TECHNICAL SPECIFICATION

NMF01:2021 LED luminaires – requirements

Edition 3.0 22.12.2020

NMF – Nordic co-operation group in the field of road equipment

NMF – Nordiskt Möte för Förbättrad vägutrustning

Contents

Foreword

This Technical Specification presents the requirements for outdoor LED luminaires. This publication has been drafted in accordance with the ISO/IEC Directives, Part 2 with the following exception:

- notes concerning only a certain road authority or authorities may also contain requirements.

In this Technical Specification, the following print types are used:

- requirements: Arial type.
- references: *italic type*.
- notes: smaller Arial type.

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Introduction

This Technical Specification has been prepared to achieve consistency, clarity and increased quality in all types of procurements for lighting on roads and in railway areas. The Specification has four main aims:

- to create a basis for improvement of national guidelines by harmonizing requirements for LED luminaires in the Nordic countries,
- to have a greater effect on the market as harmonised requirements for LED luminaires,
- to ease and increase the interaction with the manufacturers and
- to enforce a level of quality consistency of products available on the market in Nordic countries.

This Technical Specification is based on the previous edition of this document *NMF01:2019 LED luminaires – requirements, Edition 2.0, 18.6.2019* and current national guidelines of four road authorities: the Swedish Transport Administration, the Norwegian Public Roads Administration, the Danish Road Directorate and the Finnish Transport Infrastructure Agency. Furthermore, the publication is based on ongoing CIE technical committee work, current ISO, IEC, CEN standards and standard drafts, Zhaga Consortium publications as well as experiences from different outdoor lighting procurements. The purchasers, tenderers, lighting designers, manufacturers and contractors have been heard during the preparation stage of this document.

1 Scope

This Technical Specification presents the technical requirements for LED luminaires used on roads and in railway areas. This includes road lighting, tunnel lighting, lighting under bridges, underpass lighting, decorative lighting, railway lighting and railway tunnel lighting. Escape route direction signs are not in the scope of this document.

The requirements for LED luminaires presented in this publication shall be followed in all forms of contracts in design, new construction, rehabilitation and maintenance of lighting on roads and in railway areas.

Target groups for this Technical Specification are purchasers, tenderers, lighting designers, manufacturers and contractors.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application.

CIE S 017:2020 ILV International Lighting Vocabulary

EN 60529:1992 Degrees of protection provided by enclosures (IP Code)

EN 62262:2011 Degrees of protection provided by enclosures for electrical equipment against external mechanical impacts (IK code)

IEC 62717:2014 LED modules for general lighting - Performance requirements

IEC 62722-1:2014 Luminaire performance - Part 1: General requirements

IEC 62722-2-1:2014 Luminaire performance - Part 2-1: Particular requirements for LED luminaires

For dated references of this document, only the edition (or revision) cited applies. The dated reference includes all amendments to the referenced document made after the publication of the edition (or revision).

3 Terms and definitions

For the purposes of this document, the terms and definitions given in the standards *CIE S 017:2020*, *EN 60529:1992, EN 62262:2011, IEC 62717:2014*, *IEC 62722-1:2014* and *IEC 62722-2-1:2014* as well as the following apply.

NOTE 1: The terms and definitions given in the *CIE S 017:2020* are published on http://eilv.cie.co.at/.

3.1
road lighting
functional lighting for roads, streets, footways and cycleways

Note 1 to entry: If a floodlight is used to illuminate a road section, it is considered to be a road luminaire.

3.2
tunnel lighting
functional lighting for tunnels. Tunnel lighting includes normal lighting and safety lighting.

3.3
railway lighting
functional lighting for railway areas

3.4
lighting under bridges
lighting of a road section under bridge intended for drivers of motorized vehicles

3.5
underpass lighting
lighting of a footway or a cycleway section under road intended for pedestrians and pedal cyclists

3.6
decorative lighting
lighting that is purely ornamental and installed for aesthetic effect. Decorative lighting shall not include functional lighting.

Note 1 to entry: Usually means lighting fixtures provided primarily to enhance areas with a public use or pedestrian orientation, or to highlight key architectural elements, landscaping and similar design elements.

3.7
rated maximum ambient temperature
t_a
temperature assigned to a luminaire by the manufacturer to indicate the highest sustained temperature in which the luminaire may be operated under normal conditions

3.8
external wiring
wiring generally outside a luminaire

Note 1 to entry: In outdoor lighting, usually a cable between the luminaire's and the column's wiring blocks.

Note 2 to entry: External wiring is not necessarily outside a luminaire for its full length.

3.9
rated useful lifetime
time over which the luminaire is expected to function as designed

Note 1 to entry: Generally defined by a client.

3.10
median useful life
L_x
length of time until 50 % of a population of operating LED products reaches luminous flux degradation of a percentage *x*

3.11
maximum expected control gear failure rate
maximum value for the expected control gear failure rate for the given rated useful lifetime of the luminaire

3.12
group replacement
replacement of many components at one chosen time in an installation

3.13
spot replacement
replacement of a single component at one chosen time in an installation

3.14
luminaire group replacement interval
planned time between group replacement of luminaires

3.15
constant light output
functionality to constantly adjust the luminous flux of the light source based on the known or predicted depreciation behavior of the light source to enable a constant luminous flux over time

Note 1 to entry: Generally abbreviated to CLO.

3.16
CLO lifetime
time over which the CLO control ensures a constant luminous flux

3.17
luminaire cleaning interval
planned time between cleaning of (parts of) luminaires

Note 1 to entry: In outdoor lighting cleaning usually indicates cleaning of the luminaire's optics e.g. luminaire's flat glass.

3.18
luminaire extension module (LEX-M)
separate device defined by the *Zhaga Book 18:2019, Edition 2.0*, that provides an interface between the electronic control gear of a luminaire and the lighting control system, other system or other modules

Note 1 to entry: Can be installed to the luminaire extension receptacle by means of a twist-lock.

3.19
luminaire extension receptacle (LEX-R)
socketed device defined by the *Zhaga Book 18:2019*, *Edition 2.0,* that enables an installation or replacement of the luminaire extension module without tools, and enables communication between the luminaire extension module and the luminaire electronic control gear

3.20
luminaire extension cap (LEX-C)
separate unit defined by the *Zhaga Book 18:2019*, *Edition 2.0,* which can be attached to the luminaire extension receptacle

Note 1 to entry: luminaire extension cap does not hold any functionality and is used to cover the luminaire extension receptacle in case no luminaire extension module is used.

3.21
Annual Average Daily Traffic (AADT)
term used to provide the projected future average traffic volume in both directions on a section of road

3.22
DALI (Digital addressable lighting interface)
DALI is an industry-standardized protocol defined by the standard *IEC 62386*

Note 1 to entry: The standard *IEC 62386* is published in multiple parts, with several new parts in development.

Note 2 to entry: DALI-2 is based on the second edition of the standard *IEC 62386*, which also includes control devices.

3.23
stand-alone dimming
lighting control that is integrated into the electronic control gear of a luminaire and does not require any external command

Note 1 to entry: Is usually preprogrammed.

3.24
flat glass
an even, two-dimensional surface, which protects LEDs and optics of a luminaire

Note 1 to entry: Is usually, but not necessarily, made of glass.

3.25
curved glass
a gently curving surface, which protects LEDs and optics of a luminaire

Note 1 to entry: Is usually made of glass and created by bending.

3.26
LED strip
a non-integrated LED light source which needs a separate electronic control gear to operate

Note 1 to entry: Is usually a circuit board on top of which LED chips are mounted. The circuit board provides a structural base of the LED strip, a path for heat dissipation and an electricity supply through its circuitry.

Note 2 to entry: In outdoor environments an LED strip is usually sealed to protect the circuit board against intrusion from foreign matter (dirt etc.) and moisture. The LED strip can also be used with different range of profiles for installation, protection and heat dissipation.

3.27
Modulation (%)
Modulation (%) is defined as the difference between maximum and minimum luminance divided by the sum of maximum and minimum luminance (multiplied by 100)

Note 1 to entry: *Modulation (%)* is also known as percent flicker or modulation depth.

3.28
DiiA (Digital Illumination Interface Alliance)
The Digital Illumination Interface Alliance (DiiA) is an open, global consortium of lighting companies.

