-stress test evaluation of wire bond shear is not recommended, since the LED packages are typically encapsulated and the de-capsulation process could influence the result of wire bond shear evaluation. A minimum sample size of 3 x 5 is recommended.

8.6.23 Die shear test (DS)

The purpose of this test is to determine the quality of the interface between the semiconductor die and package bonding surface. The die shear shall be performed according to MIL-STD 883E. The die shear C_{pk} value shall be > 1,67 and shall be reported separately. See ISO 3534-2 for the definition of the C_{pk} value.

A post-stress test evaluation of the die shear is not recommended, since the LED packages are typically encapsulated and the de-capsulation process could influence the result of die shear evaluation. A minimum sample size of 3 x 5 is recommended.

Annex A
(normative)

Life test conditions for filament lamps

A.1 Ageing

Filament lamps shall be aged at their test voltage for approximately 1 h. For dual-filament lamps, each filament shall be aged separately. Filament lamps which fail during the ageing period shall be omitted from the test results.

A.2 Test voltage

Measurements shall be carried out at the test voltage specified in Clause 5 which shall be a stable DC or AC voltage with a frequency between 40 Hz and 60 Hz.

In the case of non-replaceable filament lamps (defined in IEC 60809), the filament lamp shall be operated at the test voltage specified in the relevant data sheet. In case an electronic regulator is used, such as pulse width modulation (PWM), this non-replaceable filament lamp should be operated in such a way that it does not negatively affect the lifetime of the filament lamp.

NOTE The test voltage is deemed to be stable when the momentary fluctuations do not exceed 1 % and the deviation of the average over the test period does not exceed 0,5 % of the specified value.

A.3 Operating position and operating conditions

Filament lamps shall be operated on a vibration-free test rack with both lamp axis and filament(s) horizontal. In the special case of double-filament lamps which include a shield, this shall be under the dipped or lower-beam filament (H-H line horizontal). In the case of filament lamps with an axial filament, the longer filament support shall be positioned above the filament.

The lamps shall be tested under normal ambient temperature conditions; assumption is 25 °C ± 10 °C.

A.4 Switching cycle

A.4.1 Single-filament lamps

A.4.1.1 Filament lamps for continuous operation

Filament lamps shall be switched off twice daily for periods of not less than 15 min, such periods not being considered as part of the life.

A.4.1.2 Filament lamps for intermittent operation

Filament lamps for intermittent operation as used in stop-lamps and flashing direction indicators shall be operated in the following switching cycle:

- 15 s on for intermittent (flashing) operation;
- 15 s off;
- flashing frequency: 90/min;
- on/off ratio 1:1.

The whole flashing operation time is considered as life.

A.4.2 Dual-filament lamps for headlamps

The filaments shall be operated alternately according to the following cycle and starting with the lower beam filament:

- dipped or lower-beam filament: 15 h on/45 min off;
- main or upper-beam filament: 7,5 h on/45 min off.

The end of the life is determined by failure of either filament.

The off periods are not considered as part of the life.

NOTE The life of the lower-beam filament represents two-thirds of the total life, the life of the upper-beam filament one-third.

A.4.3 Dual-filament lamps for light signalling equipment

A.4.3.1 General

Life testing shall be carried out for each filament separately. Life testing of the low-wattage filament shall be carried out on filament lamps other than those used for life testing of the high-wattage filament.

A.4.3.2 Filaments for continuous operation

The switching cycle shall be as specified in A.4.1.1.

A.4.3.3 Filaments for intermittent operation

The switching cycle shall be as specified in A.4.1.2.

A.5 Luminous flux and colour maintenance

Tests may be interrupted for determination of the luminous flux and colour maintenance.

Annex B
(normative)

Vibration tests

B.1 General

These tests are designed to ensure that lamps satisfactorily completing this schedule will not be adversely affected by shock and vibration in normal service.

Two levels of test are specified which are referred to as "standard test" and "heavy-duty test" and the appropriate level shall be selected for the intended vehicle usage.

The acceleration levels and frequency spectra used in these tests are based on extensive investigations into the characteristics experienced at lamp mounting positions on a wide range of vehicles and in normal service conditions.

Although the standard test relates to normal vehicle service conditions, investigations have shown that the more arduous conditions given by heavy goods vehicles require lamps of a greater mechanical strength.

Within the constraints of dimensional and photometric specifications, the ultimate strength of an incandescent lamp is limited by the properties of the filament material. These restrict the mechanical stress to which a lamp can be subjected.

Higher vibration levels may impair the performance of lamps.

Two tests methods are specified:

a) a wideband random vibration test (WBR);
b) a narrowband random vibration test (NBR).

The WBR test is the preferred one, as simulation of service conditions can be achieved most accurately by the use of WBR equipment. However, studies have indicated that a relationship exists between WBR and NBR vibrations. For the purpose of this document, both tests are equal for testing motor vehicle lamps to vibration resistance.

Analysis of vibration measurements, taken under transient conditions such as door, boot and bonnet closures, shows compatibility with the significant features of both the WBR and NBR test programmes.

The generally accepted requirements of a fatigue life of 10^7 reversals are encompassed by the schedule in IEC 60068-2-6.

Measurements of vibration and shock characteristics in service reveal frequencies of up to 20 000 Hz.

A vibration level is expressed as acceleration spectral density (ASD). It is the spectral density of an acceleration variable and is given in units of acceleration squared per unit frequency.

ASD spectrum defines the way ASD varies within the frequency range.

The ASD levels at frequencies above 1 000 Hz are, however, so low as to be insignificant, as the resonant frequencies of the critical construction features of most automobile lamps fall within the range of 200 Hz to 800 Hz. This, together with problems in the design of fixtures suitable for operation at frequencies above this level, has led to the adoption of 1 000 Hz as the maximum limit for the test schedules (excluding half bandwidth).

B.2 Test conditions

B.2.1 General

Figure B.1 details the preferred arrangement of equipment for the testing of lamps of WBR or NBR tests.

In order to be assured of reliable and reproducible test results, the following procedures should be followed.

B.2.2 Mounting (see IEC 60068-2-47)

The lamp caps shall be fastened rigidly to the work holders on the vibration head. This may be achieved by clamping, soldering or embedding. Electrical connection to the lamps shall be made by the use of soldered wires or other means such that electrical connection is ensured during the whole test.

On tests including higher frequencies, it is essential that fixtures are designed in such a way that the propagation path (the distance between lamp and moving coil) is always shorter than the one-quarter wavelength of the velocity of sound in the fixture material.

B.2.3 Measuring points

A measuring point is the position at which measurements are made to ensure that the test requirements are met. The measuring point shall be on the fixture as close as possible to the position at which the lamp is held and the detector shall be rigidly connected to it.

If several lamps are mounted on a single fixture, the measuring point may be related to the fixture generally rather than the lamp fixing points.

The resonant frequency of the fully loaded fixture shall always be higher than the maximum test frequency.

B.2.4 Control point

The signal from the transducer mounted at the measuring point shall be used as a means of maintaining the specified vibration characteristics.

B.2.5 Conditioning

Filament lamps shall be aged for 30 min at test voltage as given in the relevant data sheets of IEC 60809 or in the relevant data sheets of non-replaceable filament lamps. No ageing period is required for discharge lamps, but lamps which fail before starting a vibration test shall be omitted from the test results.

B.2.6 Axis of vibration

Field measurements on vehicles have shown that automobile lamps are usually subjected to greater stresses in the vertical plane than in either of the horizontal planes. It is therefore recommended that a vertical direction of excitation be used for testing with the principal lamp axis and filament(s) horizontal.

B.2.7 WBR test – Basic motion

The basic motion of the control point on the test fixture (see Figure B.1) shall be rectilinear and of a stochastic nature with a normal (Gaussian) distribution of instantaneous acceleration values. Peak values are limited to three times the r.m.s. value as determined by the ASD profile and its frequency range (i.e. "3σ-clipping"). Experience has shown that a peak factor set to 2,3 at the exciter corresponds to a 3 σ test signal at the control point because of filtering by the vibrator (see ISO 5344).

B.3 Test conditions

B.3.1 General

The test voltage for filament lamps shall be in accordance with IEC 60809 or with the specification in the relevant data sheets of non-replaceable filament lamps. For discharge lamps, the conditions of Clause D.2 apply.

The specific vibration test conditions are given as follows (see Tables B.1, B.2, B.3 and B.4):

Table B.1 – Vibration test on motor vehicle lamps – Test conditions

Narrowband random vibration test	Standard test conditions	Table B.2
	Heavy-duty test conditions	Table B.3
Wideband random vibration test	Standard test conditions	Table B.4

B.3.2 Narrowband random vibration tests

Table B.2 – Vibration test on motor vehicle lamps – Standard test conditions (narrowband)

Narrowband random vibration test		
1	**Frequency range**	30 Hz to 1 050 Hz
2	**Bandwidth**	100 Hz
3	**Sweep range**	80 Hz to 1 000 Hz
4	**Sweep rate**	1 octave/min
5	**Sweep duration (full cycle)**	7,3 min
6	**ASD spectrum**	0,12 g^2/Hz (= 3,5 g eff.) from 80 Hz to 150 Hz 0,014 g^2/Hz (= 1,2 g eff.) from 150 Hz to 1 000 Hz
7	**Tolerance of the acceleration values**	±1 dB
8	**Test duration**	20 h
9	**Switching cycle**	20 min lit to 10 min unlit
10	**Compressor speed**	10 dB/s

**Table B.3 – Vibration test on motor vehicle lamps –
Heavy-duty test conditions**

Narrowband random vibration test		
1	**Frequency range**	30 Hz to 1 050 Hz
2	**Bandwidth**	100 Hz
3	**Sweep range**	80 Hz to 1 000 Hz
4	**Sweep rate**	1 octave/min
5	**Sweep duration (full cycle)**	7,3 min
6	**ASD spectrum**	0,36 g^2/Hz (= 6,0 g eff.) from 80 Hz to 150 Hz 0,09 g^2/Hz (= 3,0 g eff.) from 150 Hz to 1 000 Hz
7	**Tolerance of the acceleration values**	±1 dB
8	**Test duration**	20 h
9	**Switching cycle**	10 min lit to 10 min unlit
10	**Compressor speed**	10 dB/s

B.3.3 Wideband random vibration tests

Test requirements are given in Table B.4 for standard service.

Requirements for heavy-duty service are under consideration.

**Table B.4 – Vibration test on motor vehicle lamps –
Standard test conditions (wideband)**

Wideband random vibration test			
1	**Frequency range**	12 Hz to 1 002 Hz	
2	**ASD spectrum**	Hz	g^2/Hz
		12	0,01
		12 to 24	0,01 to 0,15
		24 to 54	0,15
		54 to 1 002	0,15 to 0,008 2
3	**Total r.m.s. acceleration level**	5,4 g ± 1 dB	
4	**Tolerance of the true ASD values**	±3 dB	
5	**Switching cycle**	20 min lit to 10 min unlit	
6	**Test duration**	20 h	

NOTE 1 The acceleration level increases logarithmically with the logarithm of the frequency in the range 12 Hz to 24 Hz (12 dB/octave) and it decreases in the range 54 Hz to 1 002 Hz (–3 dB/octave). Outside the specified frequency range, the ASD level has to decrease with gradients as steep as possible.

NOTE 2 All data are provisional.

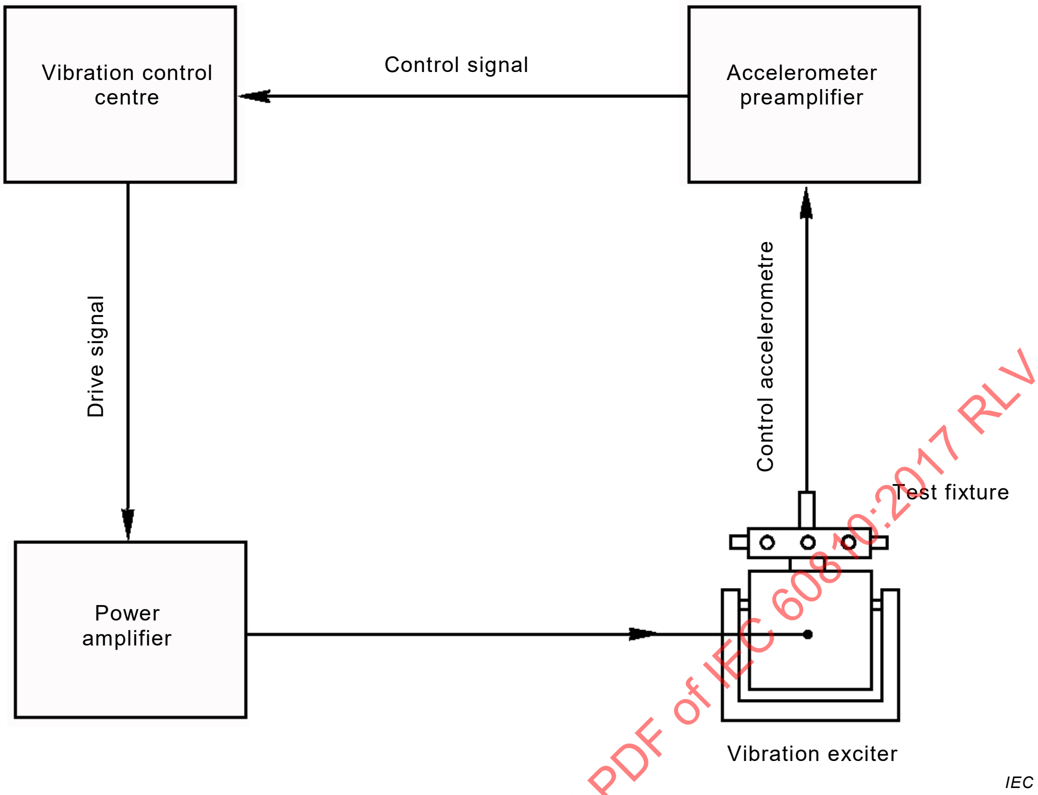


Figure B.1 – Recommended equipment layout for vibration testing

Annex C
(normative)

Glass-bulb strength test

C.1 General

If required, the test specified in Annex C shall be used to determine the glass-bulb strength of certain road vehicle filament lamps.

This test is necessary for these filament lamps because mechanical handling is utilized for their assembly in equipment.

C.2 Test equipment and procedure

C.2.1 Principle of the test equipment

See Figure C.1.

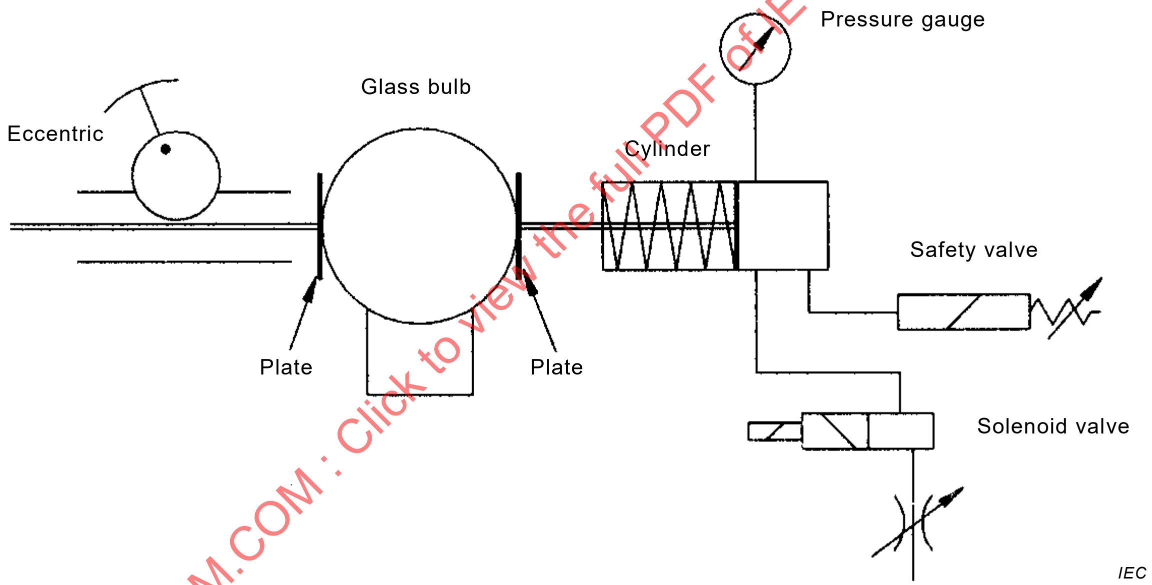


Figure C.1 – Diagrammatic sketch of the principle of the test equipment

The test apparatus consists mainly of

- a pneumatic cylinder applying the necessary force;
- two plates transmitting the force onto the test sample;
- a measuring apparatus indicating the applied force.

C.2.2 Test conditions

This apparatus shall test bulbs with a maximum diameter of 50 mm. The bulb shall be tested with a slowly increasing compressive force. In no case shall bulbs be exposed to a shock load.

The increase of force from 0 N to 200 N shall be in 4 s to 5 s during which period the force increases approximately in a linear manner.

It shall be possible to limit the maximum force of the apparatus to 200 N by a compression safety valve. The apparatus shall incorporate a suitable protective screen to prevent injury from glass fragments in the event of a bulb failure during the test.

C.2.3 Requirements for plates

Each plate shall have a plane smooth surface with a diameter of approximately 20 mm and shall be of hardened tool steel. The hardness of the plates shall lie between 55 Rockwell and 60 Rockwell (HRC).

C.3 Requirements

The compression strength of the bulb shall not fall below the values stated in Table C.1 taking an AQL of 1 % as a basis.

Table C.1 – Compression strength

Category	Minimum glass-bulb strength N
P21/5W	40
P21W	40
P27/7W	40
P27W	40
PR21/5W	40
PR21W	40
PY21W	40
PY27/7W	40
R10W	40
R2	40
R5W	40
RR10W	40
RR5W	40
RY10W	40
T4W	40
W10W	40
W15/5W	40
W2.3W	40
W21/5W	40
W21W	40
W3W	40
W5W	40
WP21W	40
WR5W	40
WT21/5W	40
WT21W	40
WTY21/5W	40
WTY21W	40
WY10W	40
WY16W	40
WY21W	40
WY5W	40

C.4 Evaluation

C.4.1 General

One of the following procedures shall be applied.

C.4.2 Assessment based on attributes

Set the test apparatus at the minimum force specified in Table C.1. A first sample is selected randomly from the batch, the number selected being determined by the batch size (see Table C.2). The number of bulbs failing are compared with the acceptance and rejection numbers. If there is no decision, a second sample is tested in accordance with Table C.2.

Table C.2 – Inspection by attributes – Double sampling plan

Batch size	Sample	Accept	Reject
1 201 to 3 200	1st sample $n1$ = 80	1	4
	2nd sample $n2$ = 80	4	5
3 201 to 10 000	1st sample $n1$ = 125	2	5
	2nd sample $n2$ = 125	6	7
10 001 to 35 000	1st sample $n1$ = 200	3	7
	2nd sample $n2$ = 200	8	9
35 001 to 150 000	1st sample $n1$ = 315	5	9
	2nd sample $n2$ = 315	12	13
If a second sample has to be taken, the number of filament lamps failing in the combined sample is compared with the acceptance and rejection numbers in the corresponding line.			

This random test, based on attributes, corresponds to the tests given in ISO 2859-1.

C.4.3 Assessment based on variables

The size of the sample (selected randomly) is determined by the batch size as shown in Table C.3.

Each filament lamp is tested until it fails and the value at which this occurs is recorded.

The result is assessed as follows.

The lower quality statistic (Q_L) is calculated using the equation:

$$Q_L = \frac{\overline{X} - 40}{S}$$

where

$\overline{X}$ is the mean value of all the results in the sample;

S is the standard deviation:

$$S = \sqrt{\frac{\sum_{i=1}^{i=n} (X_i - \overline{X})^2}{n - 1}}$$

where

X_i is the value of individual results;

n is the number of results.

The test is passed if: $Q_L \geq K$

where

K is the acceptability constant determined from Table C.3.

Table C.3 – Inspection by variables – "S" method of assessment

Batch size			Sample size	Acceptability constant K
1 201	to	3 200	15	1,79
3 201	to	10 000	20	1,82
10 001	to	35 000	25	1,85
35 001	to	150 000	35	1,89

NOTE 1 The statistical basis of this method assumes that the distribution of results is normal, or nearly so.

NOTE 2 Tests for normality can be made by the use of probability paper plots in accordance with ISO 2854.

NOTE 3 This test, based on variables, corresponds to the tests given in ISO 3951.

Annex D
(normative)

Life and luminous flux maintenance test conditions for discharge lamps

D.1 Ageing

No ageing period is required, but lamps which fail before starting the life test shall be omitted from the test results.

For lamps subject to the luminous flux maintenance test, the initial luminous flux shall be measured after 10 on/off switching cycles as specified in Clause D.4.

D.2 Test circuit and test voltage

Discharge lamps shall be tested with the ballast submitted by the lamp manufacturer and, preferably, designed to operate the lamp in a nominal 12 V system. The test voltage to the ballast shall be 13,5 V. The power supply to the ballast shall be sufficient to secure the high-current flow.

D.3 Burning position and operating conditions

Discharge lamps shall be operated in free air with an ambient temperature of 25 °C ± 5 °C. The burning position shall be horizontal within 10°, with the lead wire down.

Precautions should be taken to avoid potential hazards due to high voltages, UV radiation and risk of bulb breakage during starting, run-up and operation of some discharge lamp types.

D.4 Switching cycle

One on/off switching cycle is built up of the following 10 on/off periods (see Table D.1):

Table D.1 – On/off switching cycle

Period	On min	Off min
1	20	0,2
2	8	5
3	5	3
4	3	3
5	2	3
6	1	3
7	0,5	3
8	0,3	0,3
9	20	4,7
10	20	15

The total duration of one on/off switching cycle is 120 min, during which the lamp is switched on for 79,8 min and switched off for 40,2 min. The time during which the lamp is switched off is not considered as part of the life.

For discharge lamps with two defined power modes, a power switching cycle according to Table D.2 shall be applied in addition.

One power switching cycle has a total duration of 113 min. The power switching cycle is superimposed onto the on/off switching cycle of Table D.1.

