

TRAFIKVERKET



Vejdirektoratet



Statens vegvesen

TECHNICAL SPECIFICATION

NMF01:2024 LED luminaires – requirements

DRAFT

Edition 5.0 10.6.2024

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

NMF – Nordiskt
Möte för Förbättrad
vägutrustning

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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 supplement:

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

This document supersedes *NMF01:2023 LED luminaires – requirements, Edition 4.1, 27.6.2023*.

LED luminaires shall meet the requirements set out in this Technical Specification at the latest by 31.12.2024.

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

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

This publication was prepared by a working group:

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NMF
Month 2024

1 Introduction

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

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

12 This Technical Specification is based on the previous edition of this document *NMF01:2023*
13 *LED luminaires – requirements, Edition 4.1, 27.6.2023* and current national guidelines of
14 four road authorities: the Swedish Transport Administration, the Norwegian Public Roads
15 Administration, the Danish Road Directorate and the Finnish Transport
16 Infrastructure Agency. Furthermore, the publication is based on ongoing CIE technical
17 committee work, current ISO, IEC and CEN standards and standard drafts, Zhaga
18 Consortium publications as well as experiences from different outdoor lighting procurements.
19 The purchasers, tenderers, lighting designers, manufacturers and contractors have been
20 heard during the preparation stage of this document.

21 **1 Scope**

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

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

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

31 **2 Normative references**

32 The documents introduced in Bibliography, in whole or in part, are normatively referenced in
33 this document and are indispensable for its application.

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

37 **3 Terms and definitions**

38 For the purposes of this document, the terms and definitions given in the standards
39 *CIE S 017/E:2020*, *EN 60529:1992*, *EN IEC 60598-1:2021*, *EN 62262:2011*, *IEC 62717:2014*,
40 *IEC 62722-1:2022* and *IEC 62722-2-1:2023* as well as the following apply.

41 NOTE 1: The terms and definitions given in the *CIE S 017/E:2020* are published on
42 <https://cie.co.at/e-ilv>.

43 **3.1**

44 **road lighting**

45 functional lighting for roads, streets, footways and cycleways

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

47 **3.2**

48 **tunnel lighting**

49 functional lighting for tunnels. Tunnel lighting includes normal lighting, safety lighting and
50 evacuation lighting.

51 **3.3**

52 **railway lighting**

53 functional lighting for railway platforms (open parts and covered parts) and railway yards

54 **3.4**

55 **lighting under bridges**

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

57 **3.5**

58 **underpass lighting**

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

60 **3.6**

61 **decorative lighting**

62 lighting that is purely ornamental and installed for aesthetic effect. Decorative lighting shall not

63 include functional lighting.

64 Note 1 to entry: Usually means lighting fixtures primarily intended to enhance the appearance of public areas
65 and navigation within those areas, or to highlight important architectural elements, landscaping, and similar
66 design elements.

67 **3.7**
68 **rated maximum ambient temperature**

69 t_a
70 temperature assigned to a luminaire by the manufacturer to indicate the highest sustained
71 temperature in which the luminaire may be operated under normal conditions

72 **3.8**
73 **external wiring**
74 wiring generally outside a luminaire

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

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

77 **3.9**
78 **group replacement**
79 replacement of many components at one chosen time in an installation

80 **3.10**
81 **spot replacement**
82 replacement of a single component at one chosen time in an installation

83 **3.11**
84 **luminaire group replacement interval**
85 planned time between group replacement of luminaires

86 **3.12**
87 **constant light output**
88 functionality to constantly adjust the luminous flux of the light source based on the known or
89 predicted depreciation behavior of the light source to enable a constant luminous flux over time

90 Note 1 to entry: Generally abbreviated to CLO.

91 **3.13**
92 **CLO lifetime**
93 time over which the CLO control ensures a constant luminous flux

94 **3.14**
95 **luminaire cleaning interval**
96 planned time between cleaning of (parts of) luminaires

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

99 **3.15**
100 **luminaire extension module (Z-LEX-M)**
101 separate device defined by the *Zhaga Book 18:2021, Edition 3.0*, that provides an interface
102 between the electronic control gear of a luminaire and the lighting control system, other system or
103 other modules

104 Note 1 to entry: Can be installed to the luminaire extension receptacle (Z-LEX-R) by means of a twist-lock.

105 **3.16**
106 **luminaire extension receptacle (Z-LEX-R)**
107 socketed device defined by the *Zhaga Book 18:2021, Edition 3.0*, that enables an installation or
108 replacement of the luminaire extension module (Z-LEX-M) without tools, and enables
109 communication between the luminaire extension module (Z-LEX-M) and the luminaire electronic
110 control gear

111 **3.17**
112 **luminaire extension cap (Z-LEX-C)**
113 separate unit defined by the *Zhaga Book 18:2021, Edition 3.0*, which can be attached to the
114 luminaire extension receptacle (Z-LEX-R)

115 Note 1 to entry: luminaire extension cap does not hold any functionality and is used to cover the luminaire
116 extension receptacle (Z-LEX-R) in case no luminaire extension module (Z-LEX-M) is used.

117 **3.18**
118 **Annual Average Daily Traffic (AADT)**
119 term used to provide the projected future average traffic volume in both directions on a section of
120 road

121 **3.19**
122 **DALI (Digital addressable lighting interface)**
123 DALI is an industry-standardized protocol defined by the standard *EN IEC 62386*

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

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

128 **3.20**
129 **stand-alone dimming**
130 lighting control that is integrated into the electronic control gear of a luminaire and does not require
131 any external command

132 Note 1 to entry: Is usually preprogrammed.

133 **3.21**
134 **flat glass**
135 an even surface, which protects LEDs and optics of a luminaire

136 **3.22**
137 **curved glass**
138 a gently curving surface, which protects LEDs and optics of a luminaire

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

140 **3.23**
141 **LED strip**
142 a non-integrated LED light source which needs a separate electronic control gear to operate

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

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

148 **3.24**
149 **Flicker P_{st}^{LM}**
150 the metric for flicker, where *st* stands for short-term flicker indicator and *LM* for light flickermeter
151 method

152 Note 1 to entry: Unless otherwise specified, the P_{st} evaluation time is 10 min in accordance with *EN 61000-*
153 *4-15:2013*.

