

Lighting of Railway Premises

- Minimizing obtrusive lighting
according to current regulations -

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German Rail Premises (excerpt)

5400 small, medium or large passenger railway stations
with

900 station buildings, 9600 platforms, 2000 underpasses,
3450 platform roofs, and 8500 weather houses

~ 1.000.000 luminaires

- Stations are located in all different environmental zones classified as E1 to E4 in CIE 150:2003, i.e. in natural, rural, suburban, and urban surroundings
- Depending on illuminance levels required for **safety and comfort for passengers and personal**, and on reflection properties of platforms surfaces, some light will be spread into the surrounding environment
- This **spill light** should be minimized by adequate measures

Purpose of General Platform Lighting: Revealing Contrasts also for Visually Impaired Passengers



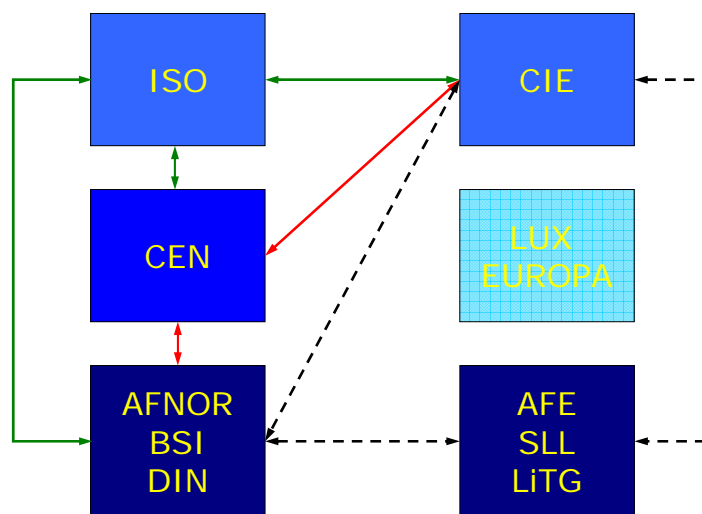
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Standardisation Bodies and Lighting Societies



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The Divisions of the International Commission on Illumination (CIE, 2016)

- Div. I Vision & Colour
- Div. II Physical Measurement of Light and Radiation
- Div. III Interior Environment and Lighting Design
- **Div. IV Lighting and Signalling for Transport**
- **Div. V Exterior and other Lighting Applications**
- Div. VI Photo-biology and Photo-chemistry
- Div. VIII Image Technology

Relevant CIE Publications for EN 12464-2:2014

- CIE 112:1994 "Glare Evaluation System for Use within Outdoor Sports and Area Lighting"
- **CIE 129:1998 "Guide for Lighting Exterior Work Places"**
- CIE 140:2000 "Road Lighting Calculations"
- **CIE 150:2003 "Guide on the Limitations of the Effects of Obtrusive Light from Outdoor Lighting Installations"**
- CIE 154:2003 "Maintenance of Outdoor Lighting Systems"
- CIE 115:2010 "Lighting of Roads for Motor and Pedestrian Traffic"

CEN TC 169 Light and Lighting (2016)

- **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 13032-1/2/4)**
- 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
- WG12 TC169/226 JWG Road Lighting (EN 13201:2015)
- WG13 Effect of Light on Human Beings
- WG14 ErP Lighting Mandate Management Group

National and specific Regulations on which EN 12464-2:2014 is based

- A.F.E. „Recommandations relatives à l'éclairage des voies publiques“
- CIBSE LG6 „The Outdoor Environment“
- DIN 5035 „Beleuchtung mit künstlichem Licht“
- ICAO „International Standards and Recommended Practices, Aerodromes“
- **DB 954.9103 „Beleuchtungsanlagen im gleisnahen und/oder sicherheitsrelevanten Bereich“**
- **DB Richtlinie 813.05 „Personenbahnhöfe planen; Beleuchtungsanlagen“**
- **LAI Hinweise zur Messung, Beurteilung und Minderung von Lichtimmissionen, Bund/Länder Arbeitsgemeinschaft für Immissionsschutz, 2014**

etc.

