Planning of road lighting

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Road lighting task

- Good vision depends on eye adaptation level.
- The adaptation of our visual system is influenced by the luminous levels in our environment.
- The main task of road lighting is to assure proper luminous levels in our environment and so to enable good vision.

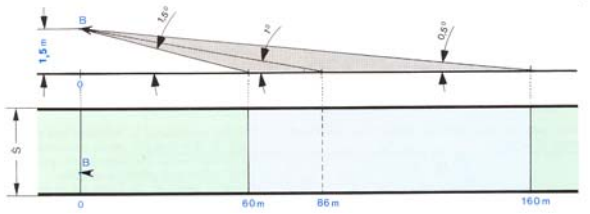
Standardi

Standards about road lighting:

- CEN/TR 13201-1: Guidelines on selection of lighting classes ,
- SIST EN 13201-2: Performance requirements ,
- SIST EN 13201-3: Calculation of performance ,
- SIST EN 13201-4: Methods of measuring lighting performance SIST EN 13201-5: Energy performance indicators .

Field of observation

For the road user, only the part of the road in a field of vision is important.



Field of observation

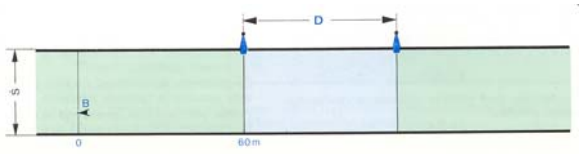
- Eye of the driver is located at a height of 1.5 m above the road on the right half side of the road (point B).
- The view is directed forwards and downwards at an angle of 1°.
- Field of view includes additional 0.5° to each side, covering the area between 0.5° and 1.5°.
- Field observation starts so at 60 m distance from the driver and extends up to 160 m distance.
- There is an international agreement that field of observation always starts at luminaire.

Field of calculation

- When the driver moves forward also the field of observation moves forward and is therefore variable.
- As the field of observation starts at luminaire it chances only until next luminaire and then repeats.
- Driver's field of observation so repeats after every luminaire.
- That is the reason why the field of calculation only includes the longitudinal part of the road between two luminaires.
- In traverse direction field of calculation includes the entire width of the carriageway or the width of the one-direction carriageway if they are separated.

Field of calculation

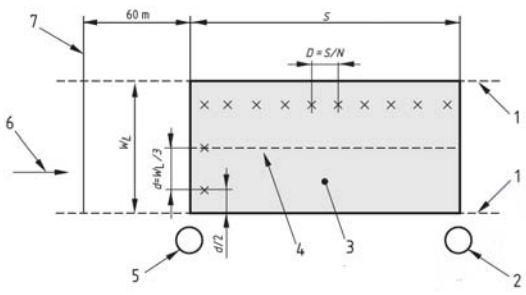
As the situation repeat, it is enough if the calculations are made on field of calculation (between two luminaires) and not on the entire field of observation.



Calculation points

- Calculation points are points in field of calculation in which the luminance or illuminance is calculated or measured.
- Calculation points shall be equally distributed over the entire field of calculation.
- There should be at least 10 points in the longitudinal direction of field of calculation (between two luminaires).
- There should be three rows of calculation points in traverse direction, equally spaced and the first starting at 1/6 of the carriageway width .

Calculation points



Calculation points

In previous picture:

1 .. Edge of carriageway;
2 .. Last luminaire in calculation field;
3 .. Field of calculation;
4 .. Centre-line of lane;
5 .. First luminaire in calculation field;
6 .. Observation direction;
7 .. Observer's longitudinal position.
X .. lines of calculation points in the transverse and longitudinal directions.

Calculation points

Spacing in longitudinal direction:

spacing between points is D=S/N where:

S is spacing between luminaires
N is number of calculation points

if $S \leq 30$ m than N = 10;
if $S > 30$ m then N should be the smallest integer which gives $D \leq 3$ m

Calculation points

Spacing in transverzal direction:

spacing between points is $d = W_L/3$ where:

W_L is width of carriageway

The outermost calculation points are spaced d/2 from the edges of the carriageway.

Luminance and illuminance

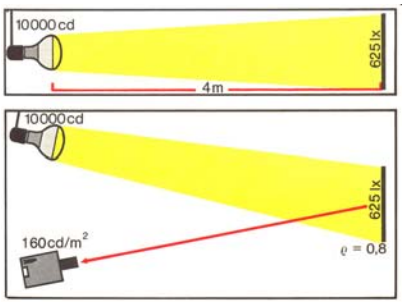
Lighting conditions on the road and around it can be expressed with:

- luminance L (cd/m^2)

and/or

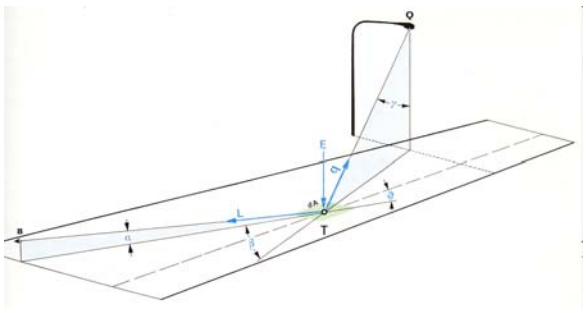
- illuminance E (lx)

Luminance and illuminance



Illuminance depends only on light source and distance to the illuminated area, **luminance** depends also on reflectance of the illuminated area.

