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Project Planning

Quality requirements of road luminaires and lighting fixtures, 13 April 2016

The quality requirements for luminaires with discharge lamps or LEDs given in this publication are followed in all forms of contracts on roads and their pedestrian and cycle paths as well as in rest areas, under bridges and tunnels. These quality requirements do not apply to luminaires and floodlights used in installation heights over 20 m.

These quality requirements do not apply to luminaires used in tunnel evacuation lighting, special lighting or high-mast lighting. Their quality requirements shall be determined on a project-specific basis.

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FURTHER INFORMATION

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Foreword

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The previous version of this publication, section 33630 of part 2 of the publication **Infra-rakentamisen yleiset laatuvaatimukset InfraRYL 2006** on the general quality requirements in infrastructure construction, as well as experiences from both general and job-specific quality requirements constitute the starting points for these guidelines. The clients, lighting planners, people participating in drawing up the tender documents and monitoring the installation, as well as certain contractors and manufacturers have been heard in connection with drawing up the instructions.

Helsinki, April 2016

Finnish Transport Agency
Project Planning Department

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1 Type examination of luminaires used on roads

The road luminaires used on roads as well as the luminaires under bridges and in tunnels shall be type approved by the Finnish Transport Agency. The luminaire's type examination is done to ensure the quality of the luminaires. The examination is done for the Finnish Transport Agency's own activities.

The type examination process and all the approved luminaire types have been presented in the Finnish Transport Agency's guide **Hyväksytyt tievalaisimet**.

2 Performance requirements

The luminaire shall have the light distribution characteristics in the C - γ - system measured by a conformity assessment body in accordance with the standard SFS-EN 13201-3 and parts 1, 2 and 4 of the standard SFS-EN 13032. The conformity assessment body shall comply with the Regulation 765/2008/EC. The light distribution files shall be delivered in LDT format.

The luminaire shall be designed for the type of light source in question. The luminaire's light distribution characteristics shall be suitable for the project so that they are as economical as possible. The economy is proven by lighting calculations and/or life cycle costs analysis. Lighting calculations and life cycle costs analysis are presented in sections 6.2.6 and 6.6 of the Finnish Transport Agency's instructions **Maantie- ja rautatiealueiden valaistuksen suunnittelu**.

The requirements for the ecological design of energy-related products have been presented in the Directive 2009/125/EC. The energy efficiency requirements for luminaires and ballasts have been presented in the Commission Regulation (EC) No 245/2009. In addition, the Commission Regulation (EU) No 347/2010 amending the previous regulation shall be taken into account.

High-pressure sodium vapour lamps shall fulfil the performance requirements of the standard SFS-EN 60662, and metal halide lamps shall fulfil the performance requirements of the standard SFS-EN 61167.

The discharge lamp controlgear shall fulfil the performance requirements of the standard SFS-EN 60923.

The technical specifications, performance and lifetime of an LED luminaire shall be presented in accordance with the standard IEC 62722-2-1 and those of the LED module correspondingly in accordance with the standard IEC 62717, taking the specifications made to this document into account. A recommendation for the format used in presenting the technical specifications of an LED luminaire can be found in Appendix 1.

The LED luminaire controlgear shall fulfil the performance requirements of the standard SFS-EN 62384.

The lifetime of an LED luminaire shall be stated for the values L_xB_{10} and C_y at the ambient temperature $t_a = 25\text{ }^\circ\text{C}$, when x is ≥ 80 and y is ≤ 10 . For example, the values $L_{80}B_{10}$ mean that after the specified lifetime, a maximum of 10% of the LED modules/luminaires are permitted to have a reduction in luminous flux of more than 20%. Abrupt failures of the LED modules/luminaires are not taken into account. Correspondingly, the value C_{10} means that at the end of the specified lifetime, a maximum of 10% of the LED modules/luminaires fail to produce any luminous flux at all. The C_y value shall include malfunctions in the controlgear and the other luminaire electronics.