Figure D.1 show the superposition of the two switching cycles.

NOTE The power switching cycle duration of 113 min is chosen to avoid synchronicity with the 120 min of the on/off cycle. Over the total test duration this results in a percentage of 71 % in low power operation (e. g. low beam) and 29 % high power operation (e. g. high beam).

Table D.2 – Power switching cycle

Period	Power mode	Time min
A	High power	3
B	Low power	20
C	High power	10
D	Low power	20
E	High power	10
F	Low power	20
G	High power	10
H	Low power	20

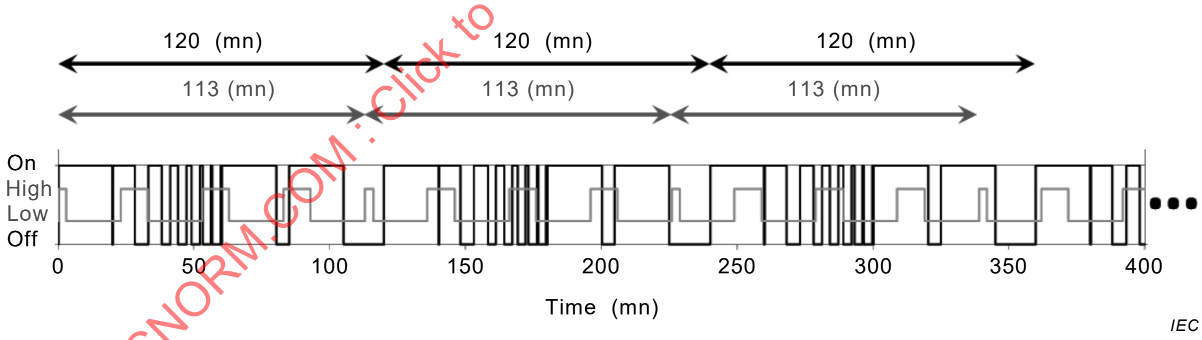


Figure D.1 – Superposition of on/off switching and power switching cycle

Life tests may be interrupted for the purpose of the luminous flux maintenance test.

For discharge lamps with two defined power modes, an additional fast power switching cycle according to Table D.3 shall be performed on 10 lamps. The test consists of 10 steps “5 s low – 2 s high” and 10 steps “20 s low – 10 s high” These 20 steps are repeated until 50 000 operations are reached. A maximum of one lamp may fail the test (no light emitted).

Table D.3 – Fast power switching cycle

Operations	Steps	Power mode	Time s
1	1	Low power	5
2	2	High power	2
3	3	Low power	5
4	4	High power	2
5	5	Low power	5
6	6	High power	2
7	7	Low power	5
8	8	High power	2
9	9	Low power	5
10	10	High power	2
11	11	Low power	20
12	12	High power	10
13	13	Low power	20
14	14	High power	10
15	15	Low power	20
16	16	High power	10
17	17	Low power	20
18	18	High power	10
19	19	Low power	20
20	20	High power	10
21	1	Low power	5
22	2	High power	2
….	….	…	…
50 000	20	High power	10

D.5 Luminous flux maintenance

The luminous flux maintenance is measured after the lamp has been operated 75 % of the characteristic life as declared by the manufacturer.

Annex E
(normative)

Bulb deflection test

E.1 General

If required, the test specified in Annex E shall be used to determine the strength of the bulb-to-cap connection of discharge lamps.

E.2 Test set-up and procedure

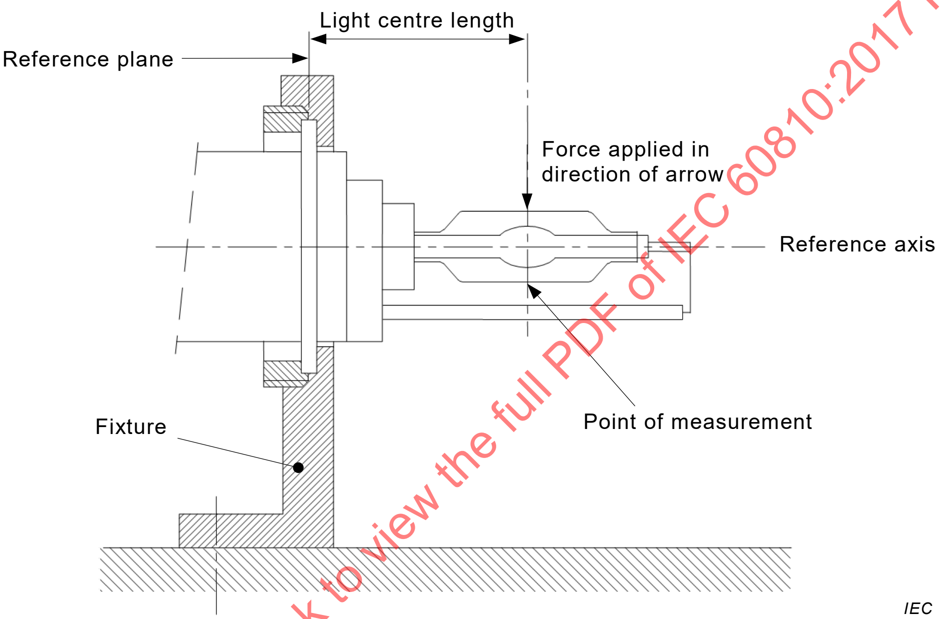


Figure E.1 – Sketch of the test set-up

The lamp shall be rigidly and horizontally mounted in the fixture (see Figure E.1), with the reference notch in the up position. A force of 18 N is applied on the glass bulb

- at a distance from the reference plane equal to the light centre length of the lamp;
- perpendicular to the reference axis;
- using a rod with a hard rubber tip with a minimum spherical radius of 1 mm;
- four times, spaced 90° apart, starting in the vertical direction.

NOTE The spacing of 90° is approximate, depending on the position of the outer supply wire.

The force shall be gradually increased from 0 N to 18 N.

The bulb deflection shall be measured at the glass surface 180° opposite to the force application.

A different lamp shall be used for each force application at 0°, 90°, 180° and 270°.

E.3 Requirement

The deflection shall not exceed 0,13 mm in the direction of the force applied.

Annex F
(informative)

Guidance on equipment design

F.1 Pinch temperature limit

Headlamps, fog-lamps and signalling lamps should be so designed that in operation the pinch temperature of halogen lamps does not exceed 400 °C.

Specially prepared filament lamps are required for the pinch temperature test and reference should be made to the filament lamp supplier.

NOTE For pinch temperature measuring method, see IEC 60682.

F.2 Solder temperature limit

Headlamps, fog-lamps and signalling lamps should be so designed that in operation the solder temperature of filament lamps does not exceed the following limits:

- 180 °C for single-filament lamps;
- 180 °C for double-filament lamps.

F.3 Maximum filament lamp outline

Maximum filament lamp outline is provided as guidance for designers of lighting equipment and is based on a maximum sized filament lamp inclusive of bulb-to-cap eccentricity and tilt. Observance of these requirements in the equipment design will ensure mechanical acceptance of filament lamps complying with IEC 60809. Details are given in Figures F.2 to F.5.

F.4 Maximum surge voltage

Maximum surge voltage values are provided as guidance for designers of electrical equipment. They are specified as maximum tolerable duration as a function of the height of voltage surge.

This does not imply that values shorter than the specified ones have a negligible effect on filament lamp performance, but only that a higher voltage or duration in any case harm the filament lamp and should be avoided. Values in graphical form are given in Figure F.1.

F.5 Recommended instructions for use and handling of halogen filament lamps

It is recommended that the following points be included in any instructions for use if supplied with halogen filament lamps covered by this document. Symbols as shown in Annex H (Clauses H.2 to H.5) may be used in addition or as an alternative to text information.

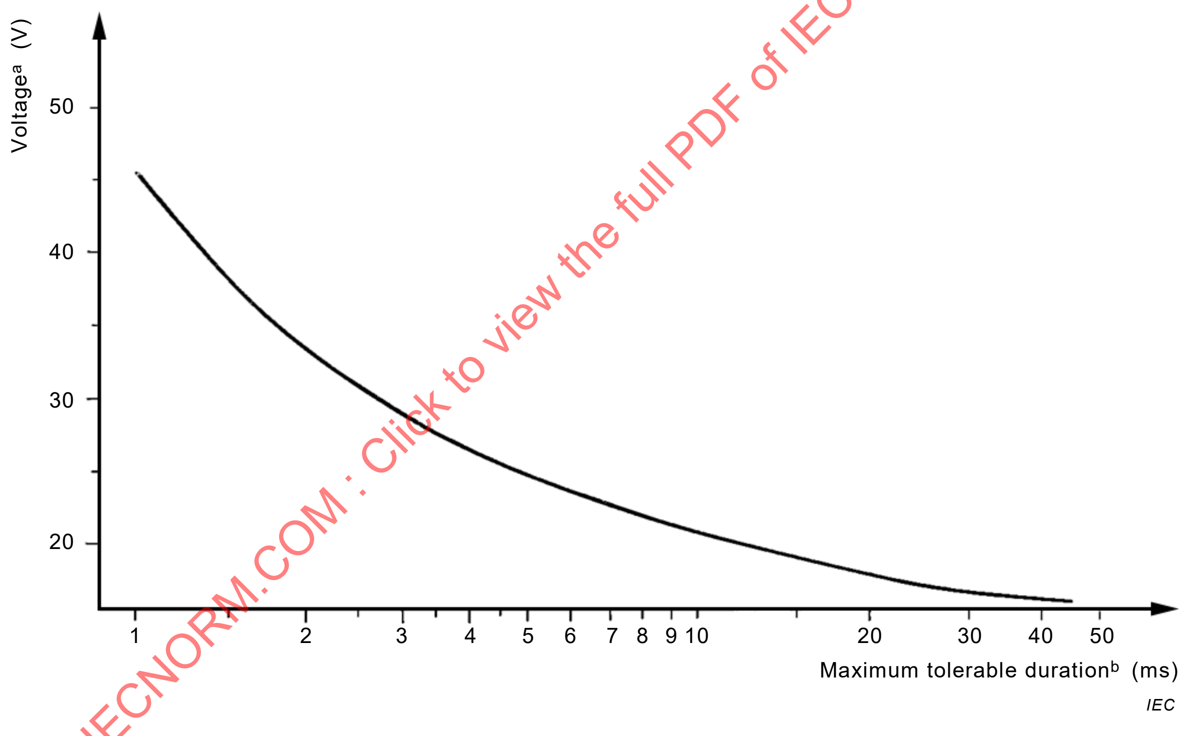
- Halogen filament lamps operate at high bulb temperatures and care should be taken to avoid touching the bulb in any circumstances.
- If filament lamps with quartz bulb are touched, they should be cleaned before use with a lint-free cloth moistened with methylated spirit.
- Filament lamps with scratched or otherwise damaged bulbs should not be used.

NOTE In some instances filament lamp manufacturers give information that the filament lamp contains gas under pressure and recommend protective measures when handling it.

F.6 Recommended instructions for use and handling of discharge lamps

It is recommended that the following points are included in any instructions for use if supplied with discharge lamps covered by this document. Symbols as shown in Annex H (Clauses H.2 to H.10) may be used in addition or as an alternative to text information.

- Care should be taken to avoid touching the bulb in any circumstances. The use of protective gloves and eye protection is advised. If the bulb is touched, it should be cleaned before use with a lint-free cloth moistened with methylated spirit. Lamps with scratched bulbs should not be used.
- Discharge lamps operate with a suitable ballast which produces very high voltage when switching and during operation. During operation, the bulb of the discharge lamp emits UV-radiation. In order to avoid any safety risk or impairment of health, the discharge lamps should only be used in closed headlamps.
- Discharge lamps operate at high temperatures. Before handling, the lamp should be left to cool down for an appropriate time and the supply voltage to the ballast should be disconnected.



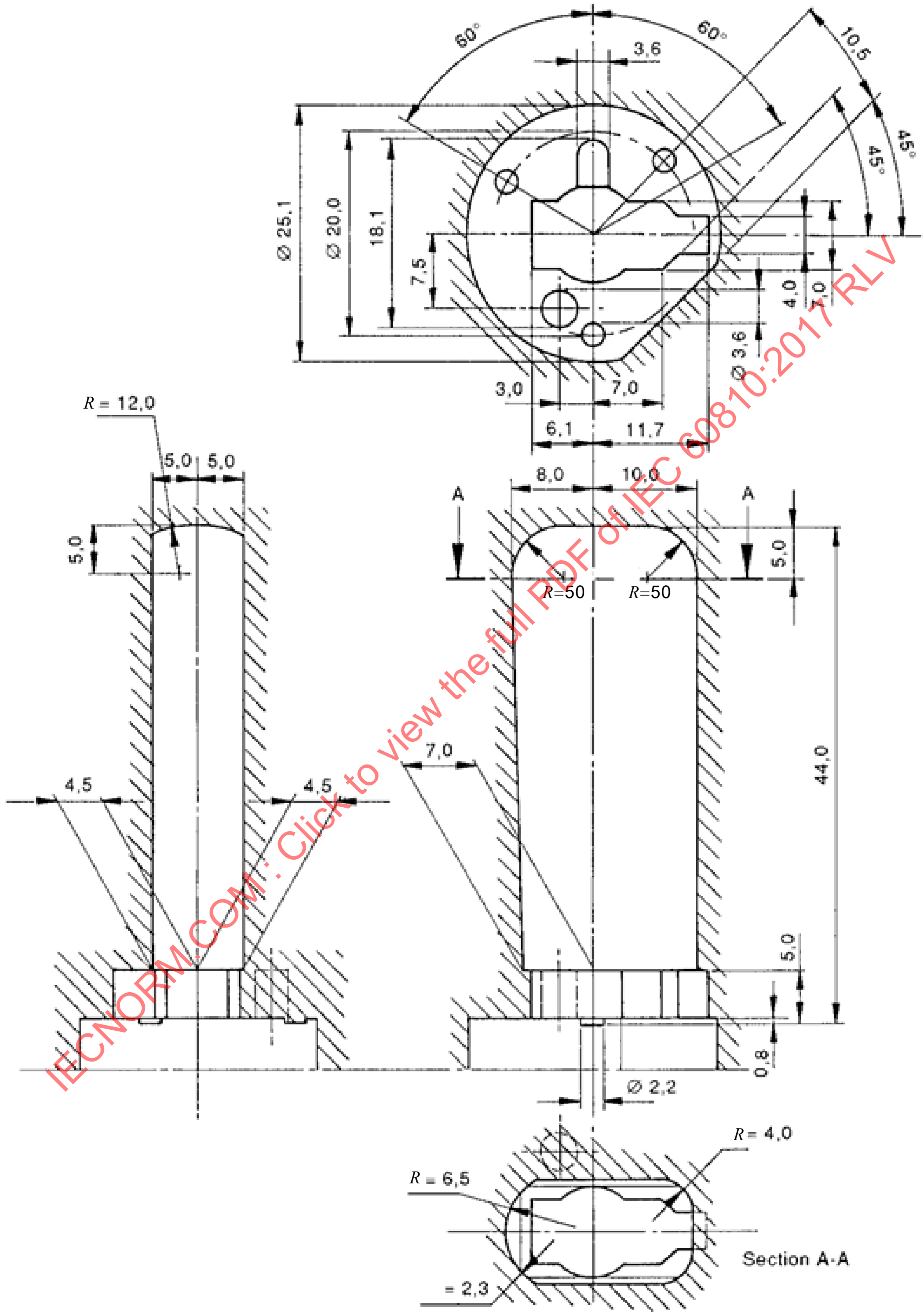
[a] Voltage surges are superimposed on a stabilized voltage of 14,5 V after a burning period of at least 30 s. The voltage shown on the graph above is the sum of the stabilized 14,5 V and the voltage surge.

[b] If this maximum tolerable duration is exceeded, a certain percentage of filament lamps will fail immediately. The resulting influence on the non-failing filament lamps is being studied.

NOTE Data for 24 V filament lamps are under consideration. Further details of the surge are under consideration.

Figure F.1 – Voltage surges for 12 V filament lamps – Maximum tolerable duration for a voltage surge as a function of its height

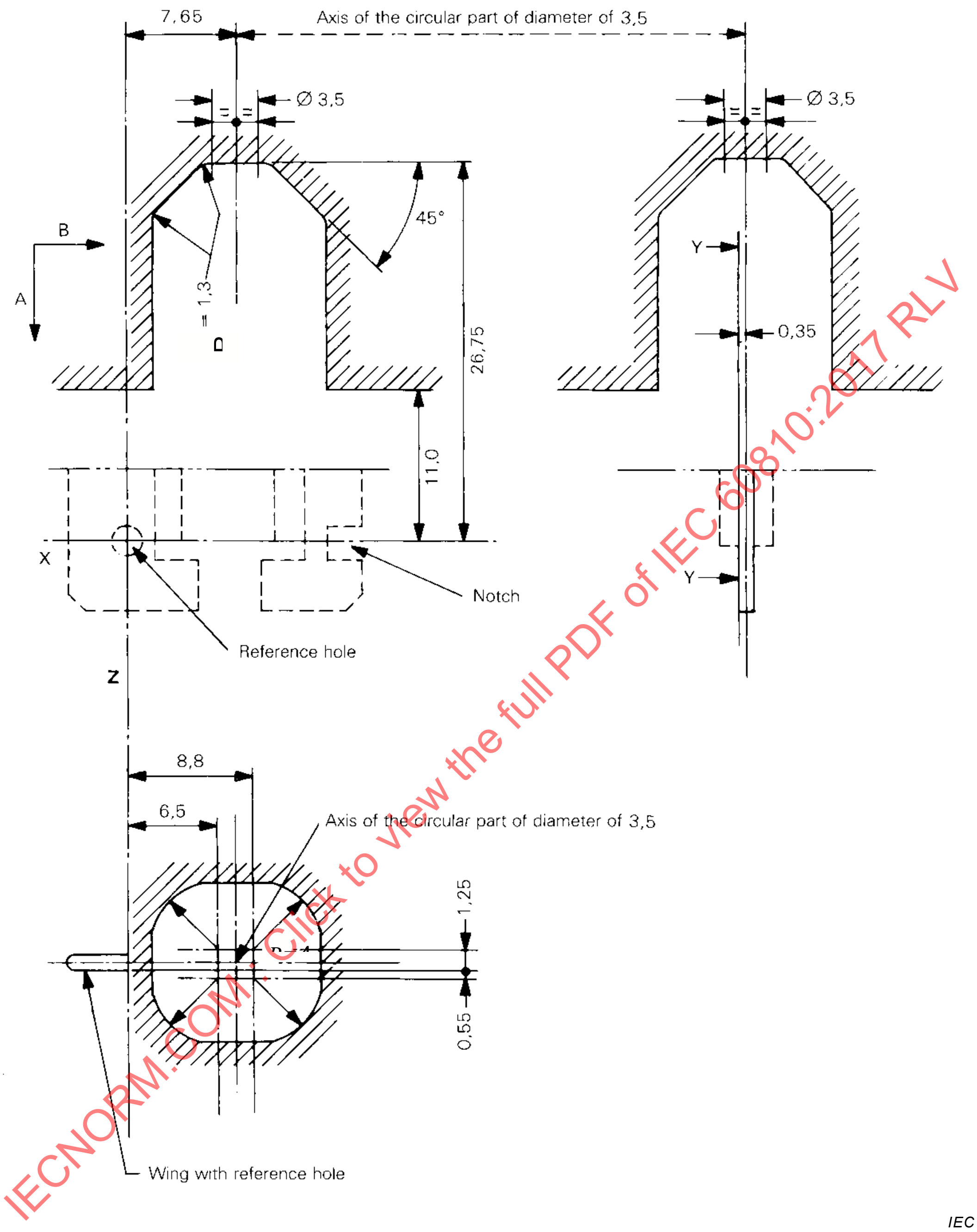
Dimensions in millimetres



IEC

Figure F.2 – Maximum filament lamp outlines H1

Dimensions in millimetres



Key

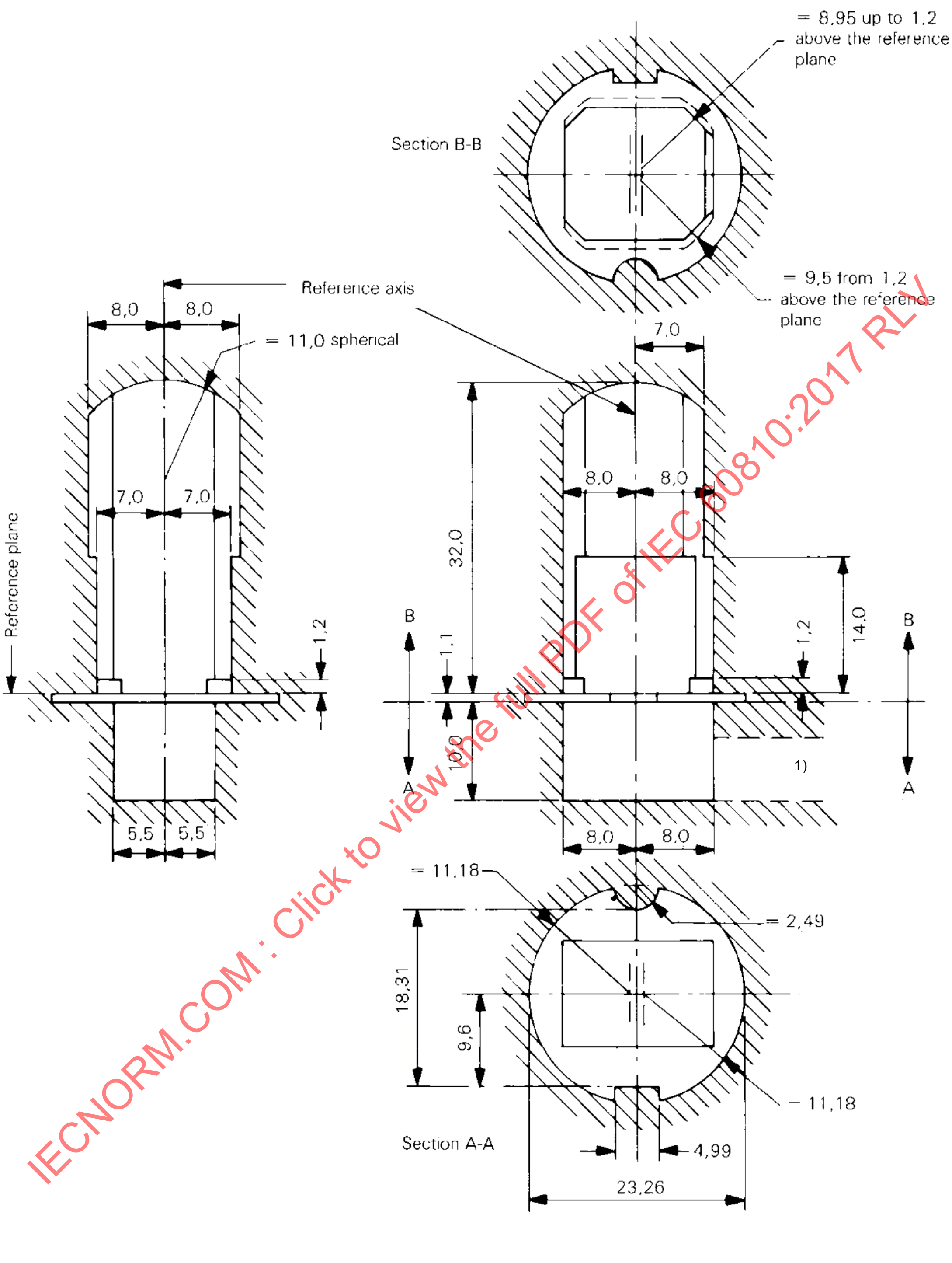
X Reference axis common to the reference hole and the notch