Luminance and illuminance



Luminance and illuminance

- Luminance is important on roads with motorized traffic.
- The visual task of driver on such road is clearly defined: the area in front of vehicle..
- The direction of driving also defines the viewing direction.

Luminance and illuminance

On traffic areas with defined viewing direction (roads) the lighting should be planed according to concept of luminance.

Luminance and illuminance

- Luminance of the traffic area depends on:
  - position of the observer;
  - viewing direction;
  - geometry of the luminaire;
  - reflection properties of the traffic surface;
  - luminous flux of the light source;
  - luminous intensity distribution of luminaire.

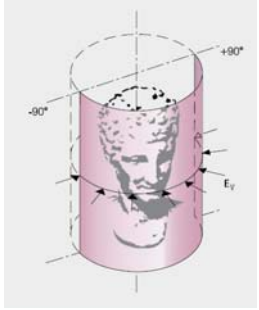
Luminance and illuminance

- On traffic areas for pedestrians and mixed traffic the visual task can not be so clearly defined.
- The same is with viewing direction, which can also not be specified.
- That is why the concept of luminance can not be used in such cases.

Luminance and illuminance

On traffic areas where viewing direction can not be clearly defined and/or are intended for mixed traffic the illuminance concept should be used.

Luminance and illuminance



- Different illuminances should be considered:
- horizontal illuminance of traffic areas as well as (in areas for pedestrians
- vertical,
- hemispherical and
- semicylindrical illuminance

What is the right luminance?

Appropriate values were determined on the basis of different studies and are covered in a variety of recommendations and standards:

- **CIE documents,**
- **EN standards (EN 13201)**
- **national standards.**

What is the right luminance?

			Traffic flow (vehicles per day)		
Separation of carrige-ways	Inter-changes spacing	Intersection density /km	<15.000	15.000 do 25.000	>25.000
Yes	> 3 km		0,75	1,00	1,00
	< 3 km		1,00	1,00	1,50
		< 3	0,75	0,75	1,00
		> 3	0,75	1,00	1,50
no	> 3 km		1,00	1,50	1,50
	< 3 km		1,50	1,50	1,50
		< 3	0,75	1,00	1,50
		> 3	1,00	1,50	1,50

Standards and recommen-dations state minimum luminance (cd/m^2) based on road parameters and traffic:

What is the right luminance?

Standard CEN/TR 13201-1 knows three groups of lighting classes for road lighting:

- **classes M for motorized traffic**
- **classes C for conflict areas**
- **classes P for pedestrian and load speed areas.**

Beside classes P there are also classes HS (hemispherical), SC (semi-cylindrical) and EV (vertical) for pedestrian areas.

What is the right luminance?

First we choose right area and that proper lighting class in this area:

- classes M from M1 to M6
- classes C from C0 to C5
- classes P fromP1 to P7

for the areas for pedestrians we can also choose HS, SC or EV classes based on rcomendations in national standards.

What is the right luminance?

Parameter	Options	Description *		Weighting Value F_W *
Design speed or speed limit	Very high	v ≥ 100 km/h		2
	High	70 < v < 100 km/h		1
	Moderate	40 < v ≤ 70 km/h		-1
	Low	v ≤ 40 km/h		-2
Traffic volume		Motorways, multilane routes	Two-lane routes	
	High	> 65% of maximum capacity	> 45% of maximum capacity	1
	Moderate	35% - 65% of maximum capacity	15% - 45% of maximum capacity	0
	Low	< 35% of maximum capacity	< 15% of maximum capacity	-1
Traffic composition	Mixed with high percentage of non-motorized			2
	Mixed			1
	Motorized only			0
Separation of carriageway	No			1
	Yes			0
Junction density		Intersection/km	Interchanges, distance between bridges, km	
	High	> 3	< 3	1
	Moderate	≤ 3	≥ 3	0
Parked vehicles	Present			1
	Not present			0
Ambient luminosity	High	Shopping windows, advertisement expressions, sport fields, station areas, storage areas		1
	Moderate	normal situation		0
	Low			-1
Navigational task	Very difficult			2
	Difficult			1
	Easy			0

* The values stated in the column are an example. Any adaptation of the method or more appropriate weighting values can be used instead, on the national level.

Selection of M classes: with the help of table the right weighting values are selected and added:

class M=6-VWS

important:

VWS<0 →VWS=0

M≤0 →M=1

What is the right luminance?