The value L_xB_{10} shall include the optical losses in accordance with table 4 of the standard IEC 62717. These are losses due to changes in the characteristics of lenses, reflector materials and phosphorus as well as changes in the light distribution characteristics throughout the luminaire's specified lifetime.

The L_xF_z values shall not be used for outdoor lighting.

In lighting calculations, the lamp lumen maintenance factor is specified based on the L_xB_{10} value given with the specified lifetime. The ambient temperature factor shall not be used in lighting calculations, unless it has otherwise been agreed with the client. If the temperature factor is used, it shall be the same for all of the luminaires being compared.

The maintenance factors of different light sources are presented in section 2.5 of the Finnish Transport Agency's instructions **Maantie- ja rautatiealueiden valaistuksen suunnittelu**. Municipalities also use their own maintenance factor tables.

The (nominal value) of an LED luminaire's rated colour rendering index shall be $R_a \geq 70$. The recommended correlated colour temperature of an LED luminaire in road and street lighting as well as lighting under bridges and in tunnels is 4000 K ($3985 \text{ K} \pm 275 \text{ K}$). Higher colour temperatures shall not be used, unless agreed with the client. The initial and maintained chromaticity coordinates of the light produced by LED luminaires shall stay within a 7-step MacAdam ellipse.

The luminaire shall be equipped with markings in accordance with the standard SFS-EN 60598-1. In addition, it is recommended that the light distribution type (optics type) of an LED luminaire should be marked on the luminaire, e.g. on the luminaire's rating plate or a separate marking label.

3 Electrotechnical and electrical safety requirements

The controlgear voltage is 230 V. The luminaire shall be compensated at least up to the value of 0.90, and it shall not be overcompensated. The $\cos \varphi$ value of a dimmed luminaire shall be ≥ 0.70 . The luminaire shall be built in a way that prevents unreasonable impairment in the electrical network service when the luminaire has been connected to the network and the network is used in normal operating conditions.

A protection class II luminaire shall not have an earth terminal.

The 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 below. Standards other than those mentioned below 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 requirements shall be proved 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 765/2008/EC.

- SFS-EN 60598 part 2, chapter 3: **Luminaires for road and street lighting**, or part 2, chapter 5: **Floodlights**, used in conjunction with part 1: **General requirements and tests**.
- SFS-EN 61347: part 2, chapter 9: **Particular requirements for electromagnetic controlgear for discharge lamps (excluding fluorescent lamps)** used in conjunction with part 1: **General and safety requirements**.
- SFS-EN 61347: part 2, chapter 13: **Particular requirements for d.c. or a.c. supplied electronic controlgear for LED modules** used in conjunction with part 1: **General and safety requirements**.
- SFS-EN 62031 **LED modules for general lighting. Safety specifications**.
- SFS-EN 62493 **Assessment of lighting equipment related to human exposure to electromagnetic fields**.

The luminaire shall comply with the Directive 2014/30/EU, and it shall fulfil the EMC requirements specified in the Directive in accordance with the standards mentioned below. Standards other than those mentioned below 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 requirements shall be proved 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 765/2008/EC.

- SFS-EN 55015 **Limits and methods of measurement of radio disturbance characteristics of electrical lighting and similar equipment.**
- SFS-EN 61000 part 3, chapter 2: **Electromagnetic compatibility (EMC). Limits for harmonic current emissions (equipment input current ≤ 16 A per phase).**
- SFS-EN 61000 part 3, chapter 3: **Electromagnetic compatibility (EMC). 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.**
- SFS-EN 61547 **Equipment for general lighting purposes. EMC immunity requirements.**

The 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).**

A photobiological radiation measurement shall be conducted on the luminaire in accordance with the technical report IEC/TR 62778. The requirement is included in the standard SFS-EN 60598-1:2015. A luminaire in accordance with a previous edition of the standard SFS-EN 60598-1 can also be tested in accordance with the standard SFS-EN 62471. The CE marking requires that the level of photobiological radiation has been measured.

