ZUMTOBEL

The Lighting Handbook

Your concise
reference book –
always ready to hand.

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Lighting technology

Chapter 2
Standard values for indoor and outdoor lighting
Based on the new European standards

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Lighting application

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Technology

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Lamps

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Lighting control and control gear

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Technology and tables

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Design tools

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Chapter 1

Lighting technology

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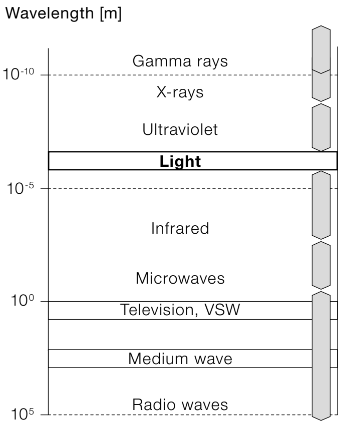
What is light?

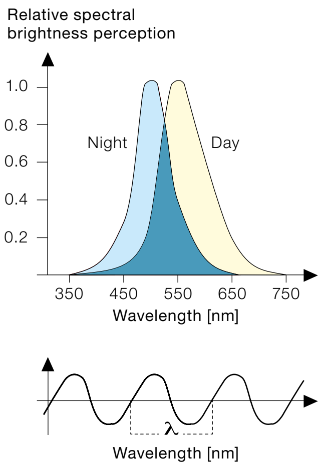
Light is that part of the electromagnetic spectrum that is perceived by our eyes. The wavelength range is between 380 and 780 nm.

By day we see in colour, while at night we can only see in shades of grey.

What is light?



What does the human eye see?

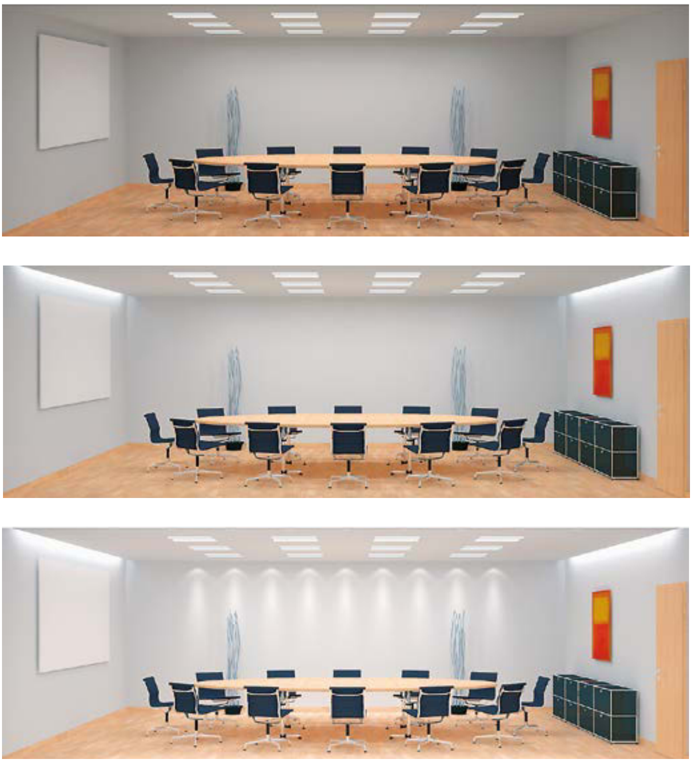


Light has a triple effect

- Light for **visual** functions
  - Illumination of task area in conformity with relevant standards
  - Glare-free and convenient

- Light creating **biological** effects
  - Supporting people's circadian rhythm
  - Stimulating or relaxing

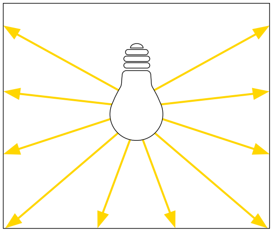
- Light for **emotional** perception
  - Lighting enhancing architecture
  - Creating scenes and effects



Basic parameters used in lighting

Luminous flux – Luminous intensity – Illuminance – Luminance

Luminous flux Φ

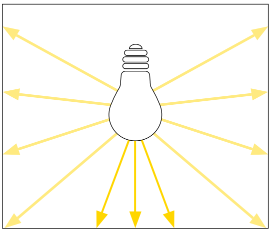


Lumen [lm]

$$I = \frac{\Phi}{\Omega}$$

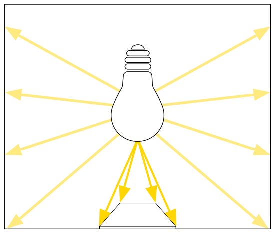
$$E = \frac{\Phi}{A}$$

Luminous intensity I



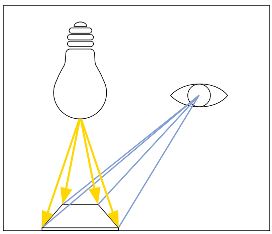
Candela [lm/sr]=[cd]

Illuminance E



Lux [lm/m²]=[lx]

Luminance L



[lm/sr*m²]=[cd/m²]

$$L = \frac{I}{A_L \cdot \cos\epsilon}$$

$$L = \frac{E \cdot \rho^*}{\pi}$$

Ω = solid angle into which luminous flux is emitted
A = area hit by luminous flux
$A_L \cdot \cos\epsilon$ = visible areas of light source
ρ = reflectance of area
π = 3.14
* = for diffuse surface areas

Luminous flux

The **luminous flux** describes the quantity of light emitted by a light source.
The **luminous efficiency** is the ratio of the luminous flux to the electrical power consumed (lm/W). It is a measure of a light source's economic efficiency.