154 Note 2 to entry: The light flickermeter is based on the *EN 61000-4-15:2013* specifications.

155 **3.25**
156 **DiiA (Digital Illumination Interface Alliance)**
157 The Digital Illumination Interface Alliance (DiiA) is an open, global consortium of lighting companies

158 **3.26**
159 **Zhaga Consortium**
160 a global lighting-industry organization that aims to standardize interfaces of components of LED
161 luminaires

162 **3.27**
163 **D4i**
164 an extension of the DALI-2 certification program that brings standardization to small DALI networks
165 inside luminaires

166 **3.28**
167 **evacuation lighting**
168 lighting whose function is to guide tunnel users to evacuate the tunnel on foot in case of emergency
169 circumstances such as fire

170 **3.29**
171 **evacuation route lighting**
172 lighting provided to ensure that the means of evacuation can be identified and safely used when
173 the location is occupied

174 Note 1 to entry: Evacuation route marker lights or LED strips, which are used to guide pedestrians and
175 delineate an evacuation route to an emergency exit.

176 **3.30**
177 **emergency exit lighting**
178 lighting to make emergency exits visible and identifiable

179 Note 1 to entry: Emergency exit marker lights or LED strips, which are used to delineate the frame of an
180 emergency exit.

181 **4 Symbols, units and abbreviations**

182 The symbols, units and abbreviations in Table 1 apply.

183 *Table 1. Symbols, units and abbreviations.*

Symbol/ abbreviation	Description	Unit
CLO	constant light output (see 3.12 and 7.6)	-
t_a	rated maximum ambient temperature (see 3.7)	°C
t_q	rated ambient performance temperature value (see IEC 62722-2-1:2023)	°C
R_a	general colour rendering index (see CIE S 017/E:2020)	-
T_{cp}	correlated colour temperature (see CIE S 017/E:2020)	K
L_x	median useful life (see IEC 62722-2-1:2023) for x % remaining luminous flux	h
x	luminous flux maintenance factor (see IEC 62722-2-1:2023)	-
AFV	abrupt failure value at median useful life L_x (see IEC 62722-2-1:2023)	%
η_l	luminaire luminous efficacy (see IEC 62722-2-1:2023)	lm/W
f_m	maintenance factor (see 7.4)	1
f_{LF}	luminous flux factor (see 7.5 and 7.6)	1
f_{LM}	luminaire maintenance factor (see 7.7)	1
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 median useful life (see 7.6)	lm
Φ_i	initial luminaire luminous flux (see 7.6)	lm
H_M	luminaire mounting height (CIE S 017/E:2020)	m
DALI	Digital Addressable Lighting Interface (see 3.19)	-
DiiA	Digital Illumination Interface Alliance (see 3.25)	-
λ	circuit power factor (see IEC 62384:2020)	1
AADT	Annual Average Daily Traffic (see 3.18)	veh/d
P_{st}^{LM}	metric for flicker (see 3.24)	-

184 **5 Light sources in lighting installations**

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

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

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

192 **6 Safety requirements**

193 **6.1 Low Voltage Directive**

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

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

203 *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 IEC 60598-1:2021	Luminaires - Part 1: General requirements and tests	X	X	X	X
EN IEC 60598-2-1:2021	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 IEC 60598-2-22:2022	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, safety lighting in tunnels etc. ^c Includes areas and objects illuminated by floodlights, for example interchange area lighting, parking area lighting, railway yard lighting, decorative lighting, etc. ^d Includes evacuation route marker lights and emergency exit marker lights in tunnels but does not include LED strips.					

204 A luminaire shall be equipped with marking in accordance with the standard *EN IEC 60598-1:2021*. The durability of the marking shall fulfil the test requirements defined in the standard
205 *EN IEC 60598-1:2021*.
206

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

209 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 IEC 60598-1:2021*.
210

211 The luminaire electronic control gear voltage is 230 V. The luminaire control gear circuit power
212 factor shall be $\lambda \geq 0.90$ for luminaires with a rated input power of ≤ 50 W and $\lambda \geq 0.95$ for
213 luminaires with a rated input power of > 50 W (100 % power, initial luminaire luminous flux Φ_i).
214 The electronic control gear circuit power factor of a dimmed luminaire (dimmed to 20 % of the
215 initial luminous flux Φ_i) shall be $\lambda \geq 0.50$ for luminaires with a rated input power of ≤ 50 W and
216 $\lambda \geq 0.60$ for luminaires with a rated input power of > 50 W (100 % power).

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

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

221 Road and railway luminaires shall have protection class II in accordance with the standard EN
222 IEC 60598-1:2021.

223 NOTE 3: In Finnish Transport Infrastructure Agency and the Norwegian Public Roads Administration
224 projects road luminaires shall have protection class I or II in accordance with the standard EN IEC
225 60598-1:2021.

226 Tunnel luminaires shall have protection class I or II in accordance with the standard EN IEC
227 60598-1:2021. Road tunnel evacuation route lighting luminaires and emergency exit lighting
228 luminaires shall have protection class II or III (SELV/PELV) in accordance with the standard
229 EN IEC 60598-1:2021.

230 The external wiring shall be suitable for use outdoors.

231 NOTE 4: If the external wiring (see 3.8) is exposed to direct sunlight (for example overhead wiring), the
232 cable sheath should be made of UV resistant material.

233 For the external wiring of all road lighting installations, the nominal cross-sectional areas of
234 the cable's wires shall be ≥ 1.5 mm². The wires shall have stranded conductors according to
235 the standard *EN 60228:2005*.

236 NOTE 5: Longer external cables may require a higher nominal cross-sectional area due to mechanical
237 strength or electrotechnical requirements, for example 2.5 mm². This is also dependent on the cable
238 type used.

239 NOTE 6: In Finnish Transport Infrastructure Agency projects also wires with solid conductors according
240 to the standard *EN 60228:2005* can be used.

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

245 In road lighting installations the external cable between the luminaire's and the column's wiring
246 blocks shall not be equipped with a cable connector.

247 NOTE 7: In Danish Road Directorate catenary lighting projects the external cable can be equipped with
248 a cable connector.