A discharge lamp luminaire shall have a maintenance switch or some other comparable device, such as a plugable wiring block, which can be used to ensure that the luminaire is disconnected from electrical grid during maintenance. The switch or block shall not be damaged during repeated use in ambient temperatures of ≥ -15 °C.

In installations with wooden columns or metal columns and overhead cabling, the luminaire cable shall fulfil the following requirements.

- On roads, the nominal cross-sectional area of the wires shall be 2.5 mm² to ensure that the cable has sufficient mechanical strength and that the electrotechnical requirements are fulfilled in all cases. On streets, the nominal cross-sectional area of the luminaire cable shall be at least 1.5 mm².
- The wires shall be annealed copper cable wires (stranded flexible).
- The sheath shall be lead-free weatherproof PVC, and it shall be round and smooth in shape to ensure a successful cable entry.
- When wiring cables, the smallest permitted bending radius is 10 x the cable diameter and the lowest permitted handling temperature is -15 °C. The cable shall not be damaged when pulled through a normal column and bracket.
- The cable shall remain undamaged when it is bent permanently with a bending radius of at least 3 x cable diameter.
- The cable shall not become detrimentally brittle within 30 years.

In installations with metal columns and ground cabling, the luminaire cable shall fulfil the following requirements:

- On roads, the nominal cross-sectional area of the wires shall be 2.5 mm² to ensure that the cable has sufficient mechanical strength and that the electrotechnical requirements are fulfilled in all cases. On streets, the nominal cross-sectional area of the luminaire cable shall be at least 1.5 mm².

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- When wiring cables, the smallest permitted bending radius is 10 x the cable diameter and the lowest permitted handling temperature is -15 °C. The cable shall not be damaged when pulled through a normal column and bracket.
- The cable shall remain undamaged when it is bent permanently with a bending radius of at least 3 x cable diameter.
- The maintenance switch is placed so that there is no need to bend the cable during maintenance.

All electronics (controlgear and LED modules) in the protection class I road luminaires and luminaires under bridges shall have three-level protection for the intervals L-PE, N-L and N-PE. The overvoltage protection shall be at least 6 kV/3 kA for all three intervals.

All electronics (controlgear and LED modules) in the protection class II road luminaires and luminaires under bridges shall be protected in the interval N-L. The overvoltage protection shall be at least 6 kV/3 kA.

The luminaire electronics shall operate without malfunctioning at ambient temperatures from -40 to +40 °C.

A discharge lamp luminaire shall be equipped with an automatic shutdown function that activates in case of a malfunction to prevent the lamp from flickering.

4 Structural requirements

The luminaire shall have a sufficient ability to withstand external stresses, especially with regard to luminaires on pedestrian and cycle paths, in tunnels and places susceptible to vibration, such as bridges.

Installing the luminaire shall be quick and easy. The structure of a discharge lamp luminaire shall make it possible to open the luminaire and change the lamp without tools. It shall be possible to replace the controlgear of a discharge lamp luminaire with commonly available tools. If an LED luminaire is intended for maintenance in field conditions, it shall be possible to replace the LED luminaire's LED modules and controlgear quickly and easily using commonly available tools.

For side entry fixed luminaires, the angle of tilt shall be 5° (0 degrees in relation to the bracket), unless it has otherwise been agreed with the client. For post top fixed luminaires the angle of tilt shall be 0–5 degrees, unless it has otherwise been agreed with the client

The luminaire post top or side entry fixing equipment shall be compatible with the standard SFS-EN 40-2.

The body of the luminaire shall be made completely out of metal. The service life of the luminaire's body shall be at least 30 years, or in the case of an LED luminaire, the whole rated lifetime of the luminaire, if this is less than 30 years. The surface treatment of the body shall maintain its protective characteristics, and the luminaire shall not develop any discolouration throughout its lifetime. The hot dip galvanized coating of articles shall be carried out in accordance with the standard SFS-EN ISO 1461. The luminaire's corrosion resistance shall fulfil the requirements of the standard SFS-EN 60598-1 and the requirements of the corrosivity categories of Table 1.