3.29
Zhaga Consortium
a global lighting-industry organization that aims to standardize interfaces of components of LED luminaires

3.30
D4i
an extension of the DALI-2 certification program that brings standardization to small DALI networks inside luminaires

4 Symbols, units and abbreviations

The symbols, units and abbreviations in Table 1 apply.

Table 1. Symbols, units and abbreviations.

Symbol/ abbreviation	Description	Unit
CLO	constant light output (see 3.15 and 7.6)	-
t_a	rated maximum ambient temperature (see 3.7)	°C
t_q	rated ambient performance temperature (see *IEC 62722-2-1:2014*, 3.3)	°C
R_a	rated general colour rendering index (see *CIE S 017:2020*)	-
T_{cp}	rated correlated colour temperature (see *CIE S 017:2020*)	K
L_x	median useful life (see 3.10) for *x* % remaining luminous flux	h
η_l	luminaire luminous efficacy (see *IEC 62722-2-1:2014*, 3.6)	lm/W
f_m	maintenance factor (see 7.4)	-
f_{LF}	luminous flux factor (see 7.5 and 7.6)	-
f_{LM}	luminaire maintenance factor (see 7.7)	-
Φ_L	luminaire luminous flux	lm
Φ_{CLO}	CLO-corrected luminaire luminous flux (see 7.6)	lm
Φ_e	luminaire luminous flux at the end of rated useful lifetime (see 7.6)	lm
Φ_i	initial luminaire luminous flux (see 7.6)	lm
H_M	luminaire mounting height (*CIE S 017:2020*)	m
DALI	Digital Addressable Lighting Interface (see 3.22)	-
DiiA	Digital Illumination Interface Alliance (see 3.28)	-
λ	circuit power factor (see *IEC 62384:2020*)	-
AADT	Annual Average Daily Traffic (see 3.21)	-

5 Light sources in lighting installations

In this publication, light sources used in luminaires are considered to contribute to the performance of the luminaire as a system. No individual requirements for the light sources as such are stated.

When constructing new lighting and in the rehabilitation of current lighting installations only the LED luminaires shall be used.

For general road, tunnel and railway lighting, only phosphor-converted inorganic LEDs producing white light shall be used.

6 Safety requirements

6.1 Low Voltage Directive

A luminaire shall comply with the *Low Voltage Directive 2014/35/EU*, and it shall fulfil the luminaire safety requirements specified in the Directive in accordance with the standards mentioned in Table 2. Standards other than those mentioned in Table 2 can also be used to demonstrate compliance with the Directive. In that case, sufficient background for demonstrating compliance with the Directive shall be presented.

Fulfilment of the luminaire safety requirements shall be evidenced with a manufacturer's declaration of conformity related to the CE marking and its technical documents, or with test results by a conformity assessment body. The conformity assessment body shall comply with the *Regulation (EC) No 765/2008*.

Table 2. Safety standards specified in the Low Voltage Directive 2014/35/EU.

Standard Number	Description	General purpose luminaires [a]	Road and tunnel lighting [b]	Flood-lighting [c]	Evacuation lighting [d]
EN 60598-1:2015	Luminaires - Part 1: General requirements and tests	X	X	X	X
EN 60598-2-1:2015	Luminaires - Part 2-1: Particular requirements – Fixed general purpose luminaires	X			
EN 60598-2-3:2003	Luminaires - Part 2-3: Particular requirements - Luminaires for road and street lighting		X		
EN 60598-2-5:2015	Luminaires - Part 2-5: Particular requirements - Floodlights			X	
EN 60598-2-22:2014	Luminaires - Part 2-22: Particular requirements - Luminaires for emergency lighting				X
EN 62493:2015	Assessment of lighting equipment related to human exposure to electromagnetic fields	X	X	X	X

[a] *Includes LED strips.*

[b] *Also includes street lighting, lighting for pedestrian and cycle areas, standby lighting in tunnels etc.*

[c] *Includes areas and objects illuminated by floodlights, for example interchange area lighting, parking area lighting, railway lighting, decorative lighting, etc.*

[d] *Includes tunnel evacuation lighting, railway tunnel evacuation lighting, etc.*

A luminaire shall be equipped with marking in accordance with the standard *EN 60598-1:2015*. The durability of the marking shall fulfil the test requirements defined in the standard *EN 60598-1:2015*.

NOTE 1: Markings to be observed during maintenance should be visible on the outside of a luminaire or behind a cover that is removed during control gear or other component replacement.

A luminaire shall be assessed for blue light hazard according to the technical report *IEC/TR 62778:2014*. The requirement is included in the standard *EN 60598-1:2015*.

The luminaire electronic control gear voltage is 230 V. The luminaire control gear circuit power factor shall be $\lambda \geq 0.90$ for luminaires with a rated input power of ≤ 50 W and $\lambda \geq 0.95$ for luminaires with a rated input power of > 50 W (100 % power, initial luminaire luminous flux Φ_i). The electronic control gear circuit power factor of a dimmed luminaire (dimmed to 20 % of the initial luminous flux Φ_i) shall be $\lambda \geq 0.60$.

A luminaire including all electronics shall operate without malfunctioning at an ambient temperature of $-35 \leq t_a \leq +25$ °C.

NOTE 2: In Danish Road Directorate projects, a luminaire including all electronics shall operate without malfunctioning at an ambient temperature of $-20 \leq t_a \leq +25$ °C.

Road and railway luminaires shall have protection class II.

NOTE 3: In Finnish Transport Infrastructure Agency and the Norwegian Public Roads Administration projects road and railway luminaires shall have protection class I or II.

Tunnel luminaires shall have protection class I. Road tunnel evacuation lighting luminaires (marker lights or LED strips) shall have protection class II.

The external wiring shall be suitable for use outdoors.

NOTE 4: If the external wiring is exposed to direct sunlight (for example overhead wiring), the cable sheath should be made of lead-free weatherproof PVC.

For the external wiring of all outdoor lighting installations, the nominal cross-sectional areas of the cable's wires shall be ≥ 1.5 mm^2.

NOTE 5: In Danish Road Directorate projects, wires with a nominal cross-sectional area of 1.0 mm^2 can also be used.

NOTE 6: Longer external cables may require a higher nominal cross-sectional area due to mechanical strength or electrotechnical requirements, for example 2.5 mm^2. This is also dependent on the cable type used.

The external cable type shall be such that it remains undamaged when pulled through a normal column and bracket or when it is bent permanently with a bending radius of at least three times the cable diameter. For the requirements above, the lowest permitted handling ambient temperature is $t_a = -15$ °C.

6.2 Electromagnetic Compatibility Directive

A luminaire shall comply with the *Electromagnetic Compatibility (EMC) Directive 2014/30/EU*, and it shall fulfil the EMC requirements specified in the Directive in accordance with the standards mentioned in Table 3. Standards other than those mentioned in Table 3 can also be used to demonstrate compliance with the Directive. In that case, sufficient background for demonstrating compliance with the Directive shall be presented.

Fulfilment of the EMC requirements shall be evidenced with a manufacturer's declaration of conformity related to the CE marking and its technical documents, or with test results by a conformity assessment body. The conformity assessment body shall comply with the *Regulation (EC) No 765/2008*.

Table 3. EMC standards specified in the Electromagnetic Compatibility (EMC) Directive 2014/30/EU.

Standard Number	Description	General purpose luminaires [a]	Road and tunnel lighting [b]	Flood-lighting [c]	Evacuation lighting [d]
EN 55015:2019	Limits and methods of measurement of radio disturbance characteristics of electrical lighting and similar equipment	X	X	X	X
EN IEC 61000-3-2: 2019	Electromagnetic compatibility (EMC) - Part 3-2: Limits - Limits for harmonic current emissions (equipment input current ≤16 A per phase)	X	X	X	X
EN 61000-3-3:2013	Electromagnetic compatibility (EMC) - Part 3-3: Limits - Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems, for equipment with rated current ≤16 A per phase and not subject to conditional connection	X	X	X	X
EN 61547:2010	Equipment for general lighting purposes. EMC immunity requirements.	X	X	X	X

[a] *Includes LED strips.*

[b] *Also includes street lighting, lighting for pedestrian and cycle areas, standby lighting etc.*

[c] *Includes areas and objects illuminated by floodlights, for example interchange area lighting, parking area lighting, railway lighting, decorative lighting, etc.*

[d] *Includes tunnel evacuation lighting, railway tunnel evacuation lighting, etc.*

The surge immunity of a luminaire shall be at least 6 kV in differential mode and 8 kV in common mode. The test shall be performed according to the standard *EN 61000-4-5:2014* using a 1.2/50 µs – 8/20 µs combination wave with a 2 Ω source impedance in differential mode and a 12 Ω source impedance in common mode.