249 **6.2 Electromagnetic Compatibility Directive**

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

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

259 Table 3. EMC standards specified in the Electromagnetic Compatibility (EMC) Directive
260 2014/30/EU.

Standard Number	Description	General purpose luminaires ^a	Road and tunnel lighting ^b	Flood-lighting ^c	Evacuation lighting ^d
EN IEC 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 IEC 61547:2023	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, safety lighting etc. ^c Includes areas and objects illuminated by floodlights, for example interchange area lighting, parking area lighting, railway yard lighting, decorative lighting, etc. ^d Includes tunnel evacuation lighting, railway tunnel evacuation lighting, etc.					

261 The surge immunity of a luminaire shall be at least 6 kV in differential mode and 10 kV in
262 common mode according to the standard EN IEC 61547:2023.

263 For installations with high masts ($H_M > 20$ m), the surge immunity of a luminaire shall be at
264 least 10 kV in differential mode and 10 kV in common mode according to the standard EN IEC
265 61547:2023.

266 NOTE 1: To obtain the requirements above, a separate surge protective device can be applied.

267 If a separate surge protective device is used to meet the surge immunity requirements, it shall
268 be tested in accordance with the standard EN 61643-11:2013.

269 NOTE 2: For luminaires with external control gear, the overvoltage protection should be located before
270 the external control gear.

271 The surge immunity requirements stated above do not apply to tunnel lighting, railway tunnel
272 lighting, ceiling lighting (e.g. covered part of railway platforms) and decorative lighting. The
273 minimum surge immunity requirements for these lighting systems are in accordance with the
274 standard EN IEC 61547:2023.

275 NOTE 3: In 230 V IT system maximum continuous operating voltage U_c of a surge protection device
276 should be:

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

279 Tunnel luminaires (including safety lighting and evacuation lighting) shall not cause radiated
280 disturbance in the Tetra frequency band (380...500 MHz, private Tetra frequency included).

281 The radiated disturbance generated shall not exceed the level above which radio and
282 telecommunications equipment or other equipment cannot operate as intended.

283 NOTE 4: Conformity related to the relevant harmonised standards does not guarantee that luminaire is
284 not able to cause radiated disturbance in the Tetra frequency band, and thereby violate the essential
285 requirements stated in *Electromagnetic Compatibility (EMC) Directive 2014/30/EU* Annex I.

286 NOTE 5: Further guidance on the EMC assessment where harmonised standards do not exist or are
287 not fully applied is given in the Annex 3 of the publication *Guide for the EMCD:2018*.

288 NOTE 6: This is especially valid in, but not limited to, road tunnels with Tetra coverage.

289 NOTE 7: It should be noted that Tetra emergency communications are not a specific Nordic
290 phenomenon, as Tetra emergency communication in the same frequency band is used in almost all
291 countries in Europe.

292 **6.3 RoHS 2 Directive**

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

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

303 **7 Performance requirements**

304 **7.1 Photometric data and initial luminous flux of a luminaire**

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

307 For all luminaires, the angular intervals in vertical planes (γ) and photometric azimuth (C) shall
308 be according to the standard *EN 13201-3:2015*.

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

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

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

315 **7.2 Performance requirements for luminaires**

316 A luminaire shall comply with the *Commission Regulations (EU) 2019/2020* and *(EU)*
317 *2021/341*.

318 The technical specifications and the performance of a luminaire shall be presented in
319 accordance with the standards *IEC 62722-1:2022*, *IEC 62722-2-1:2023* and *IEC 62717:2014*,
320 taking the specifications of this document into account. A recommendation for the format used
321 in presenting the technical specifications and the performance of a luminaire can be found in
322 Annex A.

323 **7.3 Median useful life of a luminaire**

324 The median useful life L_x (h) of a luminaire is defined by the client. If no value is given by the
325 client, the median useful life of the luminaire is the value presented in Table 4.

326 NOTE 1: The luminaire group replacement interval of an installation should follow the median useful
327 life of the luminaire.

328 The manufacturer shall provide the rated luminous flux maintenance factor x at the rated
329 ambient temperature $t_q = 25$ °C for the required median useful life of the luminaire according
330 to the standards *IEC 62722-2-1:2023* and *IEC 62717:2014*. The manufacturer shall also
331 provide the rated abrupt failure value AFV (%) of the luminaire at median useful life. The rated
332 luminous flux maintenance factor x and the rated abrupt failure value AFV (%) shall fulfil the
333 requirements presented in Table 4.

334 *Table 4. Requirements for a luminaire's median useful life (h), luminous flux maintenance factor x*
335 *and abrupt failure value AFV (%) at median useful life.*

Luminaire type	Median useful life L_x (h)	Luminous flux maintenance factor x (%) at median useful life	Abrupt failure value AFV (%) at median useful life
Road luminaire, tunnel luminaire, railway yard luminaire, luminaires on open parts of platforms	100 000	≥ 90	≤ 10
Luminaire under bridge, underpass luminaire	100 000	≥ 80	≤ 10
Floodlight, decorative lighting luminaire, ceiling luminaire (e.g. covered parts of railway platforms), evacuation route lighting luminaire and emergency exit lighting luminaire ^a	50 000	≥ 80	≤ 10
^a <i>If evacuation route lighting luminaires and emergency exit lighting luminaires are on during normal conditions, the minimum requirements shall be 100 000 h, ≥ 80 and ≤ 10 %.</i>			

336 **7.4 Maintenance factor**

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

340 The maintenance factor f_m is determined using the following formula:

341
$$f_m = f_{LF} \cdot f_{LM} \quad (1)$$

342 where

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

346 EXAMPLE 1: Road lighting. The given median useful life of a luminaire = 100 000 h, the received luminous
347 flux maintenance factor $x = 90$, no CLO, the luminaire cleaning interval every 6 years.

348
$$f_M = 0.90 \cdot 0.90 = 0.81$$

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

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

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

359 7.5 Luminous flux factor

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

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

365 The f_{LF} shall be determined based on the median useful life of a luminaire (see 7.3) and shall be
366 provided by the manufacturer according to the standard IEC 62722-2-1:2023 and section 7.3 of
367 this document. In this case x of the the median useful life L_x equals f_{LF} .

368 EXAMPLE 1: The median useful life $L_{90} = 100\ 000$ h translates to 90 % remaining luminous flux at
369 100 000 h, which results in $f_{LF} = 0.90$.

