

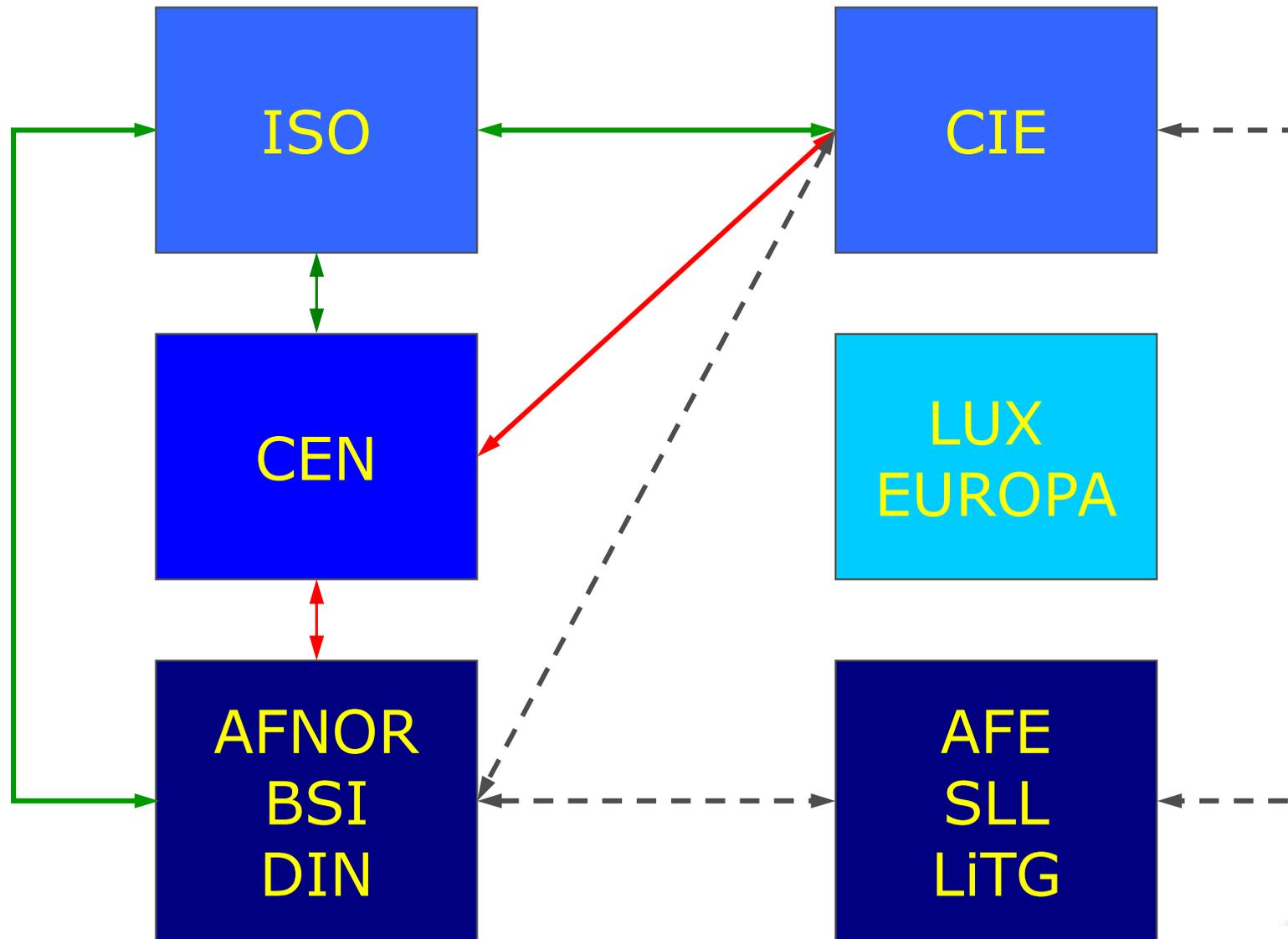
TAKING
COOPERATION
FORWARD

 Transnational Seminar - Module IV, Cesena/Italy, 23./24.10.2018

 **Public Lighting Standards - Part I (fundamentals)**

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Standardisation Bodies - the Network



The six Divisions of the International Commission on Illumination (CIE), 2018

- Division 1 Vision & Colour
- Division 2 Physical Measurement of Light and Radiation
- Division 3 Interior Environment and Lighting Design
- Division 4 Transportation and Exterior Applications

CIE 115:2010 “Lighting of roads for motor and pedestrian traffic”

- Division 6 Photo-biology and Photo-chemistry
- Division 8 Image Technology



- The purpose of **road lighting in general** is to provide visual cues and to reveal obstacles, so that a **safe vehicular operation is possible**.
- **Fixed road lighting** provides not only illumination on the road, but also on the nearby surroundings revealing extraneous objects and **is opening up the field of view**.
- This is of particular importance in **areas of high visual complexity** where there may be different types of road users at the same time (motorists, cyclists, pedestrians, slow moving vehicles).
- The **lighting of residential areas** is mainly provided to give safe passage to pedestrians, to reveal obstacles on their way, and **to enable the recognition of people**.



- The European Committee for Standardization (CEN), a public standards organization, was founded in 1961 with the aim to promote the economy of the European Union (EU) in global trading, the welfare of European citizens and the environment by providing an efficient infrastructure to interested parties for the development, maintenance and **distribution of coherent sets of standards and specifications**.
- European Standards can be used to **enhance safety, security and performance, improve energy efficiency, and protect consumers, workers and the environment**. European standards are **developed by teams of experts who**, nominated by their national standardization organisation, **have particular knowledge** of the specific sector or topic that is being addressed.
- **Standards are prepared by Technical Committees** (TCs). Each Technical Committee has its own field of operation within which a work programme of identified standards is developed and executed.



- One of the about 400 CEN Technical Bodies is the **Technical Committee CEN/TC 169 'Light and Lighting'**.
- This committee is responsible for **standards in the field of vision**, photometry and colourimetry, involving natural and man-made optical radiation over the ultra-violet, the visible and the infrared regions of the spectrum, and application subjects **covering all usages of light, indoors and outdoors, including environmental, energy and sustainability requirements and aesthetic and non-image forming biological aspects**.
- Altogether there are **14 working groups** (WGs) dealing with the elaboration of standards covering the different aspects of light and lighting.
- **In the field of road lighting the most important working group is the CEN/TC 169 'Light and lighting' and CEN/TC 226 'Road equipment' joint working group 'Road lighting' (CEN/TC 169 WG12).**



- **WG1 Basic Terms and Criteria (EN 12665)**
- WG2 Lighting of Work Places (EN 12464-1/2, EN 13032-2)
- WG3 Emergency Lighting (EN 1838, EN 13032-3)
- WG4 Sports Lighting (EN 12193)
- WG5 Road Lighting (EN 13201:2003)
- WG6 Tunnel Lighting (CR 14380, EN 16276)
- **WG7 Photometry (EN 13032-1, EN 13032-4)**
- WG8 Photobiology (EN 14255, EN 16237)
- WG9 Energy Performance of Buildings - Energy Requirements for Lighting (EN 15193)
- WG10 Performance of Optical Materials for Luminaires (EN 16268)
- WG11 Daylight (EN 17037)
- **WG12 TC169/226 JWG Road Lighting (TR/EN 13201, EN 13032-5)**
- WG13 Effect of Light on Human Beings
- WG14 ErP Lighting Mandate Management Group



- It is the scope of CEN/TC 169 Working Group 12 to **specify lighting requirements for all classes of roads and road users** which meet the needs of visual performance, comfort and safety.
- **It gives lighting values** in terms of average luminances, average and minimum illuminances, uniformities, illuminance ratios, glare restrictions and the colour properties of the light sources to design and control road lighting installations and **methods to calculate and measure these values.**
- The working group also provides details on how to **measure and control the energy efficiency of road lighting installations.**
- **Documents concerning road lighting should not be in contradiction** to other reports or standards, in particular to those elaborated by working groups of CEN/TC 169 'Light and lighting'.



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- The **main objective** of this project is to make a shift from conventional municipal infrastructure planning towards a modern **energy efficient and demand-orientated lighting** design and better light and energy management.
- The process itself presents smart solutions that will be developed and implemented as **test pilots within the project lifetime**.
- They will significantly contribute to the reduction of CO₂-emissions in local districts and regions and enhance the quality of stay.
- The **specific objectives** comprise the promotion of user-accepted energy efficient lighting solutions by improving the quality of light according to social needs and to **harmonize public lighting standards and norms**.