For installations with overhead cabling or masts (H_M ≥ 20 m), the surge immunity of a luminaire shall be at least 10 kV in differential mode and 10 kV in common mode. To obtain this requirement, a separate surge protective device can be applied. In that case the test shall be performed according to the standard EN 61643-11:2013, test class III, using a 1.2/50 µs – 8/20 µs combination wave with a 2 Ω generator impedance and the surge immunity requirement shall correspond to the open source voltage.

NOTE 1: For luminaires with external control gear, the overvoltage protection should be located before the external control gear.

NOTE 2: The overvoltage protection in tunnel lighting, railway tunnel lighting, ceiling lighting (railway platforms), lighting under bridges and underpass lighting can be in a technical room or operation room and should protect the lighting system in general.

NOTE 3: In 230 V IT system maximum continuous operating voltage *Uc* of a surge protection device should be:

- type 2: ≥ 350 V and
- type 3: ≥ 440 V between L – PE and ≥ 275 V between L – L (phase to phase).

The surge immunity requirements do not apply to decorative lighting.

Tunnel luminaires (including standby lighting and evacuation lighting) shall not cause radiated

disturbance in the Tetra frequency band (380 – 500 MHz, private Tetra frequency included). Conformity related to the relevant harmonised standards does not guarantee that luminaire is not able to cause radiated disturbance in the Tetra frequency band, and thereby violate the essential requirements stated in *Electromagnetic Compatibility (EMC) Directive 2014/30/EU Annex I*.

NOTE 4: Further guidance on the EMC assessment where harmonised standards do not exist or are not fully applied is given in the Annex 3 of the publication *Guide for the EMCD:2018*.

NOTE 5: This is especially valid in, but not limited to, road tunnels with Tetra coverage.

NOTE 6: It should be noted that Tetra emergency communications are not a specific Nordic phenomenon, as Tetra emergency communication in the same frequency band is used in almost all countries in Europe.

6.3 RoHS 2 Directive

A luminaire shall comply with the *Directive 2011/65/EU on the restriction of the use of certain hazardous substances in electrical and electronic equipment (RoHS 2)* and it shall fulfil the requirements specified in the Directive in accordance with the standard *EN IEC 63000:2018*. Standards other than *EN IEC 63000:2018* can also be used to demonstrate compliance with the Directive. In that case, sufficient background for demonstrating compliance with the Directive shall be presented.

Fulfilment of the RoHS 2 requirements shall be evidenced with a manufacturer's declaration of conformity related to the CE marking and its technical documents, or with test results by a conformity assessment body. The conformity assessment body shall comply with the *Regulation (EC) No 765/2008*.

7 Performance requirements

7.1 Photometric data and initial luminous flux of a luminaire

A luminaire shall have the light distribution characteristics in the C - γ - system measured in accordance with the standards *EN 13032-1:2004* and *EN 13032-4:2015.*

For all luminaires the angular intervals in vertical planes (γ) shall at most be 1,0° from 0° to 180°.

For all luminaires the angular interval in photometric azimuth (C) shall be according to the standard *EN 13201-3:2015*.

The light distribution files shall be delivered in EULUMDAT file format.

The initial luminous flux Φ_i of a luminaire shall not be lower than -10 % of the initial luminous flux Φ_i of the light distribution file representing the luminaire. The requirement includes all measurement uncertainties described in the standard *EN 13032-4:2015*.

NOTE 1: If the light distribution file representing the luminaire is not requested, the initial luminous flux Φ_i of a luminaire should not be lower than -10 % of the value provided in the technical specifications.

7.2 Performance requirements for luminaires

The technical specifications and the performance of a luminaire shall be presented in accordance with the standards *IEC 62722-1:2014*, *IEC 62722-2-1:2014* and *IEC 62717:2014*, taking the specifications of this document into account. A recommendation for the format used in presenting the technical specifications and the performance of a luminaire can be found in Annex A.

7.3 Rated useful lifetime of a luminaire

The rated useful lifetime of a luminaire is defined by the client. If no value is given by the client, the rated useful lifetime of the luminaire is the value presented in Table 4.

NOTE 1: The luminaire group replacement interval of an installation should follow the rated useful lifetime of the luminaire.

The *h* values of the median useful life L_x shall follow the given rated useful lifetime of the luminaire. The manufacturer shall provide the value L_x (value *x*) at the rated ambient temperature t_q = 25 °C for the given rated useful lifetime of the luminaire according to the standards *IEC 62722-2-1:2014* and *IEC 62717:2014*. The manufacturer shall also provide the expected control gear failure rate for the given rated useful lifetime of the luminaire. *x* value and the maximum expected control gear failure rate shall fulfil the minimum requirements presented in Table 4.

Table 4. Minimum requirements for a luminaire's rated useful lifetime, luminous flux degradation and maximum expected control gear failure rate.

Luminaire type	Rated useful lifetime	Luminous flux degradation	Maximum expected control gear failure rate
Road luminaire, interior zone luminaire (road tunnel) [a]	100 000 h	L_{90}	10 %
Luminaire under bridge, underpass luminaire	100 000 h	L_{80}	10 %
Floodlight, decorative lighting luminaire, ceiling luminaire (railway platforms)	50 000 h	L_{80}	10 %
Threshold and transition zone luminaires (road tunnel) [b]	50 000 h	L_{90}	10 %
Evacuation lighting luminaire [c]	25 000 h	L_{90}	10 %

[a] *Minimum requirements apply if interior zone luminaires are on during day and night. Otherwise, the minimum requirements shall be the same as for threshold and transition zone luminaires.*

[b] *Minimum requirements apply if threshold and transition zone luminaires are off during night. Otherwise, the minimum requirements shall be the same as for interior zone luminaires.*

[c] *Minimum requirements apply if evacuation lighting luminaires are on only in evacuation circumstances. If evacuation lighting luminaires are on during normal conditions, the minimum requirements shall be 100 000 h, L_{80} and 10 %.*

7.4 Maintenance factor

The maintenance factor f_m shall be employed in lighting designs to ensure that the target requirements are met throughout the rated useful lifetime of a luminaire when the luminaire is maintained according to the defined maintenance schedule.

The maintenance factor f_m is determined using the following formula:

$$f_m = f_{LF} \cdot f_{LM} \qquad (1)$$

where

f_m is the maintenance factor,
f_{LF} is the luminous flux factor (see 7.5 and 7.6), and
f_{LM} is the luminaire maintenance factor (see 7.7).

EXAMPLE 1: Road lighting. The given rated useful lifetime of a luminaire = 100 000 h, the received luminous flux degradation value = L_{90}, no CLO, the luminaire cleaning interval every 6 years.

$f_M = 0.90 \cdot 0.90 = 0.81$

In outdoor lighting, the survival factor and the surface maintenance factor are not considered in the determination of the overall maintenance factor.

NOTE 1: In outdoor lighting, it is usually not possible to compensate for the failed luminaire by increasing the initial luminous flux of other luminaires due to the survival factor. For that reason, the survival factor is not considered in the determination of the maintenance factor f_m (or set to 1.0). For failed luminaires, a spot replacement regime is applied with agreed response times.

NOTE 2: In outdoor lighting the surface maintenance factor is not considered (or set to 1.0) because depreciations of surface reflections of the area of interest are usually not known (for example, road surface and surroundings of a carriageway). In tunnels and underpasses, the effects of the surface maintenance factor are compensated for by the use of a lower luminaire maintenance factor; see Table 5.

7.5 Luminous flux factor

The luminous flux factor f_{LF} describes the depreciation of the luminous flux over time due to the ageing of a luminaire during regular operation (this excludes external factors such as for example dirt, optics and flat glass). This is defined as the ratio of depreciated luminous flux to the initial luminous flux Φ_i.