EN 12464-2:2014, Lighting Design Criteria

- Luminance distribution (description only)
- **Illuminance levels (maintained values), uniformities, and diversities** (for task areas and surroundings)
- **Limitation of glare (GR)**
- Directionality of light (description only)
- **Colour appearance and colour rendering (R_a)**
- Avoidance of flicker and stroboscopic effects (description only)
- **Limitation of obtrusive light**

EN 12464-2:2014, passenger volume dependent lighting requirements

Type of platform	E_m	U_o	U_d	GR_L
Open platforms, very small number of passengers , e.g. train stops	5 lx	0.20	0.10	55
Open platforms, small number of passengers , e.g. rural and local trains	10 lx	0.25	0.125	50
Open platforms, medium number of passengers , e.g. suburban or regional trains or inter-city services	20 lx	0.30	0.166	45
Open platforms, large number of passengers , e.g. inter-city services	50 lx	0.40	0.20	45
Covered platforms, small number of passengers , e.g. suburban or regional trains or inter-city services	50 lx	0.40	0.20	45
Covered platforms, large number of passengers , e.g. inter-city services	100 lx	0.50	0.33	45

EN 12464-2:2014, Obtrusive Light (I), Definitions

- Guidance for the **assessment of obtrusive light** is given in publication CIE 150-2003 "Guide on the Limitation of the Effects of Obtrusive Light from Outdoor Lighting Installations".
- **Obtrusive Light:** Light, outside the area to be lit, which, because of quantitative, directional or spectral attributes in a given context, gives rise to annoyance, discomfort, distraction or a reduction in the ability to see essential information.
- **Curfew:** The time after which stricter requirements (for the control of obtrusive light) will apply; often a condition of use of lighting applied by a government controlling authority, e.g. the local government
- The different limits given are differentiated according to the **environmental zones (E1 to E4)**. The differentiation takes account of the **ambient brightness of the environment** to be experienced.

EN 12464-2:2014, Obtrusive Light (II), Environmental Zones

Zone	Surrounding	Lighting Environment	Examples
E1	Natural	Intrinsically dark	National parks, protected sides
E2	Rural	Low district brightness	Industrial or residential rural areas
E3	Suburban	Medium district brightness	Industrial or residential suburbs
E4	Urban	High district brightness	Town centres, commercial areas

EN 12464-2:2014, Obtrusive Light (III), Parameters

- Maximum vertical illuminance (E_v) on properties (for pre- and post-curfew hours)
- Maximum luminous intensities of individual light sources into potentially obtrusive directions (for pre- and post-curfew hours), not distance dependent
- Maximum upward light ratios (ULR), direct flux only
- Maximum average luminances of building facades (L_b) and signs (L_s)
- **Maximum threshold increments (TI) for users of nearby transport systems**

EN 12464-2:2014, Obtrusive Light (IV), Maximum Obtrusive Light Permitted

Zone	Illuminance on Properties		Luminaire Intensity		Upward Light Ratio ULR in %	Luminance	
	E_v in lx		I in cd			L_b in cd/m ²	L_s in cd/m ²
	Pre-curfew	Post-curfew	Pre-curfew	Post-curfew	Building facade	Signs	
E1	2	0	2500	0	0	0	50
E2	5	1	7500	500	5	5	400
E3	10	2	10000	1000	15	10	800
E4	25	5	25000	2500	25	15	1000

Following the A-deviation in EN 12464-2:2014, Annex A, in Germany the „Hinweise zur Messung, Beurteilung und Minderung von Lichtimmissionen“ des Bund-/Länderausschusses für Immissionsschutz have to be observed.

EN 12464-2:2014, Obtrusive Light (V), Maximum Obtrusive Light Permitted, A Deviation

Immissionsort (Einwirkungsort) Gebietsart nach § BauNVO	Beleuchtungsstärke E_F in lx		Immissionsrichtwert k für Blendung		
	6 Uhr bis 22 Uhr	22 Uhr bis 6 Uhr	6 Uhr bis 20 Uhr	20 Uhr bis 22 Uhr	22 Uhr bis 6 Uhr
Kurgebiete, Krankenhäuser, Pflegeanstalten (§ 11)	1	1	32	32	32
reine Wohngebiete (§ 3), allgemeine Wohngebiete (§ 4), besondere Wohngebiete (§ 4a), Kleinsiedlungsgebiete (§ 2), Erholungsgebiete (§ 10)	3	1	96	64	32
Dorfgebiete (§ 5), Mischgebiete (§ 6)	5	1	160	160 (96)	32
Kerngebiete (§ 7), Gewerbegebiete (§ 8), Industriegebiete (§ 9)	15	5	-	-	160