Z Reference plane containing reference axis of the hole and perpendicular to X axis

Y Supporting plane of the wings

Figure F.3 – Maximum filament lamp outlines H2

Dimensions in millimetres



1 Maximum lamp outline for the passage of the insulated cable and connector tab.

Figure F.4 – Maximum filament lamp outlines H3

Dimensions in millimetres

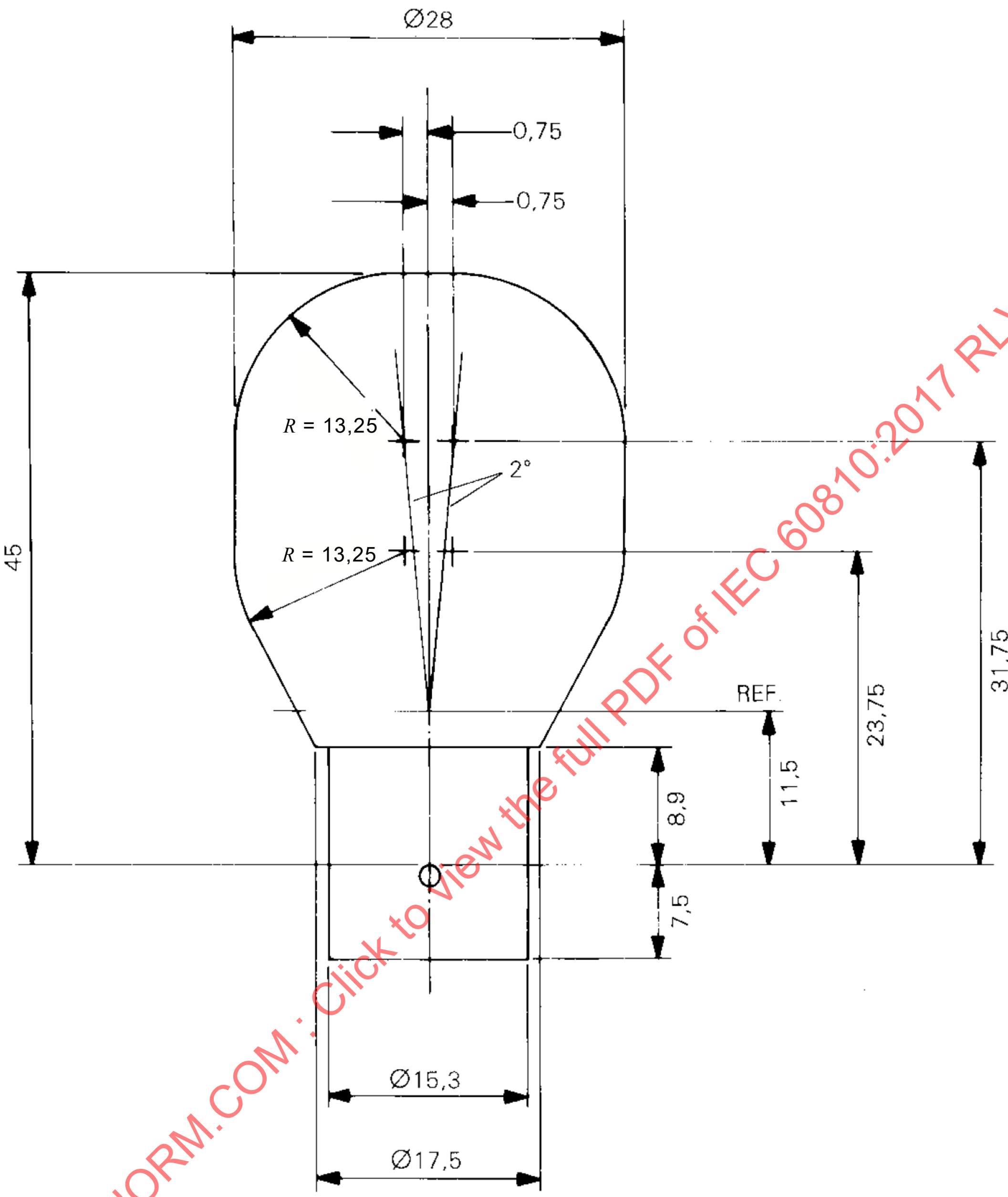


Figure F.5 – Maximum filament lamp outlines P21W, PY21W, P21/4W and P21/5W

Annex G
(informative)

Ballast design

Discharge lamps with integrated starting device may make use of a spark gap to generate the high-voltage starting pulse. The ballast should provide an open-circuit voltage as follows (see Table G.1).

Table G.1 – Open circuit voltage

Open- circuit voltage (r.m.s.)	V	min.	360
		max.	600

Annex H
(informative)

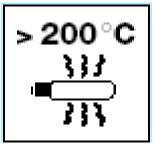
Symbols

H.1 General

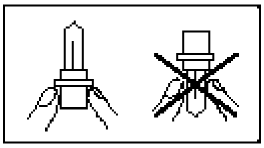
Annex H lists the symbols referred to in Clauses F.5 and F.6.

The height of graphical symbols shall not be less than 5 mm, and for letters, not less than 2 mm.

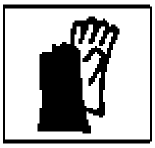
H.2 Symbol indicating that lamps operate at high temperatures



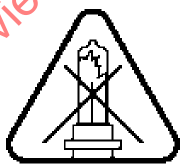
H.3 Symbol indicating that care should be taken to avoid touching the bulb



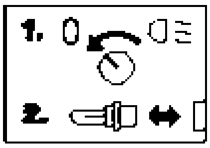
H.4 Symbol indicating that the use of protective gloves is advised



H.5 Symbol indicating that lamps with scratched or otherwise damaged bulbs should not be used



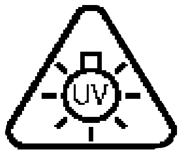
H.6 Symbol indicating that before handling, the lamp shall be switched off



H.7 Symbol indicating that the use of eye protection is advised

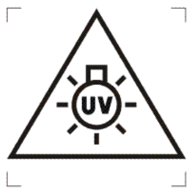
H.8 Symbol indicating that during operation, the lamp emits UV-radiation

H.8.1



The symbol in H.8.2 should be used for new products. It is under consideration to remove the symbol in H.8.1 in a future revision of this document.

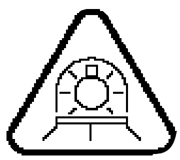
H.8.2



IEC 60417-6040:2010-08

H.9 Symbol indicating that the lamp shall be operated only in a luminaire with a protective shield

H.9.1



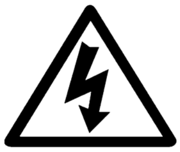
The symbol in H.9.2 should be used for new products. It is under consideration to remove symbol in H.9.1 in a future revision of this document.

H.9.2

IEC 60417-6071:2011-09

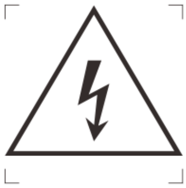
H.10 Symbol indicating dangerous voltage

H.10.1



The symbol in H.10.2 should be used for new products. It is under consideration to remove the symbol in H.10.1 in a future revision of this document.

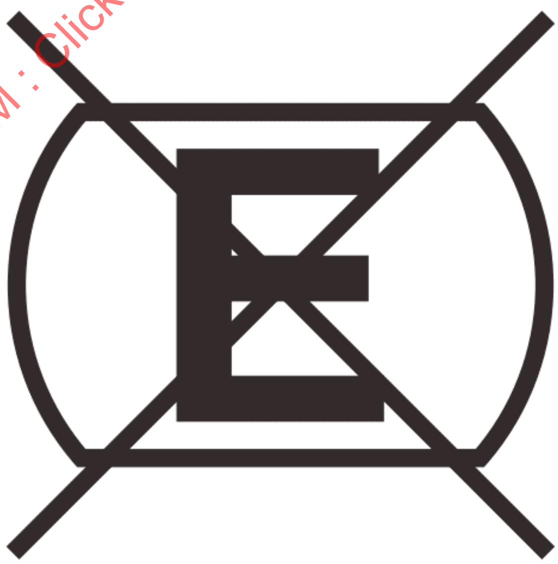
H.10.2



IEC 60417-6042:2010-11

H.11 Pictogram for instruction "Non-ECE"

The pictogram for instruction according to Figure H.1 indicates: “This product is not intended for use in applications where a light source approved (E-marked) to a UN regulation (R37, R99 and R128) is required."



IEC 60417-6362:2016-04

Figure H.1 – Pictogram for instruction "Non-ECE"

H.12 Pictogram for instruction "Interior lighting only"

The pictogram for instruction according to Figure H.2 indicates: “This product is for vehicle interior lighting only”.

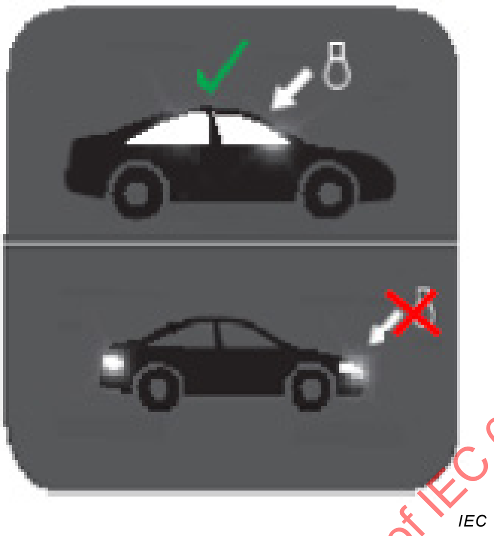


Figure H.2 – Pictogram for instruction "Interior lighting only"

Annex I
(normative)

Luminous flux maintenance test conditions for LED light sources

I.1 Ageing

LED light sources shall be aged at their test voltage for 48 h under the operating conditions specified in I.3. LED light sources which fail during the ageing period shall be omitted from the test results.

I.2 Test voltage

Tests shall be carried out at a test voltage of:

- 13,5 V for signal light sources and 13,2 V for front lighting light sources, for products intended for a 12 V board voltage;
- 28 V for products intended for a 24 V board voltage.

The applied voltage shall be a stable direct current.

If the LED light source is intended to be operated by an electronic light source controlgear, the test voltage shall be applied to the input terminals of the controlgear. In this case, the output of the electronic light source controlgear, for example voltage, electrical current, power, operating mode shall be described in the test report.

NOTE The test voltage is deemed to be stable when the momentary fluctuations do not exceed 1 % and the deviation of the average over the test period does not exceed 0,5 % of the specified value.

I.3 Operating conditions

I.3.1 Test rack

LED light sources shall be operated on a vibration-free test rack.

I.3.2 LED light sources with integrated thermal management

LED light sources with integrated thermal management shall be installed in a chamber with the following characteristics:

- well-mixed air, but no excessive forced convection across the light source;
- ambient air temperature in the chamber: 25 °C ± 10 °C.

I.3.3 LED light sources with external thermal management

LED light sources, for which the thermal management is intended to be achieved in conjunction with the luminaire/device or a separate thermal management component, shall be operated at the specified base temperature T_p. The base temperature T_p shall be included in the test report and shall be part of the luminous flux maintenance declaration by the manufacturer.

NOTE Control of the T_p temperature during testing can be achieved by active or passive methods for example a heat-sink, a heat-sink combined with a cooling fan or a Peltier-cooling-element.

Examples of possible product data are given in Table I.1.

Table I.1 – Examples of possible product data

Type	$L_{70}T_c$ h	$L_{70}B_{10}$ h
Product designation at T_p = 100 °C	2 500	1 500
Product designation at T_p = 70 °C	3 500	2 500

I.4 Switching cycle

I.4.1 Single-function LED light sources

I.4.1.1 LED light sources for continuous operation

LED light sources shall be switched off twice daily for periods of not less than 15 min, such periods not being considered as part of the life.

I.4.1.2 LED light sources for intermittent operation

LED light sources for intermittent operation as used in direction indicators shall be operated in the following switching cycle:

- 115 min continuous on or flashing, as appropriate;
- 5 min off;
- flashing frequency: 90/min; on/off ratio 1:1.

The whole flashing operation time is considered as life.

I.4.2 Dual-function LED light sources for headlamps

The functions shall be operated alternately according to the following cycle and starting with the lower beam function:

- passing-beam function: 15 h on/45 min off;
- driving-beam function: 7,5 h on/45 min off.

The lifetime values for the light source are determined by the lower performing of the two functions.

The off periods are not considered as part of the life.

NOTE The operation of the passing-beam function represents two-thirds of the total life, the operation of the driving-beam function one-third.

I.4.3 Multiple-function LED light sources for light signalling equipment

Luminous flux maintenance testing may be carried out either for each function separately, or with all functions operated simultaneously or with the functions operated alternately.

In the case of an alternate operation, each function shall be operated with a minimum on-period of 10 h.

If different operating conditions (e.g. dimming) are used for the same LED light source in order to fulfil different functions, luminous flux maintenance testing may be carried out at the most onerous conditions.

For LED light sources for continuous operation, the switching cycle shall be as specified in I.4.1.1.

For LED light sources for intermittent operation, the switching cycle shall be as specified in I.4.1.2.

I.5 Luminous flux maintenance measurements

Tests may be interrupted for the determination of the luminous flux maintenance.

Luminous flux maintenance measurements should be carried out at regular intervals, at a maximum time interval of 1 000 h.

For the measurement of the luminous flux, an integrating method shall be used. The LED light source shall be operated in a dry and still atmosphere at an ambient temperature of 23 °C ± 5 °C.

LED light sources, for which the thermal management is intended to be achieved by additional provisions, shall be operated at the specified performance temperature T_p.

Measurements shall be carried out when photometric stability has occurred.

The moment at which the photometry is stable is defined as the point in time at which the variation of the photometric value is less than 3 % within any 15 min period.

I.6 Colour measurement

The colour of the emitted light shall be measured, using an integrating method, at the same time as the luminous flux maintenance measurements and under the same conditions as specified in I.5.

The colour shall be expressed in CIE-coordinates and shall remain within the respective colour boundaries as given in 4.4.1 of IEC 60809:2014 (for colour specification, see also UN Regulation R48 Revision 12:2014, 2.29).

If the colour of the emitted light has shifted outside the respective colour specification, the light source shall be considered to have failed and the luminous flux maintenance test shall be stopped.

If the colour of the emitted light is produced by a combination of light source radiation and secondary optics, all colour measurements shall be carried out with secondary optics.

In this case, the optical properties of the secondary optics shall be described in the test report.

Annex J
(normative)

Destructive physical analysis for LED packages

J.1 Description

The purpose of this examination is to determine the capability of a LED package's internal materials, design, and workmanship to withstand forces induced by various stresses induced during environmental testing.

J.2 Equipment

The following equipment is required:

a) optical microscope having magnification capability of up to 50X;

b) de-capsulation equipment.

J.3 Procedure

The following procedure shall be followed:

a) LED packages selected for this test shall have successfully completed environmental testing as listed in 8.6.9. (PTMCL test, WHTOL test, H2S and FMGC test).

b) The LED packages shall be opened or de-capsulated in order to expose the internal die/substrate and determine the extent of any mechanical damage. An additional cross sectional cut through chip interconnect (chip/glue/leadframe) may be performed for the validation of corrosion stability. The cross sectional cut shall be done after the LED package is de-capsulated. The process used to de-capsulate the LED package shall ensure that it does not cause degradation of the leads and bonds. The internal die or substrate shall be completely exposed and free of packaging material.

c) The LED packages shall be examined under a magnification of up to 50X to the criteria listed in J.4.

d) Failed LED packages shall be analysed to determine the cause of the failure. A failure analysis report documenting this analysis shall be prepared on all failures. If the analysis shows that the failure was caused by the package opening process, the test shall be repeated on a second group of LED packages.

J.4 Failure criteria

LED packages shall be considered to have failed if they exhibit any of the following:

a) visible evidence of non-conforming to the LED packages' certificate of design, construction and qualification;

b) visible evidence of corrosion, contamination, delamination or metallization voids;

c) visible evidence of die/substrate cracks or defects;

d) visible evidence of wire, die, or termination bond defects;

e) visible evidence of dendrite growth or electromigration.

Annex K
(informative)

Communication sheet LED package testing

SUBJECT: LED package stress test qualification according to IEC 60810

DEVICE:		**Report No.:**	
Family package:		**Date:**	

Key product data: [Reference to applicable product specification sheet]

nominal drive current I_f

minimum drive current I_f

maximum drive current I_f

mininum operating temperature $T_{s,\ min}$

maximum operating temperature $T_{s,\ max}$

$R_{th,electr}$. (typical) and $R_{th,electr}$. (maximum)

TEST PERFORMED	CONDITION	DURATION/ TEST REPEATS	SAMPLE SIZE	FAILURES		
				Electrical	Photometrical	Visual
8.6.3 High temperature operating life (HTOL) *JESD22-A108D*	T_S = __°C I_F = __ mA T_S = __°C I_F = __ mA	1 000 h	3 x 26			
8.6.4 Temperature cycling (TMCL) *JESD22-A104E*	Preconditioning: JEDEC level __ TMCL condition _ -__°C/+___°C __min each extreme Transfer time __ s	1 000 cycles	3 x 26			
8.6.5 Wet high temperature operating life – minimum rated drive current (WHTOL) *JESD22-A101C*	Preconditioning: JEDEC Level __ T_S = 85°C, RH= 85 %; I_F = __ mA $t_{on\ /\ off}$ = 30 min	1 000 h	3 x 26			
8.6.6 Power temperature cycling (PTMCL) *JESD22-A105C*	Preconditioning: JEDEC level __ PTMCL condition _: -__/+___°C I_F = __ mA $t_{on\ /\ off}$ = 5 min	1 000 h	3 x 26			

TEST PERFORMED	CONDITION	DURATION/ TEST REPEATS	SAMPLE SIZE	FAILURES		
				Electrical	Photometrical	Visual
8.6.7 Electrostatic discharge (ESD-HBM) *JS-001-2012*	Human body model 8 000 V		3 x 26			
8.6.8 Electrostatic discharge (ESD-MM) *JESD22-A115C*	Machine model 400 V		3 x 26			
8.6.10 Physical dimension (PD)	According to data sheet		3 x 26			
8.6.11 Vibrations variable frequency (VVF) *JESD22-B103B*	**Constant displacement:** 1,5 mm (20 Hz to 100 Hz) **Peak acceleration:** 200 m/s^2 (100 Hz to 2 000 Hz) Duration one cycle: ≥ 4 min Cycles per axis: 4 Number of axes: 3 (X;Y;Z)	1x	3 x 26			
8.6.12 Mechanical shock (MS) *JESD22-B110B*	**Shock type:** Half sinus **Max. acceleration:** 1 500 g **Shock duration:** 0,5 ms **Number of shocks:** 5 in each direction **Number of directions:** 6 (±X, ±Y, ±Z) → 30 shocks total	1x	3 x 26			
8.6.13 Resistance to soldering heat (RSH-TTW) *JESD22-B106D*	TTW-soldering	3x	3 x 26			
8.6.14 Resistance to soldering heat (RSH-reflow) *JESD22-A113F*	Reflow soldering 260 °C	3x	3 x 26			
8.6.15 Solderability (SO) *IEC 60068-2-58*	Process temperature group __	1x	3 x 10			
8.6.16 Thermal shock (TMSK) *JESD22-A106B*	TMSK condition _: -__°C/+___°C (liquid-to-liquid)	1 000 cycles	3 x 26			
8.6.17 Hydrogen sulphide (H2S) *IEC 60068-2-43*	T_A = 40 °C RH = 90 % 10 – 15 × 10^{-6} H_2S	336 h	3 x 26			
8.6.18 Pulsed operating life (PLT) *JESD22-A108D*	T_S = 55 °C I_F = __ mA t = 100 µs; D = 3 %	1 000 h	3 x 26			
8.6.19 Dew test (DEW)	$T_{A\ min}$ = 30 °C – 65 °C Time at 65 °C __h RH = 90 % to 98 %;	1 008 h	3 x 26			

TEST PERFORMED	CONDITION	DURATION/ TEST REPEATS	SAMPLE SIZE	FAILURES		
				Electrical	Photometrical	Visual
8.6.20 Flow mixed gas corrosion (FMGC) *IEC 60068-2-60*	Test method 4 T_A = 25 °C RH = 75 %	500 h	3 x 26			

TEST PERFORMED	SAMPLE SIZE	C_{pk} VALUE
8.6.21 Wire bond pull test (WBP) *MIL-STD 883E*		
8.6.22 Bond shear test (BS) *JEDEC STD22-B116*		
8.6.23 Die shear test (DS) *MIL-STD 883E*		

<u>Failure criteria:</u>

Electrical: V_f (I_f (nominal) = __ mA) >__ V; ±10 % from initial value

Photometrical:

- Radiant power/luminous flux: I_v (I_f (nominal) = __ mA) absolute limit: ± __% max.
- Colour coordinates: x (I_f (nominal) = __ mA) < 0,01

  y (I_f (nominal) = __ mA) < 0,01

Visual: e.g. broken or damaged package or leads

Conclusion: The tested devices fulfil the reliability requirements.