- (Urban) **dynamic lighting is adaptive lighting**, i.e. it is being provided **where and when it is needed** depending on different variable conditions, such as **travelling speed, traffic volume and/or composition, ambient luminances, weathers and other exterior factors** in a way that **it reduces light pollution as well as energy consumption; beyond that it recognizes varying human and social needs**, such as aesthetics or feeling of safety, as a basic concern and key factor in the design of adaptive public lighting



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- **M classes** are intended for drivers of **m**otorized vehicles for use on traffic routes allowing medium to high driving speeds
- **C classes** are also intended for drivers of motorized vehicles, but for use on conflict areas
- **P classes and HS classes** are intended for **p**edestrians and pedal cyclists
- **SC classes** are intended as an additional class in situations where public lighting is necessary for identification of persons
- **EV classes** are intended as an additional class in situations where vertical surfaces need to be seen



- In the European standard EN 13201-2:2015 'Road lighting - Part 2: Performance requirements' **a lighting class is defined by a set of photometric requirements** aiming at the visual needs of certain road users in certain types of road areas under specified environmental conditions.
- In this European standard **which has to be implemented by the national standards organizations** of the participating countries there are basically **three more important sets of lighting classes** described:

M classes for areas intended for **m**otorized traffic

C classes for **c**onflict areas

P classes for **p**edestrian and low speed areas



- The controlling criteria for the lighting of roads for motorized traffic are the luminance level and uniformity of the carriageway, the illuminance level of the surrounds of the road, and the limitation of disability glare.
- The most important (**fixed or time-dependent**) parameters to be considered are:
 - Speed
 - Traffic volume
 - Traffic composition
 - Separation of carriageways
 - Intersection density
 - Parked vehicles
 - Ambient luminance
 - Difficulty of navigational task / Visual guidance / Traffic control



Lighting Classes M for Motorized Traffic

Lighting class	Road surface luminance			Wet	Threshold increment	Lighting of the surroundings
	Dry		U_{ow}			
	L_{av} in cd/m^2	U_o		U_l	f_{TI} in %	R_{EI}
M1	2.00	0.40	0.70	0.15	10	0.35
M2	1.50	0.40	0.70		10	0.35
M3	1.00	0.40	0.60		15	0.30
M4	0.75	0.40	0.60		15	0.30
M5	0.50	0.35	0.40		15	0.30
M6	0.30	0.35	0.40		20	0.30

L_{av} average luminance
 U_o overall uniformity
 U_l longitudinal uniformity

U_{ow} overall uniformity, **wet**
 f_{TI} threshold increment
 R_{EI} edge illuminance ratio



- Conflict areas occur wherever **vehicle streams intersect each other** or run into areas frequented by pedestrians, cyclists, or other road users.
- Areas showing a **change in road geometry**, such as a reduced number of lanes or a reduced lane or carriageway width (an area with measures of traffic calming), are also regarded as conflict areas.
- Their existence results in an **increased potential for collisions** between vehicles, between vehicles and pedestrians, cyclists and other road users, and/or between vehicles and fixed objects.
- The **lighting of a conflict area** should reveal the position of the kerbs and the road markings, the directions of the roads, the presence of pedestrians, other road users, and/or obstructions, and the movement of vehicles in the vicinity.



- C classes are mainly intended for use when conventions for road surface luminance calculations do not apply, e.g. viewing distances are less than 60 m.
- The controlling criteria for the lighting of conflict areas are the **average illuminance** and the **overall uniformity** of the carriageway only or also of different other road areas.
- In addition it could be necessary to calculate **threshold increment** for relevant observer positions and viewing directions in the conflict area (**limitation of disability glare**).



Lighting Classes C for Conflict Areas

Lighting class	Average illuminance over whole of used surface E_{av} in lx	Uniformity of illuminance U_o (E)	Threshold increment f_{TI} in %
C0	50	0.40	15
C1	30	0.40	15
C2	20	0.40	15
C3	15.0	0.40	20
C4	10.0	0.40	20
C5	7.50	0.40	20



- The lighting classes P are intended predominantly for **pedestrians and pedal cyclists** for use on footways and cycle ways, but also for drivers of **motorized vehicles at low speed** in pedestrian areas, on emergency or parking lanes, and for other road areas lying separately or along a carriageway of a traffic route or a residential road etc.
- The **visual tasks, sometimes vertical**, i.e. **recognition of faces**, and needs of pedestrians differ from those of drivers in many respects.
- **Speed of movement is generally much lower** and relevant objects to be seen are closer than those important for drivers of motorized vehicles.



Lighting Classes P for Pedestrian Areas

Lighting Class	Average horizontal illuminance $E_{h,av}$ in lx ^a	Minimum horizontal illuminance $E_{h,min}$ in lx	Threshold increment f_{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	15.0	3.00	20	5.0	3.0
P2	10.0	2.00	25	3.0	2.0
P3	7.50	1.50	25	2.5	1.5
P4	5.00	1.00	30	1.5	1.0
P5	3.00	0.60	30	1.0	0.6
P6	2.00	0.40	35	0.6	0.4
P7	---	---	---	---	---

^a To provide for uniformity, the actual value of the maintained average illuminance shall not exceed 1,5 times the average value indicated for the class.



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- Horizontal (E_h), vertical (E_v), hemispherical (E_{hs}) and semi-cylindrical (E_{sc}) illuminances **as maintained values**
- Road surface luminances (L_p) **as maintained values**
- Overall (U_o) and longitudinal (U_l) uniformities
- Threshold increments (TI) **as initial values**
- Edge Illuminance Ratio (EIR)



- Luminaires are regarded as point sources of light
- Validity of inverse square law
- The road surface is flat and level and has uniform reflection properties over the area considered, (standard or extended r-tables)
- Light reflected from the surrounds and inter-reflected light is disregarded as well as obstruction to the light from luminaires by trees and other objects
- Atmospheric absorption is regarded as zero



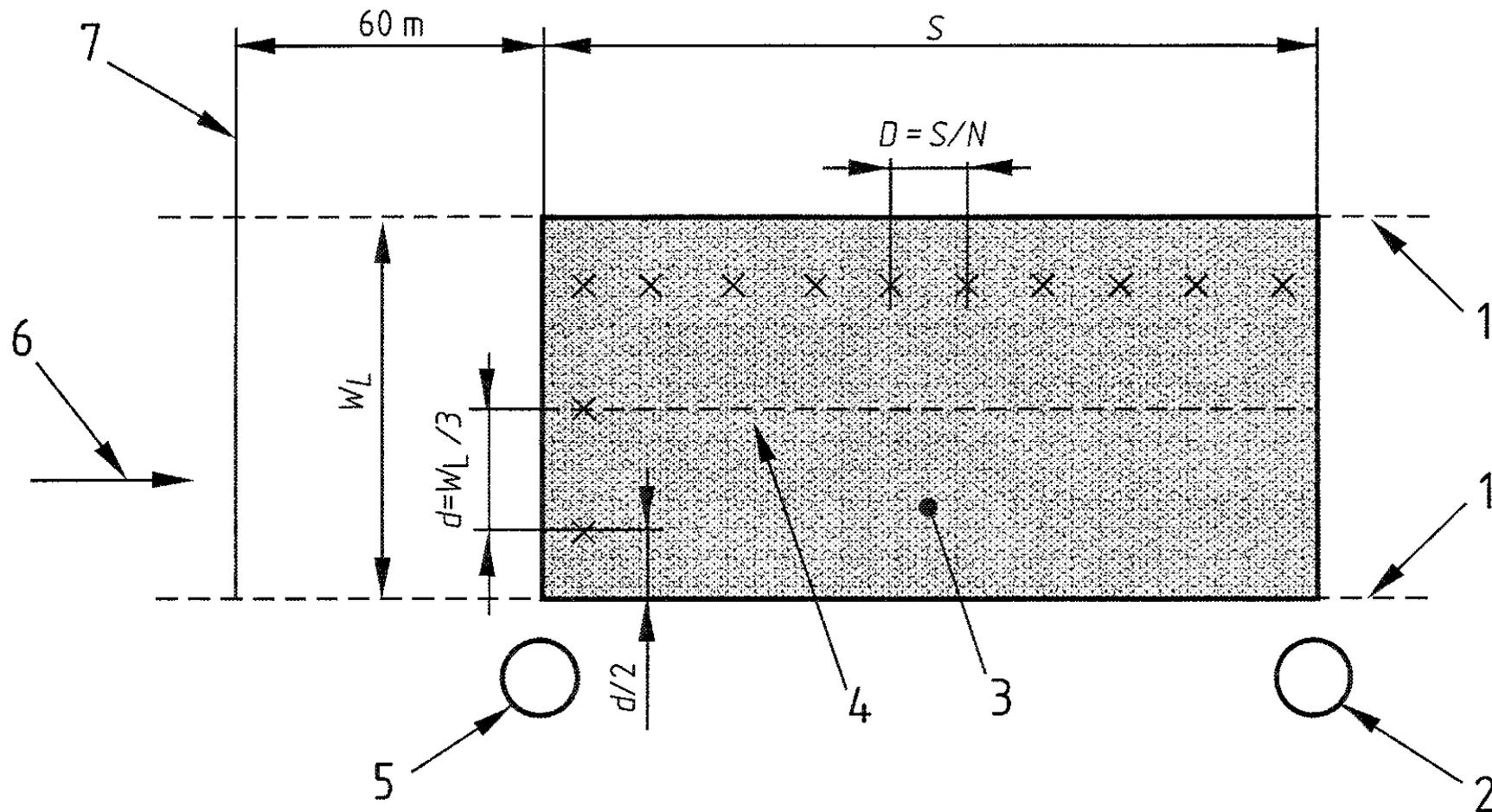
- Interpolation of luminous intensity distribution:
always linear for $\Delta C \leq 5^\circ$ and $\Delta \gamma \leq 2.5^\circ$
Note: The angular spacings should be reduced in case of luminous intensity distributions with great variations (LED).
- Interpolation of standard or extended r-tables always linear
- Observer (line of sight 1° below the horizontal) in the centre line of each lane for the calculation of L , U_o , U_l , and TI
- All luminaires within the boundary of the r-tables to be included in the calculation