Abbreviation: Φ Phi Unit: lm Lumen

Luminous intensity

The **luminous intensity** describes the quantity of light that is radiated in a particular direction.
This is a useful measurement for directive lighting elements such as reflectors. It is represented by the **luminous intensity distribution curve** (LDC).

Abbreviation: I Unit: cd Candela

Illuminance

Illuminance describes the quantity of luminous flux falling on a surface. It decreases by the square of the distance (inverse square law). Relevant standards specify the required illuminance (e.g. EN 12464 "Lighting of indoor workplaces").

$$\text{Illuminance: } E(\text{lx}) = \frac{\text{luminous flux (lm)}}{\text{area (m}^2\text{)}}$$

Abbreviation: E Unit: lx Lux

Luminance

Luminance is the only basic lighting parameter that is perceived by the eye.
It specifies the brightness of a surface and is essentially dependent on its reflectance (finish and colour).

Abbreviation: L Unit: cd/m²

Quality characteristics of lighting

The right light – traditional and new quality criteria

Traditional quality criteria
– Glare limitation
– Good modelling
– Correct light colour
– Avoidance of reflections
– Harmonious brightness distribution
– Sufficient illumination level
– Appropriate colour rendering

New quality criteria
– Changing lighting situations
– Personal control
– Energy efficiency
– Daylight integration
– Light as an interior design element

Illuminance – definition of terminology

Illuminance maintenance value $\bar{E}_m$: value below which the illuminance level must not fall in the visual task area.

Visual task area: illuminance levels are specified for specific visual tasks and are designed for the area in which these may take place.

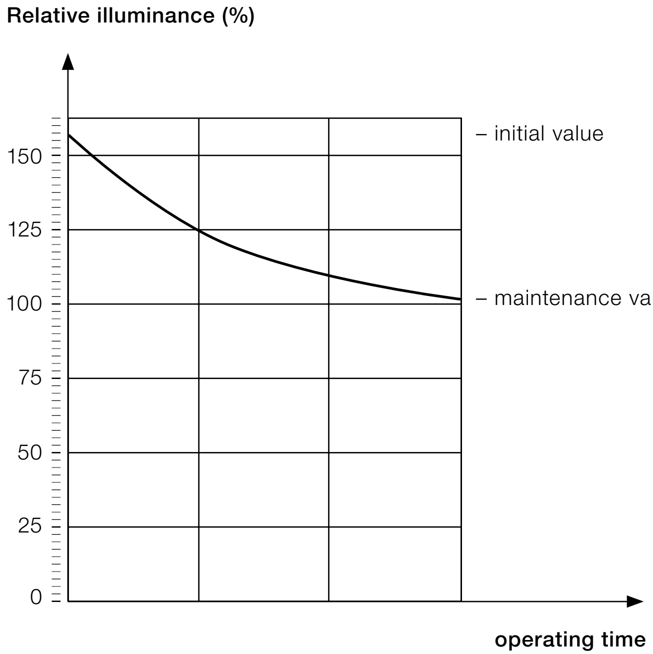
If the exact location is unknown, the room as a whole or a defined area of the workstation is used for specification.

The visual task area may be a horizontal, vertical or inclined plane.

Area immediately surrounding the visual task area: here illuminance may be one level lower than in the visual task area (e.g. 300 lx to 500 lx).

Maintenance factor: the initial value multiplied by the maintenance factor gives the illuminance maintenance value.
The maintenance factor can be determined individually, and takes the installation's reduction in luminous flux caused by soiling and ageing of lamps, luminaires and room surfaces into account.

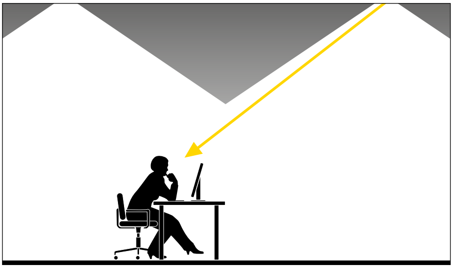
The maintenance schedule (the cleaning and maintenance intervals for the lamps and installation) must be documented.
See also Section 9 – Checklists.



Maintenance value = maintenance factor x initial value

Glare – glare limitation

Direct glare

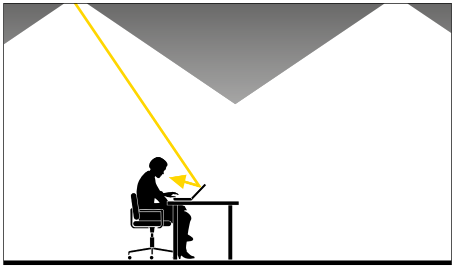


Cause
– Luminaires without glare control
– Very bright surfaces

Effect
– Loss of concentration
– More frequent mistakes
– Fatigue

Remedy
– Luminaires with limited luminance levels
– Blinds on windows

Reflected glare



Cause
– Reflective surfaces
– Incorrect luminaire arrangement
– Incorrect workstation position

Effect
– Loss of concentration
– More frequent mistakes
– Fatigue

Remedy
– Matching luminaire to workstation (layout)
– Indirect lighting
– Matt surfaces

On quality characteristics

European Standard EN 12464 regulates the lighting of indoor workplaces. In doing so, the unified glare rating method is used to evaluate (psychological) glare.

UGR is based on a glare formula. This formula takes account of all the luminaires in the system that contribute to the sensation of glare.

UGR levels for luminaires are determined using the tabular method according to CIE 117. Zumtobel also specifies the UGR index complied with by all luminaires concerned.