For outdoor lighting the luminous flux factor f_{LF} shall be determined at luminaire level.

The f_{LF} shall be determined based on the rated useful lifetime of a luminaire (see 7.3) and shall be provided by the manufacturer according to the standard *IEC 62722-2-1:2014* and section 7.3 of this document. In this case *x* of the the median useful life L_x equals f_{LF}.

EXAMPLE 1: The median useful life L_{90} = 100 000 h translates to 90 % remaining luminous flux at 100 000 h, which results in f_{LF} = 0.90.

NOTE 1: If constant light output control is used, the luminous flux factor f_{LF} should be determined based on section 7.6.

7.6 Determination of the luminous flux factor in case of constant light output control

A constant light output (CLO) control of a luminaire shall always be used, if available, for the selected luminaire type.

The CLO lifetime shall be the same as the rated useful lifetime of a luminaire, see 7.3.

NOTE 1: In CLO installations, light source behaviour and electronic control gear behaviour are interlinked. In the case of premature control gear failure, the replaced components should match the performance and behaviour of the original part prior to failure.

Luminaires utilising a constant light output control adjust the luminous flux based on the known or predicted depreciation behaviour of the light source to enable a constant luminous flux over time. This is realised by initially dimming the light source to the predicted end-of-life flux and increasing the current (and as such the power consumption) over time to compensate for the depreciation in luminous flux due to ageing of the light source.

NOTE 2: If CLO control is used, the manufacturer should provide the average rated input power of the luminaire (W) for the rated useful lifetime of the luminaire and the rated input power of the luminaire (W) at the end of rated useful lifetime.

NOTE 3: The increasing power consumption over time should be considered in the electrical design and energy calculations for the installation, but also when comparing different luminaires with and without CLO.

NOTE 4: CLO refers to the standalone feature based on known or predicted depreciation and does not include external input such as sensors. As such, it only applies to the luminous flux factor f_{LF}.

Figure 1 shows a simplified representation of a luminaire not using CLO, based on

L_{90} = 100 000 h (i.e. 10 % depreciation after 100 000 hours). Both power and luminous flux are set to their maximum value (point A). Over time, power remains the same (line between point A and B) whereas the luminous flux depreciates to the luminaire luminous flux at the end of the rated useful lifetime Φ_e (line between point A and C, 90 % of initial luminaire luminous flux Φ_i).

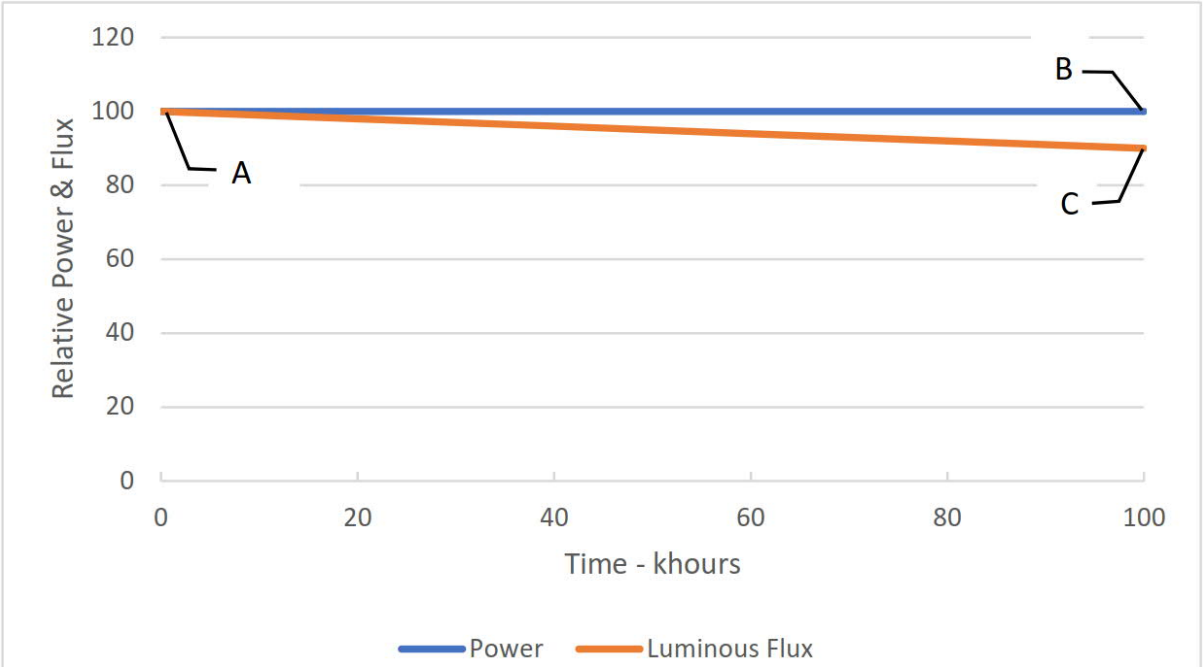

Figure 1. Illustration of CLO principle using simplified graph representation. A luminaire without CLO control.

Figure 2 shows a simplified representation of the same luminaire, but with CLO control. Both power and luminous flux start at 10 % below their maximum value at 0 h (point D – as in the operation of the luminaire without CLO the total flux depreciation is 10 % at the end of the rated useful lifetime). Over time, luminous flux is kept constant (line between point D and F) by increasing the power (line between point D and E). Note that at the end of rated useful lifetime, both luminaires have the same power consumption (B versus E) and the same luminous flux (C versus F).

In practice, there are two ways CLO luminaire specifications are provided by manufacturers. Depending on which of the two options is used, the luminous flux factor f_{LF} shall be determined differently. The current known options are:

1. the initial (without CLO control) specifications are specified, Figure 1 – point A (in which case the CLO correction needs to be done by using the luminous flux factor f_{LF}, as there was no CLO control),
2. the corrected luminous flux is given, Figure 2 – point D (in which case no correction is needed as this is already represented in the corrected luminous flux, f_{LF} = 1.00).

For CLO luminaires, the luminous flux factor f_{LF} shall be determined as follows:

If $\Phi_L = \Phi_{CLO}$, then f_{LF} = 1.00, (2)

If $\Phi_L = \Phi_i$, then $f_{LF} = \Phi_e / \Phi_i$,

where

Φ_L is the specified luminaire luminous flux,
Φ_{CLO} is the CLO-corrected luminaire luminous flux (i.e. Figure 2 – point D),
Φ_e is the luminaire luminous flux at the end of the rated useful lifetime without CLO control (i.e. Figure 1 – point C),
Φ_i is the initial luminaire luminous flux without CLO control (i.e. Figure 1 – point A).

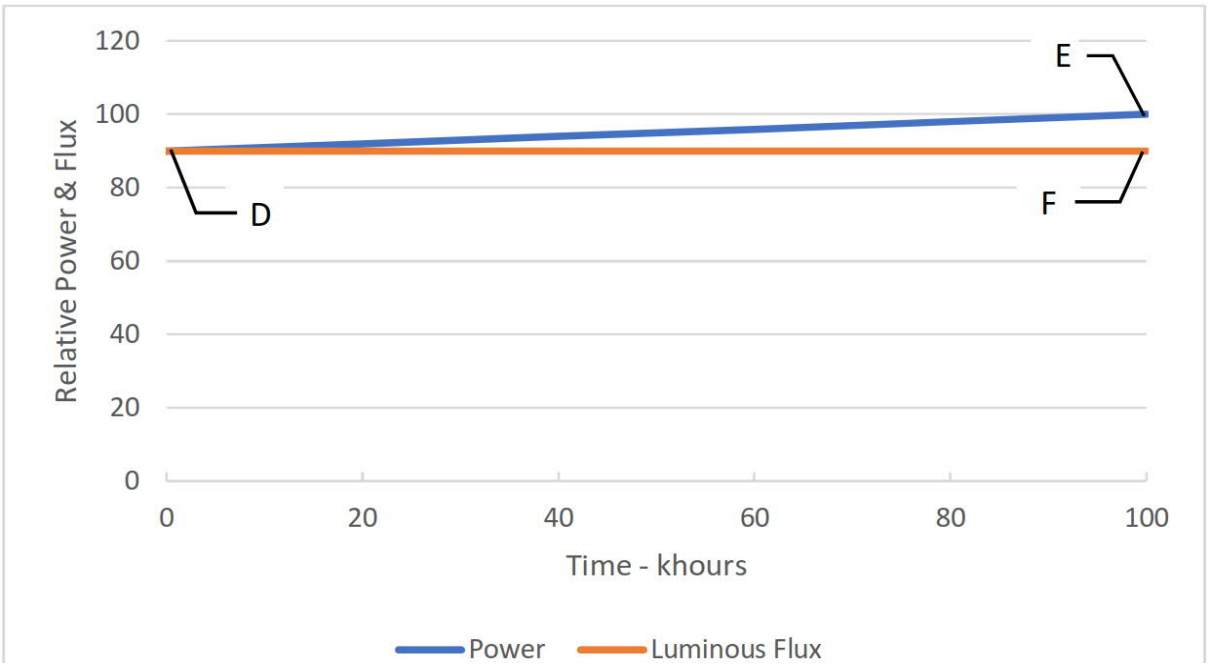

Figure 2. Illustration of CLO principle using simplified graph representation. A luminaire with CLO control.