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

372 7.6 Determination of the luminous flux factor in case of constant light output control

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

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

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

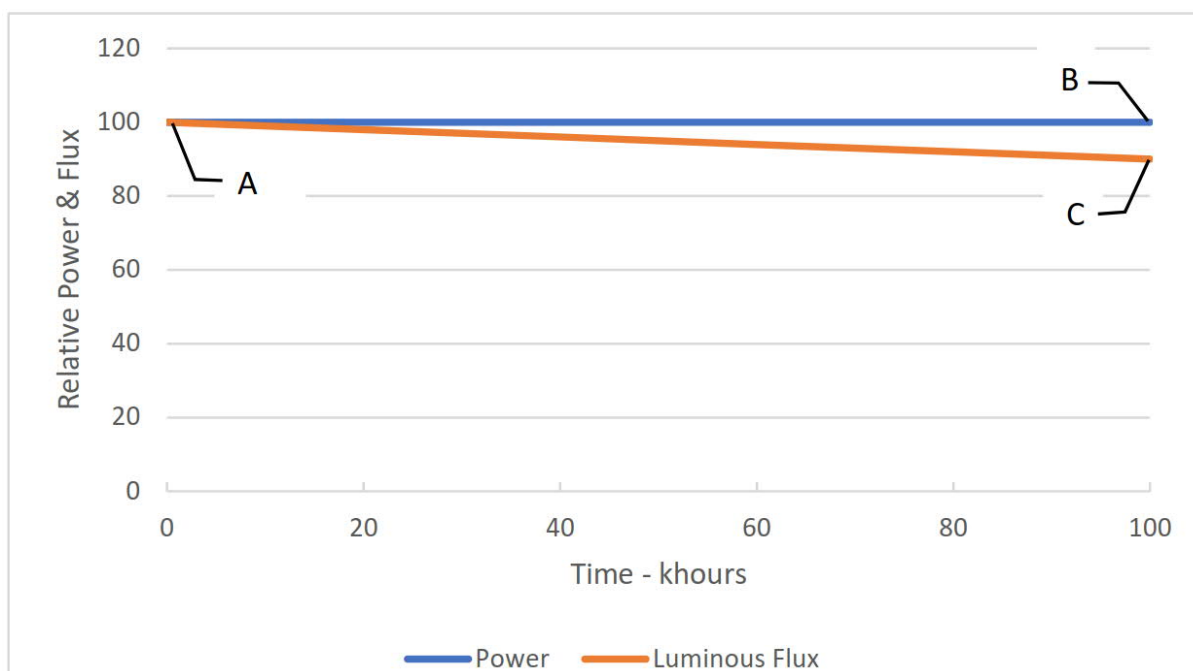
379 Luminaires utilising a constant light output control adjust the luminous flux based on the known or
380 predicted depreciation behaviour of the light source to enable a constant luminous flux over time.
381 This is realised by initially dimming the light source to the predicted end-of-life flux and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

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

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

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

392 Figure 1 shows a simplified representation of a luminaire not using CLO, based on
393 $L_{90} = 100\ 000$ h (i.e. 10 % depreciation after 100 000 hours). Both power and luminous flux are set
394 to their maximum value (point A). Over time, power remains the same (line between point A and
395 B) whereas the luminous flux depreciates to the luminaire luminous flux at the end of the median
396 useful life Φ_e (line between point A and C, 90 % of initial luminaire luminous flux Φ_i).



397

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

400 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
401 the luminaire without CLO the total flux depreciation is 10 % at the end of the median useful life).
402 Over time, luminous flux is kept constant (line between point D and F) by increasing the power (line
403 between point D and E). Note that at the end of median useful life, both luminaires have the same
404 power consumption (B versus E) and the same luminous flux (C versus F).
405

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

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

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

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

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

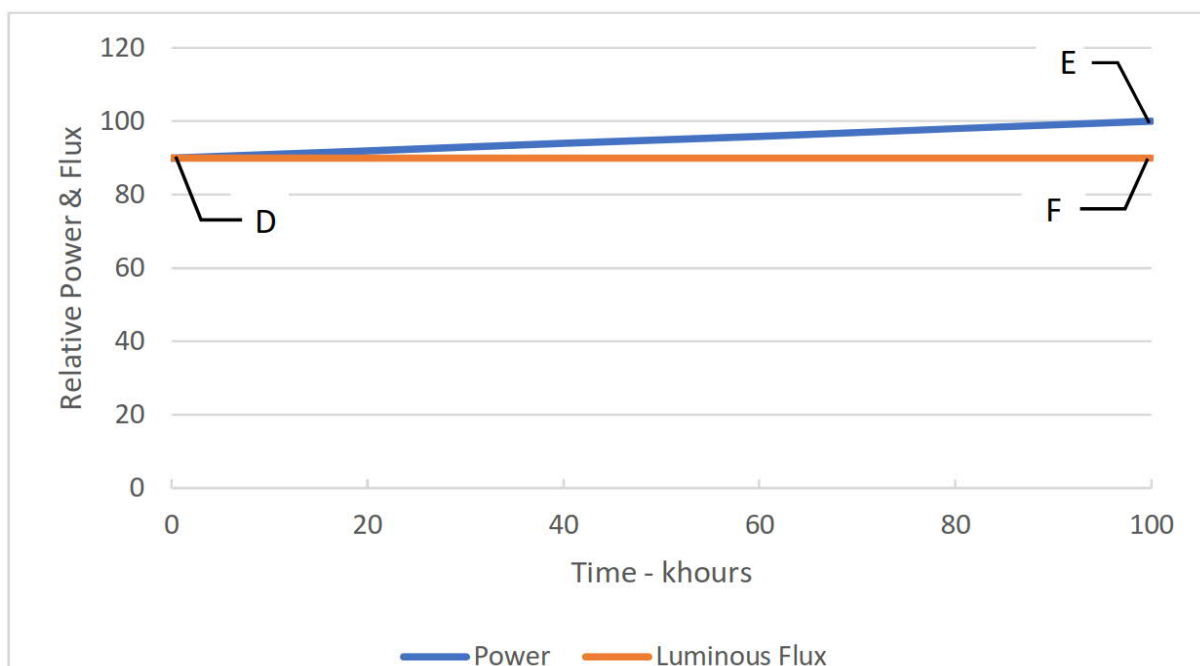
417 where

418 Φ_L is the specified luminaire luminous flux,

419 Φ_{CLO} is the CLO-corrected luminaire luminous flux (i.e. Figure 2 – point D),

420 Φ_e is the luminaire luminous flux at the end of the median useful life without CLO control (i.e.
421 Figure 1 – point C),

422 Φ_i is the initial luminaire luminous flux without CLO control (i.e. Figure 1 – point A).