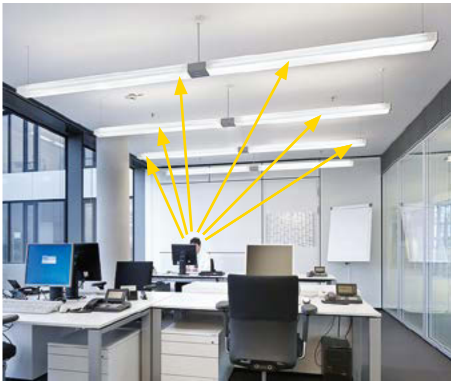
Reference values for specific room sizes are given in the data sheets.

UGR levels are available for each individual product in the corresponding photometric data sheet.
Example: www.zumtobel.com/42178787 (Photometry tab)

UGR limits (UGR_L) that must not be exceeded:

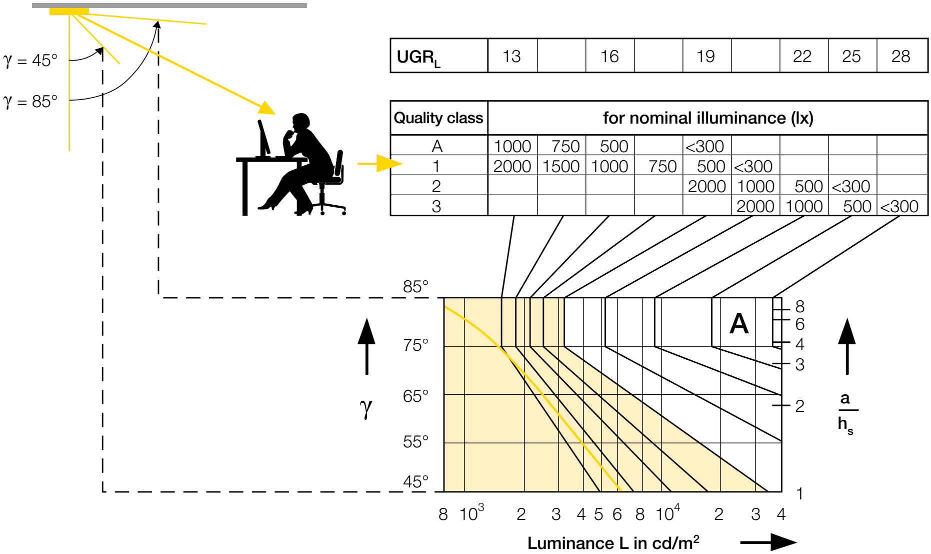
≤ 16	Technical drawing
≤ 19	Reading, writing, training, meetings, computer-based work
≤ 22	Craft and light industries
≤ 25	Heavy industry
≤ 28	Railway platforms, foyers

The UGR limits are specified in the EN 12464 standard for activities and visual tasks (see tables on pages 29–39).



$$UGR = 8 \log \left(\underbrace{\frac{0.25}{L_b}}_{(1)} \underbrace{\sum \frac{L^2 \Omega}{P^2}}_{(2)} \right)$$

The UGR method takes account of the brightness of walls and ceilings (1) as well as all luminaires in the system that contribute to the sensation of glare (2). The result is a UGR index.



The luminance limiting curve method assesses the mean luminance between 45° and 85°, and formerly even the glare effect of a luminaire.

The new European standard sets UGR = 19 as the maximum permissible value for offices, which is equivalent to the luminance limiting curve for 500 lx in Quality class 1.

UGR values are available for each individual product in the corresponding photometric data sheet.
Example: www.zumtobel.com/42178787 (Photometry tab)

Illuminance levels on ceilings and walls

Unlit ceilings and walls create an unpleasant room impression. Bright surfaces, however, pleasantly enhance the room climate.

The EN 12464 standard therefore requires an illuminance level of at least 30 lx or 50 lx* on ceilings and at least 50 lx or 75 lx* on walls. In fact, these levels ought to be significantly exceeded and should be at least 175 lx on walls.

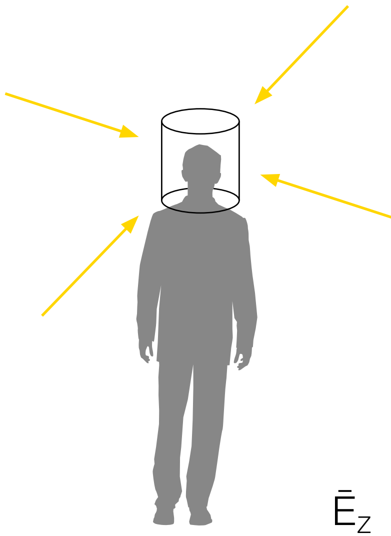
* in offices, class rooms, hospitals

Spatial illumination

In order to enhance people's and objects' recognisability in a room, basic requirements are placed on cylindrical illuminance $\bar{E}_Z$ and modelling.

Hence, $\bar{E}_Z$ should be as high as 150 lx in rooms used for communication.

Modelling is the ratio between cylindrical and horizontal illuminance at a specific point and should be between 0.3 and 0.6.



Light colour

The light colour describes the colour appearance of the light.

	Colour temperature	Appearance	Association
ww (warm white)	up to 3300 K	reddish	warm
nw (intermediate white)	3300–5300 K	white	neutral
tw (cool white)	from 5300 K	bluish	cool

In addition to the colours of the surfaces, it is also the light colour that determines a room's basic atmosphere!

Colour rendering

Colour rendering index R_a	≥90	80–89	70–79	60–69	40–59	20–39
Daylight	•					
LED	•	•	•			
Halogen lamp	•	•				
Compact fluorescent lamp	•	•				
Fluorescent lamp	•	•	–	–	–	
High-pressure mercury lamp				–	–	
Metal halide lamp	•	•		–		
High-pressure sodium lamp		•		–	–	–

– = Banned or no longer recommended under EU Regulation 245/2009 (EUP), due to low efficiency and inappropriate colour rendering.