Limits for vertical illuminances on properties and for glare

Quelle: LITG Publikation 12.3

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Glare caused by inclined Luminaires



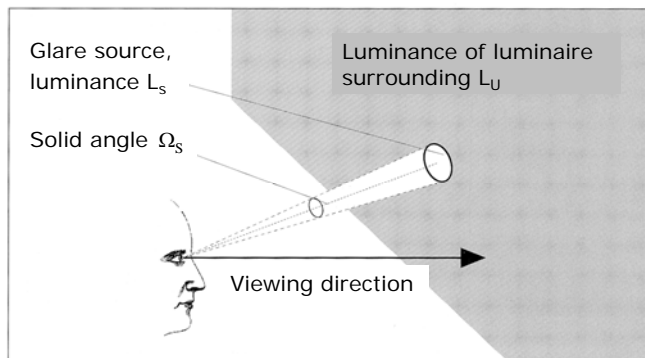
Photo: Axel Stockmar, Celle

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Evaluation of Obtrusive Glare, LiTG Publication 12:2011



$$\bar{L}_{\max} = k \cdot \sqrt{\frac{L_U}{\Omega_S}}$$

L_{\max} ... maximum tolerable
luminance of glare source

Quelle: LiTG Publikation 12.3

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EN 12464-2:2014, Maximum Values of Threshold Increment from non-road Lighting Installations

	Road classification			
	No road lighting	M5	M4/M3	M2/M1
Threshold increment (TI)	15% based on adaptation luminance of 0,1 cd/m ²	15% based on adaptation luminance of 1,0 cd/m ²	15% based on adaptation luminance of 2,0 cd/m ²	15% based on adaptation luminance of 5,0 cd/m ²

For users of transport systems for the relevant viewing positions in the path of travel the threshold increment shall not exceed 15 % based on the actual adaptation level.

If the adaptation level is not known and no road lighting is provided, an adaptation luminance of 0,1 cd/m² shall be applied.

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Evaluation of Glare experienced by Train Driver (DB Guidelines 813.0502)

- The disability glare experienced by a train driver when approaching an open or covered station shall be evaluated using the **threshold increment** method.
- The **standard observer position** for a straight horizontal section of a platform is given with an eye height of 2,20 m above the platform surface, and 1,66 m sidewise the platform edge with a viewing direction parallel the platform (track) 1° below the horizontal, and at such a distance in front of the first luminaire so that the first luminaire is seen at 20° above the horizontal.
- Under the assumption that the adaptation luminance is equivalent to **1/10 of the average luminance of the platform surface**, the **threshold increment shall not exceed 15 %**.

Minimizing Obtrusive Light (I)

- **Roof mounted** (fluorescent) luminaires for direct illumination in horizontal (recessed) position along platform edge do not cause glare problems for passengers, personal, and train drivers if the glare rating limits given in EN 12464-2 are fulfilled
- There is no light emission for angles of elevation greater or equal 90°, the **upward light ratio (ULR) is zero**
- **Pole mounted** luminaires for direct illumination in standard arrangements (mounting height 6 m, luminaire spacing 20 m) need to have restricted luminous intensities at angles of elevation greater or equal 70° to fulfil the glare restrictions (train drivers)
- There is no light emission for angles of elevation greater or equal 90°, the **upward light ratio (ULR) is zero**
- **High pole lighting** using floodlights not recommended at all

Minimizing Obtrusive Light (II)

- Adjustment of illumination levels according to number of passengers as specified in revised EN 12464-2:2014, lower levels create less spill light
- Reduction of average illuminance during night time; e.g. between 11 pm and 5 am one step down, but not less than 5 lx
- Switching off platform lighting during hours of guaranteed non-operation of trains in natural/rural surroundings
- Reduction of luminaire mounting height (e.g. from standard 6 m down to 4 m mounting height) in natural surroundings
- Additional shielding of luminaires to minimize the size of the illuminated area outside the platform in natural surroundings