7.7 Luminaire maintenance factor

The luminaire maintenance factor f_{LM} describes the relative output of a luminaire due to dirt deposited on light sources, optical components or other external factors influencing the luminaire output. The luminaire maintenance factor f_{LM} shall be based upon a luminaire's characteristics and environmental conditions.

The luminaire maintenance factor f_{LM} for outdoor luminaires shall be based upon the combination of luminaire design (rated according to IP code), the environmental pollution category and the luminaire cleaning interval.

The luminaire cleaning interval has a significant impact on the maintenance factor. The minimum requirements for luminaire cleaning intervals for various locations are shown in Table 5. Based on these minimum requirements, the f_{LM} values for different applications are defined in Table 5. The luminaire cleaning interval of the road tunnel is dependent on the annual average daily traffic volume (AADT), tunnel type and tunnel location.

The luminaire cleaning interval and the luminaire maintenance factor f_{LM} shall be defined on the national level or given by the client. If no values are given or defined, the maximum luminaire cleaning interval and the luminaire maintenance factor f_{LM} are the values presented in Table 5.

Table 5. The minimum requirements for luminaire cleaning intervals for various locations and corresponding f_{LM} values.

Location	Luminaire cleaning interval, max	Luminaire maintenance factor f_{LM}
Roads, railway areas, decorative lighting, luminaire mounting height $H_A \geq 4.0$ m	every 6 years	0.90
Roads, railway areas, decorative lighting, luminaire mounting height $H_A < 4.0$ m	every 6 years	0.85
Road tunnels	dependent on the AADT, tunnel type and tunnel location	0.85
Railway tunnels with a brake curve	every 3 years	0.50
Railway tunnels without a brake curve	every 3 years	0.70

7.8 Colour rendering index and colour temperature

The rated values of the luminaire's general colour rendering index R_a and the correlated colour temperature T_{cp} shall be according to Table 6.

NOTE 1: Luminaire luminous efficacy increases with increasing colour temperature. Therefore, it is recommended to use 4 000 K correlated colour temperature where no other specific requirements are set.

NOTE 2: In urban and public areas 3 000 K can be used for instance to create atmosphere and with certain products to achieve a higher general colour rendering index.

Table 6. The general colour rendering index R_a and the rated correlated colour temperature T_{cp} requirements in various locations.

Location	Correlated colour temperature T_{cp}	Colour rendering index R_a
Roads in rural areas, road and railway tunnels, railway yards	4 000 K [a]	$R_a \geq 70$ [a]
Roads in urban areas, public areas and railway stations	3 000 K [b]	$R_a \geq 80$ [b]
[a] *In Swedish Transport Administration projects values 3 000 K and $R_a \geq 70$ shall be used.* [b] *In Finnish Transport Infrastructure Agency projects values 4 000 K and $R_a \geq 70$ shall be used.*		

The performance requirements specified in Table 6 do not apply to road tunnel evacuation lighting, railway tunnel lighting and decorative lighting.

7.9 Chromaticity coordinate values

For luminaires of the same type within a lighting installation, rated chromaticity coordinate values, both initial and maintained, shall fulfil the tolerance requirements presented in Table 7.

Table 7. Tolerance (category) requirements on rated chromaticity coordinate values.

Distance between luminaires within a lighting installation	Colour variation tolerance, size of MacAdam ellipse, centred on the rated colour target	
	Initial	Maintained
< 5 m	5	5
≥ 5 m	7	7

7.10 Luminaire luminous efficacy

The luminaire luminous efficacy shall be $\eta_l \geq 120$ lm/W (100 % power, initial luminaire luminous flux Φ_i).

The luminaire luminous efficacy requirements do not apply to lighting under bridges, underpass lighting, road tunnel evacuation lighting, railway lighting, railway tunnel lighting and decorative lighting.

7.11 Flicker

The luminaire's *Modulation (%)* shall operate in the shaded area presented in Figure 3. The *Modulation (%)* requirement shall be fulfilled by a luminaire operating at 20 % ≤ Φ_L ≤ 100 % of the initial luminaire luminous flux Φ_i.

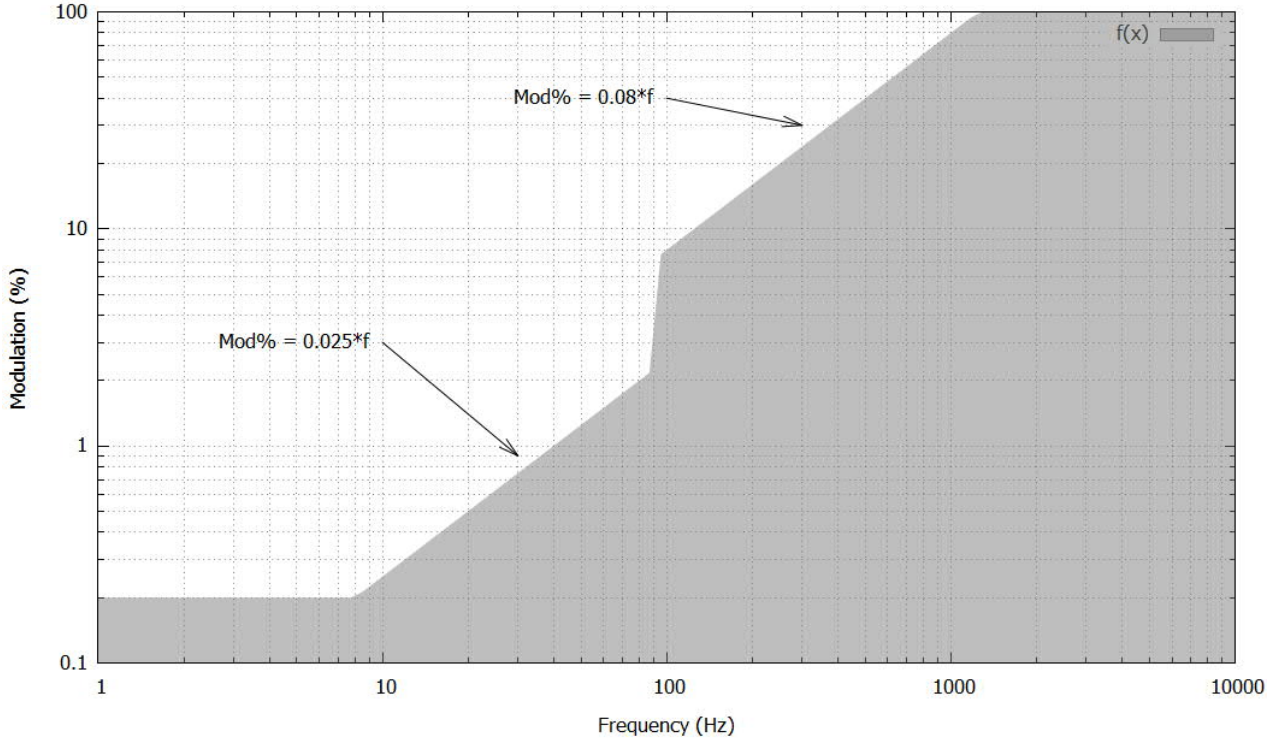

Figure 3. Practices for modulating current in LEDs based on the document IEEE Std 1789:2015.

