



„Adaptive Road Lighting“
according to CIE Publication 115:2007
„Recommendations for the Lighting of
Roads for Motor and Pedestrian Traffic“

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Lighting Classes in CIE 115:2007



There are 3 different sets of lighting classes in CIE publication 115:2007 from which appropriate **lighting quality criteria / requirements** can be selected:

M Lighting Classes for **m**otorized traffic

C Lighting Classes for **c**onflict areas

P Lighting Classes for **p**edestrian and low speed traffic areas

Selection of Lighting Situation, Influencing Parameters in general



- Speed (composition of users in the same relevant area)
- Geometry (separation of carriageways, type of junctions, intersection density, conflict areas, measures for traffic calming)
- Traffic use (traffic flow of vehicles, cyclists, pedestrians, parked vehicles, crime risk / facial recognition, difficulty of navigational task)
- Environmental influences (complexity of visual field, ambient luminance, weather type, colour rendition)
- Visual guidance, traffic control

Selection of **M** Lighting Class (CIE 115:2007), Parameters for Motorized Traffic



- Speed: high or moderate
- Traffic volume: very high, high, moderate, low, or very low
- Traffic composition: motorized only, mixed, or mixed with high percentage of non-motorized
- Separation of carriageways: no or yes
- Intersection density: high or moderate
- Parked vehicles: present or not present
- Ambient luminance: very high, high, moderate, low or very low
- Visual guidance, traffic control: poor, good, very good

Parameters for the Selection of a Lighting Class **M** for Motorized Traffic (CIE 115:2007)



Parameter	Options	Weighting Factor WF	WF selected
Speed	High	1	
	Moderate	0	
Traffic volume	Very high	1	
	High	0.5	
	Moderate	0	
	Low	-0.5	
	Very Low	-1	
Traffic composition	Motorized only	0	
	Mixed	0.5	
	Mixed, high percentage of non-motorized	1	
Separation of carriageways	No	1	
	Yes	0	
Intersection density	High	1	
	Moderate	0	
Parked vehicles	Present	1	
	Not present	0	
Ambient luminance	Very high	1	
	High	0.5	
	Moderate	0	
	Low	-0.5	
	Very low	-1	
Visual guidance, traffic control	Poor	0.5	
	Good	0	
	Very good	-0.5	
		Sum of Weighting Factors	SWF

Parameters for the Selection of a Lighting Class **M** for Motorized Traffic (**example**)



Parameter	Options	Weighting Factor WF	WF selected
Speed	High	1	1
	Moderate	0	
Traffic volume	Very high	1	1
	High	0.5	
	Moderate	0	
	Low	-0.5	
	Very Low	-1	
Traffic composition	Motorized only	0	0
	Mixed	0.5	
	Mixed, high percentage of non-motorized	1	
Separation of carriageways	No	1	0
	Yes	0	
Intersection density	High	1	0
	Moderate	0	
Parked vehicles	Present	1	0
	Not present	0	
Ambient luminance	Very high	1	0
	High	0.5	
	Moderate	0	
	Low	-0.5	
	Very low	-1	
Visual guidance, traffic control	Poor	0.5	0
	Good	0	
	Very good	-0.5	
		Sum of Weighting Factors	SWF = 2

Number of Lighting Class M = 6 – SWF

M Lighting Classes (CIE 115:2007)



LIGHTING CLASS	dry			wet *	TI in %	SR
	L_{av} in cd/m^2	U_o	U_l	U_o		
M1	2.0	0.40	0.70	0.15	10	0.5
M2	1.5	0.40	0.70	0.15	10	0.5
M3	1.0	0.40	0.60	0.15	10	0.5
M4	0.75	0.40	0.60	0.15	15	0.5
M5	0.50	0.35	0.40	0.15	15	0.5
M6	0.30	0.35	0.40	0.15	20	0.5

* Applicable in addition where road surfaces are wet for a substantial part of the hours of darkness and appropriate road surface reflectance data are available

Lighting requirements for motorized traffic

Conflict Areas (CIE 115:2007)



Conflict areas occur whenever **vehicle streams intersect each other** or run into areas frequented by pedestrians, cyclists, or other road users, or when the existing road is connected to a stretch with **substandard geometry**, such as a reduced number of lanes or a reduced lane or road width.