Annex L
(normative)

Re-testing matrix for LED packages testing

For product and/or process changes the ZVEI Guideline “Guideline for Customer Notifications of Product and/or Process Changes (PCN) of Electronic Components specified for Automotive Applications” including the DeltaQualificationMatrix (DeQuMa) shall be applied.

Annex M
(informative)

Guidelines for LED packages robustness validation

M.1 General

Annex M[3] gives guidance on a robustness validation procedure for LED packages.

The purpose of these guidelines is to show procedures that can give relevant information on the degradation of LED packages under over-stress conditions, and to give guidance on using this information in combination with acceleration models to predict the degradation behaviour and the time-to-failure under typical application conditions. During the testing, the stress level is increased beyond the specification limit of the LED package until significant degradation is observed. The failures over time under over-stress conditions are recorded. In addition, the degradation modes are investigated by using a non-destructive and destructive physical analysis (DPA). By combining the measured failure rates for each degradation mode under over-stress conditions with relevant acceleration models, information can be obtained on the expected degradation over time under use conditions in automotive lighting applications.

NOTE It is not possible to develop acceleration models for all over-stress conditions, for example when no significant degradation is observed.

“Robustness testing”, according to this document, is defined as over-stress testing beyond the product specification limits until significant degradation is observed.

“Moderate overstress testing”, according to this document, is defined as the subset of this information that can be combined with models to make predictions about the lifetimes and failure rates under real application conditions within the product specification limits.

Figure M.1 shows the basic over-stress testing concept for two stress parameters.

[3] The procedure of robustness validation is derived from a similar approach developed by the ZVEI (Requirements and test conditions for LED packages, November 2012, Revision 1.9)

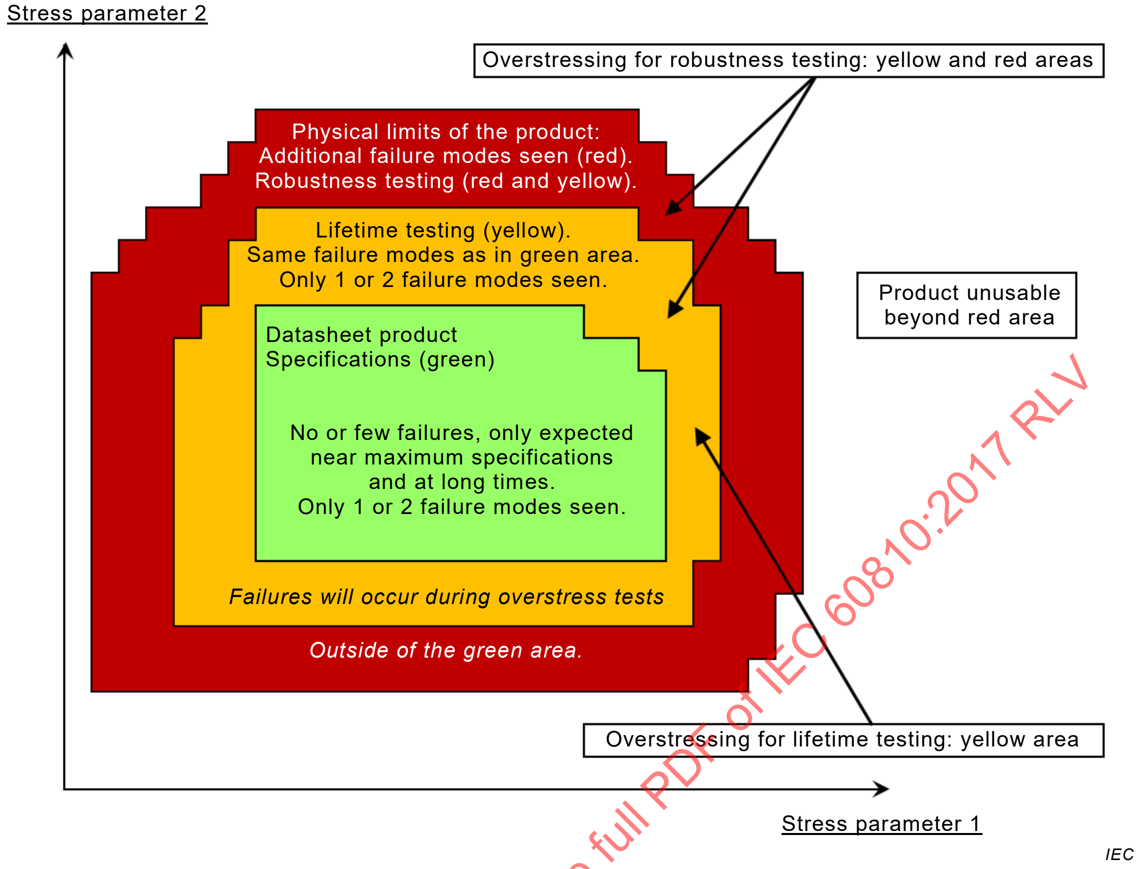


Figure M.1 – Concept of over-stress testing for two stress parameters

The "moderate overstress testing" parametric area (yellow) is such that the degradation modes observed are the same ones as seen in the "product specification" area, and/or are relevant to operation immediately beyond it.

Beyond the "moderate overstress testing" parametric area (red and beyond), new degradation modes are observed, and special considerations need to be taken so that acceleration models and the lifetime estimates are still representative of the automotive use conditions within or near the boundaries of the product specification.

Figure M.2 shows a flow diagram for the robustness validation process.

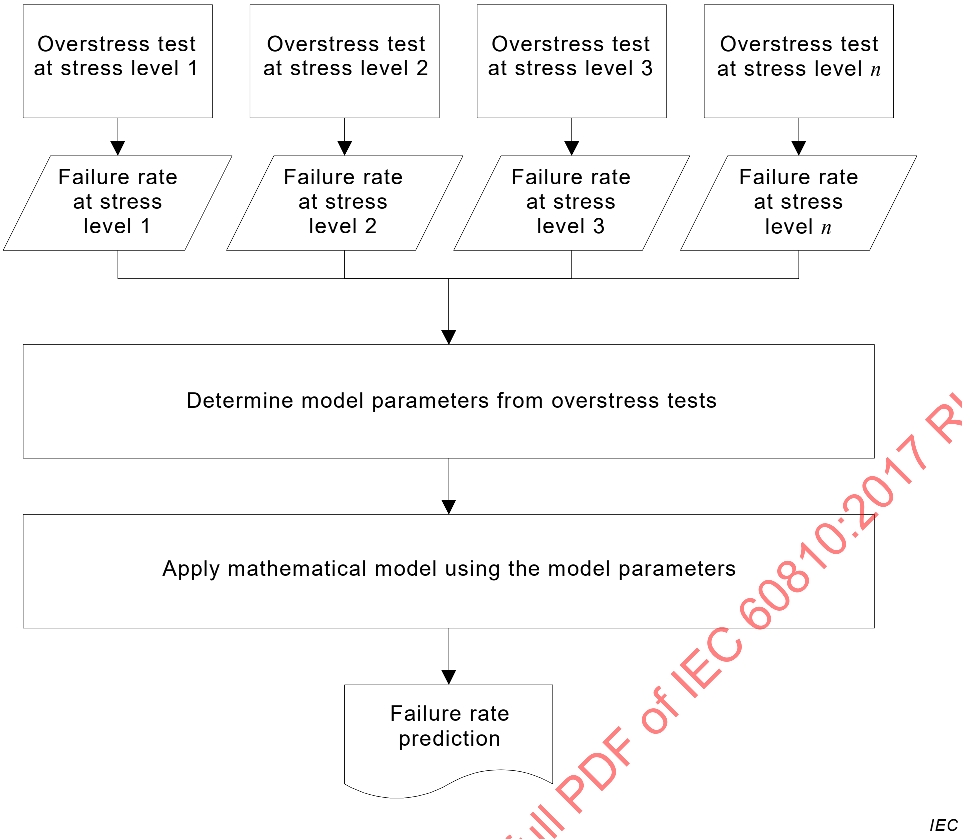


Figure M.2 – Flow diagram for the robustness validation process

Clause M.5 defines a set of over-stress tests that should be considered for robustness validations for new LED packages.

Clause M.7 gives relevant mathematical models.

Where appropriate, family robustness validation may be done and a rationale should be given by the supplier. For family definition, see 8.1.

For product and/or process changes the ZVEI Guideline including the DeltaQualificationMatrix (DeQuMa) "Guideline for Customer Notifications of Product and/or Process Changes (PCN) of Electronic Components specified for Automotive Applications" should be applied.

This document makes reference to other IEC standards or standards from other organizations (e.g. JEDEC). Where relevant, further details on the test definitions can be found in these documents. Test conditions in this document may deviate from test conditions in the reference documents. In such a case, further definitions in the reference document should still be applied as appropriate.

M.2 Test samples

M.2.1 Lot requirements

Unless specified otherwise, a minimum of 30 LED packages taken from three different batches of 10 each should be used for each test and for each over-stress condition. For family qualification, the three different batches should be considered to represent the whole variety of the qualification family.

The sample size may be reduced due to capacity constraints or experimental limitations. The reason(s) for sample size reduction should be provided with the report.

M.2.2 Production requirements

All LED packages should be produced on tooling and processes at the manufacturing site that will be used to support LED package deliveries at projected production volumes. Alternatively, laboratory samples from the latest phase of development may be used; this should be documented in the test report.

M.2.3 Pre- and post-stress test requirements

Electrical and photometric values (forward voltage, luminous flux or radiant power and/or intensity, colour parameter) should be measured before and after stress testing (see also M.5.1).

NOTE A simple light/no light test is under consideration for testing at different temperatures.

Where possible, the LED packages used for the robustness validation should meet the product specification parameters measured at the nominal test conditions before over-stress testing.

M.2.4 Assembly of LED packages on test boards

LED packages may need to be assembled on test boards. An appropriate choice of test board, interconnect material and process should be made by the manufacturer. The choice of test board, interconnect material and process should be documented for each individual test in the test report.

M.3 Definition of end-of-test criteria

The LED manufacturer should define end-of-test criteria and report these with a justification. Typical testing time is 1 500 h to 2 000 h. Testing beyond 3 000 h is not recommended. In case of physical damage, this should be documented by means of DPA.

M.4 Test sequence of over-stress testing

For each over-stress test, tests should be carried out at different stress levels. Each stress test should be carried out on separate samples. One stress level should be inside (or on the border of) the product specification, i.e. it should be the same as for the qualification test; then the stress level should be increased step-by-step beyond the product specification.

It is recommended to choose at least three over-stress levels per stress parameter within the “moderate-overstress testing” (yellow) area (see Figure M.1). For robustness validation, additional stress levels may be chosen within the “robustness testing” (yellow and red areas), until at least 30 % of the tested parts have failed the criteria or a typical testing time of 1 500 h to 2 000 h is reached.

Table M.1 shows an over-stress matrix for two stress parameters in the case where no knowledge on the potential degradation mechanism exists. In that case, it is recommended to evaluate this comprehensive test matrix to study end of life versus stress level. If experience with potential degradation mechanism of this LED family exists, only a subset of tests is required.

Table M.1 – Typical over-stress matrix for two stress parameters

	Stress 2 →				
Stress 1 ↓	**Stress 2 level 1 (inside specification)**	**Over-stress 2 level 2**	**Over-stress 2 level 3**	**Over-stress 2 level 4**	**Over-stress 2 level *n***
Stress 1 level 1 (inside specification)	0				
Over-stress 1 level 2		1	1	1	
Over-stress 1 level 3		1	1	1	2
Over-stress 1 level 4		1	1	1	2
Over-stress 1 level *n*			2	2	2

Key

"0" (green) = no failures (within the green "product specification" area in Figure M.1).

"1" (yellow) = some failures (within the yellow "moderate overstress testing" area in Figure M.1), investigating relevant degradation modes for acceleration of application use conditions.

"2" (red) = significant failures (red area, near or beyond physical limit of the product in Figure M.1), investigating the physical boundaries in more detail.

M.5 Over-stress test definition

M.5.1 Pre- and post-electrical and photometric test

All LED packages should be tested at nominal or maximum or stress drive current according to the following requirements of the appropriate LED package specification (manufacturer's datasheet) prior to and after the following tests:

- luminous flux or radiant power or intensity (whichever is appropriate);
- forward voltage;
- colour coordinates x,y or dominant wavelength λ_d or peak wave length λ_p (whichever is appropriate).

In addition, the forward voltage at the minimum (or lower) current should be recorded.

The nominal drive current should be defined by the LED package supplier; typically this is the drive current used for LED binning.

M.5.2 Pre- and post-external visual (EV) test

The construction, marking and workmanship of the LED package should be inspected according to JESD22-B101B prior to and after the following tests.

M.5.3 High temperature operating life (HTOL) and low temperature operating life (LTOL) tests

The purpose of this test is to evaluate the performance of the LED package under stress due to high temperature operation. The test should be conducted according to JESD22-A108D; the following test conditions apply:

- typical duration 2 000 h;
- over-stress parameters: T_j, I_f.

As part of the robustness investigation, the following HTOL over-stress conditions should be tested for a minimum of 1 500 h:

- $T_j = T_{j,max} + 15$ K for high-power (≥ 1W rated power) LED packages
- $T_j = T_{j,max} + 30$ K for mid-power (< 1W rated power) LED packages
- $I_f = 125\ \%\ I_{f,max}$ mA for high-power (≥ 1 W rated power) LED packages
- $I_f = 150\ \%\ I_{f,max}$ mA for mid-power (< 1 W rated power) LED packages
- 78 LED packages taken from three different batches (production lot) of 26 each should be used.
- For all surface mount solder reflowable: preconditioning according to JESD22-A113F followed by three Pb-Free reflow solder cycles. Reflow cycles should be completed between 15 min and 4 h after preconditioning is completed.

As part of the robustness investigation, the following LTOL over-stress condition should be tested for a minimum of 1 500 h:

- $T_{ambient}$ = -40 °C
- $I_f = 125\ \%\ I_{f,max}$ mA for high-hower (≥ 1 W rated power) LED packages
- $I_f = 150\ \%\ I_{f,max}$ mA for mid-power (< 1 W rated power) LED packages
- 78 LED packages taken from three different batches (production lot) of 26 each should be used.
- For all surface mount solder reflowable: preconditioning according to JESD22-A113F followed by three Pb-Free reflow solder cycles. Reflow cycles should be completed between 15 min and 4 h after preconditioning is completed.

M.5.4 Temperature cycling (TMCL) test

The purpose of this test is to evaluate the performance of the LED package under stress due to temperature cycles without operation of the LED. The LED package should be tested according to JESD22-A104E; the following test conditions apply:

- Typical duration: 1 000 cycles.
- Recommendation: soak mode 4, with soak time 15 min and transfer time 15 min.
- $T_{s,max}$ and $T_{s,min}$ combinations are listed in Table 1 of JESD22-A104E. Other $T_{s,max}$ and $T_{s,min}$ combinations than the ones specified in Table 1 of JESD22-A104E (test conditions A to N) may be considered.
- Over-stress parameters: $T_{s,max}$, $T_{s,min}$, transfer rate.

The choice of the TMCL cycle condition and the transfer time should be reported.

M.5.5 Wet high temperature operating life (WHTOL) test

The purpose of this test is to evaluate the performance of the LED package under stress due to temperature and humidity. The LED package should be tested according to JESD22-A101C. The following test conditions apply:

- Typical duration: 2 000 h.
- The LED should be operated either continuously DC or with a power cycle of 30 min on/30 min off (power duty factor = 50 %).
- Other currents, chamber temperatures, and chamber relative humidities (RH) or moisture contents (MC)[4], with or without a power cycle, may be chosen to develop WHTOL models. All other test provisions should be in accordance with JESD22-A101C.

4 Absolute humidity absorbed by the LED package.

- Efforts should be made to estimate the relative humidty (RH) and/or moisture content (MC) values near the LED during the power-on and during the power-off cycles.
- The tests should be performed at the minimum and maximum rated drive currents corresponding to the T_j of the LED during the power-on operation.
- Over-stress parameters: $RH_{chamber}$ or $MC_{chamber}$, I_f, $T_{chamber}$, power duty factor.

As part of the robustness investigation, the following over-stress conditions should be tested for a minimum of 1 500 h:

- 85 °C / 85 % RH ambient
- I_f = 125 % $I_{f,max}$ mA for high-power (≥ 1W rated power) LED packages
- I_f = 150 % $I_{f,max}$ mA for mid-power (< 1W rated power) LED packages
- 78 LED packages taken from three different batches (production lot) of 26 each should be used.
- For all surface mount solder reflowable: preconditioning according to JESD22-A113F followed by three Pb-Free reflow solder cycles. Reflow cycles should be completed between 15 min and 4 h after preconditioning is completed.

M.5.6 Power temperature cycling (PTMCL) test

The purpose of this test is to evaluate the performance of the LED package under stress due to temperature cycles during operation of the LED package. The LED package should be tested according to JESD22-A105C; the following test conditions apply:

- Typical duration: 1 000 temperature cycles.
- Power cycle 5 min on/5 min off operated at the corresponding maximum rated drive current.
- Other $T_{s,max}$ than the ones specified in Table 1 of JESD22-A105C (test conditions A and B) may be chosen.
- Over-stress parameters: $T_{s,min}$, $T_{s,max}$, I_f, transition time, dwell time.
- $T_{j,min}$ and $T_{j,max}$ should be reported for both on and off cycles.

As part of the robustness investigation, the following over-stress conditions should be tested for 1 500 temperature cycles:

- $T_{s,min}$ = -40 °C; $T_{s,max}$ = 125 °C
- 10 min dwell, 20 min transfer (1 h cycle)
- 2 min on/2 min off
- I_f = 130 % $I_{f,max}$ mA for high-power (≥ 1W rated power) LED packages
- I_f = 150 % $I_{f,max}$ mA for mid-power (< 1W rated power) LED packages
- 78 LED packages taken from three different batches (production lot) of 26 each should be used.
- For all surface mount solder reflowable: preconditioning according to JESD22-A113F followed by three Pb-Free reflow solder cycles. Reflow cycles should be completed between 15 min and 4 h after preconditioning is completed.

M.5.7 Thermal shock (TMSK) test

The purpose of this test is to evaluate the performance of the LED package under stress due to thermal shock. The LED package should be tested according to JESD22-A106B (or IEC 60068-2-14). The following conditions should apply:

- typical duration: 1 000 cycles;
- over-stress parameters: $T_{s,min}$, $T_{s,max}$;

- one (or both) of the options below should be chosen:
- Option 1: liquid to liquid. Other $T_{s,max}$ and $T_{s,min}$ combinations than the ones specified in Table 1 of JESD22-A106B (test conditions A to D) may be chosen,
- Option 2: air to air. Other $T_{s,max}$ and $T_{s,min}$ combinations may be chosen. A typical air-to-air test test condition is: $T_{s,max}$ = 125 °C, $T_{s,min}$ = -40 °C, soak time 30 min, transfer time 10 s.

As part of the robustness investigation, the following over-stress conditions should be tested for 3 000 cycles:

- $T_{s,min}$: -55 °C; $T_{s,max}$: 150 °C
- 10 s transfer
- Dwell time 15 min
- 78 LED packages taken from three different batches (production lot) of 26 each should be used.
- For all surface mount solder reflowable: preconditioning according to JESD22-A113F followed by three Pb-Free reflow solder cycles. Reflow cycles should be completed between 15 min and 4 h after preconditioning is completed.

M.6 Destructive physical analysis (DPA) test

The purpose of this test is to evaluate the degradation mechanisms induced by the stresses during environmental over-stress testing.

The DPA analysis is used to identify the degradation mechanism and to determine if the degradation mode is application related or not (see also Figure M. 1).

Guidance for DPA is given in Annex J. DPA should be performed on random samples of failed units after completion of the over-stress tests (minimum two samples). The post electrical and photometrical test of these samples should be executed before the destructive physical analysis.

M.7 Projection models

The following models are available to calculate the acceleration factors, see Table M.2.

NOTE The formulae in Clause M.7 assume X-stress > X-use (where X = T, I_f or ES, RH or MC, T_{max}-$T_{min,}$ cycle time), and are written consistently such that a + sign is always in front of power and exponential exponents.

The models shall always use the corresponding T_j (the LED junction temperature, in K) to calculate the LED‘s optical and electrical properties. Modelling of solder joints or of package mechanical properties shall use T_c or T_s (in K) instead.