423

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

426 7.7 Luminaire maintenance factor

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

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

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

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

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

Location	Luminaire cleaning interval, max	Luminaire maintenance factor f_{LM}
Roads, railway areas, luminaire mounting height $H_A \geq 4.0$ m	every 6 years	0.90
Roads, railway areas, 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

444 **7.8 Colour rendering index and colour temperature**

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

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

Location	Correlated colour temperature T_{cp}	Colour rendering index R_a
Tunnels	4 000 K	$R_a \geq 70$
Roads ^{a,b} , open parts of railway platforms, railway yards ^c	3 000 K	$R_a \geq 70$
Public areas and covered parts of railway platforms	3 000 K	$R_a \geq 80$
^a In Finnish Transport Infrastructure Agency projects $T_{cp} = 4\ 000\ K$ shall be used. ^b In Danish Road Directorate projects, values 3 000 K or 4 000 K are specified at the project level. ^c In Finnish Transport Infrastructure Agency projects values 3 000 K and $R_a \geq 80$ shall be used for open parts of railway platforms and values 4 000 K and $R_a \geq 70$ for railway yards.		

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

451 **7.9 Chromaticity coordinate values**

452 For luminaires of the same type within a lighting installation, rated chromaticity coordinate
453 values, both initial and maintained, shall fulfil the tolerance requirements presented in Table
454 7.

455 *Table 7. Tolerance (category) requirements on 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
$\geq 5\ m$	7	7

456 **7.10 Luminaire luminous efficacy**

457 The luminaire luminous efficacy shall be according to Table 8.

458 *Table 8. The minimum requirements for luminaire luminous efficacy η_l .*

Correlated colour temperature T_{cp}	Colour rendering index R_a	Initial luminaire luminous flux Φ_i (100 % power)	Luminaire luminous efficacy η_l
3 000 K	$R_a \geq 80$	< 2 000 lm	$\geq 105\ \text{lm} / \text{W}$
		$\geq 2\ 000\ \text{lm}$	$\geq 115\ \text{lm} / \text{W}$
	$R_a \geq 70$	< 2 000 lm	$\geq 120\ \text{lm} / \text{W}$
		$\geq 2\ 000\ \text{lm}$	$\geq 130\ \text{lm} / \text{W}$
4 000 K	$R_a \geq 70$	< 2 000 lm	$\geq 130\ \text{lm} / \text{W}$
		$\geq 2\ 000\ \text{lm}$	$\geq 140\ \text{lm} / \text{W}$

459 The luminaire luminous efficacy requirements shown in Table 8 do not apply to tunnel
460 evacuation lighting and decorative lighting.

461 **7.11 Flicker**

462 The flicker for a luminaire at full load (100 % power, initial luminaire luminous flux Φ_i) and dimmed
463 to 40 % of the initial luminous flux Φ_i shall be $P_{st}^{LM} \leq 0,5$. The flicker shall be measured in
464 accordance to the technical report *IEC/TR 61547-1:2020*.

465 **7.12 Road tunnel evacuation lighting requirements**

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

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

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

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

475 If an LED strip is used to delineate the frame of an emergency exit and the emergency exit
476 lighting is permanently illuminated, the LED strip shall fulfil the following performance
477 requirements:

- 478 – the minimum opening of 120 degrees for vertical plane
- 479 – the average initial luminaire luminous flux of $200 \leq \Phi_i \leq 250$ lm/m
- 480 – the minimum initial luminaire luminous flux of $\Phi_i = 180$ lm/m
- 481 – green colour according to the standard *ISO 3864-4:2011*.

482 In emergency circumstances if an LED strip is used to delineate the frame of an emergency
483 exit, the LED strip shall fulfil the following performance requirements:

- 484 – the minimum opening of 120 degrees for vertical plane
- 485 – the average initial luminaire luminous flux of $400 \leq \Phi_i \leq 500$ lm/m
- 486 – the minimum initial luminaire luminous flux of $\Phi_i = 360$ lm/m
- 487 – green colour according to the standard *ISO 3864-4:2011*.

488 NOTE 2: The same LED strip can be used for permanent emergency exit lighting and lighting in
489 emergency circumstances by controlling the initial luminaire luminous flux.

490 During an emergency the emergency exit lighting shall flash (from 0 % to 100 %) to attract the
491 attention of fleeing pedestrians. A frequency of flashing shall be within a range of 1 Hz to 4 Hz
492 with a duty cycle of 50 %.

493 **8 Structural requirements**

494 **8.1 General structural requirements**

495 All electronics of a luminaire shall be protected against moisture, condensation and corrosion
496 for the whole median useful life of the luminaire.