Corrosivity category *	Material	Environment
C5 (I-M)	Aluminium and steel	Tunnels. Coastal areas with high salt content.
C4	Aluminium and steel	Industrial areas and coastal areas with moderate salt content.
C3	Aluminium and steel	Other environments.

* The corrosivity categories are in accordance with the standard SFS-EN ISO 9223.

Table 1. Corrosivity category requirements for corrosion resistance in different environments.

The nuts and screws < M8 as well as latches shall be made out of stainless steel 18/8. The nuts and screws that are larger than this shall have a hot dip galvanized coating in accordance with the standard SFS-EN ISO 1461, and their corrosion resistance shall fulfil the requirements of the standard SFS-EN 60598-1 and the requirements of the corrosivity categories in Table 1.

The structure of the luminaires shall prevent the formation of icicles.

The shape of the luminaire shall ensure that the effective projected wind surface area is as small as possible (form factor < 1.2).

The cord anchorage shall be in accordance with chapter 5 of the standard SFS-EN 60598-1, so that there is no stress on the wiring block. The cord anchorage shall withstand a load that is five times the mass of the cable to be supported; however, 6 kg at minimum.

The ingress protection class of road and street luminaires as well as luminaires under bridges shall be at least IP65 in accordance with the standards SFS-EN 60598-1 and SFS-EN 60529. Correspondingly, the ingress protection class of luminaires in tunnels shall be at least IP66. The structure of the luminaire shall prevent the accumulation of condensation water inside it. The cable entries shall have rounded edges of minimum radius 0,5 mm.

The luminaire's ingress protection class shall be maintained for at least 30 years in all operating conditions, or in the case of an LED luminaire, the whole rated lifetime of the luminaire, if it is shorter. An elastic material that maintains its characteristics throughout the luminaire's lifetime shall be used as the luminaire's seal. If glue is needed to attach the seal, the glue shall not become brittle and cause the luminaire's IP class to deteriorate during use.

Because luminaires under bridges and in tunnels are washed with pressurised water that contains chemicals, their seals shall be secured with turned-up edges.

A metal lampholder and its fastening shall be strong enough to keep the lamp always in the same position in which the light distribution characteristics were measured. The other requirements on lampholders are presented in the standard SFS-EN 60238 **Edison screw lampholders.**

The material of the reflectors shall be pure anodised aluminium, Al 99.9%. The thickness of the reflectors shall be ≥ 1.25 mm, or the stiffness shall be ensured using turned-up or reinforced edges. The reflectors of an LED luminaire can also be made out of some other material, provided that they do not move or change their reflective characteristics or shape due to vibration or changes in temperature during the whole rated lifetime of the LED luminaire. If the LED luminaire's reflectors have been made out of a material other than aluminium, the manufacturer shall provide a 10-year guarantee for the reflectors.

The service life of the luminaire's flat glass, curved glass, lens module or bowl shall be at least 30 years in all operating conditions, or in the case of an LED luminaire, the whole rated lifetime of the luminaire, if it is shorter. Flat glass refers to an even, two-dimensional surface. Curved glass refers to a gently curving surface, usually created by bending. Lens module refers to a module put in the place of flat glass, with several lenses on the module surface. A bowl refers to an optical cover that curves far outside the luminaire body; it has usually been manufactured by casting, pressing or drawing. The flat glass, curved glass, lens module and bowl shall be made out of tempered glass. A plastic material is also acceptable, provided that the durability of its brightness and transparency throughout its service life has been demonstrated in accordance with ASTM 1925 E313 or with references. In addition, the mechanical

strength of the plastic material shall be demonstrated by test results or with references.

The discharge lamp luminaires used on streets shall be equipped with flat glass, unless it has otherwise been agreed with the client.

Luminaires under bridges shall be protected against vandalism if the installation height is less than 5 m.