After we have selected right M class we can determine the needed parameters from table in SIST EN 13201-2.

Class	Luminance of the road surface of the carriageway for the dry and wet road surface condition				Disability glare	Lighting of surroundings
	Dry condition			Wet	Dry condition	
	$\bar{L}$ in cd/m² [minimum maintained]	U_o [minimum]	U_l [a] [minimum]	U_{ow} [b] [minimum]	TI in % [c] [maximum]	EIR [d] [minimum]
M1	2,00	0,40	0,70	0,15	10	0,35
M2	1,50	0,40	0,70	0,15	10	0,35
M3	1,00	0,40	0,60	0,15	15	0,30
M4	0,75	0,40	0,60	0,15	15	0,30
M5	0,50	0,35	0,40	0,15	15	0,30
M6	0,30	0,35	0,35	0,15	20	0,30

What is the right luminance?

For conflict areas (crossroads, areas with mixed traffic, reduced lane width ..) classes C are used. It such cases the viewing distances are short so C classes give us minimum needed illuminance.

When choosing C class we use M class of the road leading to conflict area and factor Q_0 (road reflection).

What is the right luminance?

If roads with different M classes crosses, smallest M class should be used. For the conflict area the M class is then additional reduced by 1 (eg. M2 insted of M3)

Lighting class M			M1	M2	M3	M4	M5	M6
Lighting class C if $Q_0 \leq 0{,}05$ cd·m^{-2}·lx^{-1}			C0	C1	C2	C3	C4	C5
Lighting class C if $0{,}05$ cd·m^{-2}·lx^{-1} < $Q_0 \leq 0{,}08$ cd·m^{-2}·lx^{-1}		C0	C1	C2	C3	C4	C5	C5
Lighting class C if $Q_0 > 0{,}09$ cd·m^{-2}·lx^{-1}	C0	C1	C2	C3	C4	C5	C5	C5

What is the right luminance?

Parameter	Options	Description *	Weighting Value $f_{W,i}$ *
Design speed or speed limit	Very high	$v \geq 100$ km/h	3
	High	$70 < v < 100$ km/h	2
	Moderate	$40 < v \leq 70$ km/h	0
	Low	$v \leq 40$ km/h	-1
Traffic volume	High		1
	Moderate		0
	Low		-1
Traffic composition	Mixed with high percentage of non-motorized		2
	Mixed		1
	Motorized only		0
Separation of carriageway	No		1
	Yes		0
Parked vehicles	Present		1
	Not present		0
Ambient luminosity	High	shopping windows, advertisement expressions, sport fields, station areas, storage areas	1
	Moderate	normal situation	0
	Low		-1
Navigational task	Very difficult		2
	Difficult		1
	Easy		0

* The values stated in the column are an example. Any adaptation of the method or more appropriate weighting values can be used instead, on the national level.

Proper C class can also be selected with the help of table (eg. for areas in city centers) with the same procedure as for M classes.

C=6-VWS

What is the right luminance?

After we selected the proper C class, the needed illuminance can be found with the help of a table in SIST EN 13201-2.

Class	Horizontal illuminance	
	$\bar{E}$ in lx [minimum maintained]	U_o [minimum]
C0	50	0,40
C1	30	0,40
C2	20,0	0,40
C3	15,0	0,40
C4	10,0	0,40
C5	7,50	0,40

What is the right luminance?

Parameter	Options	Description [a]	Weighting Value F_{Wx} [a]
Travel speed	Low	v ≥ 40 km/h	1
	Very low (walking speed)	Very low, walking speed	0
Use intensity	Busy		1
	Normal		0
	Quiet		-1
Traffic composition	Pedestrians, cyclists and motorized traffic		2
	Pedestrians and motorized traffic		1
	Pedestrians and cyclists only		1
	Pedestrians only		0
	Cyclists only		0
Parked vehicles	Present		1
	Not present		0
Ambient luminosity	High	shopping windows, advertisement expressions, sport fields, station areas, storage areas	1
	Moderate	normal situation	0
	Low		-1
Facial recognition	Necessary		Additional requirements [b]
	Not necessary		No additional requirements

[a] The values stated in the column are an example. Any adaptation of the method or more appropriate weighting values can be used instead, on the national level.
[b] Specific guidelines on use of facial recognition parameter are defined at national level for each country

In the same way the proper P class for pedestrian areas can be found:

P=6-VWS
and:
VWS<0 →VWS=0
P≤0 →P=1

What is the right luminance?

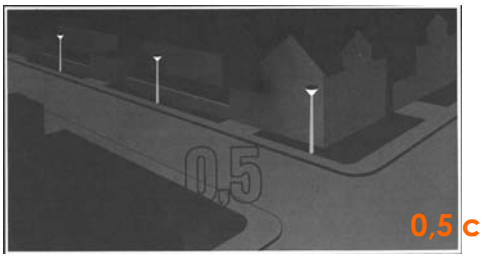
And minimum needed illuminance and its uniformity from SIST EN 13201-2.