Table M.2 – Acceleration models

Stress test	**Model**	**Acceleration factor equation**
HTOL	Arrhenius and (inverse) power law	$AF = (\frac{If\ stress}{If\ use})^{+n} \times e^{+\frac{Ea}{k}}(\frac{1}{Tuse} - \frac{1}{Tstress})$
HTOL Note: NOTE 1 $n \neq 0$ when photo-thermal and electro-chemical effects are present, which is very often the case. $n = 0$ when these effects are not significant, and for storage tests (where $I_f = 0$).		
TMCL, TMSK	Coffin-Manson	$AF = (\frac{T_{max} - T_{min} \vert stress}{T_{max} - T_{min} \vert use})^{+q}$
	Norris-Landzberg	$AF = (\frac{Cycle\ Time_{stress}}{Cycle\ Time_{use}})^{+p} \times (\frac{T_{max} - T_{\min stress}}{T_{max} - T_{\min use}})^{+q} \times e^{+\frac{Ea}{k}(\frac{1}{Tmax\ use} - \frac{1}{Tmax\ stress})}$
	Engelmaier	$AF = (\frac{DeltaD_{use}}{DeltaD_{stress}})^{+\frac{1}{c}}$ DeltaD = range of angular shear after total joint stress relaxation
WHTOL	Peck	No photo-thermal or electrical effects (applies to wet storage): $AF = (\frac{RH_{stress}}{RH_{use}})^{+r}$ or $AF = (\frac{MC_{stress}}{MC_{use}})^{+r}$ See Notes 3 and 5
WHTOL	Peck including current	Same T_j for use and stress: $AF = (\frac{RH_{stress}}{RH_{use}})^{+r} \times (\frac{I_{f,stress}}{I_{f,use}})^{+n}$ See Notes 2 and 3
WHTOL	Peck including current and T_j	T_j use ≠ T_j stress: $AF = (\frac{MC_{stress}}{MC_{use}})^{+m} \times (\frac{I_{f,stress}}{I_{f,use}})^{+n} \times e^{+\frac{Ea}{k}(\frac{1}{T\ use} - \frac{1}{T\ stress})}$ See Notes 3 and 4
WHTOL	Peck-Eyring including current and temperature	RH or MC use ≠ RH or MC stress: $AF = (\frac{I_{f\ stress}}{I_{f\ use}})^{+n} \times e^{+B(\frac{1}{MC\ use} - \frac{1}{MC\ stress})} \times e^{+\frac{Ea}{k}(\frac{1}{T\ use} - \frac{1}{T\ stress})}$ See Note 5

WHTOL Notes: NOTE 2 Electrical exponent $n \neq 0$ when photo-thermal and electro-chemical effects are present, which is very often the case. $n = 0$ when these effects are not significant, and for storage tests (where $I_f = 0$), and for some corrosion tests. NOTE 3 Peck and Peck – Non-thermal formulae are only valid for RH comparisons at about the same T_j (i.e., roughly comparable saturation vapour pressures near the LED), and for high (> 50 %) RH values. At low RH, Peck either does not hold, or holds for r values of a magnitude much smaller than at high RH, so that low RH to high RH comparisons are not well described by Peck. (RH = relative humidity = partial vapour pressure/saturation vapour pressure). NOTE 4 The simultaneous effect of temperature and humidity is often accounted for. For T_j stress different from T_j use, RH-stress corresponds to a very different moisture content (vapour density, closely approximated by partial vapour pressure) than RH use for the same RH. The moisture content is abbreviated above as MC. By using MC instead of RH, the formula can then include the Arrhenius temperature acceleration. NOTE 5 For cases when one wants to compare very different RH or MC conditions, it is better to use an exponential behaviour for humidity, through the use of the temperature-humidity variation of the Eyring relationship, rather than through a(n) (inverse) power law, since as outlined above the value of its exponent r changes dramatically over the range of interest.		
PTMCL	Combination of models	NOTE 6 Model under consideration.
Electrical only	(Inverse) power law	$AF = (\frac{I_{f\ stress}}{I_{f\ use}})^{+n}$ or $AF = (\frac{ES_{stress}}{ES_{use}})^{+n}$
orThermal only	Arrhenius	$AF = e^{+\frac{Ea}{k}(\frac{1}{T\ use} - \frac{1}{T\ stress})}$ (applies to dry storage or constant current, E_a may depend on current density)
Low-frequency power cycling	Power law	Wherever appropriate for pulsed and power cycling tests of low frequency (power-on pulsed lengths > 1 s to -10 s and/or cycle frequencies < 0,1 Hz to -1 Hz), multiply any of the expressions above by: $AF = (\frac{Duty\ Factor_{stress}}{Duty\ factor_{use}})^{+d}$

Some guidelines for the use of acceleration models include the following.

- Acceleration models useful for lifetime estimates and relevant to customer use conditions should be generated from data where the same degradation modes as the ones occurring in the field are observed ("moderate overstress testing" or yellow zone). Generally, accelerated tests are used to obtain information about one particular, relatively simple degradation mechanism (or corresponding degradation method). If there is more than one degradation mode, it is possible that the different degradation mechanisms will be accelerated at different rates. Then, unless this is accounted for in the modelling and analysis, estimates could be seriously incorrect when extrapolating to lower use-levels of the accelerating variables.
- Accelerating variables should be chosen to correspond with variables that cause actual degradation.
- Previous attempts to obtain acceleration parameters can turn to be similar to the ones of interest. With controlled changes in the principal components, the acceleration parameters will not change significantly. Only one verification test is required to prove identical acceleration parameters.
- Accelerated tests should be designed, as much as possible, to minimize the amount of extrapolation required. High levels of accelerating variables can cause extraneous degradation modes that would never occur at use-levels of the accelerating variables. If

extraneous degradation is not recognized and properly handled, this can lead to seriously incorrect conclusions. Also, the relationship may not be accurate enough over a wide range of acceleration.

- Accelerated test programmes should be planned and conducted by experts knowledgeable about the product and its use environment, the physical, chemical or mechanical aspects of the degradation mode, and the statistical aspects of the design and analysis of reliability experiments.

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Addendum 98: UN Regulation No. 99, *Uniform provisions concerning the approval of gas-discharge light sources for use in approved gas-discharge lamp units of power-driven vehicles*

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5 Withdrawn.

6 Withdrawn.

SOMMAIRE

COMMISSION ÉLECTROTECHNIQUE INTERNATIONALE

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LAMPES, SOURCES LUMINEUSES ET LED ENCAPSULÉES POUR VÉHICULES ROUTIERS – EXIGENCES DE PERFORMANCES

AVANT-PROPOS

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La Norme internationale IEC 60810 a été établie par le sous-comité 34A: Lampes, du comité d'études 34 de l'IEC: Lampes et équipements associés.

Cette cinquième édition annule et remplace la quatrième édition parue en 2014 et l'Amendement 1:2017. Cette édition constitue une révision technique.

Cette édition inclut les modifications techniques majeures suivantes par rapport à l'édition précédente:

a) actualisation et clarification du titre et du domaine d'application;
b) introduction de nouvelles sources lumineuses à LED;
c) introduction des exigences applicables aux sources lumineuses à LED;
d) introduction de lignes directrices pour la validation de la robustesse des LED encapsulées.

Le texte de cette Norme internationale est issu des documents suivants:

FDIS	Rapport de vote
34A/2021/FDIS	34A/2033/RVD

Le rapport de vote indiqué dans le tableau ci-dessus donne toute information sur le vote ayant abouti à l'approbation de cette norme.

Ce document a été rédigé selon les Directives ISO/IEC, Partie 2.

Le comité a décidé que le contenu de ce document ne sera pas modifié avant la date de stabilité indiquée sur le site web de l'IEC sous "http://webstore.iec.ch" dans les données relatives au document recherché. A cette date, le document sera

- reconduit,
- supprimé,
- remplacé par une édition révisée, ou
- amendé.

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LAMPES, SOURCES LUMINEUSES ET LED ENCAPSULÉES POUR VÉHICULES ROUTIERS – EXIGENCES DE PERFORMANCES

1 Domaine d'application

Le présent document est applicable aux lampes à filament,aux lampes à décharge, aux sources lumineuses à LED et aux LED encapsulées destinées à être utilisées dans les véhicules routiers, c'est-à-dire dans les projecteurs avant, les feux de brouillard, les feux de signalisation et l'éclairage intérieur. Il s'applique particulièrement aux lampes et sources lumineuses figurant dans l'IEC 60809.

Il spécifie les exigences et les méthodes d'essai pour le mesurage des caractéristiques de performance telles que la durée de la lampe, la conservation du flux lumineux, la résistance à la torsion, la résistance de l'ampoule de verre et la résistance aux vibrations et aux chocs. En outre, des renseignements sont donnés sur les limites de température, les encombrements maximaux et les surtensions maximales admissibles, à titre de guide pour la conception des équipements électriques et d'éclairage.

Pour certaines des exigences du présent document, le texte renvoie à des données figurant dans des tableaux. Pour les lampes qui n'apparaissent pas dans ces tableaux, les données correspondantes sont fournies par le fabricant ou le fournisseur responsable.

Les exigences de performance sont un complément aux exigences principales spécifiées dans l'IEC 60809. Elles ne sont cependant pas destinées à être utilisées par les administrations pour les homologations légales de type.

NOTE 1 Dans les différents vocabulaires et normes, différents termes sont utilisés pour désigner une «lampe à incandescence» (IEC 60050-845:1987, 845-07-04) et une «lampe à décharge» (IEC 60050-845:1987, 845-07-17). Le présent document utilise les termes «lampe à filament» et «lampe à décharge». Cependant, lorsque le terme «lampe» apparaît seul, ce terme désigne les deux types, à moins que le contexte n'indique clairement qu'il ne s'applique qu'à l'un des types.

NOTE 2 Le présent document ne s'applique pas aux luminaires.

NOTE 3 Le présent document utilise le terme source lumineuse à LED; dans d'autres normes, le terme lampes à LED peut être utilisé pour décrire des produits similaires.

2 Références normatives

Les documents suivants cités dans le texte constituent, pour tout ou partie de leur contenu, des exigences du présent document. Pour les références datées, seule l'édition citée s'applique. Pour les références non datées, la dernière édition du document de référence s'applique (y compris les éventuels amendements).

IEC 60050-845, *Vocabulaire Electrotechnique International – Partie 845: Eclairage* (disponible à l'adresse http://www.electropedia.org)

IEC 60061-1, *Culots de lampes et douilles ainsi que calibres pour le contrôle de l'interchangeabilité et de la sécurité – Partie 1: Culots de lampes*

IEC 60068-2-14, *Essais d'environnement – Partie 2-14: Essais – Essai N: Variation de température*

IEC 60068-2-43, *Essais d'environnement – Partie 2-43: Essais – Essai Kd: Essai à l'hydrogène sulfuré pour contacts et connexions*

IEC 60068-2-58, *Essais d'environnement – Partie 2-58: Essais – Essai Td: Méthodes d'essai de la soudabilité, résistance de la métallisation à la dissolution et résistance à la chaleur de brasage des composants pour montage en surface (CMS)*

IEC 60068-2-60, *Essais d'environnement – Partie 2-60: Essais – Essai Ke: Essai de corrosion dans un flux de mélange de gaz*

IEC 60809:2014, *Lampes pour véhicules routiers – Exigences dimensionnelles, électriques et lumineuses*

CISPR 25, *Véhicules, bateaux et moteurs à combustion interne – Caractéristiques des perturbations radioélectriques – Limites et méthodes de mesure pour la protection des récepteurs embarqués*

ISO 7637-2:2011, *Véhicules routiers – Perturbations électriques par conduction et par couplage – Partie 2: Perturbations électriques transitoires par conduction uniquement le long des lignes d'alimentation*

ISO 10605, *Véhicules routiers – Méthodes d'essai des perturbations électriques provenant de décharges électrostatiques*

Règlements Nations Unies sur les Véhicules – Accord 1958, *Accord concernant l'adoption de prescriptions techniques uniformes applicables aux véhicules à roues, aux équipements et aux pièces susceptibles d'être montés ou utilisés sur un véhicule à roues et les conditions de reconnaissance réciproque des homologations délivrées conformément à ces prescriptions* (disponible à l'adresse www.unece.org/trans/main/wp29/wp29regs.html)[1]

Additif 36: Règlement N° 37, Prescriptions uniformes relatives à l'homologation des lampes à *incandescence destinées à être utilisées dans les feux homologués des véhicules à moteur et de leurs remorques*

Additif 47: Règlement N° 48, *Prescriptions uniformes relatives à l'homologation des véhicules en ce qui concerne l'installation des dispositifs d'éclairage et de signalisation lumineuse*

Additif 100: Règlement N° 101, *Prescriptions uniformes relatives à l'homologation des voitures particulières mues uniquement par un moteur à combustion interne ou mues par une chaîne de traction électrique hybride en ce qui concerne la mesure des émissions de dioxyde de carbone et de la consommation de carburant et/ou la mesure de la consommation d'énergie électrique et de l'autonomie en mode électrique, et des véhicules des catégories M1 et N1 mus uniquement par une chaîne de traction électrique en ce qui concerne la mesure de la consommation d'énergie électrique et de l'autonomie*

Additif 122: Règlement N° 123, *Prescriptions uniformes concernant l'homologation des systèmes d'éclairage avant adaptatifs (AFS) destinés aux véhicules automobiles*

Additif 127: Règlement N° 128, *Prescriptions uniformes concernant l'homologation des sources lumineuses à diodes électroluminescentes (DEL) destinées à être utilisées dans les feux de signalisation homologués des véhicules à moteur et de leurs remorques*

JESD22-A101C, *Steady-state temperature humidity bias life test* (disponible en anglais seulement)

JESD22-A104E, *Temperature cycling* (disponible en anglais seulement)

JESD22-A105C, *Power and temperature cycling* (disponible en anglais seulement)

JESD22-A106B, *Thermal shock* (disponible en anglais seulement)

1 Également désigné *Accord 1958.* Dans le texte du présent document, les règlements relevant de cet accord sont référencés sous la forme, par exemple, Règlement ONU 37 ou R37.

JESD22-A108D, *Temperature, bias, and operating life* (disponible en anglais seulement)

JESD22-A113F, *Preconditioning of plastic surface mount devices prior to reliability testing* (disponible en anglais seulement)

JESD22-A115C, *Electrostatic discharge (ESD) sensitivity testing machine model (MM)* (disponible en anglais seulement)

JESD22-B101B, *External visual* (disponible en anglais seulement)

JESD22-B103B, *Vibration, variable frequency* (disponible en anglais seulement)

JESD22-B110B, *Mechanical shock* (disponible en anglais seulement)

JESD22-B106D, *Resistance to solder shock for through-hole mounted devices* (disponible en anglais seulement)

JESD22-B116:1998, *Wire Bond Shear Test Method* (disponible en anglais seulement)

JESD51-50:2012-04, *Overview of methodologies for the thermal measurement of single- and multi-chip, single- and multi-pn-junction light-emitting diodes (LEDs)* (disponible en anglais seulement)

JESD51-51:2012-04, *Implementation of the electrical test method for the measurement of real thermal resistance and impedance of light-emitting diodes with exposed cooling surface* (disponible en anglais seulement)

JESD51-52:2012-04, *Guidelines for combining CIE 127-2007 total flux measurements with thermal measurements of leds with exposed cooling surface* (disponible en anglais seulement)

JESD51-53:2012-05, *Terms, definitions and units glossary for LED thermal testing* (disponible en anglais seulement)

ANSI/IPC/ECA J-STD-002C, *Solderability tests for component leads, terminations, lugs, terminals and wires* (disponible en anglais seulement)

ANSI/ESDA/JEDEC JS-001-2012, *Joint JEDEC/ESDA standard for electrostatic discharge sensitivity testing human body model (HBM) – component level* (disponible en anglais seulement)

MIL-STD-883E:2015, *Visual Inspection Criteria* (disponible en anglais seulement)

ZVEI "*Guideline for Customer Notifications of Product and/or Process Changes (PCN) of Electronic Components specified for Automotive Applications*" 4th revised Edition, October 2016, Rev. 3 (disponible en anglais seulement)

3 Termes et définitions

Pour les besoins du présent document, les termes et définitions de l'IEC 60050-845 et l'IEC 60809, ainsi que les suivants s'appliquent.

L'ISO et l'IEC tiennent à jour des bases de données terminologiques destinées à être utilisées en normalisation, consultables aux adresses suivantes:

- IEC Electropedia: disponible à l'adresse http://www.electropedia.org/

- ISO Online browsing platform: disponible à l'adresse http://www.iso.org/obp

3.1
durée de vie
totalité du temps (exprimé en heures) pendant lequel une lampe a fonctionné avant d'être hors d'usage

Note 1 à l'article: Les lampes à filament sont considérées comme telles selon l'un ou l'autre des critères suivants:

a) la fin de vie est l'instant où se produit la mise hors d'usage du filament;

b) la durée de vie d'une lampe à deux filaments est l'instant où se produit la mise hors d'usage de l'un ou l'autre des filaments, si la lampe est soumise à l'essai selon un cycle d'allumage impliquant le fonctionnement alterné des deux filaments.

3.2
durée de vie caractéristique
T
T_c
constante de la distribution de Weibull indiquant le temps au bout duquel 63,2 % du nombre de lampes soumises à l'essai, du même type, ont atteint la fin de leur durée de vie individuelle

3.3
durée de vie B_3
constante de la distribution de Weibull indiquant le temps au bout duquel 3 % du nombre de lampes soumises à l'essai, du même type, ont atteint la fin de leur durée de vie individuelle

3.4
conservation du flux lumineux
rapport entre le flux lumineux d'une lampe, à un instant donné de sa vie, et son flux lumineux initial, la lampe ayant fonctionné dans des conditions spécifiques

EXEMPLE 1 L_{70} est la durée en heures correspondant à une conservation du flux lumineux de 70 %.

EXEMPLE 2 L_{50} est la durée en heures correspondant à une conservation du flux lumineux de 50 %.

3.5
flux lumineux initial
flux lumineux d'une lampe mesuré après un vieillissement spécifié

Note 1 à l'article: Le vieillissement est spécifié à l'Annexe C de l'IEC 60809:2014 pour les lampes à filament, à l'Annexe D du présent document pour les lampes à décharge ou à l'Annexe I du présent document pour les sources lumineuses à LED

3.6
valeur assignée
valeur d'une caractéristique spécifiée, pour le fonctionnement d'une lampe, à la tension d'essai et/ou à d'autres conditions spécifiées

3.7
température limite au pincement
température maximale admissible au pincement, afin d'assurer à une lampe une performance satisfaisante en service

3.8
température limite de la soudure
température maximale admissible de la soudure afin d'assurer à une lampe une performance satisfaisante en service

3.9
encombrement maximal d'une lampe
contour délimitant le volume à réserver, pour la lampe, dans l'appareil correspondant

3.10
lampe pour usage intensif
lampe qui doit satisfaire aux conditions d'essai renforcé spécifiées dans le Tableau B.2 de l'IEC 60810 en complément des exigences spécifiées dans l'IEC 60809

Note 1 à l'article: Une lampe est déclarée lampe pour usage intensif par le fabricant ou le fournisseur responsable.

3.11
durée de vie B_{10}
constante de la distribution de Weibull indiquant le temps au bout duquel 10 % du nombre de lampes soumises à l'essai, du même type, ont atteint la fin de leur durée de vie individuelle

3.12
LED encapsulée
diode solide à jonction p-n émettant un rayonnement optique sous l'action d'un courant électrique

Note 1 à l'article: Des exemples sont présentés à la Figure 1.

Note 2 à l'article: Dans la terminologie ONU, le terme «LED» est utilisé avec la même définition.

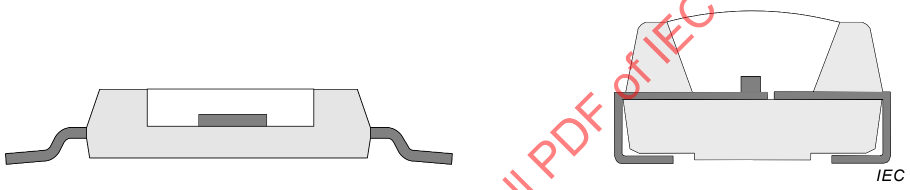


Figure 1 – Exemples de LED encapsulées

3.13
source lumineuse à LED
source lumineuse où le rayonnement visible est émis par une ou plusieurs LED

Note 1 à l'article: Une source lumineuse à LED peut ou peut ne pas exiger un appareillage de commande électronique supplémentaire et peut ou peut ne pas exiger de dispositions supplémentaires concernant la gestion thermique.

3.13.1
module à LED
source lumineuse à LED qui ne peut être remplacée qu'au moyen d'outils mécaniques

Note 1 à l'article: Les modules à LED sont généralement considérés comme des composants destinés à être utilisés dans les commerces, le monde du travail ou les industries, et ne sont généralement pas destinés à être vendus au grand public.

Note 2 à l'article: Des exemples sont présentés aux Figures 2 et 3.

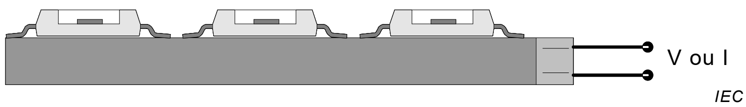


Figure 2 – Exemple de module à LED sans dissipateur thermique intégré

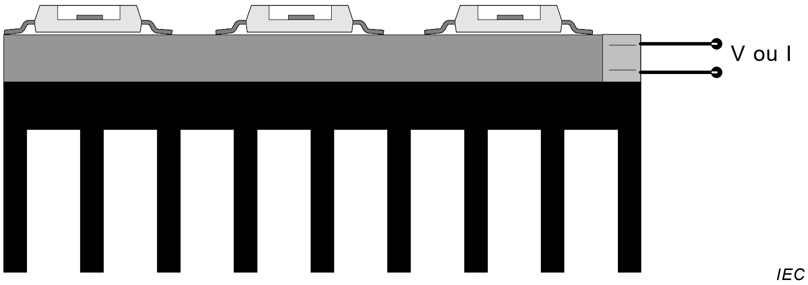


Figure 3 – Exemple de module à LED avec dissipateur thermique intégré

3.13.2
source lumineuse à LED remplaçable
source lumineuse à LED qui peut être remplacée facilement sans l'aide d'outils spéciaux

Note 1 à l'article: Les sources lumineuses à LED remplaçables sont généralement destinées à être vendues au grand public comme élément de remplacement.

Note 2 à l'article: Un exemple est présenté à la Figure 4.