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

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

- 501 The ingress protection rating of a luminaire shall be IP66 in accordance with the standards *EN*
502 *IEC 60598-1:2021* and *EN 60529:1992*.
- 503 NOTE 3: In decorative lighting and on covered parts of railway platforms (ceiling luminaire), luminaires
504 with the ingress protection rating of IP65 can also be used.
- 505 The ingress protection rating of a luminaire shall remain IP66 for the whole median useful life
506 of the luminaire, including appropriate maintenance.
- 507 NOTE 4: This can be achieved by using an elastic material that maintains its characteristics throughout
508 the median useful life of the luminaire as the luminaire's seal, for example.
- 509 NOTE 5: If glue is required to attach the seal, the glue should not become brittle and cause the
510 luminaire's IP code to deteriorate during use.
- 511 Cable entries shall provide the degree of protection against dust or moisture in accordance with
512 the ingress protection rating of the luminaire, when an appropriate external cable is installed.
- 513 NOTE 6: For cable entries the degree of protection against dust and moisture can be ensured by using cable
514 glands with adequate IP code or weather and temperature resistant cable TET grommets, for example.
- 515 Cable entries shall have rounded edges with a minimum radius of 0.5 mm.
- 516 An electronic control gear within a luminaire shall be protected against moisture and condensation.
517 This protection shall be achieved by either applying conformal coating or potting which entails filling
518 the control gear housing with a homogeneous and dense mass. The electronic control gear shall
519 operate without malfunctioning at an ambient temperature of $-35 \leq t_a \leq +25$ °C.
- 520 A luminaire housing (not including flat glass, seals, vents, nuts, screws, latches etc.) shall be
521 made from die cast aluminium, extruded aluminium or stainless steel.
- 522 NOTE 7: A luminaire housing or parts of a luminaire housing, that are not exposed to direct sunlight
523 can also be made from materials other than die cast aluminium, extruded aluminium or stainless steel.
- 524 NOTE 8: In Danish Road Directorate projects, a luminaire housing can also be made from other
525 materials. In this case, sufficient background for choosing that material instead of die cast aluminium,
526 extruded aluminium or stainless steel should be provided.
- 527 If a luminaire housing is made from stainless steel, the exterior nuts, screws, latches and other
528 fasteners of a luminaire shall be made from stainless steel A4 according to the standard *EN*
529 *ISO 3506-1:2020*.
- 530 The service life of the luminaire housing, post top or side entry fixing equipment, seals, vents,
531 nuts, screws, latches etc. shall be at least the same as the median useful life of the luminaire.
- 532 The corrosion resistance of a luminaire shall fulfil the requirements of the corrosivity categories
533 of Table 9. The test procedures and duration shall be as specified in Table 9.
- 534 Metal components in contact with one another shall be made from metals which lie close to
535 each other in the galvanic series to avoid electrolytic corrosion. If metals do not lie close
536 enough to each other in the galvanic series, a galvanic separation shall be established
537 between the materials to ensure a corresponding corrosion protection.
- 538 EXAMPLE 1: Brass or other copper alloys should not be used in contact with aluminium or aluminium alloys.
- 539 The cord anchorage of a luminaire shall fulfil the requirements of the standard *EN IEC 60598-*
540 *1:2021* so that the external cable and wires are relieved from strain, including twisting, when
541 they are connected to the wiring block of the luminaire.
- 542 NOTE 9: Cable tie should not be used as the cord anchorage of a luminaire.

543 *Table 9. Corrosivity category requirements for corrosion resistance in different environments and*
544 *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 EN ISO 12944-1:2017	Test according to EN ISO 9227:2022 (neutral salt spray test)
Tunnels ^a , coastal areas with high salt content ^b	C5	high (H)	1 440 h
Industrial areas and coastal areas with moderate salt content ^b	C4	high (H)	720 h
Other environments	C3	high (H)	480 h
^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.			

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

547 A luminaire shall have no electromechanical parts e.g. motors, ventilators, conventional relays.

548 **8.2 Additional road luminaire requirements**

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

551 NOTE 1: IK code requirements do not include external components, such as luminaire extension
552 module (Z-LEX-M).

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

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

559 NOTE 3: Glass protects lenses from ultraviolet radiation to some extent.

560 NOTE 4: The light distribution properties of a luminaire with curved glass or with lens modules as the flat
561 glass change more than those of a luminaire with flat glass, due to dirt.

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

563 A luminaire post top or side entry fixing equipment shall be made from die cast aluminium, extruded
564 aluminium or stainless steel. The fixing equipment shall be a closed structure when installed on
565 the lantern fixing.

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

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

575 NOTE 6: In Danish Road Directorate projects, the luminaire tilt angle can be fixed at 0°.

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

577 The direction of the catenary luminaire's optics shall be clearly marked on the luminaire and
578 indicated in the installation instructions. The marking shall be visible from the outside of the
579 luminaire when viewed from below.

580 **8.3 Additional requirements for underpass luminaires and luminaires under bridges**

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

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

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

589 **8.4 Additional road tunnel luminaire requirements**

590 A luminaire housing (not including flat glass, seals, vents, nuts, screws, latches etc.) of a tunnel
591 luminaire shall be made from stainless steel type 1.4404 according to the standard *EN 10088-*
592 *1:2024*, die cast aluminium or extruded aluminium. If a tunnel luminaire housing is made from
593 stainless steel, all exterior nuts, screws, latches and other fasteners of a luminaire shall be
594 made from stainless steel A4 according to the standard *EN ISO 3506-1:2020*. If a tunnel
595 luminaire housing is made from aluminium, the aluminium alloy shall contain copper
596 $Cu < 0,1$ %.

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

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

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

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

607 The requirements above apply also for safety lighting luminaire.

608 For asymmetrical counter-beam and pro-beam luminaires the direction of the luminaire's
609 optics shall be clearly marked on the luminaire and indicated in the installation instructions.
610 The marking shall be visible from the outside of the luminaire when viewed from below.

611 **8.5 Additional railway luminaire requirements**

612 **8.5.1 Covered parts of platforms**

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

615 If the mounting height of a railway luminaire is $H_M < 4.0$ m, the luminaire shall not be openable

616 without tools.

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

618 **8.5.2 Open parts of platforms**

619 The provisions of Clause 8.2 apply.

620 NOTE 1: In Swedish Transport Administration projects, the luminaire tilt angle can be fixed at 0°.

621 **8.5.3 Yards**

622 For installations with high masts ($H_M > 20$ m), a control gear of a floodlight can be placed outside
623 the floodlight and lantern fixing requirements can be defined on the project level. Otherwise, the
624 provisions of Clause 8.2 apply.

625 **8.6 Additional railway tunnel luminaire requirements**

626 Luminaires in railway tunnels shall be able to withstand the estimated pressure and suction
627 loads, which occur when a train passes a tunnel.

628 **8.7 Additional decorative lighting luminaire requirements**

629 If the mounting height of a decorative lighting luminaire is $H_M < 4.0$ m, the protection rating of
630 the luminaire against external mechanical impacts shall be at least IK10 in accordance with
631 the standard *EN 62262:2011*. If the mounting height is $4.0 \text{ m} \leq H_M \leq 10.0$ m, the protection
632 rating of the luminaire against external mechanical impacts shall be at least IK08 in
633 accordance with the standard *EN 62262:2011*.

634 If the mounting height of a decorative lighting luminaire is $H_M < 3.0$ m, the luminaire shall not
635 be openable without tools.

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

637 The aforementioned requirements do not apply to decorative lighting in tunnels.

638 **8.8 Additional road tunnel evacuation lighting luminaire requirements**

639 The protection rating of a road tunnel evacuation route lighting luminaire and emergency exit
640 lighting luminaire against external mechanical impacts shall be at least IK08 in accordance
641 with the standard *EN 62262:2011*.