Measuring illuminance

The Mean illuminance is the arithmetic brilliance level measured with a luxmeter in a defined grid, under precisely specified conditions.

Measuring instruments:
Description and precision
- L: maximum precision, tolerance 3 %
- A: high precision, tolerance 5 %
- B: average precision; tolerance 10 % (minimum requirement)

Measuring conditions
- Avoid external light/daylight (measure separately and subtract)
- Check mains voltage and ambient temperature
- Use new, burnt-in lamps (discharge lamps 100 h)

Measuring grid and measuring level
In order to facilitate inspection of the lighting system, the measuring grid has been specified in the EN 12464 (Lighting of workplaces) and EN 12193 (Lighting of sports facilities) standards.

- Workplaces = 0.75 m;
  sports facilities (floor) = 0.03 m
- Circulation areas, stairs,
  car parks (floor) = 0.03 m
- Cylindrical illuminance = 1.2 m
- Measuring grid: congruent triangles
- Measuring grid not congruent with luminaire layout grid

Size of measuring field	Grid element spacing
1 m	0.2 m
5 m	0.6 m
10 m	1 m
50 m	3 m
100 m	5 m

Types of lighting

Direct lighting
- Highly directional
- Strong glare reduction at certain angles
- Dark ceiling (cave effect)
- Limited flexibility of work-station layout
- Energy efficiency on the task level

Indirect lighting
- Diffuse lighting conditions
- Room gains in height
- Glare-free
- Workstations can be positioned anywhere
- Low energy efficiency

Indirect/direct lighting
– Pleasant room impression
– High user acceptance
– Good contrast ratios
– Flexible workstation layout
(indirect component > 60 %)

Mellow Light
– Recessed direct/indirect
solution
– Workstations can be
positioned anywhere
– Glare-free
– Reduced luminance levels
at all viewing angles
– Gives impression of daylight
in room

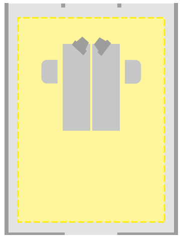
The definition of individual visual tasks for the purpose of lighting design in a room, as provided for in the EN 12464 standard, opens up new perspectives for lighting design. The quantity and quality of light can now be specified exactly for any task area.

Task area related lighting concepts are a customised tool to fully exploit the additional options provided. At the same time they offer financial scope that can be used to improve lighting comfort and enhance the effect of a room.

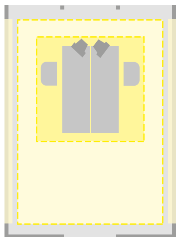
Visual function
Task area related lighting provides the right amount of light at the best possible quality for every visual task. Uniformity, control of glare and reflections, good contrast rendition and shadow detail are consistently matched to the respective task. The lighting is adjusted perfectly to the room user's needs.

Emotional and biological effects
Focusing the lighting onto clearly defined areas means saving investment and operating costs. The funds saved can be used to improve comfort and enhance the room atmosphere, for instance by exciting lighting accents, illuminated walls or dynamic lighting scenarios.

Optimum energy efficiency
Large buildings provide huge potential for optimisation of energy consumption. Lighting that is consistently focussed onto individual task areas reduces mean illuminance levels and therefore the average expenditure on energy. Savings can be further increased by using daylight-based lighting management and presence detectors.



Room-related lighting concepts take neither individual task areas nor different visual tasks into account. They are based on the most demanding task performed in the room. The position of the workstation is not defined, the entire room disposes of a uniform lighting quality.



Lighting focussed onto individual visual task areas provides for varied light design in the room. By illuminating walls, for instance, rooms can be designed to be much more open and attractive; dynamic lighting situations can enhance their visual quality.

Humanergy Balance

Human aspects + Energy efficiency = Humanergy Balance

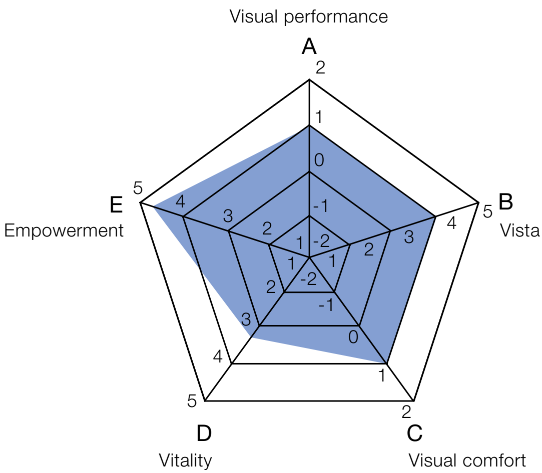
The Humanergy Balance concept harmonises both aspects of lighting and makes it possible to assess them: ELI, the lighting quality indicator, takes their physical and psychological effects on people into account; LENI, the energy efficiency indicator, assesses the economic and ecological aspects of light.

Comprehensive assessment of lighting quality (ELI)

The Ergonomic Lighting Indicator (ELI) allows to assess lighting quality in terms of quantity, using five descriptive quality criteria.

Checklists are used to record the individual criteria, which are displayed in a Kiviat graph (spider chart). The outermost line in the graph indicates optimum fulfilment of a criterion.

Example of ELI assessment using a spider chart:



Calculation of energy efficiency (LENI)

The Lighting Energy Numeric Indicator (LENI) stands for a lighting installation's actual energy consumption in kWh per square metre per year.

LENI is determined according to the specifications of the EN 15193 standard (assessment of buildings in terms of energy used – energy requirements made on lighting).