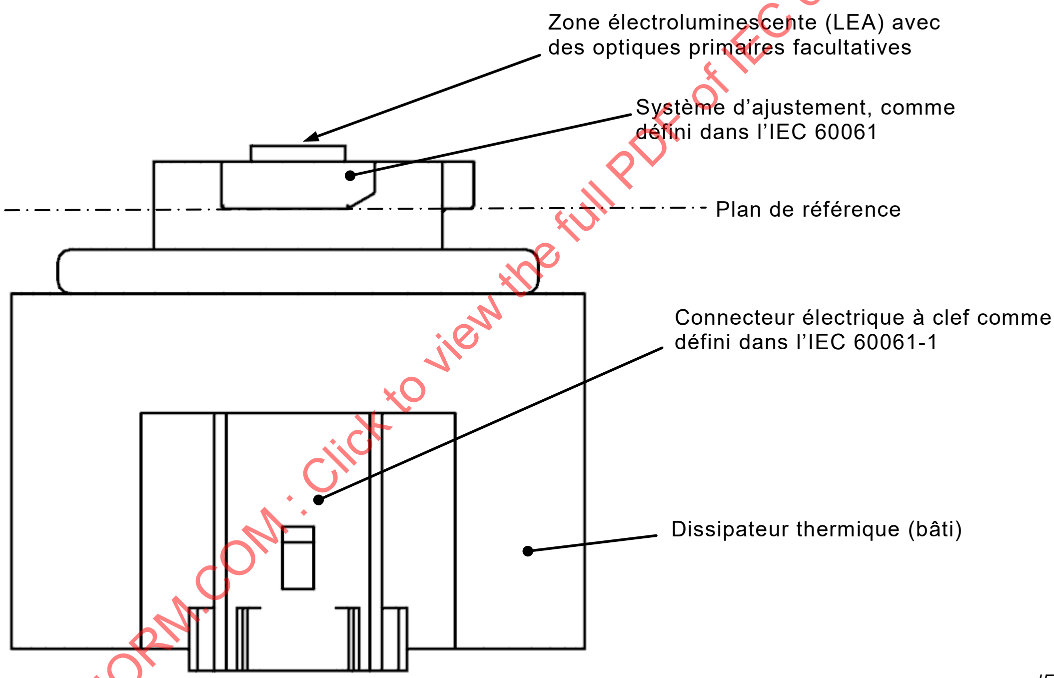


Figure 4 – Exemple de source lumineuse à LED remplaçable

3.13.3
source lumineuse à LED non remplaçable
source lumineuse à LED qui ne peut pas être retirée du dispositif ou du luminaire

Note 1 à l'article: Les sources lumineuses à LED non remplaçables sont généralement conçues comme composants destinés à être intégrés au luminaire ou au dispositif par les fabricants. Elles sont conçues pour être des parties constitutives indivisibles d'un dispositif d'éclairage ou d'un feu de signalisation, ou d'éléments, de modules ou d'unités de ce type de dispositifs.

Note 2 à l'article: Un exemple est présenté à la Figure 5.

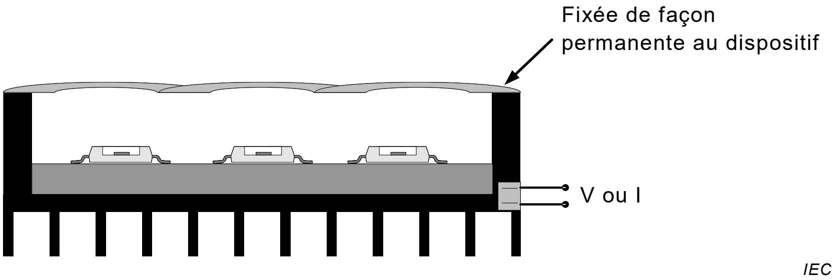


Figure 5 – Exemple de source lumineuse à LED non remplaçable

3.14
T_p
température à un emplacement spécifié à la surface de la source lumineuse à LED (point T_p) qui peut être mesurée lors du fonctionnement de la source lumineuse et qui peut être corrélée à la température de la jonction p-n de la LED

Note 1 à l'article: Le point T_p est généralement spécifié par le fabricant de la source lumineuse à LED ou sa fiche technique.

3.15
appareillage de commande électronique de source lumineuse
un ou plusieurs composants disposés entre l'alimentation et la source lumineuse afin de réguler la tension et/ou le courant électrique de cette dernière

3.16
température de la LED encapsulée
T_s
température du point de fixation des couples thermoélectriques sur la LED encapsulée, telle que définie par le fabricant du boîtier

4 Exigences et conditions d'essai relatives aux lampes à filament

4.1 Fonction principale et interchangeabilité

Les lampes à filament doivent satisfaire à l'IEC 60809.

4.2 Résistance à la torsion

Le culot doit être solide et fermement fixé à l'ampoule.

La conformité est vérifiée avant et après l'essai de durée de vie, en soumettant la lampe à filament aux couples de torsion suivants:

- lampes à filament avec culots à baïonnette
  - pour les chemises de diamètre de 9 m: 0,3 Nm;
  - pour les chemises de diamètre 15 mm: 1,5 Nm;
  - pour les chemises de diamètre 20 mm: 3,0 Nm;
- lampes à filament avec culots à vis
  - pour les chemises de diamètre 10 mm: 0,8 Nm.

NOTE Les couples de torsion ci-dessous sont tous à l'étude.

Le couple de torsion ne doit pas être appliqué brusquement, mais doit augmenter progressivement de 0 à la valeur spécifiée.

Les valeurs sont basées sur un niveau de non-conformité de 1 %.

4.3 Durée de vie caractéristique T_c

La durée de vie T_c, mesurée sur un échantillonnage d'essai, d'au moins 20 lampes à filament, doit être d'au moins 96 % de la valeur assignée donnée dans le Tableau 3.

La conformité est vérifiée par les essais de durée de vie spécifiés à l'Annexe A.

4.4 Durée de vie B_3

La durée de vie B_3 ne doit pas être inférieure à la valeur assignée donnée dans le Tableau 3.

La conformité est vérifiée par les essais de durée de vie spécifiés à l'Annexe A.

Le nombre de lampes à filament hors service avant la durée exigée ne doit pas dépasser les valeurs du Tableau 1.

Tableau 1 – Conditions de conformité pour la durée de vie B_3

Nombre de lampes à filament soumises à l'essai	Limite d'acceptation
23 à 35	2
36 à 48	3
49 à 60	4
61 à 74	5
75 à 92	6

4.5 Conservation du flux lumineux

La conservation du flux lumineux ne doit pas être inférieure à la valeur assignée donnée dans le Tableau 4. Cette valeur est basée sur un niveau de non-conformité de 10 %.

4.6 Résistance aux vibrations et aux chocs

Dans le cas où la durée de vie pratique est influencée par des vibrations ou des chocs, les méthodes d'essai et procédures décrites dans l'Annexe B doivent être utilisées afin d'évaluer la performance.

Les lampes à filament sont considérées comme ayant entièrement satisfait à l'essai de vibrations aléatoires à large bande ou à bande étroite, tel qu'il est décrit à l'Annexe B, si elles continuent à fonctionner pendant et après l'essai.

Le nombre de lampes à filament mises hors d'usage lors de l'un des essais ne doit pas dépasser les valeurs du Tableau 2 (valeurs basées sur un niveau de qualité acceptable (NQA) de 4 %).

Tableau 2 – Conditions de conformité pour l'essai de vibrations

Nombre de lampes à filament soumises à l'essai	Limite d'acceptation
14 à 20	2
21 à 32	3
33 à 41	4
42 à 50	5
51 à 65	6

4.7 Résistance de l'ampoule en verre

Dans le cas où les ampoules sont affaiblies par une manipulation mécanique lors de leur assemblage dans un matériel, les méthodes d'essai et procédures définies dans l'Annexe C doivent être utilisées afin d'évaluer la performance. Les ampoules doivent supporter la force de compression spécifiée.

5 Fiches techniques des lampes à filament

Les valeurs des durées de vie assignées et de conservation du flux lumineux des lampes à filament pour véhicules routiers sont soumises à l'essai dans les conditions spécifiées à l'Annexe A.

Les Tableaux 3 et 4 donnent les valeurs des durées de vie assignées et de conservation du flux lumineux en fonctionnement continu.

Tableau 3 – Valeurs des durées de vie assignées, en fonctionnement continu

Numéro de fiche technique des lampes à filament		Type	12 V			24 V		
IEC 60809[a]	ONU[b]	Catégorie	Essai V	B_3/h	T_c/h	Essai V	B_3/h	T_c/h
Lampes pour applications d'éclairage avant								
2310	R37-H1	H1	13,2	150	400	28,0	90	250
2320	-	H2	13,2	90	250	28,0	90	250
2330	R37-H3	H3	13,2	150	400	28,0	90	250
2120	R37-H4	H4 (HB/LB)	13,2	125/250	250/500	28,0	100/200	200/400
2315	R37-H7	H7	13,2	300	500	28,0	200	400
2365	R37-H8	H8, H8B	13,2	400	800			
2370	R37-H9	H9, H9B	13,2	250	500			
2375	R37-H10	H10	13,2	800	1 600			
2380	R37-H11	H11, H11B	13,2	350	600	28,0	300	600
2385	R37-H12	H12	13,2	480	970			
-	R37-H13	H13,H13A (HB/LB)	13,2	170/1 200	350/2 500			
-	R37-H15	H15 (HB/DRL)	13,2	250/2 000	500/4 000	28,0	200/1 500	400/3 000
-	R37-H16	H16, H16B	13,2	500	1 000			
-	R37-H17	H17	13,2	100/200	200/400			
-	R37-H18	H18	13,2	300	500			
-	R37-H19	H19 (HB/LB)	13,2	125/250	250/500			

Numéro de fiche technique des lampes à filament		Type	12 V			24 V		
IEC 60809[a]	ONU[b]	Catégorie	Essai V	B_3/h	T_c/h	Essai V	B_3/h	T_c/h
-	R37-H20	H20	13,2	100	200			
3430	R37-H27W	H27W/1 H27W/2	13,5	90	190			
2325	R37-HB3	HB3/ HB3A	13,2	250	500			
2335	R37-HB4	HB4/ HB4A	13,2	850	1 700			
2420	R37-HIR2	HIR2	13,2	300	600			
2130	R37-HS1	HS1 (HB/LB)	13,2	75/150	150/300			
2340	R37-HS2	HS2	13,2	100	250			
-	R37-PSX26W	PSX26W	13,2	1 000	2 000			
2110	R37-R2	R2 (HB / LB)	13,2	30/60	90/160			
2150	R37-S1/S2	S2	13,2	50/100	100/200			
Lampes pour applications de signalisation								
		C5W	13,5	350	750	28,0	120	350
3410	R37-H6W	H6W, HY6W	13,5	350	700			
-	R37-H10W	H10W/1	13,5	150	400			
-	R37-H10W	HY10W/1	13,5	300	600			
3420	R37-H21W	H21W	13,5	200	400	28,0	90	180
-	R37-HY21W	HY21W	13,5	200	400	28,0	90	180
-	R37-P13W	P13W	13,5	4 000	8 000			
-	R37-P19W	P19W	13,5	1 000	2 000			
3310	R37-P21W	P21W	13,5	120	320	28,0	60	160
3120	R37-P21/4W	P21/4W	13,5	60/600	160/1 600	28,0	60/600	160/1 600
3110	R37-P21/5W	P21/5W	13,5	60/600	160/1 600	28,0	60/600	160/1 600
-	R37-P24W	P24W	13,5	750	1500			
3315	R37-P27W	P27W	13,5	550	1320			
-	R37-P27/7W	P27/7W	13,5	550/3 690	1 320/8 820			
-	R37-PR21W	PR21W	13,5	120	320	28,0	60	160
-	R37-PR21/5W	PR21/5W	13,5	60/600	160/1 600			

Numéro de fiche technique des lampes à filament		**Type**	**12 V**			**24 V**		
IEC 60809[a]	**ONU**[b]	**Catégorie**	**Essai V**	B_3**/h**	T_c**/h**	**Essai V**	B_3**/h**	T_c**/h**
-	R37-P19W	PSY19W	13,5	1 200	2 400			
-	R37-P24W	PSY24W	13,5	1 000	2 000			
-	R37-P19W	PY19W	13,5	1 200	2 400			
3311	R37-PY21W	PY21W	13,5	120	320	28,0	60	160
-	R37-P24W	PY24W	13,5	1 000	2 000			
3141	R37-PY27/7W	PY27/7W	13,5	550/3 600	1 300/8 000			
3320	R37-R5W	R5W	13,5	100	300	28,0	80	225
3330	R37-R10W	R10W	13,5	100	300	28,0	80	225
-	R37-R10W	RY10W	13,5	100	300			
3340	R37-T4W	T4W	13,5	300	750	28,0	120	350
4310	R37-W3W	W3W	13,5	500	1 500	28,0	400	1 100
4320	R37-W5W	W5W	13,5	200	500	28,0	120	350
4340	R37-W16W	W16W	13,5	250	700			
4321	R37-W5W	WY5W	13,5	200	500			
4120	R37-C21W	C21W	13,5	40	110			
-	R37-WY16W	WY16W	13,5	250	700			
-	R37-W21W	W21W	13,5	120	320			
-	R37-W21/5W	W21/5W	13,5	60/600	160/1 600			
-	R37-WY21W	WY21W	13,5	120	320			
-	R37-W15/5W	W15/5W	13,5	120/600	320/1 600			
-	R37-W10W	W10W	13,5	100	300			
-	R37-WY10W	WY10W	13,5	100	300			

Les valeurs indiquées sont des exigences minimales. En fonction de spécifications particulières des clients, différentes valeurs peuvent être obtenues, c'est-à-dire, durée de vie plus courte avec un flux lumineux plus élevé ou durée de vie plus longue avec un flux lumineux inférieur. Ceci doit être négocié entre les fabricants de lampes à filament et leurs clients.

En l'absence de contact direct entre le client et le fournisseur, les informations relatives à l'écart provenant des données temporelles de durée de vie recommandées doivent être indiquées sur le boîtier et/ou dans la documentation technique accessible au public.

[a] Si un numéro de fiche ONU est référencé, le numéro de fiche IEC fait référence à une fiche technique supprimée de l'IEC 60809:1995/AMD5:2012 et n'est donné qu'à titre d'information.

[b] Le numéro devant le tiret indique le numéro du règlement ONU.

Tableau 4 – Valeurs assignées de conservation du flux lumineux, en fonctionnement continu

Numéro de fiche technique des lampes à filament		Type	12 V			24 V		
IEC 60809[e]	ONU[f]	Catégorie	Essai V	Conservation du flux lumineux		Essai V	Conservation du flux lumineux	
				h	%		h	%
Lampes pour applications d'éclairage avant								
2110	R37-R2	R2	13,2	55[c] 110[d]	85 70	28,0 28,0	55[c] 110[d]	85 70
2120	R37-H4	H4	13,2	110[c] 225[d]	85 85	 28,0	110[c] 225[d]	85 85
2125	-	H6	14,0	75[c] 150[d]	85 80	–	–	–
2305		H5	14,0	75	85	–	–	–
2310	R37-H1	H1	13,2	170	90	28,0	170	90
2320		H2	13,2	170	90	28,0	170	90
2330	R37-H3	H3	13,2	170	90	28,0	170	90
3110	R37-P21/5W	P21/5W	13,5	110[a] 750[b]	70 70	28,0	110[a] 750[b]	70 70
3120	R37-P21/4W	P21/4W	13,5	110[a]750[b]	70 70	28,0	À l'étude	À l'étude
3310	R37-P21W	P21W	13,5	110	70	28,0	110	70
3320	R37-R5W	R5W	13,5	150	70	28,0	150	70
3330	R37-R10W	R10W	13,5	150	70	28,0	150	70
3340	R37-T4W	T4W	13,5	225	70	28,0	225	70
4110	R37-C5W	C5W	13,5	225	60	28,0	225	60
4120	R37-C21W	C21W	13,5	75	60	–	–	–
4310	R37-W3W	W3W	13,5	750	60	28,0	750	60
4320	R37-W5W	W5W	13,5	225	60	28,0	225	60

Les valeurs indiquées sont des exigences minimales. En fonction de spécifications particulières des clients, différentes valeurs peuvent être obtenues, c'est-à-dire, durée de vie plus courte avec un flux lumineux plus élevé ou durée de vie plus longue avec un flux lumineux inférieur. Ceci doit être négocié entre les fabricants de lampes à filament et leurs clients.

Les valeurs de conservation du flux lumineux pour des temps de fonctionnement prolongés sont à l'étude.

[a] Filament de forte puissance.

[b] Filament de faible puissance.

[c] Filament route.

[d] Filament croisement.

[e] Si un numéro de fiche ONU est référencé, le numéro de fiche IEC fait référence à une fiche technique supprimée de l'IEC 60809:1995/AMD5:2012 et n'est donné qu'à titre d'information.

[f] Le numéro devant le tiret indique le numéro du règlement ONU.

6 Exigences et conditions d'essai relatives aux lampes à décharge

6.1 Fonction principale et interchangeabilité

Les lampes à décharge doivent satisfaire aux exigences techniques de l'IEC 60809.

6.2 Résistance mécanique

6.2.1 Fixation de l'ampoule au culot

L'ampoule doit être solidement fixée au culot. La conformité est vérifiée au moyen de l'essai de fléchissement de l'ampoule conduit conformément à l'Annexe E.

6.2.2 Fixation de fil au culot (le cas échéant)

Si un fil est fixé au culot, cette fixation doit résister à une force de traction de 60 N. La force doit être appliquée dans la direction du fil (droit).

6.3 Durée de vie caractéristique T_c

La durée de vie T_c mesurée sur un échantillon d'essai d'au moins 20 lampes ne doit pas être inférieure à la valeur déclarée par le fabricant, laquelle doit être d'au moins 3 000 h. La conformité est vérifiée par les essais spécifiés à l'Annexe D.

6.4 Durée de vie B_3

La durée de vie B_3 mesurée sur un échantillon d'essai d'au moins 20 lampes ne doit pas être inférieure à la valeur déclarée par le fabricant, laquelle doit être d'au moins 1 500 h. La conformité est vérifiée par les essais spécifiés à l'Annexe D.

6.5 Conservation du flux lumineux

Elle doit être égale à au moins 60 % du flux lumineux initial. La conformité est vérifiée par les essais spécifiés à l'Annexe D.

Les valeurs sont basées sur un niveau de non-conformité de 10 %.

6.6 Résistance aux vibrations et aux chocs

Dans le cas où la durée de vie pratique est influencée par des vibrations ou des chocs, les méthodes d'essai et procédures décrites dans l'Annexe B doivent être utilisées afin d'évaluer la performance.

Les lampes à décharge sont considérées comme ayant entièrement satisfait à l'essai de vibrations aléatoires à large bande ou à bande étroite, tel qu'il est décrit à l'Annexe B, si elles continuent à fonctionner pendant et après l'essai. De plus, la position des électrodes doit être conforme aux exigences dimensionnelles de la norme correspondante.

Les valeurs sont basées sur un niveau de non-conformité de 4 %.

Il convient de prendre des précautions pour éviter des dangers potentiels dus aux tensions élevées, au rayonnement UV et au risque de bris de l'ampoule pendant l'amorçage, l'établissement du régime et le fonctionnement de certains types de lampe à décharge.

6.7 Lampes à décharge à dispositif d'amorçage intégré

Le poids total de la lampe ne doit pas dépasser 75 g. Des renseignements pour la conception du ballast sont donnés à l'Annexe G.

6.8 Lampes à décharge à dispositif d'amorçage et à ballast intégrés

Le poids total de la lampe ne doit pas dépasser 120 g.

Le centre de gravité des lampes qui utilisent un culot PK32d IEC doit se situer au sein d'un profil de cylindre comme l'indiquent les zones ombrées de la Figure 6.

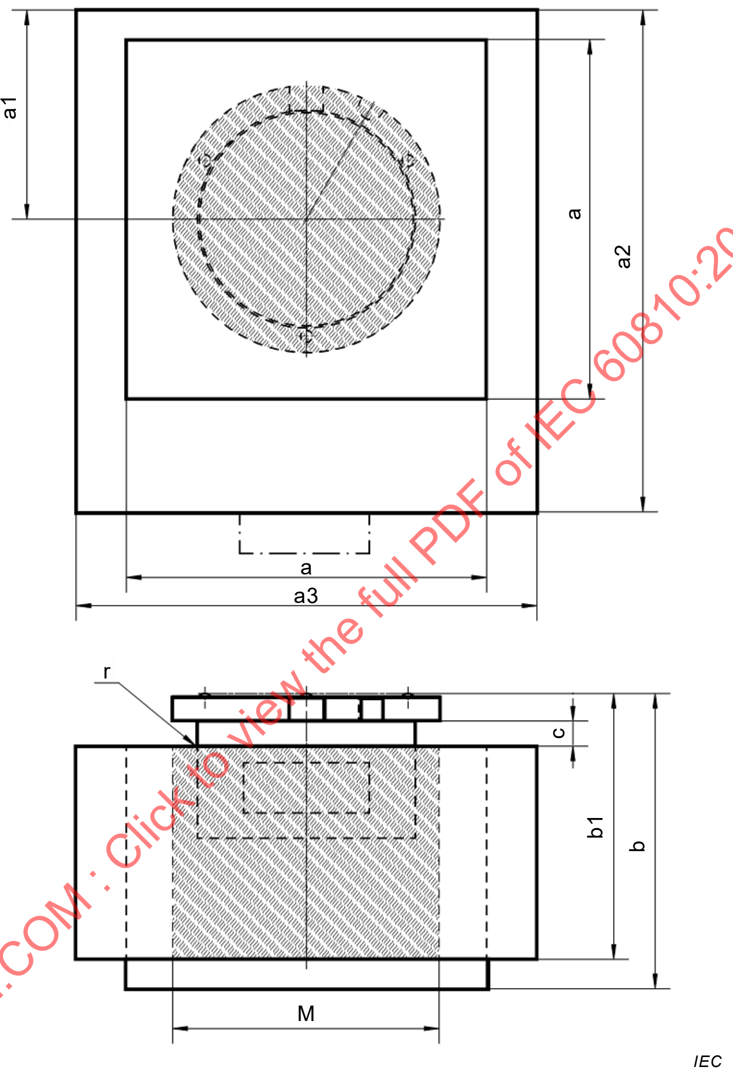


Figure 6 – Position du centre de gravité (zones ombrées)

7 Exigences et conditions d'essai relatives aux sources lumineuses à LED

7.1 Fonction principale et interchangeabilité

Les sources lumineuses à LED:

- doivent être conçues de manière à être et à rester en bon état de fonctionnement en utilisation normale;
- ne doivent présenter aucun défaut de conception ou de fabrication;
- ne doivent présenter aucune rayure ou aucune tache sur leurs surfaces optiques susceptibles d'altérer leur efficacité et leurs performances optiques.

Les sources lumineuses à LED remplaçables doivent être équipées de culots conformes à l'IEC 60061-1. Le culot doit être solide et fermement fixé au reste de la source lumineuse à LED.

Afin de déterminer si les sources lumineuses à LED satisfont aux exigences susmentionnées, un examen visuel, un contrôle dimensionnel et, si nécessaire, un ajustement d'essai doivent être réalisés.