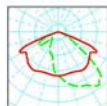
Minimizing Obtrusive Light (III)

- Use of high efficacy light sources and of high efficiency luminaires with suitable luminous intensity distributions installed in appropriate positions to provide adequate platform utilances/utilisation factors (not much light onto the tracks)
- Installation efficiency is evaluated using platform utilances or platform utilization factors
- The **Utilization Factor Platform** is defined as the ratio of the total flux received by the reference area of a platform to the total light source flux of the installation
- Depending on the average lighting level required there are limits for the power densities (in W/m^2) specified which should not be exceeded

Minimizing Obtrusive Light (IV)

- Use of luminaires with luminous intensity distributions with reduced backlight (C_{270} -plane) to limit light on properties / facades, e.g. alongside freight track areas, and to limit the disability glare for users of nearby transport systems (road, railway, waterway)
 - Reduction of light levels on roads leading to stations or to freight track areas as well as on parking lots dependent on traffic volume (adaptive lighting according to revised European Standards EN 12464-2:2014 and EN 13201-2:2015 'Road lighting')
-
- For the pre-selection of suitable luminaires 'tables platform lighting' and 'tables railway area lighting' have been developed which allow to consider the impact on the environment at an early design stage

Platform Lighting Table for Pre-Selection of Suitable Luminaires

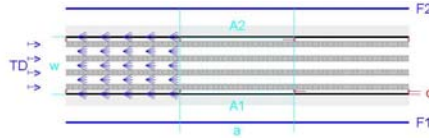
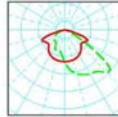


Platform Lighting Table (EN 12464-2:2014)

LED board 2x8/740mm/Lumileds (2205 lm/18.2 W)														Maintenance factor = 0.80				
w (m)	d (m)	s (m)	Mounting height h = 6.0 m							Mounting height h = 8.0 m								
			Eav (%)	Uo	Ud	ER (%)	GR	TI (%)	UFP (%)	Ps (W/m²)	Eav (%)	Uo	Ud	ER (%)	GR	TI (%)	UFP (%)	Ps (W/m²)
6.00	2.50	12.0	20.7	0.79	0.56	97	36	12	42	0.5	15.8	0.92	0.77	96	30	7.6	32	0.5
		15.0	16.6	0.64	0.40	96	39	13	42	0.4	12.9	0.81	0.61	96	31	8.5	33	0.4
		20.0	12.4	0.47	0.23	97	41	16	42	0.3	9.7	0.82	0.38	96	34	10	33	0.3
8.00	3.50	12.0	20.3	0.79	0.56	93	37	5.0	55	0.4	16.0	0.93	0.78	95	33	8.6	43	0.4
		15.0	16.2	0.64	0.40	93	40	5.7	55	0.3	12.8	0.82	0.61	95	33	9.9	43	0.3
		20.0	12.2	0.49	0.25	92	42	6.9	55	0.2	9.6	0.83	0.40	95	36	12	43	0.2
10.0	4.50	12.0	19.6	0.80	0.58	85	40	4.7	67	0.3	15.7	0.90	0.76	92	33	7.8	53	0.3
		15.0	15.7	0.67	0.42	86	41	5.4	67	0.2	12.5	0.84	0.61	92	35	9.0	53	0.2
		20.0	11.8	0.52	0.26	85	44	6.6	67	0.2	9.4	0.85	0.41	92	37	11	53	0.2
12.0	5.50	12.0	18.7	0.70	0.45	75	39	1.8	76	0.3	15.2	0.87	0.70	87	34	4.0	62	0.3
		15.0	14.9	0.73	0.41	76	40	2.0	76	0.2	12.2	0.83	0.58	87	35	4.5	62	0.2
		20.0	11.2	0.51	0.23	75	45	2.4	76	0.2	9.1	0.86	0.39	87	38	5.4	62	0.2

CEN Flux Code 41 79 99 100 100 (EN 13032-2)

Railway Area Lighting Table for Pre-Selection of Suitable Luminaires



Railway Area Lighting Table (EN 12464-2:2014)