For conflict areas, **luminance is the recommended design criterion**. However, where viewing distances are short and other factors prevent the use of the luminance criteria, **illumination** may be used on a part of the conflict area, or the entire area if the luminance criteria cannot be applied to the whole area.

M and C Lighting Classes of Comparable Lighting Level (CIE 115:2007)



Lighting class M		M1	M2	M3	M4	M5	M6
Average luminance L in cd/m ²		2.0	1.5	1.0	0.75	0.50	0.30
Lighting class C	C0	C1	C2	C3	C4	C5	
Average illuminance E in lx	50	30	20	15	10	7.5	

For M classes valid for CIE road surface reflectance of CIE publication 144:2001, table C2 with $q_0=0.07$ cd/m²/lx

Selection of **C** Lighting Class (CIE 115:2007), Parameters for Conflict Areas



- Speed: high, moderate, or low
- Traffic volume: very high, high, moderate, low, or very low
- Traffic composition: motorized only, mixed, or mixed with high percentage of non-motorized
- Separation of carriageways: no or yes
- Ambient luminance: very high, high, moderate, low or very low
- Visual guidance, traffic control: poor, good, very good

Parameters for the Selection of a Lighting Class C for Conflict Areas (CIE 115:2007)



Parameter	Options	Weighting Factor WF	WF selected
Speed	High	2	
	Moderate	1	
	Low	0	
Traffic volume	Very high	1	
	High	0.5	
	Moderate	0	
	Low	-0.5	
	Very Low	-1	
Traffic composition	Motorized only	0	
	Mixed	0.5	
	Mixed, high percentage of non-motorized	1	
Separation of carriageways	No	1	
	Yes	0	
Ambient luminance	Very high	1	
	High	0.5	
	Moderate	0	
	Low	-0.5	
	Very low	-1	
Visual guidance, traffic control	Poor	0.5	
	Good	0	
	Very good	-0.5	
		Sum of Weighting Factors	SWF

Parameters for the Selection of a Lighting Class C for Conflict Areas (example)



Parameter	Options	Weighting Factor WF	WF selected
Speed	High	2	1
	Moderate	1	
	Low	0	
Traffic volume	Very high	1	0.5
	High	0.5	
	Moderate	0	
	Low	-0.5	
	Very Low	-1	
Traffic composition	Motorized only	0	0.5
	Mixed	0.5	
	Mixed, high percentage of non-motorized	1	
Separation of carriageways	No	1	1
	Yes	0	
Ambient luminance	Very high	1	0.5
	High	0.5	
	Moderate	0	
	Low	-0.5	
	Very low	-1	
Visual guidance, traffic control	Poor	0.5	0.5
	Good	0	
	Very good	-0.5	
Number of Lighting Class C = 6 – SWF		Sum of Weighting Factors	SWF = 4

C Lighting Classes (CIE 115:2007)



LIGHTING CLASS	Average illuminance over whole of used surface E in lx	Uniformity of illuminance U_o (E)	Threshold increment TI in % *	
			High and moderate speed	Low and very low speed
C0	50	0.40	10	15
C1	30	0.40	10	15
C2	20	0.40	10	20
C3	15	0.40	10	20
C4	10	0.40	15	25
C5	7.5	0.40	15	25

* Applicable where visual tasks usually considered for the lighting of roads for motorized traffic (M classes) are of importance

Lighting requirements for conflict areas

M and C Lighting Classes of Comparable Lighting Level (CIE 115:2007)



Lighting class M		M1	M2	M3	M4	M5	M6
Average luminance L in cd/m ²		2.0	1.5	1.0	0.75	0.50	0.30
Lighting class C	C0	C1	C2	C3	C4	C5	
Average illuminance E in lx	50	30	20	15	10	7.5	

For M classes valid for CIE road surface reflectance of CIE publication 144:2001, table C2 with $q_0=0.07$ cd/m²/lx

M Lighting Classes (CIE 115:2007)



LIGHTING CLASS	dry			wet *	TI in %	SR
	L_{av} in cd/m^2	U_o	U_i	U_o		
M1	2.0	0.40	0.70	0.15	10	0.5
M2	1.5	0.40	0.70	0.15	10	0.5
M3	1.0	0.40	0.60	0.15	10	0.5
M4	0.75	0.40	0.60	0.15	15	0.5
M5	0.50	0.35	0.40	0.15	15	0.5
M6	0.30	0.35	0.40	0.15	20	0.5