Les sources lumineuses à LED doivent satisfaire aux exigences techniques de l'IEC 60809.

Lorsque les sources lumineuses à LED comportent de plusieurs fonctions, chaque fonction doit être soumise à l'essai séparément, sauf spécification contraire.

Si un appareillage de commande à source lumineuse électronique (ECG) est nécessaire au fonctionnement de la source lumineuse à LED, l'essai doit être réalisé avec un ECG approprié.

7.2 Rayonnement ultraviolet

Le rayonnement ultraviolet de la source lumineuse à LED doit être déterminé selon 5.9 de l'IEC 60809:2014. Si $k_{UV} \leq 10^{-5}$ W/lm, la source lumineuse est de type à faible rayonnement ultraviolet.

7.3 Conservation du flux lumineux et de la couleur

La valeur de conservation du flux lumineux L_{70} et la valeur de conservation de la couleur doivent être mesurées sur un échantillon d'essai d'au moins 20 sources lumineuses à LED selon la procédure donnée à l'Annexe I.

Pour les très petits lots de production, un échantillon d'essai de moins de 20 peut être acceptable.

Le fabricant doit déclarer et déterminer les valeurs $L_{70}B_{10}$.

Les valeurs mesurées ne doivent pas être inférieures à la valeur déclarée par le fabricant.

Pour les sources lumineuses à LED homologuées au titre du Règlement 128 ONU correspondant, les valeurs $L_{70}B_{10}$ ne doivent pas être inférieures à celles spécifiées dans le Tableau 5.

Tableau 5 – Valeurs $L_{70}B_{10}$ minimales pour les sources lumineuses à LED remplaçables

Catégorie selon R 128 ONU	Valeurs $L_{70}B_{10}$ minimales h
LR1	2 200 [mi] 1 000 [ma]
LW2	4 000
LR3A, LR3B	1 000
LR4A, LR4B	2 200 [mi] 1 000 [ma]
LR5A, LR5B	1 000
LW3A, LW3B	2 200
LW5A, LW5B	4 000
LY3A, LY3B	500 [fl]
LY5A, LY5B	500 [fl]

Légende

[mi]: fonction mineure

[ma]: fonction principale

[fl]: soumis à l'essai en mode clignotement, c'est-à-dire avec un rapport allumage/extinction 1:1

NOTE Dans le cas d'un fonctionnement du modulateur de largeur d'impulsion (PWM, *Pulse width modulation*), la valeur $L_{70}B_{10}$ attendue peut être supérieure (en fonction du cycle de service).

Le Tableau 6 donne les valeurs typiques de durée de fonctionnement pour les différentes fonctions pour une distance de parcours de 100 000 km, à titre d'information.

Tableau 6 – Valeurs typiques de durée de fonctionnement pour les différentes fonctions pour une distance de parcours de 100 000 km, sur la base d'une vitesse moyenne de 33,6 km/h [a]

Application prévue	Durées de fonctionnement typiques en heures pour une distance de parcours de 100 000 km
Feu de plaque d'immatriculation arrière	1 100 [b]
Feu de clignotant	250
Feu de position avant et arrière	1 100 [b]
Feu-stop	500
Feu d'encombrement	1 100
Feu de recul	50
Feu antibrouillard arrière	50
Feu de circulation diurne (DRL)	2 000
Feu de position latéral	1 100 [b]
Feu d'angle	100
Feu de croisement (faisceau-croisement)	1 000
Feu de route (faisceau-route)	100 [c]
Feu antibrouillard avant	100

[a] La vitesse de conduite moyenne est fondée sur la composition des cycles de conduite définie dans le Règlement 101 ONU.

[b] Lorsque ces sources lumineuses sont destinées à des véhicules où ces fonctions sont également actives, conjointement avec la fonction DRL, la valeur de 3 100 doit alors être utilisée.

[c] Lorsque ces sources lumineuses sont destinées à des véhicules qui utilisent la fonction «éclairage adaptatif automatisé» définie dans le Règlement 123 ONU, la valeur de 200 doit alors être utilisée.

Lorsque les exigences spécifiques de l'utilisation prévue sont connues pour la source lumineuse à LED, il convient de les prendre en compte.

La conformité est vérifiée par les essais spécifiés à l'Annexe I.

Les valeurs sont basées sur un niveau de non-conformité de 10 %.

Un exemple de données relatives à la durée de vie des sources lumineuses à LED est donné dans le Tableau 7.

Tableau 7 – Exemple de données relatives au produit

Type	Utilisation prévue	$L_{70}B_{10}$
MD0815	Feu-stop	1 500 h

7.4 Résistance aux vibrations et aux chocs

Dans le cas où la durée de vie pratique est influencée par des vibrations ou des chocs, les méthodes d'essai et procédures décrites dans l'Annexe B doivent être utilisées afin d'évaluer la performance.

Les sources lumineuses sont considérées comme ayant entièrement satisfait à l'essai de vibrations aléatoires à large bande ou à bande étroite, tel qu'il est décrit à l'Annexe B, si elles continuent à fonctionner pendant et après l'essai.

Les valeurs sont basées sur un niveau de non-conformité de 4 %.

7.5 Compatibilité électromagnétique

Les sources lumineuses à LED remplaçables doivent être classées selon la publication CISPR 25.

7.6 Essai de cycle thermique sous tension

Cet essai est destiné à déterminer la capacité de la source lumineuse à LED à résister aux variations de température ambiante.

Les sources lumineuses à LED doivent être soumises à l'essai selon la condition d'essai «Nb» de l'IEC 60068-2-14, dans les conditions suivantes (voir Figure 7):

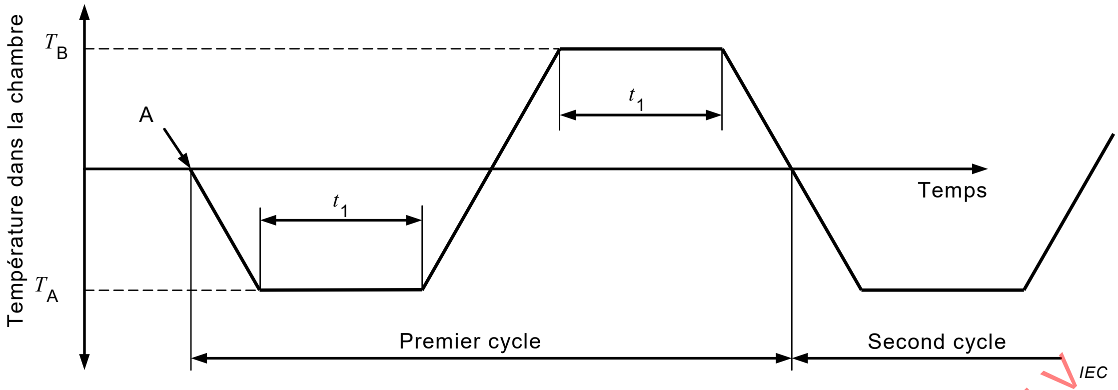
- la vitesse de variation de la température est de 3 K/min;
- le temps d'exposition t_1 doit être de 2 h au minimum;
- le nombre de cycles doit être de 15;
- l'essai doit être effectué sur un nombre minimum de 20 sources lumineuses à LED;
- pendant l'essai, la source lumineuse à LED doit être allumée et éteinte de manière continue selon des intervalles de 5 min (5 min allumée, 5 min éteinte, 5 min allumée, etc.);
- la tension d'essai doit être choisie selon I.2 du présent document;
- les températures T_A et T_B doivent être choisies selon les classes définies dans le Tableau 8.

Tableau 8 – Classes de température pour l'essai de cycle thermique sous tension

	Température inférieure T_A	Température supérieure T_B
Classe A	–40 °C	+60 °C
Classe B	–40 °C	+85 °C
Classe C	–40 °C	+105 °C

Pour les sources lumineuses à LED qui exigent un appareillage de commande de source lumineuse externe, ledit appareillage peut également être soumis à cet essai.

Les sources lumineuses à LED qui exigent des dispositions supplémentaires concernant la gestion thermique doivent être soumises à l'essai avec ces dispositions en vigueur. Une description de la conception de la gestion thermique doit être incluse dans le rapport d'essai.



Légende

A début du premier cycle

Figure 7 – Extrait de l'essai Nb défini dans l'IEC 60068-2-14, présentant le profil de cycle de température

Après l'essai de cycle thermique sous tension, les performances électriques et photométriques de la source lumineuse à LED doivent être vérifiées par essai.

Les sources lumineuses à LED sont considérées comme ayant entièrement satisfait à l'essai si elles continuent à fonctionner après l'essai, et si les performances photométriques et électriques relèvent des spécifications fournies par le fabricant.

Les valeurs sont basées sur un niveau de non-conformité de 10 %.

7.7 Masse

La masse totale de la source lumineuse à LED ne doit pas dépasser la valeur indiquée dans le Tableau 9 ou, en l'absence de celle-ci, la valeur contenue dans l'information du système sur les fiches techniques des culots spécifiées dans l'IEC 60061-1.

Tableau 9 – Masse maximale des sources lumineuses à LED

Catégorie de source lumineuse à LED	Culot	Masse g
LR1	PGJ21	60
LW2	PGJY50	50
LR3, LR4, LR5, LW3, LW5, LY3, LY5	PGJ18.5	35

7.8 Circuits typiques pour les sources lumineuses à LED

7.8.1 Généralités

Le Paragraphe 7.8 a pour objet de présenter des circuits électriques typiques pour les sources lumineuses à LED.

7.8.2 Circuits typiques pour les sources lumineuses à LED LR3, LR5, LY3, LY5, LW3 et LW5

Un circuit électrique typique pour les sources lumineuses à LED LR3, LR5, LY3, LY5, LW3 et LW5 contient

- une ou plusieurs puces LED/LED encapsulées et un pilote électronique,
- une protection électronique,

- une résistance facultative permettant de garantir un courant minimal pour les exigences d'application spéciales,

comme représenté à la Figure 8.

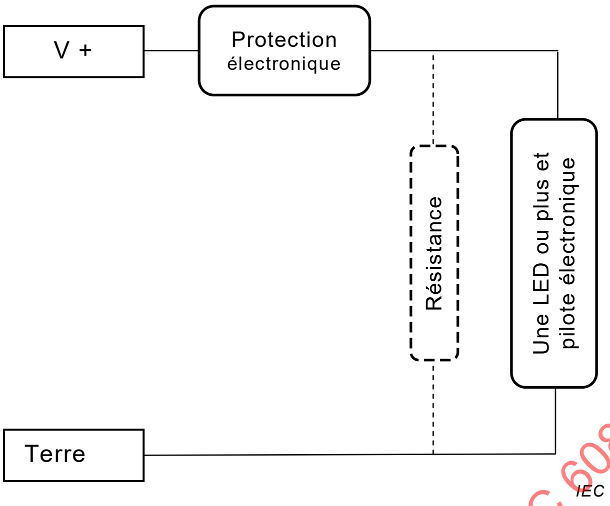


Figure 8 – Circuit électrique typique pour les sources lumineuses à LED LR3, LR5, LY3, LY5, LW3 et LW5

7.8.3 Circuits typiques pour les sources lumineuses à LED LR4

Un circuit électrique typique pour une source lumineuse à LED LR4 contient

- deux chaînes électriques (avec une terre commune);
- pour chaque chaîne, une ou plusieurs puces LED/LED encapsulées et un pilote électronique;
- pour chaque chaîne, une protection électronique;
- une résistance permettant de garantir un courant minimal de 10 mA dans la chaîne «fonction principale»

comme représenté à la Figure 9.

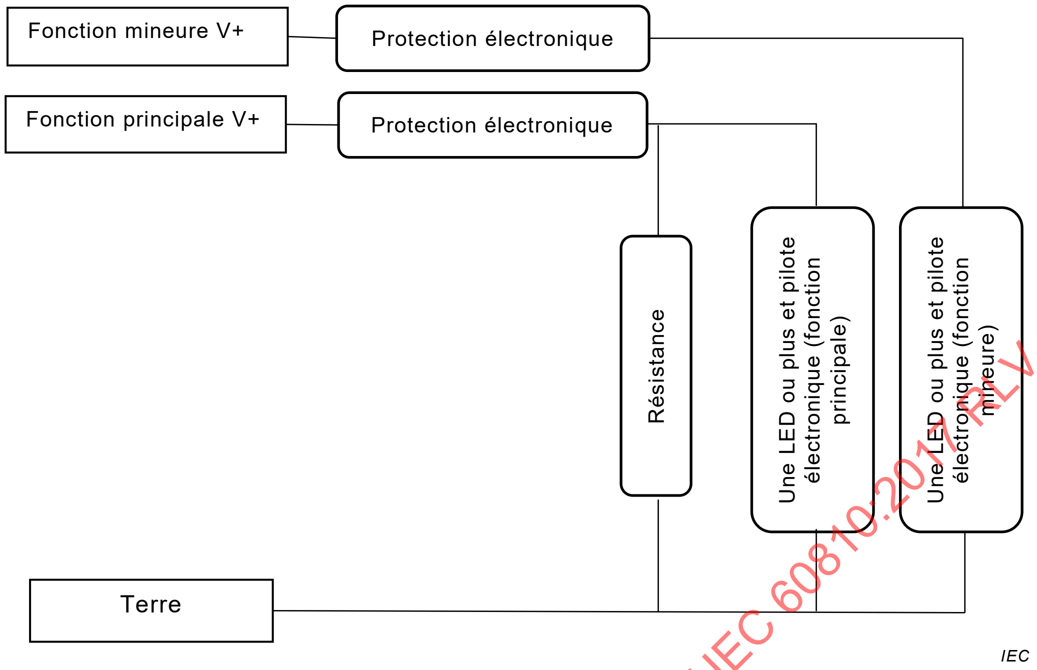


Figure 9 – Circuit électrique typique d'une source lumineuse à LED LR4

7.9 Puissance maximale consommée

Pour les sources lumineuses à LED figurant dans le Tableau 10, la puissance maximale consommée aux tensions d'essai continues de 9 V, 13,5 V et 16 V ne doit pas dépasser les valeurs données dans le Tableau 10.

Tableau 10 – Puissance maximale consommée

	Tension d'essai		
	9 V en courant continu	**13,5 V en courant continu**	**16 V en courant continu**
LR3	3,5 W	3,5 W	5 W
LR4 (fonction mineure/principale)	1,0 W / 3,5 W	1,0 W / 3,5 W	1,5 W / 5 W
LR5	3,5 W	3,5 W	5 W
LW3	5 W	5 W	10 W
LY3 [a]	5 W	5 W	10 W
LW5	8 W	8 W	10 W
LY5 [a]	8 W	8 W	12 W

NOTE Les valeurs données dans le Tableau 10 pour la puissance maximale à la tension de 13,5 V en courant continu sont issues du R128 ONU.

[a] Pendant l'état allumé, soumis à l'essai en mode clignotement, c'est à dire rapport allumage/extinction 1:1.

7.10 Essai de surtension

Cet essai a pour objet d'évaluer les performances de la source lumineuse à LED soumis à contrainte en raison de la surtension. L'essai doit être effectué sur un échantillonnage d'essai d'au moins 20 sources lumineuses à LED dans les conditions d'essai suivantes:

- pour une source lumineuse de 12 V: tension d'essai: 26 V;
- pour une source lumineuse de 24 V: tension d'essai: 52 V;

- température ambiante: 23 °C ± 5 °C;
- durée: 60 s.

Les sources lumineuses sont considérées comme ayant entièrement satisfait à l'essai, si après l'essai

- le flux lumineux n'a pas varié de plus de 20 % par rapport à la valeur initiale;
- les valeurs de chromaticité (cx, cy) restent dans les limites de couleur;
- le courant électrique n'a pas varié de plus de 10 % par rapport à la valeur initiale.

Les valeurs sont basées sur un niveau de non-conformité de 10 %.

7.11 Essai de tension inverse

Cet essai a pour objet d'évaluer les performances de la source lumineuse à LED soumise à contrainte en raison de la tension inverse. L'essai doit être effectué sur un échantillonnage d'essai d'au moins 20 sources lumineuses à LED dans les conditions d'essai suivantes:

- pour une source lumineuse de 12 V: tension d'essai: 14 V en courant continu de polarité inverse;
- pour une source lumineuse de 24 V: tension d'essai: 28 V en courant continu de polarité inverse;
- température ambiante: 23 °C ± 5 °C
- durée: 60 s.

Les sources lumineuses sont considérées comme ayant entièrement satisfait à l'essai, si après l'essai

- le flux lumineux n'a pas varié de plus de 20 % par rapport à la valeur initiale;
- les valeurs de chromaticité (cx, cy) restent dans les limites de couleur;
- le courant électrique n'a pas varié de plus de 10 % par rapport à la valeur initiale.

Les valeurs sont basées sur un niveau de non-conformité de 10 %.

7.12 Essai de tension transitoire (décroissance de champ)

Cet essai a pour objet d'évaluer les performances de la source lumineuse à LED soumise à contrainte en raison de la tension transitoire (décroissance de champ). L'essai doit être effectué sur un échantillonnage d'essai d'au moins 20 sources lumineuses à LED dans les conditions d'essai suivantes:

- conditions: voir Figure 10 et Tableau 11 (voir également ISO 7637-2, impulsion 1),
- impulsion d'essai de niveau de sévérité III;
- minimum de 500 impulsions;
- intervalle de répétition des impulsions ≥ 0,5 s.

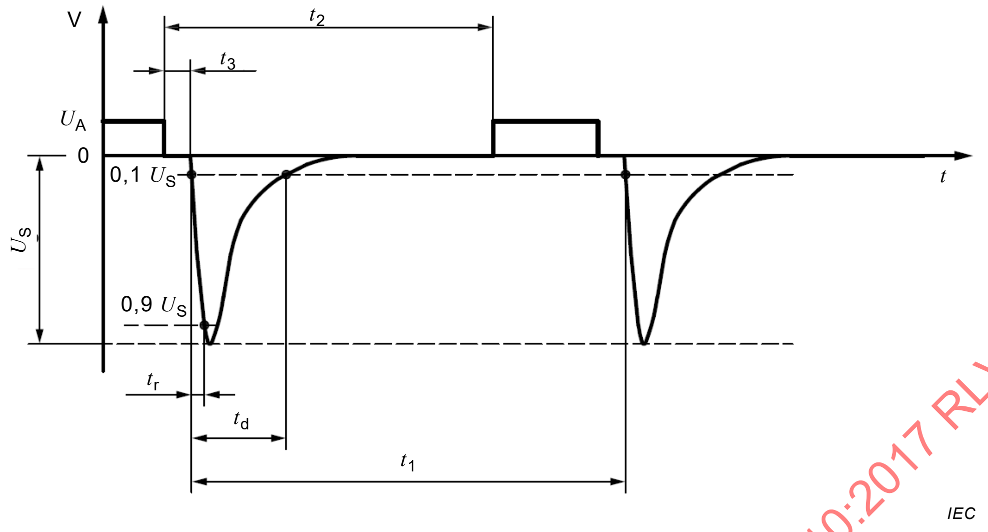


Figure 10 – Profil de l'impulsion 1 de l'ISO 7637-2

Tableau 11 – Paramètres d'essai pour l'impulsion 1 de l'ISO 7637-2

Paramètre	Système à tension nominale de 12 V	Système à tension nominale de 24 V
U_s	-75 V à -150 V	-300 V à -600 V
R_i	10 Ω	50 Ω
t_d	2 ms	1 ms
t_r	$\left(1\,^{0}_{-0,5}\right)$ µs	$\left(3\,^{0}_{-1,5}\right)$ µs
t_1 [a]	≥ 0,5 s	
t_2	200 ms	
t_3 [b]	< 100 µs	

[a] t_1 doit être choisi de sorte qu'il soit le temps minimum pour que le DUT (dispositif en essai) soit correctement initialisé avant l'application de l'impulsion suivante et doit être ≥ 0,5 s.

[b] t_3 est la durée la plus courte possible requise entre la déconnexion de la source d'alimentation et l'application de l'impulsion.

Les sources lumineuses sont considérées comme ayant entièrement satisfait à l'essai, si après l'essai

- le flux lumineux n'a pas varié de plus de 20 % par rapport à la valeur initiale;
- les valeurs de chromaticité (cx, cy) restent dans les limites de couleur;
- le courant électrique n'a pas varié de plus de 10 % par rapport à la valeur initiale.

Les valeurs sont basées sur un niveau de non-conformité de 10 %.

7.13 Essai de tension transitoire (perte de charge)

Cet essai a pour objet d'évaluer les performances de la source lumineuse à LED soumise à contrainte en raison de la tension transitoire (perte de charge). L'essai doit être effectué sur un échantillonnage d'essai d'au moins 20 sources lumineuses à LED dans les conditions d'essai suivantes:

- conditions: voir Figure 11 et Tableau 12 (voir également ISO 7637-2, impulsion 2a),

- impulsion d'essai de niveau de sévérité III;
- minimum de 500 impulsions;
- intervalle de répétition des impulsions ≥ 0,2 s.

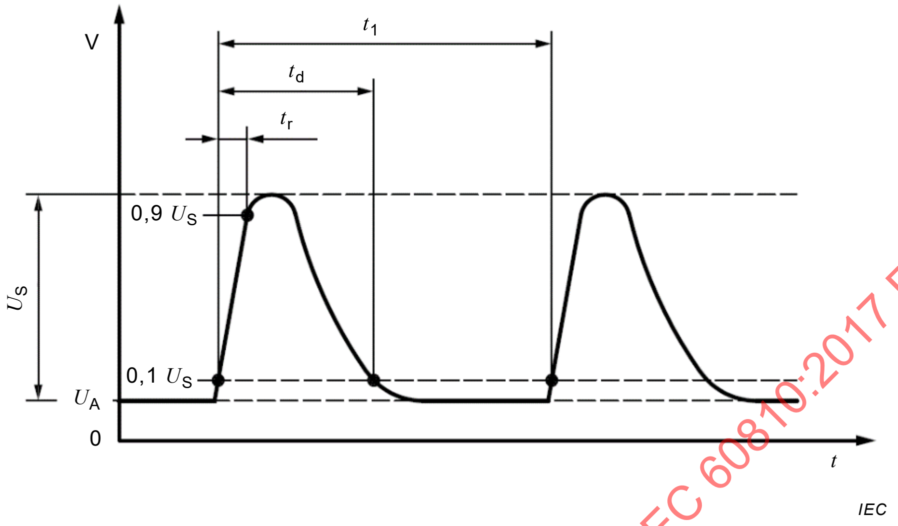


Figure 11 – Profil de l'impulsion 2a de l'ISO 7637-2

Tableau 12 – Paramètres d'essai pour l'impulsion 2a de l'ISO 7637-2

Paramètres	Système à tension nominale de 12 V et de 24 V
U_s	+37 V à + 112 V
R_i	2 Ω
t_d	0,05 ms
t_r	$\left(1^{\ 0}_{-0,5}\right)$ µs
t_1 [a]	0,2 s à 5 s
[a] Le temps de répétition t_1 peut être court en fonction de la commutation. L'utilisation d'un temps de répétition court réduit la durée de l'essai.	