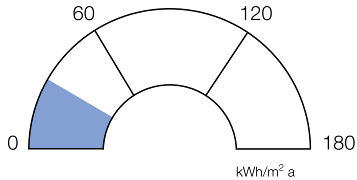
Formula for calculating a lighting installation's energy consumption

$$\text{LENI} = \frac{\sum (P_n \times F_C) \times \{(t_D \times F_O \times F_D) + (t_N \times F_O)\}}{A} \ [\text{kWh/(year} \times \text{m}^2)]$$

Without elaborating on individual parameters in greater detail, the following relevant factors are identified:
– The installed load (P_n)
– Multiplied by the annual hours of use by day (t_D) and at night (t_N)
– Reduced by the factors (≤ 1) for daylight-based control (F_D), presence-based control (F_O) and a constant lighting control system (F_C) (e.g. maintenance control)
– The area assessed (A)

LENI also takes charging energy for emergency lighting and standby energy into account.

The following factors have a positive impact on the reduction of energy consumption
– Sensible control of lighting
– Use of daylight
– Use of presence detectors
– Intelligent consideration of hours of use
– Energy-efficient lamps
– Need-based use of luminaires and lighting solutions, specified for the respective application
– Constant lighting control (maintenance control)



Energy consumption in kWh/(m² year)

Visual performance

Lighting in conformity with relevant standards is decisive for ensuring that a visual task can be identified and the related activities can be carried out. Consideration of the traditional quality characteristics of lighting has a major impact on visual task performance.

- Lighting level
- Uniformity of illuminance
- Colour rendering
- Avoiding hard shadows
- Contrast rendition
- Physiological glare

Vista

In prestigious buildings, for example, light is not only needed for seeing but also enhances the looks of the interior. Light can provide guidance and make people accept the interior on account of the first visual impression they get.

- Architectural design
- Mental design
- Guidance
- Hierarchy of perception
- External appearance
- Material
- Luminaires' protection type
- Protection against harmful radiation

Visual comfort

Light is not only needed in the visual task area, but also for perception in the room. Rooms should be illuminated with uniform brightness and lighting balance.

- Balanced brightness distribution
- Varying luminance levels
- Plasticity/modelling
- Discomfort glare
- Uniform illuminance in area around visual task
- Sense of security
- Artificial lighting complemented by daylight
- Use of flicker-free ballasts

Vitality

Light significantly influences people's activity and sense of wellbeing. Moreover, it has a positive impact on their health and may even enhance or influence biological processes.

- Sense of well-being
- Activation and stimulation
- Circadian rhythm
- Lighting similar to daylight
- Avoiding danger spots
- Avoiding thermal radiation
- Electromagnetic fields

Empowerment

Varying visual requirements, visual tasks or periods of use call for options to individually influence one's lighting situation. Sensors and control systems help users adjust the lighting situation to their personal needs.

- Individual influence by switching and dimming
- Choice of lighting scene
- Presence detection
- Daylight-based control
- Choice of lighting scenarios
- Flexibility for layout changes
- Privacy

Chapter 9 – Checklists describes the use of the charts.

Chapter 2

Standard values for indoor and outdoor lighting

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	Building sites	40
	Fuel filling service stations	40
	Industrial sites and storage areas	40
	Offshore facilities for gas and oil extraction	41
	Parking areas	41
	Petrochemical and other hazardous industries	41
	Power, electricity, gas and heat plants	41
	Railway and tramways	42
	Saw mills	42

Standard values for lighting of indoor and outdoor workplaces and sports facility lighting

Tables and figures were taken from the European standards.

“Lighting of indoor workplaces”, EN 12464-1
(June 2011)

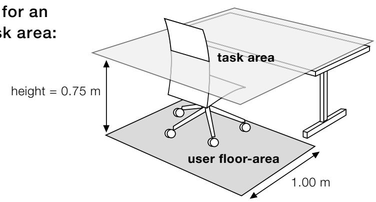
“Lighting of outdoor workplaces”, EN 12464-2
(October 2007)

“Sports facility lighting”, EN 12193
(April 2008)

The following limits have been specified in the tables:

Illuminance levels must not fall below **the $\bar{E}_m$ maintenance values** in the visual task area. If the precise location is not known, the limit should be applied to the whole room or a specific working area.

Example for an office task area:



The maintenance factors can be determined on a case-by-case basis, according to the manufacturer’s specifications (see also chapter 9 – Checklists).

Where no individual maintenance data is available, the following values are recommended as reference maintenance factors for modern technology and three-yearly maintenance: **0.67 in a clean atmosphere, and 0.50 in very dirty environments.**

EN 12464 specifies that the lighting designer must document the maintenance factor and maintenance schedule.

UGR_L is the upper limit for direct glare. The UGR value calculated in the design process must lie below this.

Uniformity **U_o** is the ratio between the lowest (E_{min}) and the mean illuminance level ($\bar{E}$) in the area to be evaluated. The result is a minimum level.

R_a is the lower limit for the colour rendering index. The R_a of the selected lamp must be equal to or greater than this value.

Type of interior, task or activity

Traffic zones and general areas inside buildings		$\bar{E}_m$	UGR_L	U_O	R_a
Circulation areas within buildings	Circulation areas and corridors	100	28	0.40	40
	Stairs, escalators, moving walkways	100	25	0.40	40
	Elevators, lifts	100	25	0.40	40
	Loading ramps/bays	150	25	0.40	40
Rest, sanitation and first aid rooms	Canteens, pantries	200	22	0.40	80
	Rest rooms	100	22	0.40	80
	Rooms for physical exercise	300	22	0.40	80
	Cloakrooms, washrooms, bathrooms, toilets	200	25	0.40	80
	Sick bays	500	19	0.60	80
	Rooms for medical attention	500	16	0.60	90
Control rooms	Plant rooms, switch gear rooms	200	25	0.40	60
	Telex, post room, switchboard	500	19	0.60	80
Store rooms, cold stores	Store and stockrooms	100	25	0.40	60
	Dispatch packing handling areas	300	25	0.60	60
Storage rack areas	Gangways: unmanned	20	–	0.40	40
	Gangways: manned	150	22	0.40	60
	Control stations	150	22	0.60	80
	Front of (high-bay) racks	200	–	0.40	60