5 Other requirements

Installation instructions either in Finnish or in English shall be delivered together with the luminaire. The instructions shall correspond to the product delivered.

The luminaire brochure shall present the luminaire's weight and effective projected wind surface area.

The outer surface of an installed discharge lamp luminaire shall have a label showing the lamp type and the nominal wattage of the lamp. The label types to be used are presented in Appendix 2.

6 Lighting control requirements

LED and metal halide luminaires shall be equipped with electronic controlgear with DALI control that can be dimmed.

High-pressure sodium lamps shall be equipped with a bi-power ballast and an automatic control relay.

The luminaire shall have space reserved for a luminaire-specific control device (120 x 80 x 50 mm) as well as an antenna for wireless control. A luminaire equipped with a luminaire-specific control device and antenna shall fulfil the requirements of the standards in section 3 and the IP class requirements in section 4.

The control principles for luminaires used on roads have been given in section 1.4 of the Finnish Transport Agency's instructions **Maantie- ja rautatiealueiden valaistuksen suunnittelu**.

The control principles for luminaires used on streets have been given in the dimming table in Appendix 3. The times and dimming values in the appendix are examples.

Appendix 1. Technical specifications of an LED luminaire to be provided by the manufacturer

Technical specifications to be provided for an LED luminaire

Luminaire manufacturer/importer	
Luminaire type and product code	

Parameters	Value
Rated input power of the luminaire (W)	
The average luminaire rated input power (W) for the given lifetime, if constant light output control is used	
Constant current of the luminaire's LEDs (mA)	
Power factor of the luminaire, cos ϕ value	
Luminaire's rated luminous flux (lm)	
Rated luminous efficacy of the luminaire (lm/W)	
Rated correlated colour temperature CCT (K)	
Rated colour rendering index (R _a)	
Rated chromaticity co-ordinate values both initial and maintained, MacAdam ellipses *)	
Luminaire lifetime (h)	
Gradual light output degradation. L _x B ₁₀ value at the ambient temperature t _a = 25 °C, for the lifetime stated above. The value of X shall be ≥ 80. **)	
Abrupt light output degradation. C _y value at the ambient temperature t _a = 25 °C, for the lifetime stated above. The value of Y must be ≤ 10. ***)	
The ingress protection class IP	
Protection against mechanical impacts IK class	
Insulation resistance and electric strength class (I or II)	
Overvoltage protection (kV/kA)	
Luminaire weight (kg)	
The luminaire's effective projected wind surface area	
The colour of the luminaire RAL (default)	
The luminaire's guarantee period (h)	

*) See section 9.1 and table 5 of the standard IEC 62717.

**) The L_xB₁₀ value shall include the optical losses in accordance with table 4 of the standard IEC 62717.

***) The C_y value shall include the malfunctions in the controlgear and other luminaire electronics.

Other information, documents and files to be delivered

A description of the luminaire's materials (body, reflectors, optical cover, etc.)

A description on the luminaire's dimming abilities

The luminaire's dimensions and an installation guide

Information about the replaceability of the luminaire's different components

The luminaire's photometric files, or information on where they can be acquired

Declaration of conformity in accordance with the instructions Quality requirements of road luminaires and lighting fixtures

Appendix 2. Labels on the lamp type and the nominal wattage of the lamp in outdoor lighting

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Nominal wattage

35W	50W	70W	80W	100W	125W	150W	250W	400W	Lamp type
									Mercury vapour lamp
									Metal halide lamp
									High-pressure sodium lamp, ellipsoid
									High-pressure sodium lamp, tubular

A label showing the lamp type and the nominal wattage of the lamp shall be attached to the outer surface of the luminaire so that it is as easily visible to the users as possible.

The label shall be attached to the outside of the luminaire so that it is exposed to direct sunlight as little as possible.

In the case of luminaires with bi-power ballasts, the label shall be changed if the wattage of the luminaire is changed during use (does not apply to lighting control).

The labels shall not fall off the luminaires, fade or change colour significantly within 30 years.