* Applicable in addition where road surfaces are wet for a substantial part of the hours of darkness and appropriate road surface reflectance data are available

Lighting requirements for motorized traffic

Selection of **P** Lighting Class (CIE 115:2007), Parameters for Pedestrian / Low Speed Areas



- Speed: low or very low (walking speed)
- Traffic volume: very high, high, moderate, low, or very low
- Traffic composition: pedestrians, cyclists and motorized traffic; pedestrians and motorized traffic; pedestrians and cyclists only; pedestrians only; cyclists only
- Parked vehicles: present or not present
- Facial recognition: necessary or not
- Ambient luminance: very high, high, moderate, low or very low

Parameters for the Selection of a Lighting Class **P** for Pedestrian Areas (CIE 115:2007)



Parameter	Options	Weighting Factor WF	WF selected
Speed	Low	1	
	Very low (walking speed)	0	
Traffic volume	Very high	1	
	High	0.5	
	Moderate	0	
	Low	-0.5	
	Very Low	-1	
Traffic composition	Pedestrians only	0	
	Cyclists only	0	
	Pedestrians and cyclists only	0.5	
	Pedestrians and motorized traffic	0.5	
	Pedestrians, cyclists and motorized traffic	1	
Parked vehicles	Present	0.5	
	Not present	0	
Facial recognition	Necessary	Additional requirement	
	Not necessary	No additional requirement	
Ambient luminance	Very high	1	
	High	0.5	
	Moderate	0	
	Low	-0.5	
	Very low	-1	
		Sum of Weighting Factors	SWF

Parameters for the Selection of a Lighting Class **P** for Low Speed Areas (**example**)



Parameter	Options	Weighting Factor WF	WF selected
Speed	Low	1	0
	Very low (walking speed)	0	
Traffic volume	Very high	1	-0.5
	High	0.5	
	Moderate	0	
	Low	-0.5	
	Very Low	-1	
Traffic composition	Pedestrians only	0	1
	Cyclists only	0	
	Pedestrians and cyclists only	0.5	
	Pedestrians and motorized traffic	0.5	
	Pedestrians, cyclists and motorized traffic	1	
Parked vehicles	Present	0.5	0.5
	Not present	0	
Facial recognition	Necessary	Additional requirement	
	Not necessary	No additional requirement	
Ambient luminance	Very high	1	0
	High	0.5	
	Moderate	0	
	Low	-0.5	
	Very low	-1	
Number of Lighting Class P = 6 – SWF		Sum of Weighting Factors	SWF = 1

Lighting Requirements for **P** Lighting Classes (Pedestrians/Low Speed Areas, CIE 115:2007)



LIGHTING CLASS	Average horizontal illuminance E_m in lx	Minimum horizontal illuminance E_{min} in lx	Threshold Increment TI in % *	Additional requirement if facial recognition is necessary	
				Minimum vertical illuminance $E_{v,min}$ in lx	Minimum semi-cylindrical illuminance $E_{sc,min}$ in lx
P1	15	3.0	20	5.0	3.0
P2	10	2.0	25	3.0	2.0
P3	7.5	1.5	25	2.5	1.5
P4	5.0	1.0	30	1.5	1.0
P5	3.0	0.6	30	1.0	0.6
P6	2.0	0.4	35	0.6	0.4

* Applicable where visual tasks usually considered for the lighting of roads for motorized traffic (M classes) and conflict areas (C classes) are of importance

To provide for uniformity the actual value of the maintained average illuminance may not exceed 1.5 times the value indicated for the class.

Adaptive Road Lighting



Adaptive lighting is defined as lighting provided **where and when** it is needed **dependent on different variable conditions**, such as speed, traffic volume and/or composition, ambient luminances, weather etc.

NOTE (CIE 115:2007):

Changes of the average lighting level should not affect the other quality criteria more than prescribed in the system of lighting classes (M, C, P).