Industrial activities and crafts					
Agriculture	Loading and operating of goods, handling equipment and machinery	200	25	0.40	80
	Buildings for livestock	50	–	0.40	40
	Sick animal pens; calving stalls	200	25	0.60	80
	Feed preparation; dairy; utensil washing	200	25	0.60	60
Bakeries	Preparation and baking	300	22	0.60	80
	Finishing, glazing, decorating	500	22	0.70	80
Cement, cement goods, concrete, bricks	Drying	50	28	0.40	20
	Preparation of materials; work on kilns and mixers	200	28	0.40	40
	General machine work	300	25	0.60	80
	Rough forms	300	25	0.60	80
Ceramics, tiles, glass, glassware	Drying	50	28	0.40	20
	Preparation, general machine work	300	25	0.60	80
	Enamelling, rolling, pressing, shaping simple parts, glazing, glass blowing	300	25	0.60	80
	Grinding, engraving, glass polishing, shaping precision parts, manufacture of glass instruments	750	19	0.70	80
	Grinding of optical glass, crystal, hand grinding and engraving	750	16	0.70	80

Type of interior, task or activity

		$\bar{E}_m$	UGR_L	U_O	R_a
Ceramics, tiles, glass, glassware	Precision work e.g. decorative grinding, hand painting	1000	16	0.70	90
	Manufacture of synthetic precious stones	1500	16	0.70	90
Chemical, plastics and rubber industry	Remote-operated processing installations	50	–	0.40	20
	Processing installations with limited manual intervention	150	28	0.40	40
	Constantly manned work places in processing installations	300	25	0.60	80
	Precision measuring rooms, laboratories	500	19	0.60	80
	Pharmaceutical production	500	22	0.60	80
	Tyre production	500	22	0.60	80
	Colour inspection	1000	16	0.70	90
	Cutting, finishing, inspection	750	19	0.70	80
Electrical industry	Cable and wire manufacture	300	25	0.60	80
	Winding:				
	– large coils	300	25	0.60	80
	– medium-sized coils	500	22	0.60	80
	– small coils	750	19	0.70	80
	Coil impregnating	300	25	0.60	80
	Galvanising	300	25	0.60	80
	Assembly work:				
	– rough e.g. large transformers	300	25	0.60	80
	– medium e.g. switchboards	500	22	0.60	80
	– fine e.g. telephones, radios, IT products (computers)	750	19	0.70	80
	– precision e.g. measuring equipment, printed circuit boards	1000	16	0.70	80
	Electronic workshops, testing, adjusting	1500	16	0.70	80
Food stuffs and luxury food industry	Work places and zones in: – breweries, malting floors – for washing, barrel filling, cleaning, sieving, peeling – cooking in preserve and chocolate factories – work places and zones in sugar factories – for drying and fermenting raw tobacco, fermentation	200	25	0.40	80
	Sorting and washing of products, milling, mixing, packing	300	25	0.60	80
	Work places and critical zones in slaughter houses, butchers, dairies mills, on filtering floor in sugar refineries	500	25	0.60	80
	Cutting and sorting of fruit and vegetables	300	25	0.60	80
	Manufacture of delicatessen foods, kitchen work, manufacture of cigars and cigarettes	500	22	0.60	80
	Inspection of glasses and bottles, product control, trimming, sorting, decoration	500	22	0.60	80

Type of interior, task or activity

		$\bar{E}_m$	UGR_L	U_O	R_a
Food stuffs and luxury food industry	Laboratories	500	19	0.60	80
	Colour inspection	1000	16	0.70	90
Foundries and metal casting	Man-size underfloor tunnels, cellars, etc.	50	–	0.40	20
	Platforms	100	25	0.40	40
	Sand preparation	200	25	0.40	80
	Dressing rooms	200	25	0.40	80
	Workstations at cupola furnaces and mixers	200	25	0.40	80
	Casting bays	200	25	0.40	80
	Shake out areas	200	25	0.40	80
	Machine moulding	200	25	0.40	80
	Hand and core moulding	300	25	0.60	80
	Die casting	300	25	0.60	80
	Model building	500	22	0.60	80
Hairdressers	Hairdressing	500	19	0.60	90
Jewellery manufacturing	Working with precious stones	1500	16	0.70	90
	Manufacture of jewellery	1000	16	0.70	90
	Watch making (manual)	1500	16	0.70	80
	Watch making (automatic)	500	19	0.60	80
Laundries and dry cleaning	Goods in, marking and sorting	300	25	0.60	80
	Washing and dry cleaning	300	25	0.60	80
	Ironing, pressing	300	25	0.60	80
	Inspection and repairs	750	19	0.70	80
Leather and leather goods	Work on vats, barrels, pits	200	25	0.40	40
	Fleshing, skiving, rubbing, tumbling of skins	300	25	0.40	80
	Saddlery work, shoe manufacture: stitching, sewing, polishing, shaping, cutting, punching	500	22	0.60	80
	Sorting	500	22	0.60	90
	Leather dyeing (machine)	500	22	0.60	80
	Quality control	1000	19	0.70	80
	Colour inspection	1000	16	0.70	90
	Shoe making	500	22	0.60	80
	Glove making	500	22	0.60	80
Metal working and processing	Open die forging	200	25	0.60	80
	Drop forging	300	25	0.60	80
	Welding	300	25	0.60	80
	Rough and average machining: tolerances ≥ 0.1 mm	300	22	0.60	80
	Precision machining; grinding: tolerances < 0.1 mm	500	19	0.70	80
	Scribing, inspection	750	19	0.70	80