Appendix 3. Outdoor lighting dimming table

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LED luminaires

The dimming of LED luminaires is implemented in 2 steps in accordance with the times and lighting classes stated below. The times are indicative. In pre-programmed luminaire control, the times are usually determined by the median point of the period of darkness, which varies by location (on average, approx. 00:20).

In the C classes, a luminance and illuminance class correspondence table is used. The dimming is implemented in accordance with the M classes.

		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 variable lighting	Residual average luminance percentage																		
		M1, C0 and C1	M1 – M2 – M3 – M2 – M1	100	100	100	100	100	100	75	75	75	50	50	50	50	50	75	75	100
M2, C2	M2 – M3 – M4 – M3 – M2	100	100	100	100	100	100	75	75	75	50	50	50	50	50	75	75	100	100	100
M3a, C3	M3 – M4 – M5 – M4 – M3	100	100	100	100	100	100	75	75	75	50	50	50	50	50	75	75	100	100	100
M3b	M3 – M4 – M5 – M4 – M3	100	100	100	100	100	100	75	75	75	50	50	50	50	50	75	75	100	100	100
M4, C4	M4 – M5 – M6 – M5 – M4	100	100	100	100	100	100	60	60	40	40	40	40	40	40	60	60	100	100	100
M5, C5	M5 – M6 – P5 – M6 – M5	100	100	100	100	100	100	60	60	40	40	40	40	40	40	60	60	100	100	100
M6	M6 – P5 – P6 – P5 – M6	100	100	100	100	100	100	60	60	40	40	40	40	40	40	60	70	100	100	100
		Residual average illuminance percentage																		
P1	P1 – P2 – P3 – P2 – P1	100	100	100	100	100	100	75	75	75	50	50	50	50	50	75	75	100	100	100
P2	P2 – P3 – P4 – P3 – P2	100	100	100	100	100	100	75	75	75	50	50	50	50	50	75	75	100	100	100
P3	P3 – P4 – P5 – P4 – P3	100	100	100	100	100	100	60	60	40	40	40	40	40	40	60	60	100	100	100
P4	P4 – P5 – P6 – P5 – P4	100	100	100	100	100	100	60	60	40	40	40	40	40	40	60	60	100	100	100

		Time, the starting hour																		
		15	16	17	18	19	20	21	22	23	00	01	02	03	04	05	06	07	08	09
Type of lighting		Residual average illuminance percentage																		
		Sport area lighting, no external control		100	100	100	100	100	100	100	50	10	10	10	10	10	10	50	50	100
Sport area lighting with external control, not activated *)		10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Sport area lighting with external control, activated *)		100	100	100	100	100	100	100	100	10	10	10	10	10	10	10	100	100	100	100

*) During the permitted hours, push-button control can be used to raise the illuminance up to 100% for two hours, after which the lighting dims back to 10%. / During the permitted hours, motion sensor control increases the illuminance to 100% for 15 minutes, after which the lighting dims back to 10%.

Luminaires with discharge lamps

The dimming of luminaires with discharge lamps is implemented in 1 step in all lighting classes in accordance with the table below.

		Time, the starting hour																		
		15	16	17	18	19	20	21	22	23	00	01	02	03	04	05	06	07	08	09
Type of lighting		Residual average luminance or illuminance percentage																		
		Road and street lighting, electronic controlgear **)		100	100	100	100	100	100	100	60	60	60	60	60	60	60	100	100	100
Road and street lighting, traditional controlgear ***)		100	100	100	100	100	100	100	Period of decreased intensity						100	100	100	100	100	
Sport area lighting, lighting turned off at night		100	100	100	100	100	100	100	0	0	0	0	0	0	0	0	100	100	100	100

**) Metal halide luminaires are dimmed to 80% for 15 minutes as the lighting dimming value changes.

***) The dimming of lighting is implemented with a bi-power ballast and an automatic control relay. The dimming begins 2 h before and ends 5 h after the median point of the period of darkness.