Class	Horizontal illuminance	
	$\bar{E}$ in lx [a] [minimum maintained]	E_{min} in lx [maintained]
P1	15,0	3,00
P2	10,0	2,00
P3	7,50	1,50
P4	5,00	1,00
P5	3,00	0,60
P6	2,00	0,40
P7	performance not determined	performance not determined

[a] To provide for uniformity, the actual value of the maintained average illuminance must not exceed 1,5 times the minimum $\bar{E}$ value indicated for the class

What is the right luminance?

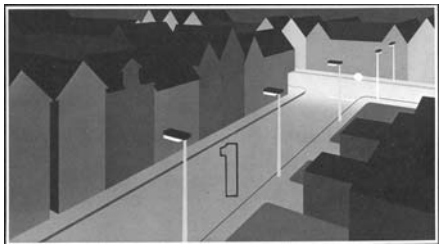
Streets with low traffic rate, low number of intersections.



0,5 cd/m²

What is the right luminance?

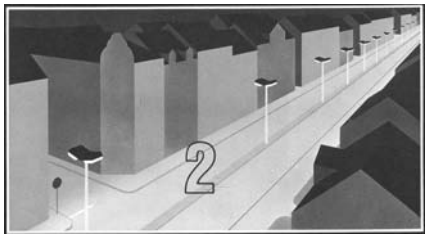
Roads with medium traffic rate, medium density of intersection.



1,0 cd/m²

What is the right luminance?

Roads with high traffic rate and/or high number of intersections …



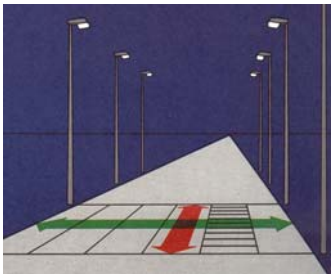
2,0 cd/m²

Uniformity of the luminance

- Objects (obstacles on the road) are only noticeable if there is a contrast between them and the surroundings.

- Proper luminance is not enough. We also need good uniformity to model a background for objects to be noticed.

Uniformity of the luminance



Needed overall uniformity of the luminance U_0 as well as longitudinal one U_l can be found in standards. Sometimes also transverse uniformity U_t is important also.

Uniformity of the luminance

Minimum needed overall and longitudinal uniformities are listed in a same table as needed luminance.

Class	Luminance of the road surface of the carriageway for the dry and wet road surface condition				Disability glare	Lighting of surroundings
	Dry condition			Wet	Dry condition	
	$\bar{L}$ in cd/m² [minimum maintained]	U_o [minimum]	U_l [a] [minimum]	U_{ow} [b] [minimum]	TI in % [c] [maximum]	EIR [d] [minimum]
M1	2,00	0,40	0,70	0,15	10	0,35

Uniformity of the luminance

How different longitudinal uniformities look like?

$U_l = 0,5$

Uniformity of the luminance

How different longitudinal uniformities look like?

$U_l = 0,625$

Uniformity of the luminance

How different longitudinal uniformities look like?

$U_l = 0,77$

Uniformity of the luminance

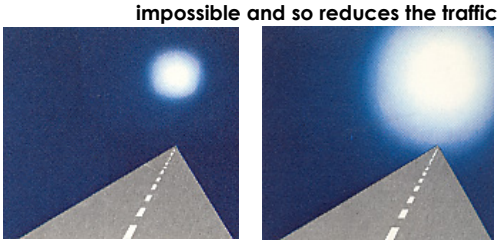
And in a real world: bad and good uniformity of luminance.

Uniformity of the luminance

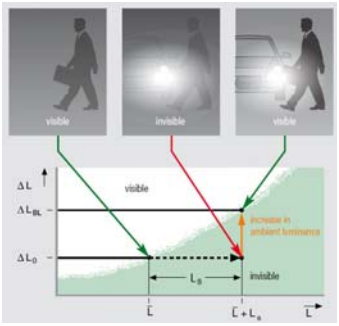
And in a real world: good and bad uniformity of luminance.

Limiting glare

Glare can impair visual performance to such an extent that reliable perception and identification are impossible and so reduces the traffic safety.



Limiting glare

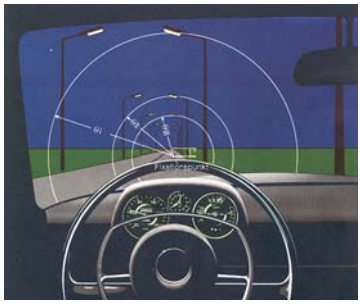


At adaptation luminance L, one need a luminance contrast ΔL_O (between object and surroundings) for the object to be visible.
Because of glare, veiling luminance causes eye to adapt to higher luminance level L+ L_s so at contrast ΔL_O, object is invisible.
To make it visible, the contrast needs to be increased to ΔL_{BL}.