642
643 For shielding the LEDs, clear polycarbonate or equivalent material shall be used. Materials used
644 in the LED strip shall fulfil the class V-0 requirements for self-extinguishing in accordance with the
645 standard *UL 94:2013*.

646
647 In tunnels, where high pressure cleaning equipment is used, the ingress protection rating of a
648 evacuation route lighting luminaire and emergency exit lighting luminaire shall be IP69 in
649 accordance with the standards *EN IEC 60598-1:2021* and *EN 60529:1992*.

650 **9 Road lighting control requirements**

651 **9.1 General requirements**

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

- 654 1. preprogrammed stand-alone dimming or mains voltage amplitude modulation
- 655 2. preprogrammed stand-alone dimming or luminaire extension receptacle (external control).

656 NOTE 1: The option 1 is used in Swedish Transport Administration projects. The option 2 is used in Danish
657 Road Directorate, Finnish Transport Infrastructure Agency and Norwegian Public Roads Administration
658 projects.

659 An underpass luminaire and a luminaire under bridge shall enable the luminaire luminous flux to
660 be controlled using at least preprogrammed stand-alone dimming.

661 **9.2 Preprogrammed stand-alone dimming**

662 In preprogrammed stand-alone dimming, the luminaire control gear shall enable a preprogrammed
663 dimming schedule with three lighting levels and five time intervals to be used during 24 hours. An
664 example of a dimming schedule for the preprogrammed stand-alone luminaire control used on
665 roads is shown in Figure 4.

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

667 NOTE 2: In Danish Road Directorate projects, the dimming schedule shown in Figure 4 is amended with the
668 Danish designations of lighting classes M-L and HS-E.

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

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

Lighting class	Time, the starting hour																		
	15	16	17	18	19	20	21	22	23	00	01	02	03	04	05	06	07	08	09
	Residual average luminance percentage																		
Lighting classes M	100	100	100	100	100	60	60	40	40	40	40	40	40	40	60	100	100	100	100
	Residual average illuminance percentage																		
Lighting classes P, C and HS	100	100	100	100	100	60	60	40	40	40	40	40	40	40	60	100	100	100	100

672 *Figure 4. Example of a dimming schedule for a preprogrammed stand-alone luminaire control.*
673
674

675 NOTE 4: The times in the schedule are indicative - in preprogrammed stand-alone dimming the times are
676 usually determined by the median point of the period of darkness, which varies by location and the time of
677 year, including any use of daylight saving time.

678 NOTE 5: The times of the dimming schedule are always programmed for winter time.

679 A preprogrammed stand-alone luminaire shall enable the inspection or the exchange of the
680 dimming schedule by using RFID (radio frequency identification) readers such as high frequency
681 (HF) RFID NFC (Near-field communication) readers.

682 **9.3 Luminaire extension receptacle**

683 If option 2 of Clause 9.1 is required, a road luminaire shall be equipped with at least one luminaire
684 extension receptacle (Z-LEX-R). The extension interface of the luminaire shall:

- 685 – be Zhaga-D4i certified or
- 686 – meet the requirements of mechanical, electrical and communication interface and luminaire

687 compliance tests given in the *Zhaga Book 18:2021, Edition 3.0*.

688 In addition, the electronic control gear shall have the addresses 0x03 – 0x77 of Memory bank 1
689 stored according to *DALI Part 251:2019*.

690 Placing the luminaire extension receptacle (Z-LEX-R) completely inside the luminaire housing is
691 not permitted.

692 NOTE 1: In Danish Road Directorate projects, one luminaire extension receptacle (Z-LEX-R) shall be
693 positioned downwards. If an additional luminaire extension receptacle is provided, it shall be positioned
694 sideways, upwards, or placed inside the luminaire (in the latter case, provided that the luminaire housing
695 does not obstruct sufficient radio communication).

696 The luminaire extension receptacle shall be built into a luminaire. The placing of the luminaire
697 extension receptacle shall be performed by the luminaire manufacturer at the luminaire assembly
698 stage. The luminaire with the receptacle shall always be equipped with a luminaire extension cap
699 (Z-LEX-C). The luminaire extension cap shall be according to the *Zhaga Book 18:2021, Edition*
700 *3.0*. The receptacle, together with the luminaire extension cap, shall provide a degree of protection
701 against dust or moisture (IP code) in accordance with the classification of the luminaire.

702 If a road luminaire is equipped with the luminaire extension receptacle, the luminaire shall enable
703 the selection of the control method between the preprogrammed stand-alone dimming and the
704 external control by using the luminaire extension module (Z-LEX-M).

705 **9.4 Additional requirements on mains voltage amplitude modulation**

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

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

713 A luminaire shall enable the selection of the control method between the preprogrammed stand-
714 alone dimming and the mains voltage amplitude modulation. This selection shall be facilitated
715 through the use of an RFID (radio frequency identification) reader such as high frequency (HF)
716 RFID NFC (Near-field communication) reader or a reader that utilizes both the external and the
717 internal wiring of the luminaire.

718 NOTE 1: The latter can be achieved by connecting wires DA+ and DA- between the wiring block of a
719 luminaire and the electronic control gear of the luminaire and by using an external cable with four or five
720 wires between the luminaire's and the column's wiring blocks.

721 NOTE 2: A luminaire manufacturer should provide recommendations for an appropriate reader.

722 **10 Other requirements**

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

725 NOTE 1: Available and downloadable without registration.

726 The declaration of conformity (DoC) of a luminaire shall be provided on request.

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

730 NOTE 2: It is recommended to deliver at least two QR code stickers with the luminaire. The QR code should
731 provide access to the luminaire's technical specifications and production details without registration.