- Length of calculation field is equal to luminaire spacing S
- Number N of calculation points along calculation field:
 $S \leq 30 \text{ m} \Rightarrow N = 10$, $S > 30 \text{ m} \Rightarrow S / N \leq 3 \text{ m}$
- Width of calculation field W is equal to the width of the carriageway
- For the calculation of road surface luminances 3 calculation points per lane across, otherwise
 $W \leq 4.5 \text{ m} \Rightarrow n = 3$, $W > 4.5 \text{ m} \Rightarrow W / n \leq 1.5 \text{ m}$

The number of calculation points is not sufficient to show non-uniformities caused by luminous intensity distributions with great variations (LED).





1 ... Edge of lane, 2 ... Last luminaire, 3 ... Field of calculation, 4 ... Centre line of lane,
5 ... First luminaire, 6 ... Observation direction, 7 ... Observer's longitudinal position

- It is generally agreed that **discomfort glare** produced by an individual source **depends on four parameters**, i.e. the **source luminance** in the direction of the observer's eye, the **solid angle** subtended by the source at the observer's eye, the **angular displacement** of the source from the observer's line of sight, and the general field luminance controlling the **adaptation level** of the observer's eye
- According to the Holladay formula, the **disability glare** effect is described as an equivalent uniform luminance resulting from stray light in the eye which superimposes on the location of the vertical image, thus lowering the contrast. This equivalent **veiling luminance** depends mainly on two parameters, i.e. the **illuminance on the observer's eye** produced by the **glare source** in the plane perpendicular to the line of sight, and the **angle** between the centre of the glare source and the line of sight



Calculation of Veiling Luminances and Threshold Increments (I), EN 13201-3:2015

- Observer in the centre line of each lane
- Observer's eye at a height of 1.5 m above road level
- First observer longitudinally at a distance of $2.75 \cdot (H - 1.5)$ meters in front of the calculation field (H ... Mounting height)
- Luminaires above a screening plane, which is inclined at 20° to the horizontal, are excluded from the calculation
- Calculation is repeated with the with the observer moved forward in increments of S / N
- Summation is performed for the first luminaire in the direction of observation and the luminaires beyond, up to a distance of 500 m in each luminaire row, using Fry's formula with $(1.5^\circ \leq \Theta \leq 60^\circ)$



Veiling luminance L_{vk} of pending luminaire k is calculated using either

$$L_{vk} = 9,86 \cdot \left[1 + \left(\frac{A_y}{66,4} \right)^4 \right] \frac{E_k}{\theta_k^2} \quad \text{when } 1.5^\circ < \Theta_k \leq 60^\circ$$

or

$$L_{vk} = E_k \cdot \left(\frac{10}{\theta_k^3} + \left[\frac{5}{\theta_k^2} \right] \cdot \left[1 + \left(\frac{A_y}{62,5} \right)^4 \right] \right) \quad \text{when } 0.1 < \Theta_k \leq 1.5^\circ$$

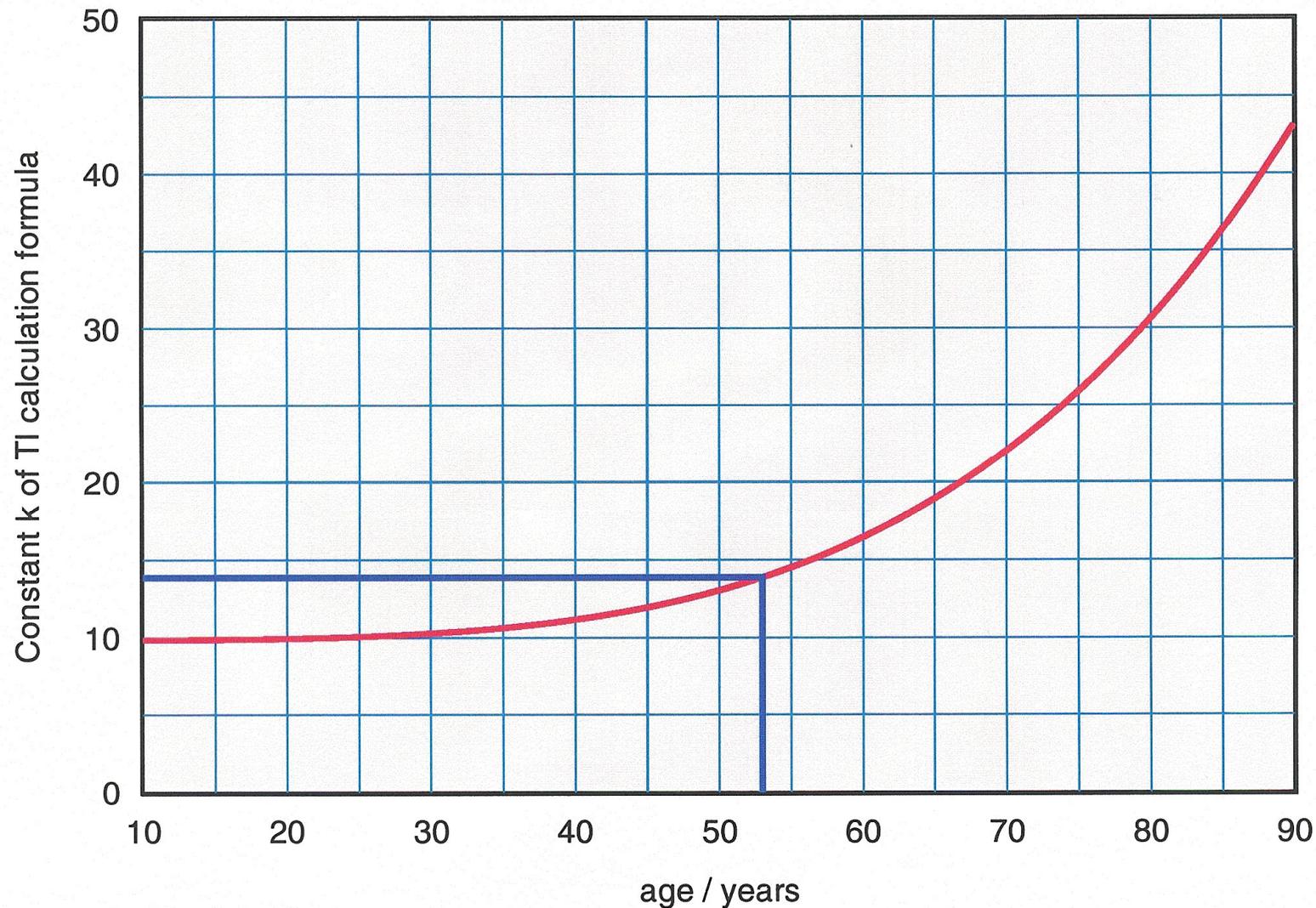
E_k initial illuminance produced by k^{th} luminaire (lx)