7.12 Road tunnel evacuation lighting requirements

The performance requirements for evacuation route marker lights and emergency exit marker lights in tunnels shall be in accordance with the standard *EN 16276:2013.*

If an LED strip is used for an evacuation route lighting, it shall fulfil the following performance requirements:

- the minimum opening of 120 degrees for vertical plane,
- the average initial luminaire luminous flux of $200 \leq \Phi_i \leq 250$ lm/m,
- the minimum initial luminaire luminous flux of $\Phi_i = 180$ lm/m,
- the rated correlated colour temperature $T_{cp} = 4\ 000$ K.

NOTE 1: The minimum initial luminaire luminous flux is intended for LED strip sections with connectors.

If an LED strip is used for emergency exit lighting and the emergency exit lighting is permanently illuminated, it shall fulfil the following performance requirements:

- the minimum opening of 160 degrees for vertical plane,
- the average initial luminaire luminous flux of $200 \leq \Phi_i \leq 250$ lm/m,
- the minimum initial luminaire luminous flux of $\Phi_i = 180$ lm/m.

In emergency circumstances if an LED strip is used for emergency exit lighting, it shall fulfil the following performance requirements:

- the minimum opening of 160 degrees for vertical plane,
- the average initial luminaire luminous flux of $400 \leq \Phi_i \leq 500$ lm/m,
- the minimum initial luminaire luminous flux of $\Phi_i = 360$ lm/m.

8 Structural requirements

8.1 General structural requirements

All electronics of a luminaire shall be protected against moisture, condensation and corrosion.

NOTE 1: Protection against moisture and condensation can usually be achieved by an adequate IP code of enclosures, good luminaire design, and the adequate pressure equalisation of a luminaire housing.

NOTE 2: Adequate pressure equalisation can be achieved by using vents, for example.

The ingress protection rating of a luminaire shall be IP66 in accordance with the standards *EN 60598-1:2015* and *EN 60529:1992*.

NOTE 3: In decorative lighting and railway platform lighting, luminaires with the ingress protection rating of IP65 can also be used.

The ingress protection rating for spaces in a luminaire not containing electronics or optics shall be at least IP4X.

The ingress protection rating of a luminaire shall remain the same for the whole rated useful lifetime of the luminaire, including appropriate maintenance.

NOTE 4: This can be achieved by using an elastic material that maintains its characteristics throughout the rated useful lifetime of the luminaire as the luminaire's seal, for example.

NOTE 5: If glue is required to attach the seal, the glue should not become brittle and cause the luminaire's IP code to deteriorate during use.

Cable entries shall provide the degree of protection against dust or moisture in accordance with the ingress protection rating of the luminaire, when an appropriate external cable is installed.

NOTE 6: For cable entries the degree of protection against dust and moisture can be ensured by using cable glands with adequate IP code or weather and temperature resistant cable TET grommets, for example.

Cable entries shall have rounded edges with a minimum radius of 0.5 mm.

A luminaire electronic control gear shall be protected against moisture and condensation by either applying conformal coating or potting (filling the housing of the control gear with a homogeneous and dense mass) intended for the operation of the control gear at an ambient temperature of $-35 \leq t_a \leq +25$ °C.

A luminaire housing (not including flat glass, seals, vents, nuts, screws, latches etc.) shall be made from die cast aluminium, extruded aluminium or stainless steel.

NOTE 7: A luminaire housing or parts of a luminaire housing, that are not exposed to direct sunlight can also be made from materials other than die cast aluminium, extruded aluminium or stainless steel.

NOTE 8: In Danish Road Directorate projects, a luminaire housing can also be made from other materials. In this case, sufficient background for choosing that material instead of die cast aluminium, extruded aluminium or stainless steel should be provided.

If a luminaire housing is made from stainless steel, the exterior nuts, screws, latches and other fasteners of a luminaire shall be made from stainless steel A4 according to the standard *EN ISO 3506-1:2020*.

The service life of the luminaire housing, fixing equipment, seals, vents, nuts, screws, latches etc. shall be at least the same as the rated useful lifetime of the luminaire.

The corrosion resistance of a luminaire shall fulfil the requirements of the corrosivity categories of Table 8. The test procedures and duration shall be as specified in Table 8.

Table 8. Corrosivity category requirements for corrosion resistance in different environments and test procedures applied based on the standard EN ISO 12944-6:2018.

Environment	Corrosivity category as defined in EN ISO 12944-2:2017	Durability ranges according to ISO 12944-1:2017	ISO 9227:2017 (neutral salt spray) h
Road tunnels and railway rock tunnels [a], coastal areas with high salt content [b]	C5	high (H)	1 440
Industrial areas and coastal areas with moderate salt content [b]	C4	high (H)	720
Other environments	C3	high (H)	480

[a] *Corrosivity category requirements do not apply to luminaires with housing made from stainless steel.*
[b] *Distances to the sea are defined at the national level.*

Metal components in contact with one another shall be made from metals which lie close to each other in the galvanic series to avoid electrolytic corrosion.

EXAMPLE 1: Brass or other copper alloys should not be used in contact with aluminium or aluminium alloys.

The cord anchorage of a luminaire shall fulfil the requirements of the standard *EN 60598-1:2015* so that the external cable and wires are relieved from strain, including twisting, when they are connected to the wiring block of the luminaire.

NOTE 9: Cable tie should not be used as the cord anchorage of a luminaire.

A luminaire shall not be disposable, in other words it shall be possible to replace the electronic control gear, LED modules and optics of the luminaire on-site or indoors.

A luminaire shall have no electromechanical parts.

8.2 Additional road luminaire requirements

The protection rating of a road luminaire against external mechanical impacts shall be at least IK08 in accordance with the standard *EN 62262:2011*.

NOTE 1: IK code requirements do not include external components, such as luminaire extension module or luminaire extension receptacle.

A road luminaire shall be equipped with flat glass. The flat glass material shall be glass. The service life of the flat glass shall be at least the same as the rated useful lifetime of the luminaire. Curved glass luminaires and luminaires with lens modules as the flat glass are not permitted. The lens module refers to a module put in the place of flat glass, with several lenses on the module surface.

NOTE 2: Flat glass is required to ensure a high luminaire maintenance factor f_{LM} value, to ease and to enhance the cleaning of the luminaire, and to reduce glare and obtrusive light produced by the luminaire.

NOTE 3: Flat glass protects lenses from ultraviolet radiation, to some extent.

The flat glass of a road luminaire shall be a part of the sealed luminaire housing.

NOTE 4: The inside of the flat glass should be behind the seal.

A luminaire post top or side entry fixing equipment shall be made from die cast aluminium, extruded

aluminium or stainless steel. The fixing equipment shall be a closed structure when installed on a post top or side entry lantern.

NOTE 5: A closed structure is required to prevent birds and other external objects from entering the column.

A luminaire shall be mountable on post top lantern fixings of 60 mm and 76 mm and on side entry lantern fixings of 42 mm and 60 mm. The luminaire post top or side entry fixing equipment shall be compatible with the standard *EN 40-2:2005*. The luminaire tilt angle shall be at least 0°, 5° and 10° for the post top lantern fixing and at least 0° and -5° for the side entry lantern fixing. The adjustment of the tilting angle shall be done in steps of 5°. The adjustment of the tilt angles shall be instructed by means of the installation instructions and markings made on the luminaire.

NOTE 6: In Danish Road Directorate projects, the luminaire tilt angle shall be 0°.

A control gear of a luminaire shall be placed inside the sealed luminaire housing.

8.3 Additional requirements for underpass luminaires and luminaires under bridges

If the mounting height of an underpass luminaire or a luminaire under bridge is H_M < 4.0 m, the protection rating of the luminaire against external mechanical impacts shall be at least IK10 in accordance with the standard *EN 62262:2011*. If the mounting height is H_M ≥ 4.0 m, the protection rating of the luminaire against external mechanical impacts shall be at least IK08 in accordance with the standard *EN 62262:2011*.

If the mounting height of a luminaire under bridge is H_M < 4.0 m, the luminaire shall not be openable without tools.

NOTE 1: The usage of anti-vandal fasteners is recommended.