Limiting glare

According to the position of the driver and the luminaire, glare is mostly caused by luminous intensities at 80° and higher.

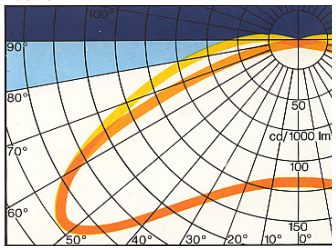
Limiting glare



Each luminaire is seen under different angle with respect to view direction. Smaller angle means more glare.

Limiting glare

worse
better



In older recommendations glare was limited by limiting luminous intensity at the angles between 80°and 90°. Today the Threshold Increment is used instead:

$$TI = \frac{\Delta L_B - \Delta L_{\min}}{\Delta L_{\min}}$$

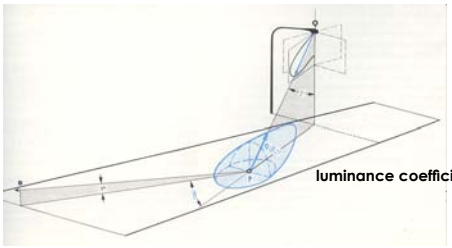
Road surface

As luminance of the traffic area depends on properties of its surface (reflectance), it is necessary to include this into planning process. There are two main characteristics of a surface:

- roughness χ_p (rough, smooth)
- reflectance q_0 (light, dark)

Road surface

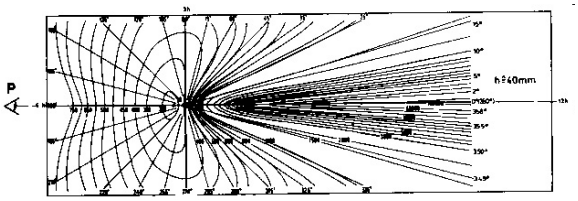
Reflectance of road surface can be presented with help of q-body ...



luminance coefficient $q = \frac{L}{E}$

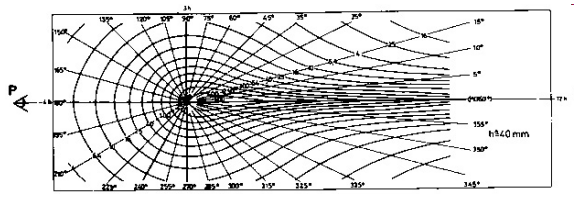
Road surface

… or in CIE-q diagram or …



Road surface

… in CIE-r diagram.



reduced luminance coefficient $r = q \cdot \cos^3 \gamma$

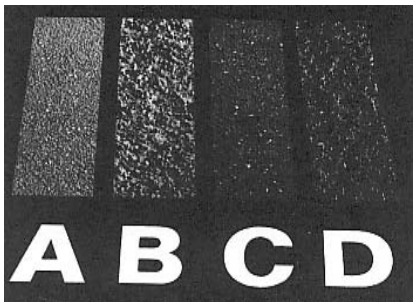
Road surface

The process can be simplified by using
"Standard reflection road classes":

R I … mostly diffuse reflectance
R II … mixed (diffuse & specular) reflectance
R III … slightly specular reflectance
R IV … mostly specular reflectance

RV … specular reflectance

Road surface



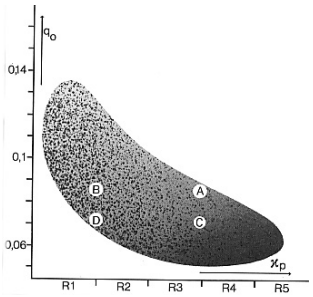
A … light, smooth

B … light, rough

C … dark, smooth

D … dark, rough

Road surface



The best lighting conditions can be achieved on light and rough surfaces (B), critical are dark and smooth surfaces (C).

Illuminance of traffic areas

In a similar way as the characteristics of lighting for roads and other traffic surfaces for motorized traffic are chosen, we also chose characteristics for lighting of traffic areas for pedestrians and mixed traffic.

The difference is that in this case we need to determine the proper minimum illuminance.

Quality criteria

Quality criteria for road lighting are:

- luminance level;
- uniformity of the luminance;
- glare limitation;
- optical guidance;
- illuminance level;
- uniformity of illuminance.

Selection of luminaires

The most important criterion for the selection of luminaires are good technical characteristics which assure proper luminance and/or illuminance levels. But other characteristics should not be neglected.

Selection of luminaires

Design

As the luminaires are installed practicaly on every 30 m of traffic areas the design (form) is also very important.

Selection of luminaires

Construction details

Appropriate design and construction of the luminaire makes the installation and maintenance easier which means savings in time and money.