Θ_k angle between the line of sight and the centre of the k^{th} luminaire ($^\circ$)

A_y age of observer in years



Calculation of Veiling Luminances and Threshold Increments (III), EN 13201-3:2015



Constant k of veiling luminance / TI calculation formula as function of age

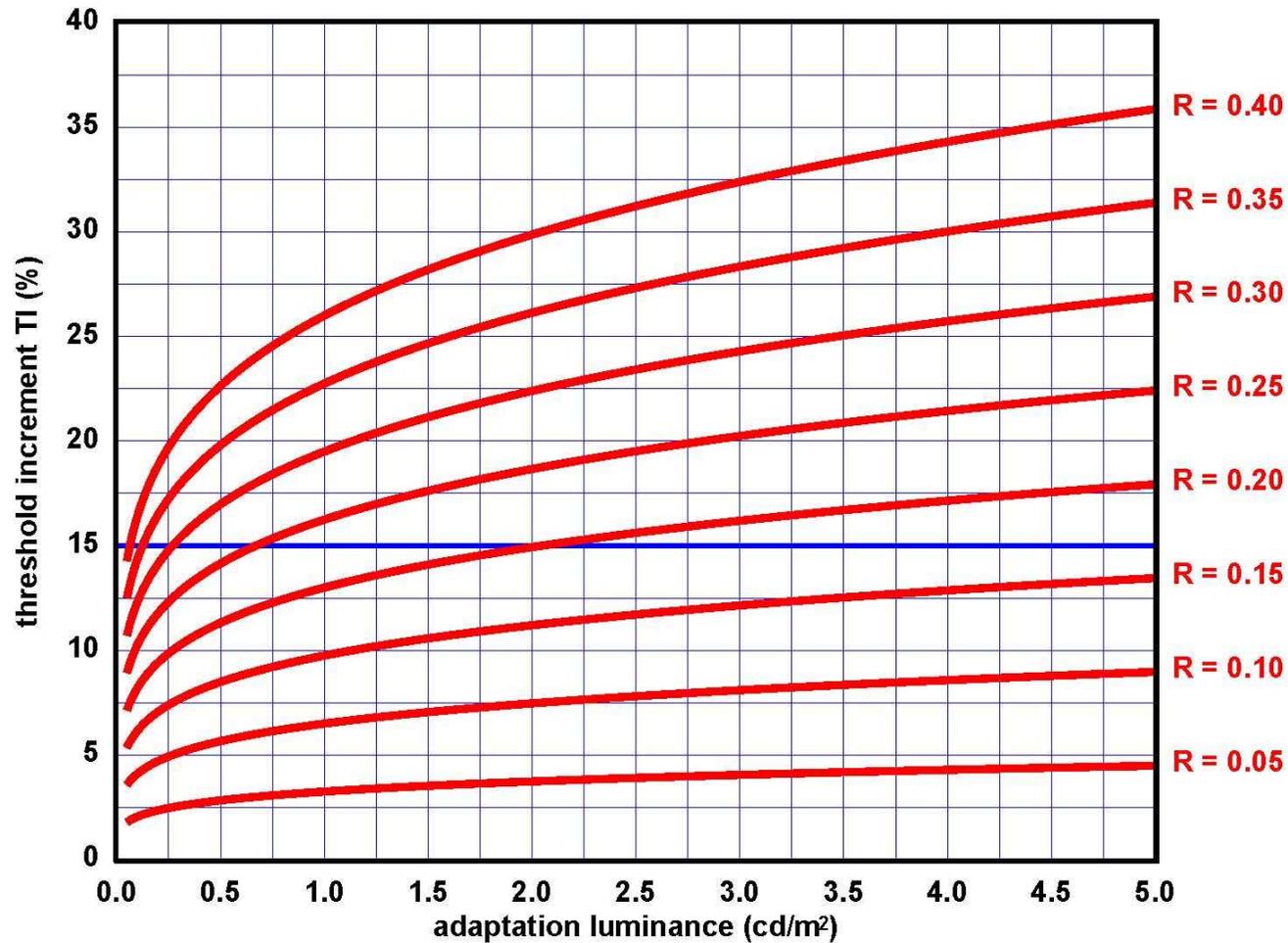


- Having obtained the **total veiling luminance** of an installation the amount of disability glare can be found by calculating the **threshold increment TI** of an object which is in use to signify the visual task.
- In road lighting the **standard object** is assumed to be 8' in angular size.
- The threshold is determined by the **adaptation luminance** at the location at which the object has to be perceived.
- At fair luminance uniformities of the road surface the adaptation luminance may be approximated by the **average road surface luminance**.
- The **relative threshold increment** is expressed as the difference of the threshold under glare condition ΔL_{glare} and its value without glare ΔL as:

$$TI = \frac{\Delta L_{glare} - \Delta L}{\Delta L} \cdot 100\%$$



Calculation of Veiling Luminances and Threshold Increments (V), Adaptive Lighting

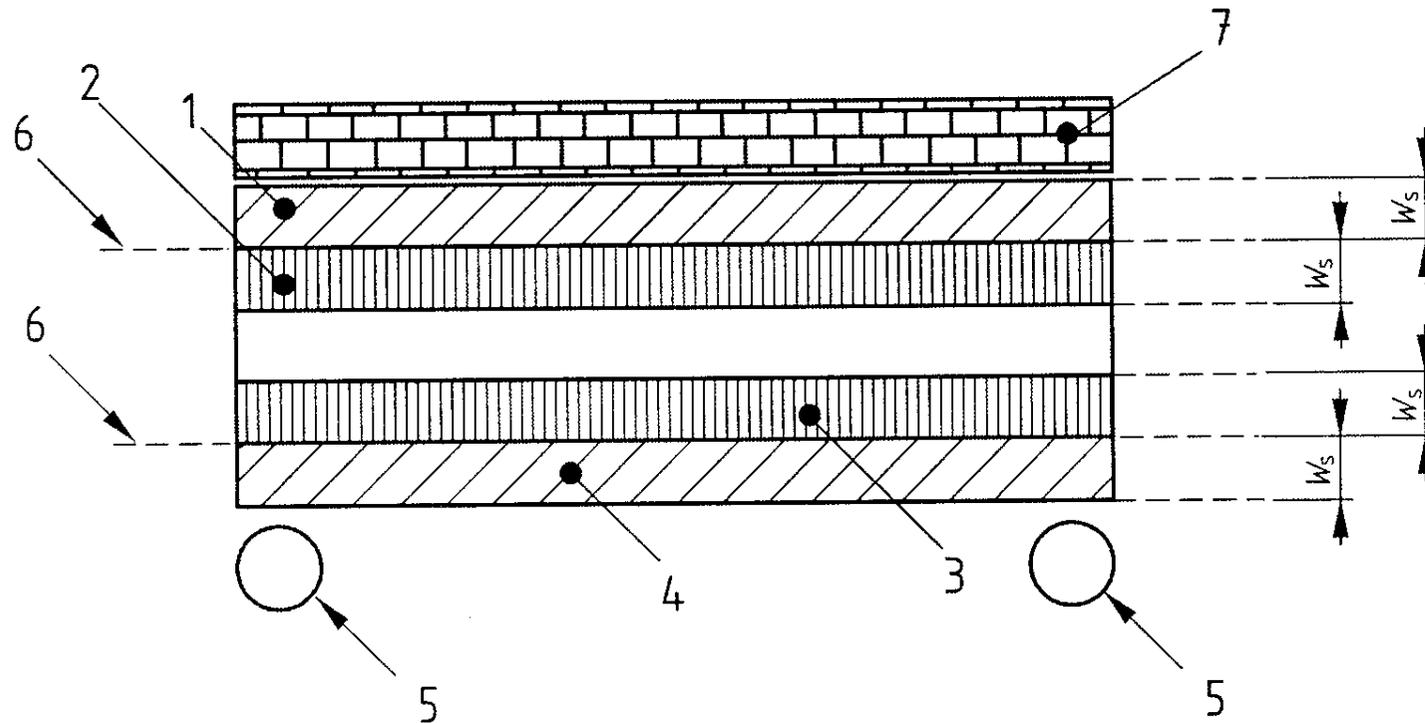


Threshold increment as function of adaptation luminance for different ratios R of veiling luminance to adaptation luminance