Type of interior, task or activity

		$\bar{E}_m$	UGR_L	U_O	R_a
Metal working and processing	Wire and pipe drawing shops; cold forming	300	25	0.60	80
	Plate machining: thickness ≥ 5 mm	200	25	0.60	80
	Sheet metalwork: thickness < 5 mm	300	22	0.60	80
	Tool making; cutting equipment manufacture	750	19	0.70	80
	Assembly: – rough – medium – fine – precision	 200 300 500 750	 25 25 22 19	 0.60 0.60 0.60 0.70	 80 80 80 80
	Galvanising	300	25	0.60	80
	Surface preparation and painting	750	25	0.70	80
	Tool, template and jig making, precision mechanics, micromechanics	1000	19	0.70	80
Paper and paper goods	Edge runners, pulp mills	200	25	0.40	80
	Paper manufacture and processing, paper and corrugating machines, cardboard manufacture	300	25	0.60	80
	Standard bookbinding work, e.g. folding, sorting, glueing, cutting, embossing, sewing	500	22	0.60	80
Power stations	Fuel supply plants	50	–	0.40	20
	Boiler houses	100	28	0.40	40
	Machine halls	200	25	0.40	80
	Side rooms, e.g. pump rooms, condenser rooms etc.; switchboards (inside buildings)	200	25	0.40	60
	Control rooms	500	16	0.70	80
Printers	Cutting, gilding, embossing, block engraving, work on stones and platens, printing machines, matrix making	500	19	0.60	80
	Paper sorting and hand printing	500	19	0.60	80
	Type setting, retouching, lithography	1000	19	0.70	80
	Colour inspection in multicoloured printing	1500	16	0.70	90
	Steel and copper engraving	2000	16	0.70	80
Rolling mills, iron and steel works	Production plants without manual operation	50	–	0.40	20
	Production plants with occasional manual operation	150	28	0.40	40
	Production plants with continuous manual operation	200	25	0.60	80
	Slab storage facilities	50	–	0.40	20
	Furnaces	200	25	0.40	20
	Mill trains; coilers; shear lines	300	25	0.60	40
	Control platforms; control panels	300	22	0.60	80
	Test, measurement and inspection	500	22	0.60	80
	Underfloor man-sized tunnels; belt sections; cellars etc.	50	–	0.40	20

Type of interior, task or activity

		$\bar{E}_m$	UGR_L	U_O	R_a
Textile manufacture and processing	Work places and zones in baths, bale opening	200	25	0.60	60
	Carding, washing, ironing, devilling machine work, drawing, combing, sizing, card cutting, pre-spinning, jute and hemp spinning	300	22	0.60	80
	Spinning, plying, reeling, winding	500	22	0.60	80
	Warping, weaving, braiding, knitting	500	22	0.60	80
	Sewing, fine knitting, taking up stitches	750	22	0.70	80
	Manual design, drawing patterns	750	22	0.70	90
	Finishing, dyeing	500	22	0.60	80
	Drying room	100	28	0.40	60
	Automatic fabric printing	500	25	0.60	80
	Burling, picking, trimming	1000	19	0.70	80
	Colour inspection; fabric control	1000	16	0.70	90
	Invisible mending	1500	19	0.70	90
	Hat manufacturing	500	22	0.60	80
Vehicle construction and repair	Body work and assembly	500	22	0.60	80
	Painting, spraying chamber, polishing chamber	750	22	0.70	80
	Painting: touch-up, inspection	1000	19	0.70	90
	Upholstery manufacture (manned)	1000	19	0.70	80
	Final inspection	1000	19	0.70	80
	General vehicle servicing, repair and inspection	300	22	0.60	80
Wood working and processing	Automatic processing e.g. drying, plywood manufacturing	50	28	0.40	40
	Steam pits	150	28	0.40	40
	Saw frames	300	25	0.60	60
	Work at joiner's bench, glueing, assembly	300	25	0.60	80
	Polishing, painting, fancy joinery	750	22	0.70	80
	Work on wood working machines e.g. turning, fluting, dressing, rebating, grooving, cutting, sawing, sinking	500	19	0.60	80
	Selection of veneer woods	750	22	0.70	90
	Marquetry, inlay work	750	22	0.70	90
	Quality control, inspection	1000	19	0.70	90

Type of interior, task or activity

Offices		$\bar{E}_m$	UGR_L	U_O	R_a
	Filing, copying, etc.	300	19	0.40	80
	Writing, typing, reading, data processing	500	19	0.60	80
	Technical drawing	750	16	0.70	80
	CAD work stations	500	19	0.60	80
	Conference and meeting rooms	500	19	0.60	80
	Reception desks	300	22	0.60	80
	Archives	200	25	0.40	80
Retail premises					
	Sales areas	300	22	0.40	80
	Till areas	500	19	0.60	80
	Wrapper tables	500	19	0.60	80
Places of public assembly					
General areas	Entrance halls	100	22	0.40	80
	Cloakrooms	200	25	0.40	80
	Lounges	200	22	0.40	80
	Ticket offices	300	22	0.60	80
Restaurants and hotels	Reception/cashier desks, porters desks	300	22	0.60	80
	Kitchens	500	22	0.60	80
	Restaurant, dining room, function room	–	–	–	80
	Self-service restaurants	200	22	0.40	80
	Buffets	300	22	0.60	80
	Conference rooms	500	19	0.60	80
	Corridors	100	25	0.40	80
Theatres, concert halls, cinemas	Practice rooms	300	22	0.60	80
	Dressing rooms	300	22	0.60	90
	Seating areas – maintenance, cleaning	200	22	0.50	80
	Stage areas – construction	300	25	0.40	80
Trade fairs, exhibition halls	General lighting	300	22	0.40	80
Museums	Exhibits, insensitive to light		according to requirements		
	Light-sensitive exhibits				
Libraries	Bookshelves	200	19	0.40	80
	Reading areas	500	19	0.60	80
	Counters	500	19	0.60	80
Public car parks (indoor)	In/out ramps (during the day)	300	25	0.40	40
	In/out ramps (at night)	75	25	0.40	40
	Traffic lanes	75	25	0.40	40
	Parking areas	75	–	0.40	40
	Ticket offices	300	19	0.60	80