Selection of luminaires

Materials

Housing and other mechanical parts of the luminaire must be resistant to corrosion. The materials should be light weighted and should have the appropriate mechanical properties and durability.

Selection of luminaires

Safety

is also an important issue. Both mechanical and electrical safety (reducing risk of touching live parts) are important.

Selection of light source

Selection of light source influences:

- Needed luminous flux of the luminaire;
- luminous intensity distribution;
- number of poles and distance between them;
- wanted colour of light;
- wanted colour rendering index;
- efficiency of installation;
- installed electrical power;
- maintenance interval.

Light emitting diode (LED)

Solid state light source based on blue power LED and orange phosphor:

mperature: 2700 - 6000 K.

fficiency: 50 to 150 lm/W.

Live span: 30.000 to 50.000 h.

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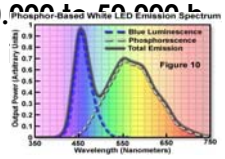


High pressure sodium lamp

Working pressure 0,25 bar, working temperature 1000 K.

Yellowish white light.

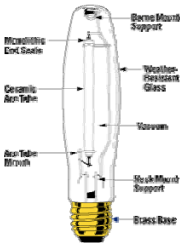
Colour temperature: 2200 K.

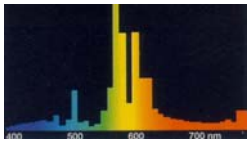
Efficiency: 95 to 150 lm/W.

Live span: up to 24.000 h.

Colour rendering index: 20 - 65.

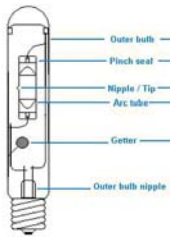
Electrical power up to: 1000 W.



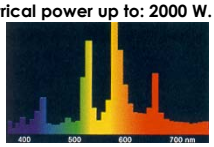


Metal halide lamp

Based on high pressure mercury lamp but with added metal halide compounds in the arc tube, which improve the efficiency and CRI of the light.

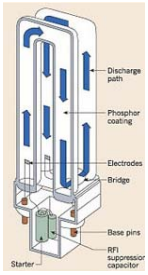


Efficiency: 67 to 95 lm/W.
Life span: 15.000 h.
Colour temperature: 3000 - 6000 K.
Colour rendering index: up to 95.
Electrical power up to: 2000 W.

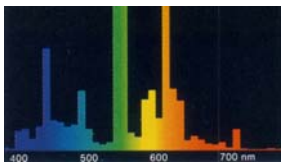


Compact fluorescent lamp

The same as fluorescent lamp but in compact design. Not for use in cold environments.

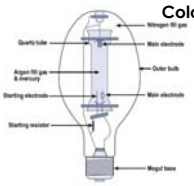


Efficiency: up to 70 lm/W.
Life span: 12.000 h.
Colour temperature: 2700 - 6500 K.
Colour rendering index: up to 85.

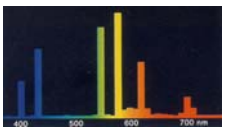


High pressure mercury lamp

Mercury vapor gives mostly UV light so fluorescent powder costing is used to transfer UV to visible light.

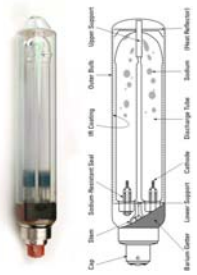


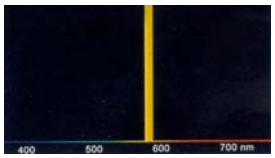
Efficiency: up to 60 lm/W.
Life span: >15.000 h.
Colour rendering index: 23 - 55.
Colour temperature: 2000 - 4000 K.
Electrical power up to: 400 W



Low pressure sodium lamp

Mostly for road lighting, not suitable for pedestrian areas.
Best efficiency: up to 200 lm/W.
monochromatic light: yellow at 589 nm.
Colour temperature: 1750 K.
Life span: 16.000 h.
Electrical power up to: 180 W



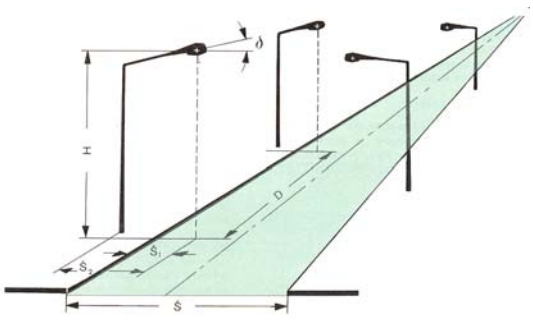


Geometry of lighting installation

Geometry of lighting installation is characterized by following parameters:

- mounting height (H);
- distance between luminaires (D);
- carriageway width (S);
- luminaire overhang (S1);
- luminaire outreach (S2);
- upcast (tilt) angle (δ).