732 **Annex A (informative) Technical specifications of an LED luminaire**

733 *Red fields should be filled by the client, if necessary*

734 *Green fields should be filled by the manufacturer*

Luminaire manufacturer	
Luminaire type and product code	

Parameters	Requirement	Rated value
Rated input power of the luminaire (W)		
Average rated input power of the luminaire (W) for the median useful life of the luminaire, if CLO control is used		
Rated input power of the luminaire (W) at the end of the median useful life, if CLO control is used		
Rated luminaire electronic control gear circuit power factor λ (100 % power) (see 6.1)		
Rated luminaire electronic control gear circuit power factor λ of a dimmed luminaire (dimmed to 20 % of the initial luminous flux Φ_i) (see 6.1)		
Rated initial luminaire luminous flux Φ_i (lm) (see 7.6)		
Rated CLO-corrected luminaire luminous flux Φ_{CLO} (see 7.6), if CLO control is used		
Rated luminaire luminous efficacy (lm/W) (see Table 8)		
Rated correlated colour temperature T_{cp} (K) (see Table 6)		
Rated general colour rendering index R_a (see Table 6)		
Rated chromaticity co-ordinate values, initial and maintained, size of the MacAdam ellipse (see Table 7)		
Rated median useful life of a luminaire (h) (see Table 4)		
Rated luminous flux maintenance factor x at the ambient temperature of $t_q = 25\text{ °C}$ at the median useful life of a luminaire (%) (see Table 4)		
Rated abrupt failure value AFV (%) at the ambient temperature of $t_q = 25\text{ °C}$ at the median useful life of a luminaire (see Table 4)		
Ingress protection rating of a luminaire, IP code (see 8.1 and 8.8)		
Protection against mechanical impacts, IK code (see 8.1 - 8.8)		
Protection class (I, II or III) (see 6.1)		
Overvoltage protection (kV) of an electronic control gear, differential mode / common mode (see 6.2)	/	/
Overvoltage protection (kV) of a separate surge protective device, differential mode / common mode (see 6.2)	/	/
Luminaire weight (kg)		
Luminaire's effective projected wind surface area		
Luminaire colour (default RAL colour)		
Number of luminaire extension receptacles and their mounting position (U = upwards, D = downwards and S = sideways, e.g., U + D)		
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 and a luminaire post top or side entry fixing equipment information		
Installation instructions for a luminaire		
Luminaire's photometric files in EULUMDAT file format, or information on where they can be acquired (on request)		
At least two QR code stickers (recommendation)		
Declaration of conformity (DoC) (on request)		

736 **Bibliography**

737 **Regulations and Directives**

738 *Commission Regulation (EU) 2019/2020 laying down ecodesign requirements for light sources*
739 *and separate control gears pursuant to Directive 2009/125/EC of the European Parliament*
740 *and of the Council and repealing Commission Regulations (EC) No 244/2009, (EC) No*
741 *245/2009 and (EU) No 1194/2012*

742 *Commission Regulation (EU) 2021/341 amending Regulations (EU) 2019/424, (EU)*
743 *2019/1781, (EU) 2019/2019, (EU) 2019/2020, (EU) 2019/2021, (EU) 2019/2022, (EU)*
744 *2019/2023 and (EU) 2019/2024 with regard to ecodesign requirements for servers and data*
745 *storage products, electric motors and variable speed drives, refrigerating appliances, light*
746 *sources and separate control gears, electronic displays, household dishwashers, household*
747 *washing machines and household washer-dryers and refrigerating appliances with a direct*
748 *sales function*

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

751 *Directive 2011/65/EU on the restriction of the use of certain hazardous substances in electrical*
752 *and electronic equipment*

753 *Directive 2014/30/EU on the harmonisation of the laws of the Member States relating to*
754 *electromagnetic compatibility (EMC)*

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

757 *Low Voltage Directive 2014/35/EU on the harmonisation of the laws of the Member States relating*
758 *to the making available on the market of electrical equipment designed for use within certain*
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760 **Standards**

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769 *data of lamps and luminaires - Part 1: Measurement and file format*

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

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

773 *EN 16276:2013 Evacuation Lighting in Road Tunnels*

774 *EN ISO 3506-1:2020 Mechanical properties of corrosion-resistant stainless steel fasteners – Part*
775 *1: Bolts, screws and studs with specified grades and property classes*

- 776 *EN 40-2:2005 Lighting columns. General requirements and dimensions*
- 777 *EN IEC 55015:2019 / A11:2020 Limits and methods of measurement of radio disturbance*
778 *characteristics of electrical lighting and similar equipment*
- 779 *EN 60228:2005 Conductors of insulated cables*
- 780 *EN 60529:1992 / A1:2000 / A2:2013 / AC:2019 Degrees of protection provided by enclosures (IP*
781 *Code)*
- 782 *EN IEC 60598-1:2021 / A11:2022 Luminaires - Part 1: General requirements and tests*
- 783 *EN IEC 60598-2-1:2021 Luminaires - Part 2-1: Particular requirements - Fixed general purpose*
784 *luminaires*
- 785 *EN 60598-2-3:2003 / A1:2011 Luminaires - Part 2-3: Particular requirements - Luminaires for road*
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- 787 *EN 60598-2-5:2015 Luminaires - Part 2-5: Particular requirements – Floodlights*
- 788 *EN IEC 60598-2-22:2022 Luminaires - Part 2-22: Particular requirements - Luminaires for*
789 *emergency lighting*
- 790 *EN IEC 61000-3-2:2019 / A2:2024 Electromagnetic compatibility (EMC) - Part 3-2: Limits - Limits*
791 *for harmonic current emissions (equipment input current ≤ 16 A per phase)*
- 792 *EN 61000-3-3:2013 / A2:2021 / AC:2022 Electromagnetic compatibility (EMC) - Part 3-3: Limits -*
793 *Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems,*
794 *for equipment with rated current ≤ 16 A per phase and not subject to conditional connection*
- 795 *EN 61000-4-15:2013 Electromagnetic compatibility (EMC) - Part 4-15: Testing and measurement*
796 *techniques - Flickermeter - Functional and design specifications*
- 797 *EN IEC 61547:2023 Equipment for general lighting purposes - EMC immunity requirements*
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799 *devices connected to low-voltage power systems – Requirements and test methods*
- 800 *EN 62262:2011 / A1:2021 Degrees of protection provided by enclosures for electrical equipment*
801 *against external mechanical impacts (IK code)*
- 802 *EN IEC 62386, the international standard for the Digital Addressable Lighting Interface, is*
803 *published in multiple Parts*
- 804 *EN 62493:2015 / A1:2022 Assessment of lighting equipment related to human exposure to*
805 *electromagnetic fields*
- 806 *EN IEC 63000:2018 Technical documentation for the assessment of electrical and electronic*
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- 808 *EN ISO 9227:2022 Corrosion tests in artificial atmospheres - Salt spray tests*
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- 827 *Zhaga Book 18:2021, Edition 3.0, Smart interface between outdoor luminaires and sensing /*
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