Parameters for the Time dependent Selection of Lighting Classes **P** for Pedestrian Areas



Parameter	Options	Weighting Factor WF	WF selected			
			t ₁ t ₂	t ₂ t ₃	t ₃ t ₄	t ₄ t ₅
Speed	Low	1				
	Very low (walking speed)	0				
Traffic volume	Very high	1				
	High	0.5				
	Moderate	0				
	Low	-0.5				
	Very Low	-1				
Traffic composition	Pedestrians only	0				
	Cyclists only	0				
	Pedestrians and cyclists only	0.5				
	Pedestrians and motorized traffic	0.5				
	Pedestrians, cyclists and motorized traffic	1				
Parked vehicles	Present	0.5				
	Not present	0				
Facial recognition	Necessary	Additional requirement				
	Not necessary	No additional requirement				
Ambient luminance	Very high	1				
	High	0.5				
	Moderate	0				
	Low	-0.5				
	Very low	-1				
Sum of Weighting Factors			S W F	S W F	S W F	S W F

Time dependent Selection of Lighting Classes

P for Pedestrian Area (example)



Parameter	Options	Weighting Factor WF	WF selected				
			t ₁ t ₂	t ₂ t ₃	t ₃ t ₄	t ₄ t ₅	
Speed	Low	1	1	0	0	0	
	Very low (walking speed)	0					
Traffic volume	Very high	1	0.5	-0.5	0.5	-0.5	
	High	0.5					
	Moderate	0					
	Low	-0.5					
	Very Low	-1					
Traffic composition	Pedestrians only	0	1	0.5	0.5	0.5	
	Cyclists only	0					
	Pedestrians and cyclists only	0.5					
	Pedestrians and motorized traffic	0.5					
	Pedestrians, cyclists and motorized traffic	1					
Parked vehicles	Present	0.5	0	0.5	0.5	0.5	
	Not present	0					
Facial recognition	Necessary	Additional requirement					
	Not necessary	No additional requirement					
Ambient luminance	Very high	1	0.5	0.5	0.5	-0.5	
	High	0.5					
	Moderate	0					
	Low	-0.5					
	Very low	-1					
Lighting Class P = 6 – SWF			Sum of Weighting Factors	3	1	2	1

Lighting Requirements for **P** Lighting Classes (Pedestrians/Low Speed Areas, CIE 115:2007)



LIGHTING CLASS	Average horizontal illuminance E_m in lx	Minimum horizontal illuminance E_{min} in lx	Threshold Increment TI in % *	Additional requirement if facial recognition is necessary	
				Minimum vertical illuminance $E_{v,min}$ in lx	Minimum semi-cylindrical illuminance $E_{sc,min}$ in lx
P1	15	3.0	20	5.0	3.0
P2	10	2.0	25	3.0	2.0
P3	7.5	1.5	25	2.5	1.5
P4	5.0	1.0	30	1.5	1.0
P5	3.0	0.6	30	1.0	0.6
P6	2.0	0.4	35	0.6	0.4

* Applicable where visual tasks usually considered for the lighting of roads for motorized traffic (M classes) and conflict areas (C classes) are of importance

To provide for uniformity the actual value of the maintained average illuminance may not exceed 1.5 times the value indicated for the class.



Annex: Evaluation of Glare in Conflict Areas

CIE 115:1995, chapter 8 on the lighting of conflict areas:

„It is often **impractical** to use TI for the quantification of disability glare because the non-standard layouts used in conflict areas make its **calculation difficult**, and because the changing viewpoint of the driver makes the **adaptation luminance uncertain**. In these circumstances it is recommended that the glare is restricted by limiting the intensity to 30 cd/klm at 80° of elevation and to 10 cd/klm at 90°, at angles of azimuth at which the luminaires are viewed by the motorist.”

In view of **adaptive road lighting** systems this approach is **not** adequate any longer.

Average / Adaptation Luminance of Conflict Area



- Adaptation luminance fixed as average luminance of luminance class M of comparable lighting level to the selected illuminance class C for the conflict area (CIE 150:2003)
- Average luminance calculated from knowledge of average illuminance E and average luminance coefficient q_0 using

$$L = q_0 \cdot E$$

- Average luminance calculated from knowledge of average illuminance E and diffuse reflectance ρ using

$$L = \rho / \pi \cdot E$$



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End

Thank you very much for your attention.