Geometry of lighting installation



Pole placement

The placement of the poles for luminaires could be:

- one sided placement;
- axial placement;
- two sided opposite placement;
- median placement and
- two sided staggered placement.

Pole placement should always be chosen according to road parameters and circumstances.

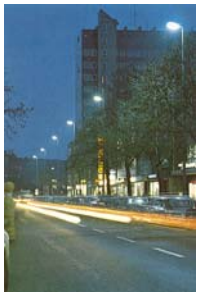
Pole placement

For different types of traffic areas and for different parts of the city, different pole placements (red dots in picture) are suitable.

One sided placement

- One sided placement is suitable for roads with small carriageway width (up to 10 m).
- Luminaire mounting height (H) must be equal or greater as carriageway width (S): (S/H)<=1
- Luminaires are usually mounted on poles.
- Luminance on lane closer to poles is larger as on the other lane.

One sided placement

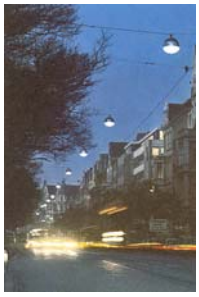


- On one-way roads poles should be placed on right side.
- On two-way roads poles should be placed on the side where the traffic is denser.
- At curves poles should be placed on outer side.

Axial placement

- Axial placement is usually used on roads where the buildings are located on both sides of the road (easier installation).
- Also here luminaire mounting height (H) must be equal or greater as carriageway width (S): (S/H)<=1

Axial placement

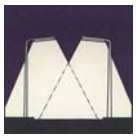


Disadvantages of this placement are:

- luminaires may be swinging because of wind.
- maintenance may cause traffic problems.

Advantage is that the (transverse) uniformity of luminance is better.

Two sided placement



- Two sided placement is used in case of wider carriageways (over 10 m), with no or only narrow (less than 2m) median.
- Two sided opposite or two sided staggered placement can be used: (S/H)<1,5.
- At two sided staggered placement the height of the luminaire can be lower that width of carriageway: (S/H)>1.
- If median is wider, we can additionally use also median placement.

Two sided placement

- The advantage of this placement is that right lane is better illuminated as left one (good for traffic safety reasons).
- Installation and maintenance of luminaires is easier as it is carried out from position outside the carriageway.

Median placement

- It is used in the case of two carriageways with a width of less than 10 m and with width of median between 2 m and 6 m.
- Luminaires are mounted on a two-arm pols positioned in the middle of median.
- Luminance distribution is about the same as at one-side placement, although it should be take into account that all luminaires illuminate both carriageways.

Median placement

- If the carriageway is widther then 10 m and width of median is less than 6 m, additional luminaires in two sided placemen on outer sides should be used.
- Placement of these might be two sided opposite (S=1 .. 1,5 H) or two sided staggered (S>1,5 H).

Special cases - guidance

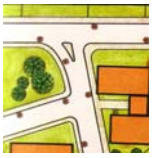
- In curves luminaires should be placed on outer side - better optical guidance.

Special cases - marking

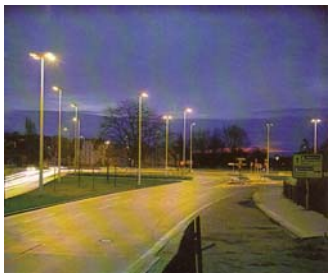
- Crossroads and other conflict areas may be „marked" with increased luminance or other light colour or with different placement of the pols.

Special cases - marking

- End of the road (crossroad with priority road) can be „marked“ by increased luminance and a pole on the other side.

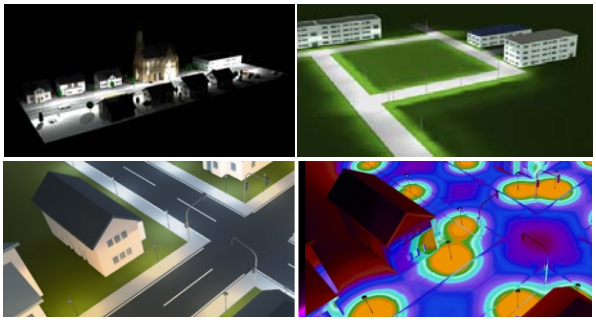


Special cases - marking



- Larger traffic areas (crossroads, roundabouts, markets …) should have at least the same luminance as roads, but could be „marked“ with higher one or with different light colour.

Computer simulation



Calculation of illuminance

Like luminance also illuminance can be calculated with different methods:

- using efficiency coefficients;
- using z iso-lux diagram;
- using grafo-analytical method;
- using computer simulation.

Computer simulation

Measurement of the road lighting

What should be measured in road lighting:

- luminance of the road surface;
- uniformity of luminance;
- illuminance of the traffic area and
- uniformity of the illuminance.