GRN107-2S/740 (10736 lm/92.7 W)		Tilt of luminaire 0°										Maintenance factor = 0.80									
w (m)	d (m)	Mounting height h = 12.0 m										Mounting height h = 14.0 m									
		s (m)	Eav (lx)	Uo	Ud	GR	Ti (%)	E/A1 (lx)	E/A2 (lx)	Ex/F1 (lx)	Ex/F2 (lx)	Eav (lx)	Uo	Ud	GR	Ti (%)	E/A1 (lx)	E/A2 (lx)	Ex/F1 (lx)	Ex/F2 (lx)	
15.0	1.00	30.0	21	0.64	0.53	46	5.6	11	11	4.0	4.0	18	0.69	0.58	45	4.7	11	11	5.1	5.1	
		35.0	18	0.64	0.47	48	6.2	9.2	9.2	3.8	3.8	16	0.67	0.54	46	5.1	9.8	9.8	4.0	4.0	
		40.0	15	0.58	0.38	49	6.8	8.1	8.1	3.7	3.7	14	0.68	0.48	48	5.5	8.6	8.6	3.7	3.7	
		45.0	14	0.52	0.30	49	7.3	7.2	7.2	3.7	3.7	12	0.63	0.41	49	6.0	7.6	7.6	3.7	3.7	
		50.0	12	0.40	0.21	51	7.9	6.5	6.5	3.7	3.7	11	0.56	0.33	49	6.4	6.9	6.9	3.7	3.7	
20.0	1.00	30.0	18	0.44	0.34	47	5.5	6.8	6.8	3.7	3.7	17	0.57	0.47	46	4.4	7.6	7.6	3.7	3.7	
		35.0	16	0.45	0.35	50	6.1	5.8	5.8	3.6	3.6	15	0.57	0.46	46	4.8	6.5	6.5	3.6	3.6	
		40.0	14	0.43	0.30	50	6.6	5.1	5.1	3.6	3.6	13	0.57	0.45	49	5.3	5.7	5.7	3.6	3.6	
		45.0	12	0.39	0.24	49	7.2	4.6	4.6	3.6	3.6	11	0.55	0.39	50	5.7	5.1	5.1	3.6	3.6	
		50.0	11	0.35	0.20	51	7.8	4.1	4.1	3.5	3.5	10	0.49	0.32	49	6.1	4.6	4.6	3.5	3.5	
25.0	1.00	30.0	15	0.30	0.21	48	5.7	5.8	5.8	3.6	3.6	15	0.38	0.30	48	4.5	5.5	5.5	3.6	3.6	
		35.0	13	0.28	0.19	50	6.2	5.0	5.0	3.5	3.5	13	0.37	0.28	48	4.9	4.7	4.7	3.5	3.5	
		40.0	11	0.26	0.19	52	6.8	4.3	4.3	3.5	3.5	11	0.37	0.29	49	5.3	4.2	4.2	3.5	3.5	
		45.0	10	0.25	0.17	50	7.4	3.9	3.9	3.5	3.5	9.8	0.37	0.27	51	5.7	3.7	3.7	3.5	3.5	
		50.0	9.1	0.23	0.14	52	7.9	3.5	3.5	3.5	3.5	8.8	0.35	0.23	50	6.1	3.3	3.3	3.5	3.5	
55.0	8.2	0.20	0.11	54	8.5	3.2	3.2	3.5	3.5	8.0	0.32	0.19	49	6.5	3.0	3.0	3.5	3.5			

CEN Flux Code 36 77 99 100 86 (EN 13032-2)

Conclusions

- Use of luminaires for direct illumination at relatively low mounting heights with appropriate luminous intensity distributions in energy efficient installations (high utilization factors) does not cause problems in terms of vertical illuminances on buildings/facades, of luminous intensities in potentially obtrusive directions (glare), and of the proportion of luminous flux emitted above the horizontal

- The describes measures play an important role in the Deutsche Bahn AG approach to minimize light pollution, obtrusive light, and sky glow

Lighting of Railway Premises

**- Minimizing obtrusive lighting
according to current regulations -**

Thank you very much for your attention!

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