8.4 Additional road tunnel luminaire requirements

A luminaire housing (not including flat glass, seals, vents, nuts, screws, latches etc.) of a tunnel luminaire shall be made from die cast aluminium, extruded aluminium or stainless steel. The aluminium alloy shall contain copper *Cu* < 0,1 %.

The protection rating of a road tunnel luminaire against external mechanical impacts shall be at least IK08 in accordance with the standard *EN 62262:2011*.

A road tunnel luminaire shall be equipped with tempered flat glass. The service life of the flat glass shall be at least the same as the rated useful lifetime of the luminaire. Curved glass luminaires and luminaires with lens modules as the flat glass are not permitted. The lens module refers to a module put in the place of flat glass, with several lenses on the module surface.

NOTE 1: Flat glass is required to ensure a high luminaire maintenance factor f_{LM} value, to ease and to enhance the cleaning of the luminaire, and to reduce glare produced by the luminaire.

The flat glass of a road tunnel luminaire shall be a part of the sealed luminaire housing.

NOTE 2: The inside of the flat glass should be behind the seal.

The requirements above apply also for standby lighting luminaire.

8.5 Additional railway luminaire requirements

The protection rating of a railway luminaire against external mechanical impacts shall be at

least IK08 in accordance with the standard EN 62262:2011.

NOTE 1: IK code requirements do not include external components, such as luminaire extension module or luminaire extension receptacle.

If the mounting height of a railway luminaire is H_M < 4.0 m, the luminaire shall not be openable without tools.

NOTE 2: The usage of anti-vandal fasteners is recommended.

8.6 Additional railway tunnel luminaire requirements

Luminaires in railway tunnels shall withstand 5 kPa in pressure and 5 kPa in suction.

8.7 Additional decorative lighting luminaire requirements

If the mounting height of a decorative lighting luminaire is H_M < 4.0 m, the protection rating of the luminaire against external mechanical impacts shall be at least IK10 in accordance with the standard *EN 62262:2011*. If the mounting height is 4.0 m ≤ H_M ≤ 10.0 m, the protection rating of the luminaire against external mechanical impacts shall be at least IK08 in accordance with the standard *EN 62262:2011*.

NOTE 1: IK code requirements do not include external components, such as luminaire extension module or luminaire extension receptacle.

If the mounting height of a decorative lighting luminaire is H_M < 4.0 m, the luminaire shall not be openable without tools.

NOTE 2: The usage of anti-vandal fasteners is recommended.

8.8 Additional road tunnel evacuation lighting luminaire requirements

The protection rating of a road tunnel evacuation lighting luminaire (marker lights or LED strips) against external mechanical impacts shall be at least IK08 in accordance with the standard *EN 62262:2011*.

In tunnels, where high temperature, high pressure cleaning equipment is used, the ingress protection rating of a road tunnel evacuation lighting luminaire (marker lights or LED strips) shall be IP69 in accordance with the standard *EN 60598-1:2015*.

9 Road lighting control requirements

9.1 General requirements

A road luminaire shall enable the luminaire luminous flux to be controlled using one of the following options:

1. preprogrammed stand-alone dimming
2. luminaire extension module and external control
3. mains voltage amplitude modulation (additional requirement)
4. preprogrammed stand-alone dimming and luminaire extension module (external control)
5. preprogrammed stand-alone dimming and mains voltage amplitude modulation.

NOTE 1: The options 1, 2 and 4 are used in Norwegian Public Roads Administration, Danish Road Directorate and Finnish Transport Infrastructure Agency projects. The options 1, 3 and 5 are used in Swedish Transport Administration projects.

An underpass luminaire and a luminaire under bridge shall enable the luminaire luminous flux to

be controlled using preprogrammed stand-alone dimming (option 1).

9.2 Preprogrammed stand-alone dimming

In preprogrammed stand-alone dimming, the luminaire electronic control gear shall be preprogrammed with a dimming schedule according to Figure 4.

NOTE 1: In Danish Road Directorate projects, dimming of conflict area lighting is not allowed.

NOTE 2: In Danish Road Directorate projects, the dimming schedule shown in Figure 4 shall be amended with the Danish designations of lighting classes.

Preprogrammed stand-alone dimming shall operate together with the constant light output control.

NOTE 3: CLO control can be considered as a “dimming” factor following line D – E in Figure 2 of this document.

		Time, the starting hour																	
		15	16	17	18	19	20	21	22	23	00	01	02	03	04	05	06	07	08	09
Lighting class	**Lighting classes for adaptive lighting**	**Residual average luminance percentage**																		
M1, C0 and C1	M1 – M2 – M3 – M2 – M1	100	100	100	100	100	75	75	50	50	50	50	50	50	50	75	100	100	100	100
M2, C2	M2 – M3 – M4 – M3 – M2	100	100	100	100	100	75	75	50	50	50	50	50	50	50	75	100	100	100	100
M3, C3	M3 – M4 – M5 – M4 – M3	100	100	100	100	100	75	75	50	50	50	50	50	50	50	75	100	100	100	100
M4, C4	M4 – M5 – M6 – M5 – M4	100	100	100	100	100	60	60	40	40	40	40	40	40	40	60	100	100	100	100
M5, C5	M5 – M6 – P5 – M6 – M5	100	100	100	100	100	60	60	40	40	40	40	40	40	40	60	100	100	100	100
Residual average illuminance percentage																				
P1	P1 – P2 – P3 – P2 – P1	100	100	100	100	100	75	75	50	50	50	50	50	50	50	75	100	100	100	100
P2	P2 – P3 – P4 – P3 – P2	100	100	100	100	100	75	75	50	50	50	50	50	50	50	75	100	100	100	100
P3, HS1	P3 – P4 – P5 – P4 – P3	100	100	100	100	100	60	60	40	40	40	40	40	40	40	60	100	100	100	100
P4, HS2	P4 – P5 – P6 – P5 – P4	100	100	100	100	100	60	60	40	40	40	40	40	40	40	60	100	100	100	100
P5, HS3	P5 – P6 – P5	100	100	100	100	100	60	60	60	60	60	60	60	60	60	60	100	100	100	100

Figure 4. A dimming schedule for a preprogrammed stand-alone luminaire control. The dimming is implemented using a maximum of three lighting levels and five time intervals depending on the lighting class of the design. The times in the schedule are indicative - in preprogrammed stand-alone dimming the times are usually determined by the median point of the period of darkness, which varies by location and the time of year, including the use of daylight saving time. In the C classes a luminance and illuminance class correspondence table is used. The dimming is implemented in accordance with the M classes.

The external and the internal wiring of a luminaire shall enable the inspection or the exchange of the dimming schedule of the preprogrammed stand-alone luminaire from the column’s wiring block (only valid for option 1 in Clause 9.1).

NOTE 4: This can be achieved by connecting wires DA+ and DA- between the wiring block of a luminaire and the electronic control gear of the luminaire and by using an external cable type 5x1,5 mm^2 between the luminaire’s and the column’s wiring blocks.

9.3 Luminaire extension module

If the luminaire extension module (LEX-M) is required, a road luminaire shall be equipped with at least one luminaire extension receptacle (LEX-R). The extension interface of the luminaire shall:

- be Zhaga-D4i certified or
- meet the requirements of mechanical, electrical and communication interface and luminaire compliance tests given in the *Zhaga Book 18:2019, Edition 2.0*.

In addition, the electronic control gear shall have the addresses 0x03 - 0x77 of Memory bank 1 stored according to DiiA specification *DALI Part 251:2019 – Memory Bank 1 Extension, version 1.1*.

Placing the luminaire extension module inside the luminaire is not permitted.

NOTE 1: In Danish Road Directorate projects, the luminaire extension module can also be placed inside the luminaire.

The luminaire extension receptacle shall be built into a luminaire. The placing of the luminaire extension receptacle shall be performed by the luminaire manufacturer at the luminaire assembly stage. The luminaire with the receptacle shall always be equipped with a luminaire extension cap (LEX-C). The luminaire extension cap shall be according to the *Zhaga Book 18:2019, Edition 2.0*. The receptacle, together with the luminaire extension cap, shall provide a degree of protection against dust or moisture (IP code) in accordance with the classification of the luminaire.