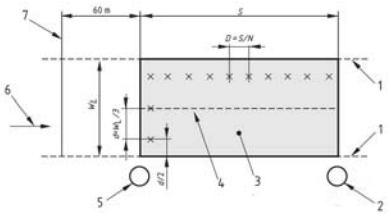
Measurement of the road lighting

Checking luminance values:
luminance of road surface can be measured in two ways:

- measurements of luminance in calculation points;
- measurement of average luminance in a field of calculation or observation with integration luminance meter.

Measurement of the road lighting

Measurement of luminance should be made in calculation points.

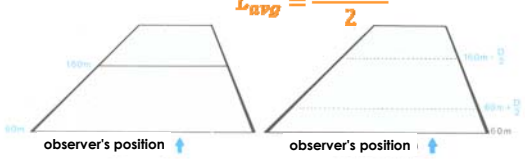


$$L_{avg} = \frac{1}{n} \cdot \sum_{i=1}^{n} L_i$$

Measurement of the road lighting

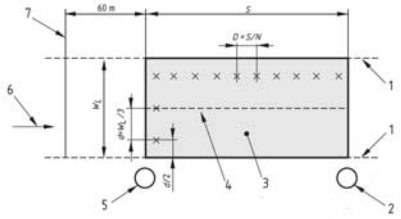
Measurement of average luminance with integration luminance meter (two measurements need to be done).

$$L_{avg} = \frac{\bar{L}_1 + \bar{L}_2}{2}$$



Measurement of the road lighting

Calculation of overall uniformity of luminance:
Overall uniformity of luminance (U_0) is calculated from average measured luminance and minimum one:



$$U_0 = \frac{L_{min}}{\bar{L}}$$

Measurement of the road lighting

Calculation of longitudinal uniformity of luminance:
Longitudinal uniformity of luminance (U_l) is calculated from maximum and minimum measured luminance in central line of calculation points:

$$U_l = \frac{L_{l\,min}}{L_{l\,max}}$$

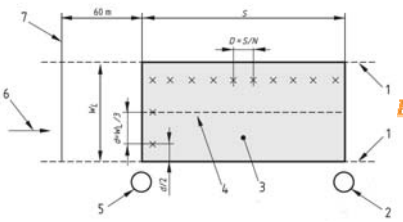
Measurement of the road lighting

Cheking illuminance values:

Level of illuminance on the traffic area is established by measurement of illuminance in calculation points inside calculation area. The measurements should be made in same points as the calculations were done.

Measurement of the road lighting

Illuminance measurements should be made in calculation points:



$$E_{avg} = \frac{1}{n} \cdot \sum_{i=1}^{n} E_i$$

Measurement of the road lighting

Calculation of uniformity of illuminance:

Overall, longitudinal or transverse uniformity of illuminance can be calculated from the measures minimum and average illuminance or minimum and maximum illuminance.

$$U_{E1} = \frac{E_{min}}{\bar{E}} \qquad U_{E2} = \frac{E_{min}}{E_{max}}$$

Planning process

1. Needed data

- surrounding situation;
- characteristic road profile;
- data of road surface layer (pavement);
- data of current and future use of road;
- requirements of investor.

Planning process

2. Lighting standards and recommendations

It should be checked which standards and recommendations need to be used:

- CIE recommendations;
- EN standards;
- national and local standards and recommendations…

Planning process

3. Technical characterization of the road

Based on gathered road data and valid standards and recommendations, the lighting class for the road should be chosen.

Planning process

4. Needed luminance and/or illuminance values

According to the class of the road the needed values for luminance, illuminance, uniformity, TI … should be chosen from the standards or recommendations.

Planning process

5. Reflectance properties of the road pavement

Based on reflectance characteristics of the road (pavement) we need to chose one of following:

- standard reflection road class or
- luminance coefficient q_0.

Planning process

6. Selection of pole placement

Based on road geometry and surroundings (road width, urbanization…) the best standard or special pole placement should be chosen.

Planning process

7. Lighting sources and luminaires

Based on traffic data, geometry, technical conditions … appropriate lighting sources and luminaires should be chosen. Aesthetic appearance of lighting installation should also be considered.

Planning process

8. Geometry of lighting installation

Based on gathered data we need to select:

- mounting height (H);
- luminaire overhang (S1);
- luminaire outreach (S2);
- upcast (tilt) angle (δ)
- distance between luminaires (D).

Planning process

9. Control calculation

Based on data and selected light sources, luminaires and geometry, following should be calculated:

- luminance (illuminance);
- uniformity;
- threshold increment.

Planning process

10. Selection of best variant

More than one variant of the project should be made and compared. All of them need to fulfill lighting requirements. At the end, the best should be selected according to:

- economic criteria;
- aesthetic appearance;
- needed maintenance.

Conclusions …

- Planning of road lighting starts with selection of needed parameters from standards and recomendations..
- Follows selection of lighting sources, luminaires, poles, their placement … .
- At the end the lighting instalation should be checked if it fulfills the needed requirements.

… end:

Questions?