Les sources lumineuses sont considérées comme ayant entièrement satisfait à l'essai, si après l'essai

- le flux lumineux n'a pas varié de plus de 20 % par rapport à la valeur initiale;
- les valeurs de chromaticité (cx, cy) restent dans les limites de couleur;
- le courant électrique n'a pas varié de plus de 10 % par rapport à la valeur initiale.

Les valeurs sont basées sur un niveau de non-conformité de 10 %.

7.14 Essai de décharge électrostatique (ESD, *electrostatic discharge*)

Cet essai a pour objet d'évaluer les performances de la source lumineuse à LED soumise à contrainte en raison de la décharge électrostatique aux bornes de la source lumineuse à LED et au niveau du boîtier. L'essai et la classification doivent être réalisés conformément à l'ISO 10605 sur un échantillonnage d'essai d'au moins 20 sources lumineuses à LED. Les détails relatifs à l'essai et les critères appliqués (le niveau de sévérité, par exemple) doivent être consignés dans le rapport d'essai.

7.15 Essai de durée de vie en fonctionnement pulsé (PLT, *pulsed operating life*)

Cet essai a pour objet d'évaluer les performances de la source lumineuse à LED soumise à contrainte en raison d'un fonctionnement pulsé.

- durée 1 000 h;
- tension de crête 13,5 V;
- T_{ambiante}= 23 °C ± 5 °C;
- largeur d'impulsion 100 µs, cycle de service 3 %. Ceci correspond à une fréquence de 300 Hz.

Les sources lumineuses sont considérées comme ayant entièrement satisfait à l'essai, si après l'essai

- le flux lumineux n'a pas varié après 100 h de plus de 20 % par rapport à la valeur initiale;
- le flux lumineux n'a pas varié après 1 000 h de plus de 20 % par rapport à la valeur initiale;
- les valeurs de chromaticité (cx, cy) restent dans les limites de couleur;
- le courant électrique n'a pas varié de plus de 10 % par rapport à la valeur initiale.

Les valeurs sont basées sur un niveau de non-conformité de 10 %.

8 Exigences et conditions d'essai relatives aux LED encapsulées

8.1 Qualification par essai de contrainte des LED encapsulées

L'Article 8 [2] définit les exigences minimales de qualification par essai de contrainte et référence les conditions d'essai relatives à la qualification des LED encapsulées.

Le présent document a pour objet de déterminer qu'une LED encapsulée est capable de satisfaire avec succès aux essais de contrainte spécifiés, et qu'il peut être ainsi prévu qu'elle offre un certain niveau de qualité/fiabilité dans les applications d'éclairage pour automobiles.

La «Qualification par essai de contrainte» selon le présent document est définie comme la pleine satisfaction aux exigences d'essai mentionnées dans le présent document.

Le Paragraphe 8.6 définit un ensemble d'essais de qualification qui doit être pris en considération pour les qualifications des nouvelles LED encapsulées. Dans le cas d'une requalification associée à une modification de conception ou de processus, un ensemble limité d'essais de qualification peut être pris en considération, voir Annexe L.

Le cas échéant, des qualifications par famille peuvent être réalisées, et il convient que le fournisseur les justifie.

La famille peut être classée suivant les caractéristiques majeures des LED encapsulées.

Le transfert des résultats n'est pas recommandé, en cas de différence en termes de

- matériau du boîtier (par exemple, pré-moule, céramique, époxy) et conception, ou
- matériau de fonte (par exemple, silicone, époxy)/lentille/fenêtre, ou
- conversion (par exemple, transfert entre couches, conversion de volume), ou

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[2] L'approche relative à la qualification par essai de contrainte des LED encapsulées, telle que décrite dans le présent document, est issue d'une approche similaire développée par le Automotive Electronics Council (Conseil pour l'électronique d'automobile) (AEC – Q101: Stress test qualification for automotive grade discrete semiconductors (Qualification par essai de contrainte pour les semiconducteurs discrets pour automobiles)).

- connexion par liaison de puces (par exemple, par adhésif, par soudure)/connexion par fil, ou
- technologie des puces (par exemple, AlInGaP, AlInGaN, AlInGaAs, saphir, quelle que soit la couleur).

Tout écart par rapport à cette recommandation doit être documenté.

Le transfert des résultats est possible, en cas de différence en termes de

- phosphore CCT (performance identique ou meilleure) ou
- taille des puces/nombre de puces dans la LED encapsulée (densité de courant identique ou inférieure ou évolutive).

Les LED encapsulées présentant les mêmes caractéristiques clés peuvent être autorisées pour usage par des qualifications par famille.

Le présent document fait référence à d'autres normes IEC ou à des normes d'autres organismes (par exemple, JEDEC). Le cas échéant, des détails supplémentaires sur les définitions d'essai peuvent être relevés dans ces documents. Les conditions d'essai décrites dans le présent document peuvent s'écarter des conditions d'essai décrites dans les documents de référence (par exemple, condition PTMCL 2). Dans ce type de cas, d'autres définitions dans le document de référence doivent continuer à être appliquées s'il y a lieu.

Les résultats de l'essai des LED encapsulées peuvent être consignés au moyen de la fiche de communication spécifiée à l'Annexe K.

Des lignes directrices pour la validation de la robustesse des LED encapsulées sont données à l'Annexe M.

8.2 Échantillons pour essai

8.2.1 Exigences concernant les lots

Sauf spécification contraire en 8.6, un nombre total de 78 LED encapsulées au minimum, prélevées sur trois lots différents composés chacun de 26 LED encapsulées, doit être utilisé pour chaque essai. Pour la qualification par famille, les 3 lots différents doivent être considérés comme représentatifs des diverses familles de qualification existantes.

La taille de l'échantillon peut être réduite à un minimum de 3 x 5 LED encapsulées en raison des problèmes techniques ou des limitations expérimentales. La ou les raisons de réduction de la taille de l'échantillon doivent être consignées dans le rapport d'essai.

8.2.2 Exigences concernant la production

Toutes les LED encapsulées de qualification doivent être produites avec les outillages et les processus disponibles sur le site de fabrication, utilisés pour prendre en charge les livraisons de LED encapsulées selon les volumes de production prévus.

8.2.3 Exigences concernant les essais de pré- et de post-contrainte

Les valeurs électriques et photométriques (tension directe, flux lumineux ou puissance rayonnante et/ou intensité, paramètre de couleur) doivent être mesurées dans les conditions d'essai nominales telles que définies dans la spécification de produit avant et après l'essai de contrainte (voir également 8.6.1).

NOTE Un essai d'allumage/extinction est à l'étude pour des essais à des températures différentes.

Toutes les LED encapsulées utilisées pour la qualification doivent satisfaire aux paramètres de spécification de produit mesurés dans les conditions d'essai nominales avant l'essai de contrainte.

8.2.4 Assemblage des LED encapsulées sur des tableaux d'essai

Il peut se révéler nécessaire d'assembler les LED encapsulées sur des tableaux d'essai. Le fabricant doit choisir un tableau d'essai, un matériau d'interconnexion et un processus appropriés. Le choix du tableau d'essai, du matériau d'interconnexion et du processus doit être documenté dans le rapport d'essai pour chaque essai individuel.

8.2.5 Préconditionnement sous atmosphère humide (MP, *moisture pre-conditioning*)

Un préconditionnement sous atmosphère humide est applicable aux composants pour montage en surface conçus pour un brasage par refusion. Toutes les LED encapsulées de qualification utilisées pour les essais suivants:

- 8.6.4 TMCL,
- 8.6.5 WHTOL,
- 8.6.6 PTMCL, et
- 8.6.14 RSH-refusion

doivent être soumises à un préconditionnement sous atmosphère humide selon la norme JESD22-A113F. L'essai électrique et photométrique initial selon 8.6.1 doit être effectué après le préconditionnement sous atmosphère humide.

8.2.6 Essai de résistance thermique (TR, *thermal resistance*)

La résistance thermique doit être vérifiée par essai selon les normes JESD51-50, JESD51-51, JESD51-52 et JESD51-53; il convient d'enregistrer la valeur $R_{\text{th electr}}$ résultante, ainsi que le rayonnement de puissance optique de la LED encapsulée pour le calcul de la valeur $R_{\text{th,real}}$ et les valeurs $R_{\text{th,electr}}$(typique) et $R_{\text{th,electr}}$(maximale) doivent être consignées (il convient d'effectuer la consignation au moyen de la fiche de communication spécifiée à l'Annexe K).

8.3 Définition des critères de mise hors d'usage

Une LED encapsulée doit être considérée comme n'ayant pas satisfait aux essais lorsque l'un quelconque des critères suivants s'applique:

- La tension directe V_f au courant d'attaque nominal I_f s'écarte de plus de ±10 % de la valeur initiale.
- La puissance rayonnante, le flux lumineux ou l'intensité au courant d'attaque nominal I_f s'écarte de plus:
  - de ± 20 % de la valeur initiale, ou
  - de ± 30 % de la valeur initiale

où ces options de ± 20 % ou ± 30 % sont laissées au choix du fabricant.

  - Un écart de ± 50 % de la valeur initiale peut être acceptable pour certaines applications d'éclairage intérieur (par exemple, LED encapsulées pour les groupes d'instrumentation).

- Les coordonnées chromatiques x,y au courant d'attaque nominal I_f d'une LED blanche s'écartent de plus de ± 0,01 de la valeur initiale. L'écart admis applicable aux LED à couleurs saturées est à l'étude. Un écart de ± 0,02 de la valeur initiale peut être acceptable pour certaines applications d'éclairage intérieur.
- La LED encapsulée présente un dommage physique visible de manière externe, imputable à l'essai d'environnement (par exemple, délaminage). Cependant, s'il est convenu (par un

accord entre le fabricant et l'utilisateur) que la cause de la mise hors d'usage est due à un mauvais traitement ou à une décharge électrostatique, la mise hors d'usage ne doit pas être prise en compte, mais être consignée comme partie intégrante de la soumission des données. Un microscope avec un grossissement compris entre 40X et 50X doit être utilisé.

Les mises hors d'usage au niveau de l'interconnexion avec le tableau d'essai ou au niveau du tableau d'essai proprement dit qui ne sont pas associées à une mise hors d'usage de la LED encapsulée ne doivent pas être prises en compte, mais être consignées comme partie intégrante de la soumission des données.

8.4 Choix entre les conditions d'essai

Un fabricant doit choisir une classe spécifique de conservation du flux lumineux selon 8.3 préalablement à l'essai de qualification. Les critères de réussite/échec appropriés doivent être applicables.

Par ailleurs, le fabricant doit choisir entre différentes classes de conditions d'essai le cas échéant (par exemple, conditions 1 à 4 du cycle TMCL définies en 8.6.4). La condition d'essai doit être documentée dans le rapport d'essai.

Généralement, il peut être par hypothèse retenu que la satisfaction aux conditions d'essai les plus sévères implique de satisfaire également aux conditions plus souples (par exemple, la satisfaction à la condition 3 TMCL implique de satisfaire également aux conditions 1 et 2 TMCL).

8.5 Critères de satisfaction aux essais de qualification/requalification

Tous les LED encapsulées en essai doivent satisfaire aux essais concernés. Dans le cas contraire, la LED encapsulée ou la famille de LED encapsulées est considéré(e) comme n'ayant pas satisfait aux essais.

Les LED encapsulées qui n'ont pas satisfait aux critères d'acceptation des essais exigés par le présent document exigent du fournisseur qu'il détermine de manière satisfaisante la cause profonde de cette mise hors d'usage et l'action corrective nécessaire afin d'assurer à l'utilisateur que le mécanisme de mise hors d'usage est compris et contenu, et que les actions correctives et préventives sont confirmées comme étant effectives, par la répétition avec succès du ou des essais de qualification applicables.

8.6 Essai de qualification

8.6.1 Essai pré- et post-électrique et photométrique

Toutes les LED encapsulées doivent être soumises à l'essai au courant d'attaque nominal selon les exigences suivantes de la spécification de LED encapsulée appropriée (fiche technique du fabricant) avant et après les essais suivants, sauf pour 8.6.2 et 8.6.10:

- flux lumineux ou puissance rayonnante ou intensité (selon l'essai approprié);
- tension directe;
- coordonnées chromatiques ou longueur d'onde dominante ou de crête (selon l'essai approprié).

NOTE Le choix entre la longueur d'onde dominante et de crête est à l'étude.

De plus, la tension directe au courant d'attaque minimum (ou inférieur) et maximum doit être enregistrée.

8.6.2 Essai pré- et post-visuel externe (EV, *external visual*)

La construction, le marquage et la qualité d'exécution de la LED encapsulée doivent être examinés selon la norme JESD22-B101B avant et après les essais suivants, sauf pour 8.6.10.

8.6.3 Essai de durée de vie en fonctionnement sous température élevée (HTOL, *high temperature operating life*)

Cet essai a pour objet d'évaluer les performances de la LED encapsulée soumise à contrainte en raison d'un fonctionnement sous température élevée. L'essai doit être effectué selon la norme JESD22-A108D; les conditions d'essai suivantes s'appliquent:

- Durée:1 000 h.
- l'essai doit être effectué:
  - au courant d'attaque maximum spécifié avec la température T_s assignée maximale correspondante, et
  - à la température T_s maximale spécifiée avec le courant d'attaque assigné maximum correspondant.

8.6.4 Essai de cycle de température (TMCL, *temperature cycling*)

Cet essai a pour objet d'évaluer les performances de la LED encapsulée soumise à contrainte en raison de l'existence de cycles de température, sans que cette LED soit en fonctionnement. La LED encapsulée doit être soumise à l'essai selon la norme JESD22-A104E; les conditions d'essai suivantes s'appliquent:

- durée: 1 000 cycles;
- mode de trempage 4 (temps de trempage minimum de 15 min).

Les températures T_s minimales et maximales suivantes doivent être choisies par le fabricant:

- Condition TMCL 1: $T_{s,min}$ = –40 °C; $T_{s,max}$ = 85 °C;
- Condition TMCL 2: $T_{s,min}$= –40 °C; $T_{s,max}$ = 100 °C;
- Condition TMCL 3: $T_{s,min}$ = –40 °C; $T_{s,max}$ = 110 °C;
- Condition TMCL 4: $T_{s,min}$= –40 °C; $T_{s,max}$ = 125 °C;
- Condition TMCL 5: $T_{s,min}$= –40 °C; $T_{s,max}$ = 150 °C.

La condition TMCL la plus proche de la plage de température de fonctionnement spécifiée par le fabricant, selon la spécification de LED encapsulée appropriée (fiche technique du fabricant) doit être choisie à moins que le fabricant ne souhaite vérifier la conformité par essai à une condition de cycle plus stricte. Le choix de la condition de cycle TMCL et le temps de transfert doivent être consignés dans le rapport d'essai.

8.6.5 Essai de durée de vie en fonctionnement sous température élevée humide (WHTOL, *wet high temperature operating life*)

Cet essai a pour objet d'évaluer les performances de la LED encapsulée soumise à contrainte en raison de la température et de l'humidité dans des conditions de fonctionnement en régime permanent. La LED encapsulée doit être soumise à l'essai selon la norme JESD22-A101C; les conditions d'essai suivantes s'appliquent:

- durée: 1 000 h;
- T_s = 85 °C;
- 85 % HR;
- cycle de puissance 30 min allumée/30 min éteinte.

Les essais doivent être réalisés au courant d'attaque assigné minimum et maximum (c'est-à-dire, caractéristiques assignées à la température T_s = 85 °C).

8.6.6 Essai de cycle de température de puissance (PTMCL, *power temperature cycling*)

Cet essai a pour objet d'évaluer les performances de la LED encapsulée soumise à contrainte en raison de l'existence de cycles de température, au cours du fonctionnement de la LED encapsulée. Cette dernière doit être soumise à l'essai selon la norme JESD22-A105C; les conditions d'essai suivantes s'appliquent:

- durée: 1 000 cycles de température;
- cycle de puissance 5 min allumée/5 min éteinte, au courant d'attaque assigné maximum correspondant.

Le fabricant doit sélectionner l'un des types d'essai suivants:

- condition PTMCL 1: T_s comprise entre –40 °C et 85 °C, (condition d'essai A selon la norme JESD22-A105C);
- condition PTMCL 2: T_s comprise entre –40 °C et 100 °C, (transition et temps de maintien selon la condition d'essai A décrite dans la norme JESD22-A105C);
- condition PTMCL 3: T_s comprise entre –40 °C et 125 °C, (condition d'essai B selon la norme JESD22-A105C).

La condition PTMCL la plus proche de la plage de température de fonctionnement spécifiée par le fabricant, selon la spécification de LED encapsulée appropriée (fiche technique du fabricant) doit être choisie à moins que le fabricant ne souhaite vérifier la conformité par essai à une condition de cycle plus stricte. Le choix de la condition PTMCL doit être consigné dans le rapport d'essai.

8.6.7 Essai de décharge électrostatique, avec utilisation du modèle du corps humain (ESD-HBM, *electrostatic discharge, human body model*)

Cet essai a pour objet d'évaluer les performances de la LED encapsulée soumise à contrainte en raison d'une décharge électrostatique, en utilisant le modèle biologique. La LED encapsulée doit être soumise à l'essai selon la norme ANSI/ESDA/JEDEC JS-001-2012.

8.6.8 Essai de décharge électrostatique, avec utilisation du modèle machine (ESD-MM, *electrostatic discharge, machine model*)

Cet essai a pour objet d'évaluer les performances de la LED encapsulée soumise à contrainte en raison d'une décharge électrostatique, en utilisant le modèle machine. La LED encapsulée doit être soumise à l'essai selon la norme JESD22-A115C.

8.6.9 Essai par analyse physique destructive (DPA, *destructive physical analysis*)

Cet essai a pour objet d'évaluer la capacité des matériaux internes, de la conception et de la qualité d'exécution du dispositif à résister aux forces induites par les diverses contraintes exercées lors de l'essai d'environnement.

Effectuer l'analyse physique destructive selon l'Annexe J sur des échantillons aléatoires de biens après achèvement de l'essai PTMCL, de l'essai WHTOL et de l'essai H2S et FMGC (2 échantillons par lot). L'essai post-électrique et post-photométrique de ces échantillons doit être réalisé préalablement à l'analyse physique destructive.

8.6.10 Essai de dimensions physiques (PD, *physical dimensions*)

Vérifier les dimensions physiques selon les dessins aux instruments de la LED encapsulée du fabricant de LED encapsulée.

8.6.11 Essai de vibrations à fréquence variable (VVF, *vibrations variable frequency*)

Cet essai a pour objet d'évaluer les performances de la LED encapsulée soumise à contrainte en raison de vibrations mécaniques à fréquence variable. La LED encapsulée doit être soumise à l'essai selon la norme JESD22-B103B.

Appliquer un déplacement constant de 1,5 mm (amplitude double) sur la plage comprise entre 20 Hz et 100 Hz et une accélération maximale constante de 200 m/s^2 sur la plage comprise entre 100 Hz et 2 kHz.

8.6.12 Essai de choc mécanique (MS, *mechanical shock*)

L'objet de cet essai est d'évaluer les performances de la LED encapsulée soumise à contrainte en raison d'un choc mécanique. La LED encapsulée doit être soumise à l'essai selon la norme JESD22-B110B:

- appliquer 15 000 m/s^2 pendant 0,5 ms;
- appliquer 5 chocs dans chaque direction, et selon trois orientations (+ et – direction $x/y/z$, c'est-à-dire 30 chocs).

8.6.13 Essai de résistance à la chaleur de brasage (RSH-TTW, *resistance to soldering heat, through the wave*)

L'essai de brasage à la vague (TTW) a pour objet d'évaluer les performances de la LED encapsulée soumise à contrainte en raison de la chaleur de brasage. La LED encapsulée doit être soumise à l'essai selon la norme JESD22-B106D.

Cet essai s'applique uniquement aux LED encapsulées déclarées par le fabricant comme pouvant être soudées par un procédé de brasage à la vague.

8.6.14 Essai de résistance à la chaleur de brasage (RSH-refusion)

Cet essai a pour objet d'évaluer les performances de la LED encapsulée soumise à contrainte en raison de la chaleur de brasage. La LED encapsulée doit être soumise à l'essai selon la norme JESD22-A113F ou la norme ANSI/IPC/ECA J-STD-002C.

Le brasage par refusion doit être vérifié par essai trois fois à une température de 260 °C. L'essai selon 8.6.1 doit être effectué avant et après chaque refusion.

Cet essai s'applique uniquement aux LED encapsulées spécifiées pour un brasage par refusion.

8.6.15 Essai de brasabilité (SO, *solderability*)

Cet essai a pour objet de déterminer l'aptitude au brasage des alliages de soudage sans plomb applicables aux LED encapsulées pour montage en surface. Les LED encapsulées doivent être soumises à l'essai selon l'IEC 60068-2-58.

Taille de l'échantillon: 3 x 10.

8.6.16 Essai de choc thermique (TMSK, *thermal shock*)

Cet essai a pour objet d'évaluer les performances de la LED encapsulée soumise à contrainte en raison d'un choc thermique. La LED encapsulée doit être soumise à l'essai selon la norme JESD22-A106B. Les conditions suivantes doivent s'appliquer:

- durée: 1 000 cycles;
- condition de cycle TMSK 1: $T_{s,min}$ = –40 °C; $T_{s,max}$ = 85 °C;