- The **Edge Illuminance Ratio** (R_{EI}) is defined as the average horizontal illuminance on two longitudinal strips of equal width each adjacent to the two edges of the carriageway, and **lying off the carriageway** (E_1, E_4), divided by the average horizontal illuminance on two longitudinal strips of equal width each adjacent to the edges of the carriageway, but **lying on the carriageway** (E_2, E_3)





$$R_{EI} = E_1 / E_2 , R_{EI} = E_4 / E_3$$

5 ... Luminaire, 6 ... Edge of carriageway, 7 ... Obstruction,
 W_s ... width of strip **always** equal width of lane, [figure 16 b) from EN 13201-3]



- Average luminance, overall uniformity, and threshold increment have to be calculated for each observer position (in the centre line of each lane) considering the total width of the carriageway
- Longitudinal uniformity is calculated for the centre line of each lane
- As result is regarded the lowest average luminance (maintained value), the lowest overall uniformity, and the lowest longitudinal uniformity (calculated for the different observer positions)
- As result is regarded the highest threshold increment (initial value) calculated for the different observer positions, the method has not been validated sufficiently yet for LED installations
- As result is regarded the lowest of the two edge illuminance ratios



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- **Horizontal E_h and vertical E_v illuminances**; requiring photometer head for measurement of planar illuminances, **also using dynamic measurement systems**
- **Hemispherical E_{hs} and semi-cylindrical E_{sc} illuminances**; requiring special purpose build photometer head
- **Road surface luminances L_p** ; requiring luminance meter with suitable performance, **also using dynamic measurement systems including imaging devices**



- **Geometric data;** height of columns, length of outreach, orientation, tilt, and rotation in application of luminaires
- **Supply voltage;** preferably using a recording voltmeter
- **Ambient temperature and humidity;** at a height of 1.0 m above ground level (preferably at 30 minutes intervals)



Example of Report, EN 13201-4:2015, Annex H (informative)

- General test information
- Geometric data
- Road surface data
- Lamp and luminaire data
- Electricity supply data
- Environmental conditions
- Condition of installation
- Measuring devices data
- Photometric measuring devices characteristics
- Measurement grid
- Light monitoring record
- Specific information for dynamic measurements



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- This part of the European Standard defines **how to calculate the energy performance indicators of road lighting installations** using the power density indicator (PDI) D_p and the annual energy consumption indicator (AECI) D_E .
- **Power density indicator (D_p)** demonstrates the energy needed for a road lighting installation, while it is fulfilling the relevant lighting requirements.
- The **annual energy consumption indicator (D_E)** determines the power consumption during a year, even if the lighting requirements change during the hours of darkness (**adaptive lighting**).



- As such, these indicators may be used for the comparison of the energy performance of different road lighting solutions and technologies for the **same lighting project**.
- **The energy performance of road lighting systems with different road geometries or different lighting requirements cannot be compared to each other directly (?),** as the energy performance is influenced by, among others, the geometry of the area to be lit as well as by the lighting requirements.
- The power density indicator (D_p) and the annual energy consumption indicator (D_E) **apply to all traffic areas covered by the series of lighting classes M, C and P** as defined in EN 13201-2:2015; they shall be presented always together.



$$D_P = \frac{P}{\sum_{i=1}^n E_i \cdot A_i}$$

- D_p power density indicator in W/(lx·m²) or in W/lm
- P system power of the lighting installation used to light the relevant areas in W
- E_i maintained average horizontal illuminance of the sub-area i in lx
- A_i size of sub-area i lit by the lighting installation in m²
- n number of sub-areas to be lit



$$D_E = \frac{\sum_{j=1}^m P_j \cdot t_j}{A}$$

- D_E annual energy consumption indicator for a road lighting installation in Wh/m²
- P_j operational power associated with the j^{th} period of operation in W
- t_j duration of j^{th} period of operation profile when power P_j is consumed in h
- A size of the area lit by the same arrangement in m²
- m number of periods with different operational power P_j



- In Annex B of EN 13201-5:2015 the **installation luminous efficacy** η_{inst} is described as a measure to evaluate the energy efficiency
- The **installation luminous efficacy** η_{inst} is defined as the **minimum luminous flux** Φ_{min} needed to provide the minimum lighting level for the specified area divided by the **total average system power** P_{total} of the lighting installation
- The **minimum luminous flux** Φ_{min} is given as average illuminance E (according to the requirement of the appropriate lighting class) times the size A of area to be considered



- For an area A, where the lighting design criterion is the **average road surface luminance**, the **average horizontal illuminance** is calculated assuming an average luminance coefficient q_0 of 0.07 1/sr
- For an area A, where the lighting design criterion is the **hemispherical illuminance**, the **average horizontal illuminance** is calculated using a conversion factor (from experience) of usually 0.65
- The **total average system power P_{total}** of the lighting installation is the average (over time of operation weighted) electrical power including the power of all devices necessary for the operation of the installation



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- For the selection of an appropriate lighting class as well as for the application of adaptive lighting a number of various parameters are considered in the different technical reports or standards.
- These parameters are generally related to:
 - **the geometry of the area under consideration (fixed)**
 - **the traffic use of the area (time-dependent)**
 - **the influence of the surrounding environment (time-dependent)**
- The most comprehensive number of parameters to be taken into account, covering the lighting classes M for motorized traffic, C for conflict areas, and P for pedestrian and low speed areas, can be found in the technical report CEN/TR 13201-1:2014.
- In the different standards usually only a sub-set of these parameters is considered, in some cases with different names for the same influence.



- Guidelines on the selection of an appropriate lighting class are given in the Technical Report CEN/TR 13201-1:2014, but **national standards organizations are not bound to implement CEN technical reports.**
- Some national standards organizations of countries participating in this INTERREG project have adopted the Technical Report CEN/TR 13201-1:2014 as national recommendation **without specifying which of the two methods described in the report has to be applied.**
- In other countries participating in this INTERREG project **the national standards organizations have elaborated or are elaborating national standards on the selection of lighting classes.**



- The **normal lighting class** M, C, or P is selected using the most onerous values for the parameters to be considered, but the application of this class **may not be justified during all hours of darkness**.
- **Temporal changes in the parameters** under consideration for the selected lighting class **could allow an adaptation of the normal lighting level**, usually by reducing the average luminance or illuminance.
- The **adapted lighting level** or levels should be from a **corresponding lighting class** M, C, or P respectively.
- Reducing the light output from every lamp of an installation using **dimming techniques** will not affect the uniformities, the object contrasts, and the glare control.
- Reducing the average lighting level by **switching off some luminaires** will usually result in **inadequate** uniformities and possibly in **excessive** disability glare.



Selection of a Lighting Class M, (CIE 115:2010, original proposal)

Parameter	Options	Weighting Value
Speed	Very high	1
	High	0,5
	Moderate	0
Traffic volume	Very high	1
	High	0,5
	Moderate	0
	Low	-0,5
	Very low	-1
Traffic composition	Mixed with high percentage of non-motorized	2
	Mixed	1
	Motorized only	0
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
	Moderate	0
	Good	-0,5



Selection of a Lighting Class M, (CEN/TR 13201-1:2014)

Parameter	Options	Description ^a		Weighting Value V_w ^a
Design speed or speed limit	Very high	$v \geq 100$ km/h		2
	High	$70 < v < 100$ km/h		1
	Moderate	$40 < v \leq 70$ km/h		-1
	Low	$v \leq 40$ 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-motorised			2
	Mixed			1
	Motorised 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

^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.