If a road luminaire is equipped with the luminaire extension receptacle, the luminaire shall enable the selection of the control method between the preprogrammed stand-alone dimming and the external control (Clause 9.1, option 4) by using the luminaire extension module.

9.4 Additional requirements on mains voltage amplitude modulation

When mains voltage amplitude modulation is in use, a road luminaire shall enable the luminous flux to be controlled using amplitude of the mains voltage. The luminaire electronic control gear shall enable a preprogrammed dimming using at least four different lighting levels. The lighting levels of the luminaire shall be reprogrammable using amplitude of the mains voltage.

To avoid an unintended change in lighting levels due to small fluctuations in the main voltage amplitude, a minimum difference of 5 V shall be used to trigger the change of the preprogrammed lighting level.

A luminaire shall enable the selection of the control method between the preprogrammed stand-alone dimming and mains voltage amplitude modulation (Clause 9.1, option 5) by using Near-field communication (NFC) or the external and the internal wiring.

10 Other requirements

Luminaire technical specifications described in Annex A, except the declaration of conformity, shall be published and made publicly available.

NOTE 1: Available and downloadable without registration.

The declaration of conformity of a luminaire shall be provided on request.

Installation instructions for a luminaire shall be delivered together with the luminaire. The instructions shall correspond to the product delivered. The instructions shall not contradict with the requirements of this document.

Annex A (informative) Technical specifications of an LED luminaire

Red fields should be filled by the client, if necessary
Green fields should be filled by the manufacturer

Luminaire manufacturer	
Luminaire type and product code	

Parameters	**Requirement**	**Value**
Rated input power of the luminaire (W)		
Average rated input power of the luminaire (W) for the rated useful lifetime of the luminaire, if CLO control is used		
Rated input power of the luminaire (W) at the end of the rated useful lifetime, if CLO control is used		
Luminaire electronic control gear circuit power factor λ (100 % power)		
Luminaire electronic control gear circuit power factor λ of a dimmed luminaire (dimmed to 20 % of the initial luminous flux Φ_i)		
Initial luminaire luminous flux Φ_i (lm) (see 7.6)		
CLO-corrected luminaire luminous flux Φ_{CLO} (see 7.6), if CLO control is used		
Rated luminaire luminous efficacy (lm/W)		
Rated correlated colour temperature T_{cp} (K)		
Rated general colour rendering index R_a		
Rated chromaticity co-ordinate values, initial and maintained, size of the MacAdam ellipse		
Rated useful lifetime of a luminaire (h)		
Luminous flux degradation at the ambient temperature of t_q = 25 °C for the rated useful lifetime of a luminaire, L_x, x value		
Maximum expected control gear failure rate at the ambient temperature of t_q = 25 °C for the rated useful lifetime of a luminaire, %		
Ingress protection rating of a luminaire, IP code		
Protection against mechanical impacts, IK code		
Protection class (I or II)		
Overvoltage protection (kV) of an electronic control gear, differential mode / common mode	/	/
Overvoltage protection (kV) of a separate surge protective device, differential mode / common mode	/	/
Luminaire weight (kg)		
Luminaire's effective projected wind surface area		
Luminaire colour (default RAL colour)		
Luminaire's guarantee period (years)		
Other information, documents and files to be delivered		
Description of the luminaire's materials (housing, reflectors, optical cover, lenses, heat sinks etc.)		
Description of the luminaire's control options		
Luminaire's dimensions		
Installation instructions for a luminaire		
Luminaire's photometric files in EULUMDAT file format, or information on where they can be acquired (on request)		
Declaration of conformity (on request)		

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CIE S 017:2020 ILV International Lighting Vocabulary, 2nd Edition

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Electromagnetic Compatibility (EMC) Directive 2014/30/EU on the harmonisation of the laws of the Member States relating to electromagnetic compatibility

EN ISO 12944-1:2017 Paints and varnishes – Corrosion protection of steel structures by protective paint systems - Part 1: General introduction

EN ISO 12944-2:2017 Paints and varnishes – Corrosion protection of steel structures by protective paint systems - Part 2: Classification of environments

EN ISO 12944-6:2018 Paints and varnishes – Corrosion protection of steel structures by protective paint systems - Part 6: Laboratory performance test methods

EN 13032-1:2004 + A1:2012 Light and lighting - Measurement and presentation of photometric data of lamps and luminaires - Part 1: Measurement and file format

EN 13032-4:2015 + A1:2019 Light and lighting - Measurement and presentation of photometric data of lamps and luminaires - Part 4: LED lamps, modules and luminaires

EN 13201-3:2015 Road lighting - Part 3: Calculation of performance

EN 16276:2013 Evacuation Lighting in Road Tunnels

EN ISO 3506-1:2020 Mechanical properties of corrosion-resistant stainless steel fasteners – Part 1: Bolts, screws and studs with specified grades and property classes

EN 40-2:2005 Lighting columns. General requirements and dimensions.

EN IEC 55015:2019 / A11:2020 Limits and methods of measurement of radio disturbance characteristics of electrical lighting and similar equipment

EN 60529:1992 / A1:2000 / A2:2013 / AC:2019 Degrees of protection provided by enclosures (IP Code)

EN 60598-1:2015 / A1:2018 Luminaires - Part 1: General requirements and tests

EN 60598-2-1:2015 Luminaires - Part 2-1: Particular requirements - Fixed general purpose luminaires

EN 60598-2-3:2003 / A1:2011 Luminaires - Part 2-3: Particular requirements - Luminaires for road and street lighting

EN 60598-2-5:2015 Luminaires - Part 2-5: Particular requirements – Floodlights

EN 60598-2-22:2014 / A1:2020 Luminaires - Part 2-22: Particular requirements - Luminaires for emergency lighting

EN IEC 61000-3-2:2019 Electromagnetic compatibility (EMC) - Part 3-2: Limits - Limits for harmonic current emissions (equipment input current ≤16 A per phase)

EN 61000-3-3:2013 / A1:2019 Electromagnetic compatibility (EMC) - Part 3-3: Limits - Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems, for equipment with rated current ≤16 A per phase and not subject to conditional connection

EN 61000-4-5:2014 / A1:2017 Electromagnetic compatibility (EMC) - Part 4-5: Testing and measurement techniques - Surge immunity test

EN 61547:2010 Equipment for general lighting purposes - EMC immunity requirements

EN 61643-11:2013 / A11:2018 Low-voltage surge protective devices - Part 11: Surge protective devices connected to low-voltage power systems – Requirements and test methods

EN 62262:2011 Degrees of protection provided by enclosures for electrical equipment against external mechanical impacts (IK code)

EN 62493:2015 Assessment of lighting equipment related to human exposure to electromagnetic fields

EN IEC 63000:2018 Technical documentation for the assessment of electrical and electronic products with respect to the restriction of hazardous substances

EN ISO 9223:2012 Corrosion of metals and alloys. Corrosivity of atmospheres. Classification, determination and estimation

EN ISO 9227:2017 Corrosion tests in artificial atmospheres – Salt spray tests

Guide for the EMCD:2018 (Directive 2014/30/EU) ANNEX 3 - EMC assessment where harmonised standards do not exist or are not fully (applied).

IEC 62384:2020 DC or AC supplied electronic control gear for LED modules – Performance requirements

IEC 62717:2014 / AMD1:2015 / AMD2:2019 LED modules for general lighting - Performance requirements

IEC 62722-1:2014 Luminaire performance - Part 1: General requirements

IEC 62722-2-1:2014 Luminaire performance - Part 2-1: Particular requirements for LED luminaires

IEC/TR 62778:2014 Application of IEC 62471 for the assessment of blue light hazard to light sources and luminaires

IEEE Std 1789:2015 IEEE Recommended practices for modulating current in high-brightness LEDs for mitigating health risks to viewers

Low Voltage Directive 2014/35/EU on the harmonisation of the laws of the Member States relating to the making available on the market of electrical equipment designed for use within certain voltage limits

NMF01:2019 LED luminaires – requirements, Edition 2.0, 18.6.2019

Regulation (EC) No 765/2008 setting out the requirements for accreditation and market surveillance relating to the marketing of products and repealing Regulation (EEC) No 339/93

Zhaga Book 18:2019, Edition 2.0, Outdoor luminaire extension interface, Zhaga Interface Specification