Alternative Method for Selection of a Lighting Class, (CEN/TR 13201-1:2014, Annex B)

Roads or streets designation	CARRIAGEWAY & SPEED LIMIT				TRAFFIC								A Product speed traffic Line I *	B Ambient luminosity High	C Mental task load High	Overall coefficient				
	Carriageway		Speed	Coefficients carriageway speed	Composition				Volume			Ambient luminosity				Mental task load	A x B or A x C	A x B x C		
	single	separated	km/h		Coefficients				Coefficients			Coefficients				1,25	1,25	Line II *	Line III *	
					1	2	3	4	3	2	1	1								1
					Not motorized	Motorized only	Mixed traffic	Mixed mainly not motorized	High	Medium	Low	Low to moderate								
Interurban motorway		X	≤ 130	5		2			3			●	●	30	—	●	38			
										2							20	25		
											1						10	12		
Urban motorway Expressway		X	≤ 110	5		2			3			—	—		●	●	38	47		
										2								25	31	
											1							12	16	
Interurban main road	X		≤ 90	5			3		3			●	●	45	—	●	56			
										2							30	38		
											1						15	19		
Main crossing road	X		≤ 70	4			3		3			—	—		●	●	45	56		
										2							30	37		
											1						15	19		
Main urban road Boulevard - Avenue	X		≤ 50	3			3		3			—	—		●	●	34	42		
										2							23	28		
											1						11	14		
Secondary urban road Avenue - Street	X		≤ 50	3			3			2		●	●	18	●	—	22			
																	9	11		
											1									
Urban service road	X		≤ 50	2			3			2		●	●	12	●	—	15			
																	6	8		
											1									
Urban road Dangerous intersections Village crossing	X		≤ 50	3			3		3			●	●	27	●	●	34	42		
										2							18	23	28	
											1						9	11	14	
Urban road in dangerous section	X		≤ 30	1			4		3			●	●	12	●	●	15	18		
										2							8	10	12	
											1						4	5	7	

* see Figure B1

- Unlikely case
- Current possible case



- AT Standard O 1051:2017, based on CEN/TR 13201-1:2014
- CR HRI CEN/TR 13201-1:2016-11-22
- CZ CSN 13201-1:2007
- DE revision of standard DIN 13201-1 in progress, based on **road categories**, expected in 2018
- IT Standard UNI 11248:2016, based on **road categories**
- PL PKN-CEN/TR 13201-1:2016-02
- SL SIST-TP CEN/TR 13201-1:2015



Categorization of Types of Road acc. to Italian Standard UNI 11248:2016

Tipo di strada	Descrizione del tipo della strada	Limiti di velocità [km h ⁻¹]	Categoria illuminotecnica di ingresso
A ₁	Autostrade extraurbane	Da 130 a 150	M1
	Autostrade urbane	130	
A ₂	Strade di servizio alle autostrade extraurbane	Da 70 a 90	M2
	Strade di servizio alle autostrade urbane	50	
B	Strade extraurbane principali	110	M2
	Strade di servizio alle strade extraurbane principali	Da 70 a 90	M3
C	Strade extraurbane secondarie (tipi C1 e C2) ¹⁾	Da 70 a 90	M2
	Strade extraurbane secondarie	50	M3
	Strade extraurbane secondarie con limiti particolari	Da 70 a 90	M2
D	Strade urbane di scorrimento ²⁾	70	M2
		50	
E	Strade urbane di quartiere	50	M3
F ³⁾	Strade locali extraurbane (tipi F1 e F2) ¹⁾	Da 70 a 90	M2
	Strade locali extraurbane	50	M4
		30	C4/P2
	Strade locali urbane	50	M4
	Strade locali urbane: centri storici, isole ambientali, zone 30	30	C3/P1
	Strade locali urbane: altre situazioni	30	C4/P2
	Strade locali urbane: aree pedonali, centri storici (utenti principali: pedoni, ammessi gli altri utenti)	5	C4/P2
	Strade locali interzonali	50	M3
30		C4/P2	
Fbis	Itinerari ciclo-pedonali ⁴⁾	Non dichiarato	P2
	Strade a destinazione particolare ¹⁾	30	

1) Secondo il Decreto Ministeriale 5 novembre 2001 N° 6792¹⁰⁾.

2) Per le strade di servizio delle strade urbane di scorrimento, definita la categoria illuminotecnica per la strada principale, si applica la categoria illuminotecnica con prestazione di luminanza immediatamente inferiore o la categoria comparabile con questa (prospetto 6).

3) Vedere punto 6.3.

4) Secondo la legge 1 agosto 2003 N° 214 "Conversione in legge, con modificazioni, del decreto legge 27 giugno 2003 N° 151, recante modifiche e integrazioni al codice della strada".



Road Layouts and Traffic Volumes associated with Types of Road acc. to UNI 11248:2016

Tipo di strada	Descrizione del tipo della strada	N° Minimo Carreggiate indipendenti	N° Minimo di Corsie per senso di marcia	N° di sensi di marcia	Portata max. di servizio per corsia (veicoli/ora)	Ulteriori requisiti minimi, caratteristiche e chiarimenti
A1	Autostrade extraurbane	2	2	2	1 100	
	Autostrade urbane	2	2	2	1 550	
A2	Strade di servizio alle autostrade extraurbane	2	1	2	Da 650 a 1 350	Sono ricomprese le strade dedicate all'accesso alle autostrade prima delle stazioni (caselli autostradali) I valori minimo e massimo dipendono dal numero di corsie
	Strade di servizio alle autostrade urbane	2	1	2	Da 1 150 a 1 650	
B	Strade extraurbane principali	2	2	2	1 000	Tangenziali e superstrade
C	Strade extraurbane secondarie (tipi C1 e C2)	1	1	2	600	Strade tipo provinciali, regionali e statali Con banchine laterali transitabili
	Strade extraurbane secondarie	1	1	2		
	Strade extraurbane secondarie con limiti particolari	1	1	2		
D	Strade urbane di scorrimento	2	2	2	950	Strade urbane di grandi dimensioni e di connessione alla rete "urbana di quartiere" o "extraurbana secondaria"
E	Strade urbane di quartiere	1	1	2	800	Proseguimento delle strade di tipo C "extraurbane secondarie" nella rete urbana Strade tipo provinciali, regionali e statali Con corsie di manovra e parcheggi esterni alla Carreggiata
			2	1		
F	Strade locali extraurbane (tipi F1 e F2)	1	1	1 o 2	450	Strade in ambito extraurbano diverse da strade di tipo B e C quali strade comunali, vicinali, ecc.
F	Strade locali extraurbane	1	1	1 o 2		
F	Strade locali interzonali	1	1	1 o 2	800	Strade locali di connessione con la "rete secondaria" e di "scorrimento" di maggior rilievo in quanto attraversano il territorio collegando aree urbane confinanti o distanti in area urbane o extraurbane
F	Strade locali urbane	1	1	1 o 2	800	Strade locali diverse da strade di tipo D e E, quali strade residenziali, artigianali, centro cittadino, centro storico, ecc.



Fixed and Variable Parameters / Example Main Road acc. to E DIN 13201-1:2018

Auswahlparameter	Optionen/Auswahlmöglichkeit	Wichtungswert VW		
Geschwindigkeit	>50 km/h	1		
	≤ 50km/h	0		
Trennung der Richtungsfahrbahnen	Nein	1		
	ja	0		
		Zwischenwert		
Variable Parameter für die adaptive Beleuchtung	Optionen/Auswahlmöglichkeit	Wichtungswert VW	Zeitpunkt	
			t ₀	t ₁
Verkehrsaufkommen	Normal	0		
	Gering	-1		
Verkehrsart Zusammensetzung	Gemischt, hoher Anteil nicht motorisiert	2		
	Gemischt	1		
	Nur motorisierter Verkehr	0		
Leuchtdichte der Umgebung	Hoch	1		
	Mittel	0		
	Gering	-1		
Parkende Fahrzeuge	zulässig	1		
	nicht zulässig	0		
Erhöhte Anforderungen	Vorhanden	1		
	Nicht vorhanden	0		
		Summe der Wichtungswerte Vws		
		Beleuchtungsklasse M = 6 - VWS		



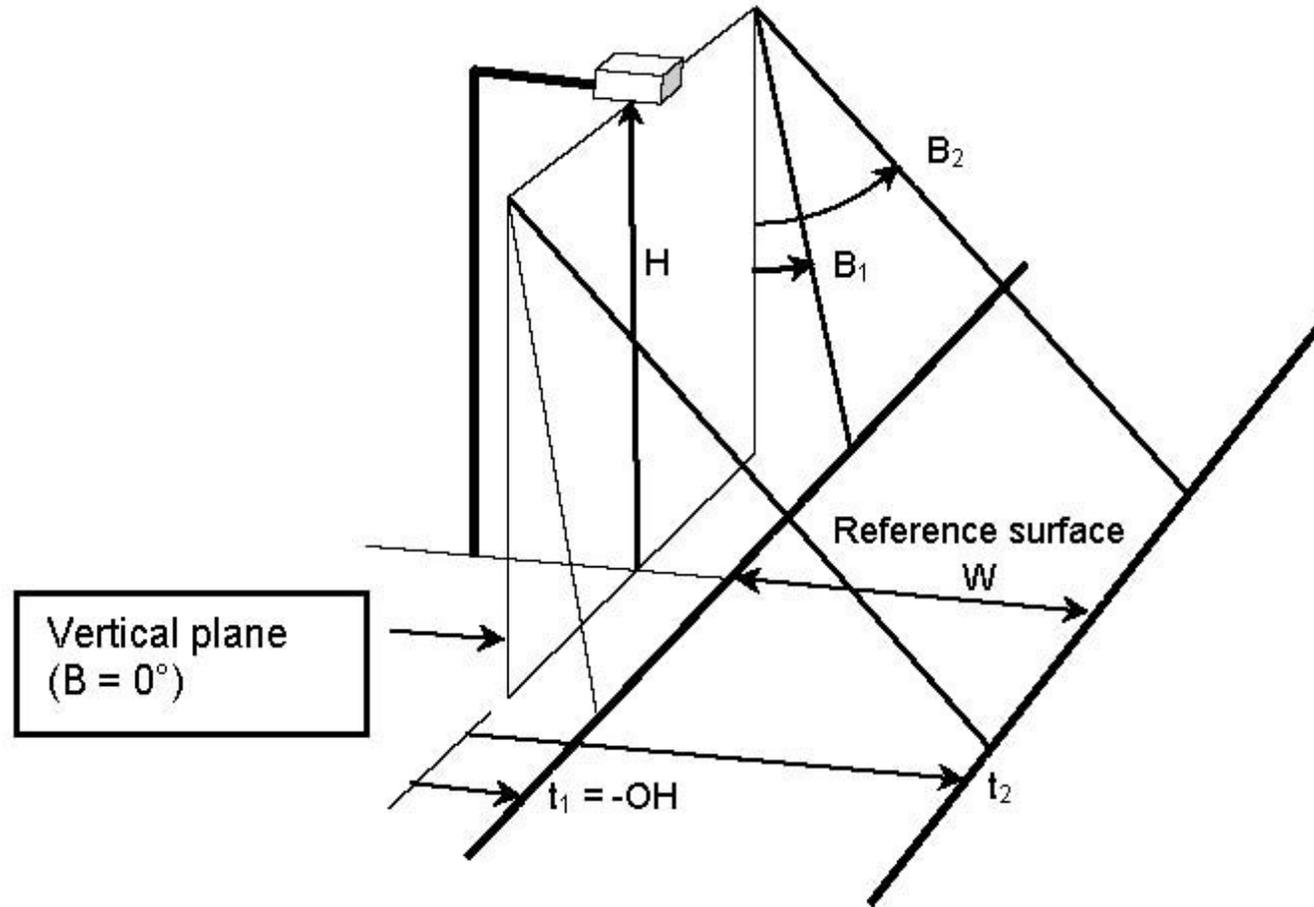
- TR 13201-1:2014 'Road lighting - Part 1: Guidelines on selection of lighting classes'
- EN 13201-2:2015 'Road lighting - Part 2: Performance requirements'
- EN 13201-3:2015 'Road lighting - Part 3: Calculation of performance'
- EN 13201-4:2015 'Road lighting - Part 4: Methods of measuring lighting performance'
- EN 13201-5:2015 'Road lighting - Part 5: Energy performance indicators'
- **EN 13032-5:2018 'Light and lighting - Measurement and presentation of photometric data of lamps and luminaires - Part 5: Presentation of data for luminaires used for road lighting'**



- The energy efficiency of a road lighting installation depends strongly on the utilization factor road lighting
- The **utilization factor road lighting** is defined as the ratio of the luminous flux received by one or more parallel strips along the road to the sum of the individual total fluxes of the lamps / light sources of the installation
- But in this European standard utilance is used in place of utilization factor because it can be applied to **luminaires with replaceable or non-replaceable lamps / light sources**
- The **utilance road lighting** is defined as the ratio of the luminous flux received by one or more parallel strips along the road to the sum of the individual total fluxes of the luminaires of the installation



Basic Position of Reference Area relative to a Luminaire in a Row of Luminaires, EN 13032-5:2018

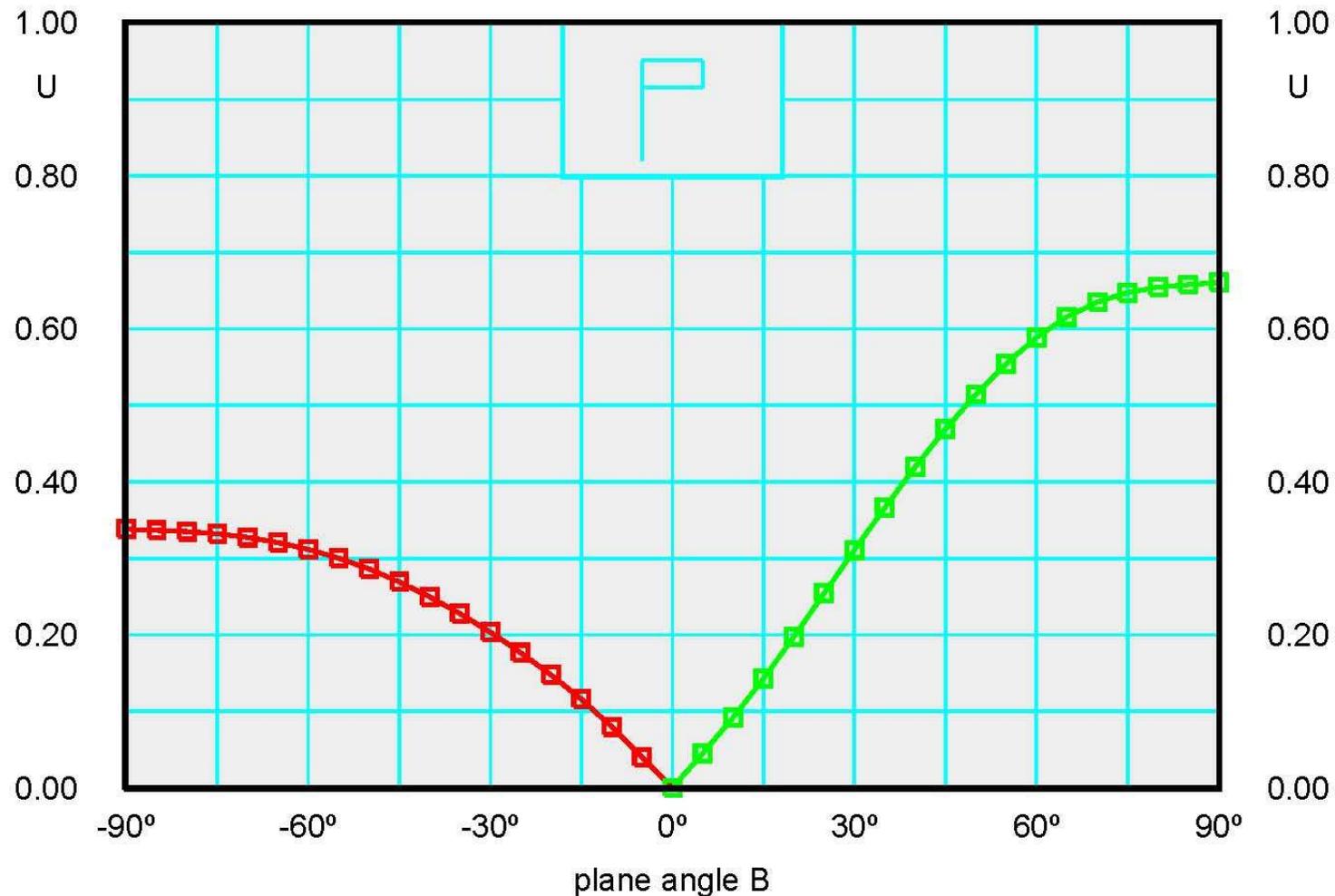


O_v overhang (m); W width of reference area (m); H luminaire mounting height (m);
 t_1, t_2 transverse distances to limiting lines; B_1, B_2 angles of inclined limiting planes ($^\circ$)



- The **utilance road lighting** is given by the ratio of the luminous flux emitted by a luminaire within a specified solid angle to the total luminous flux emitted by the same luminaire
- The **utilance** can be derived from the luminous intensity distribution of the luminaire (measured according to EN 13032-1/4) and should be provided **in angular steps not greater than 5°**
- The use and application of **(accumulated) utilances road lighting** can serve as a tool for the pre-selection of adequate luminaires to fulfil the lighting requirements as specified in EN 13201-2:2015; the knowledge of the utilance road lighting is needed for the calculation of the **installation luminous efficacy** as described in EN 13201-5:2015

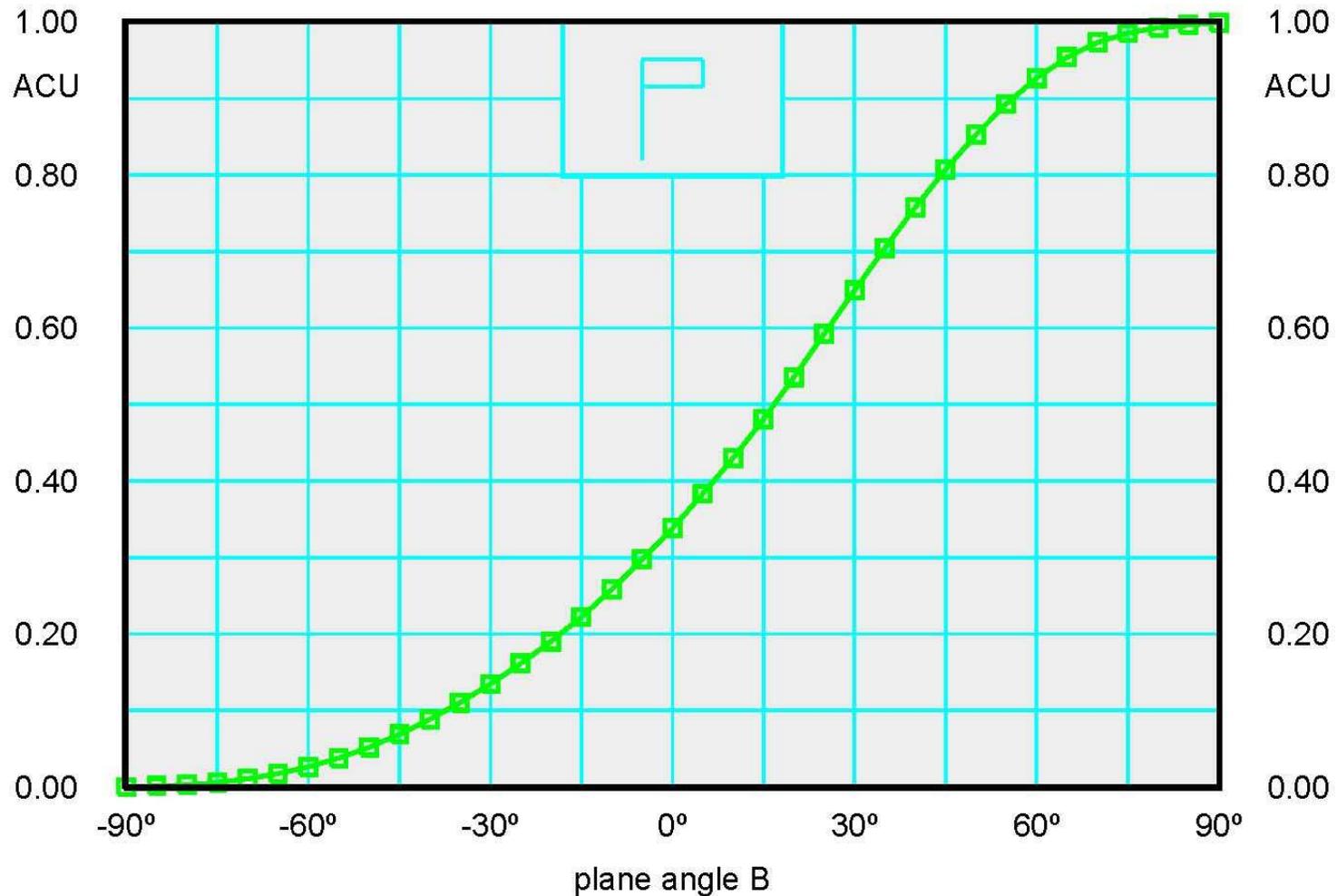




Utilances as function of plane angle B from -90° to 0° and from 0° to $+90^\circ$



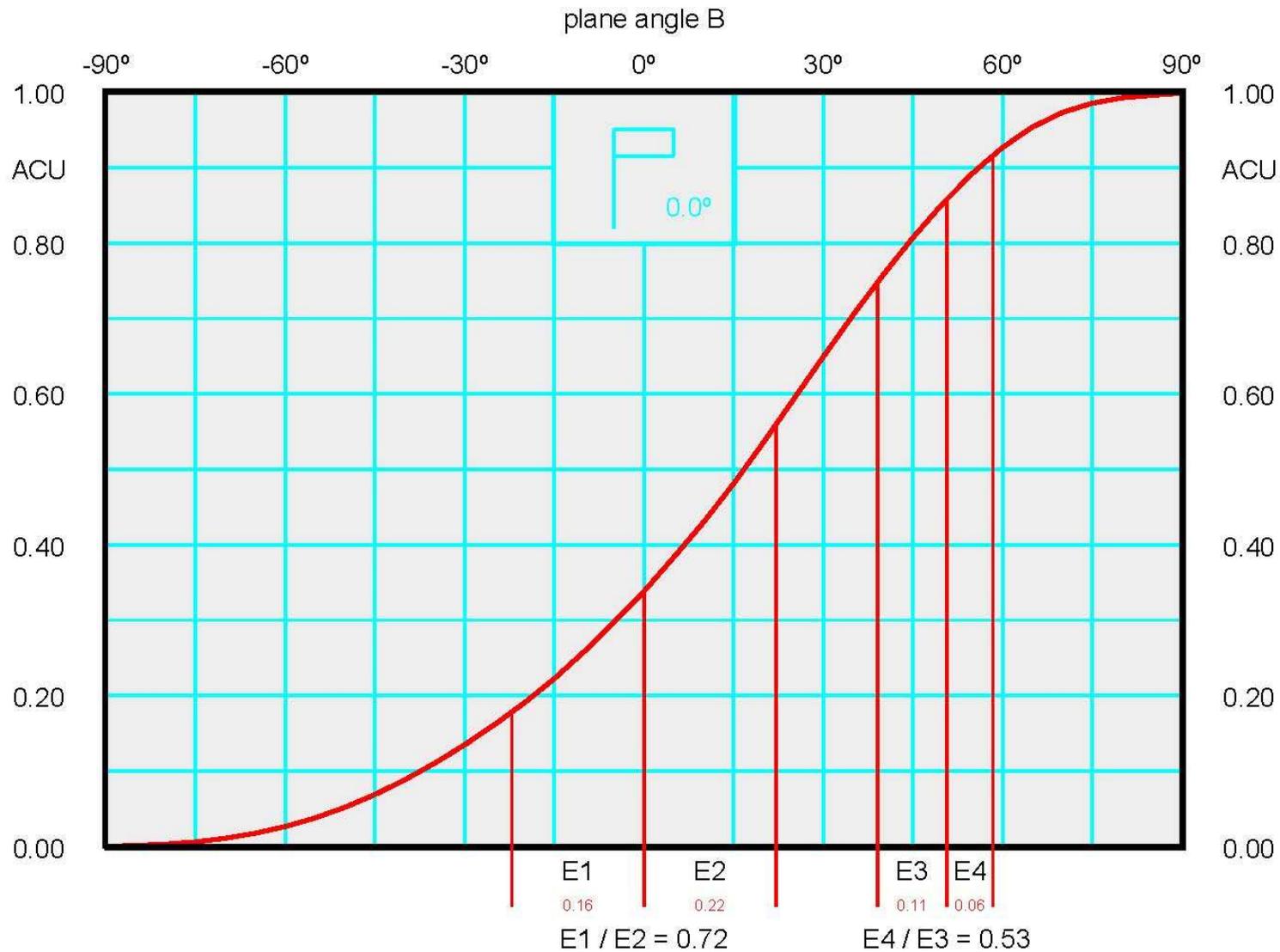
Graphic Presentation of Accumulated Utilances Road Lighting, EN 13032-5:2018



Accumulated utilances road lighting as function of plane angle B from -90° to $+90^{\circ}$



Utilances Road Lighting for Strips E1 to E4, Edge Illuminance Ratios E1/E2 and E4/E3, EN 13032-5:2018



Thank you very much for your attention!