Type of interior, task or activity

Educational premises		$\bar{E}_m$	UGR_L	U_O	R_a
Nursery school, play school	Play rooms	300	22	0.40	80
	Nurseries	300	22	0.40	80
	Handicraft rooms	300	19	0.60	80
Educational buildings	Classrooms, tutorial rooms	300	19	0.60	80
	Classrooms for evening classes and adults education	500	19	0.60	80
	Lecture halls	500	19	0.60	80
	Black, green wallboards and whiteboards	500	19	0.70	80
	Demonstration tables	500	19	0.70	80
	Art rooms	500	19	0.60	80
	Art rooms in art schools	750	19	0.70	90
	Technical drawing rooms	750	16	0.70	80
	Practical rooms and laboratories	500	19	0.60	80
	Handicraft rooms	500	19	0.60	80
	Teaching workshops	500	19	0.60	80
	Music practice rooms	300	19	0.60	80
	Computer practice rooms (menu driven)	300	19	0.60	80
	Language laboratories	300	19	0.60	80
	Preparation rooms and workshops	500	22	0.60	80
	Entrance halls	200	22	0.40	80
	Circulation areas, corridors	100	25	0.40	80
	Stairs	150	25	0.40	80
	Student common rooms and assembly halls	200	22	0.40	80
	Teachers rooms	300	19	0.60	80
	Library: bookshelves	200	19	0.60	80
	Library: reading areas	500	19	0.60	80
	Stock rooms for teaching materials	100	25	0.40	80
	Sports halls, gymnasiums, swimming pools (general use)	300	22	0.60	80
	School canteens	200	22	0.40	80
	Kitchens	500	22	0.60	80
Health care premises					
Rooms for general use	Waiting rooms	200	22	0.40	80
	Corridors: during the day	100	22	0.40	80
	Corridors: cleaning	100	22	0.40	80
	Corridors: during the night	50	22	0.40	80
	Multiple-use corridors	200	22	0.60	80
	Day rooms	200	22	0.60	80

Type of interior, task or activity

		$\bar{E}_m$	UGR_L	U_O	R_a
Rooms for general use	Elevators, lifts for passengers and visitors	100	22	0.60	80
	Service lifts	200	22	0.60	80
Staff rooms	Staff offices	500	19	0.60	80
	Staff rooms	300	19	0.60	80
Wards, maternity wards	General lighting	100	19	0.40	80
	Reading lighting	300	19	0.70	80
	Simple examinations	300	19	0.60	80
	Examination and treatment	1000	19	0.70	90
	Night lighting, observation lighting	5	–	–	80
	Bathrooms and toilets for patients	200	22	0.40	80
Examination rooms (general)	General lighting	500	19	0.60	90
	Examination and treatment	1000	19	0.70	90
Eye examination rooms	General lighting	500	19	0.60	90
	Examination of the outer eye	1000	–	–	90
	Reading and colour vision tests with vision charts	500	16	0.70	90
Ear examination rooms	General lighting	500	19	0.60	90
	Ear examination	1000	–	–	90
Scanner rooms	General lighting	300	19	0.60	80
	Scanners with image enhancers and television systems	50	19	–	80
Delivery rooms	General lighting	300	19	0.60	80
	Examination and treatment	1000	19	0.70	80
Treatment rooms (general)	Dialysis	500	19	0.60	80
	Dermatology	500	19	0.60	90
	Endoscopy rooms	300	19	0.60	80
	Plaster rooms	500	19	0.60	80
	Medical baths	300	19	0.60	80
	Massage and radiotherapy	300	19	0.60	80
Operating areas	Pre-op and recovery rooms	500	19	0.60	90
	Operating theatres	1000	19	0.60	90
	Operating cavity			–	
Intensive care units	General lighting	100	19	0.60	90
	Simple examinations	300	19	0.60	90
	Examination and treatment	1000	19	0.70	90
	Night watch	20	19	–	90
Dentists	General lighting	500	19	0.60	90
	At the patient	1000	–	0.70	90
	Operating cavity	–	–	–	–
	White teeth matching	–	–	–	–

Type of interior, task or activity

		$\bar{E}_m$	UGR_L	U_O	R_a
Laboratories and pharmacies	General lighting	500	19	0.60	80
	Colour inspection	1000	19	0.70	90
Decontamination rooms	Sterilisation rooms	300	22	0.60	80
	Disinfection rooms	300	22	0.60	80
Autopsy rooms and mortuaries	General lighting	500	19	0.60	90
	Autopsy tables and dissecting tables	5000	–	–	90
Transportational areas					
Airports	Arrival and departure halls, baggage claim areas	200	22	0.40	80
	Connecting areas, escalators, travelators	150	22	0.40	80
	Information desks, check-in desks	500	19	0.70	80
	Customs and passport control desks	500	19	0.70	80
	Waiting areas	200	22	0.40	80
	Luggage store rooms	200	25	0.40	80
	Security check areas	300	19	0.60	80
	Air traffic control towers	500	16	0.60	80
	Testing and repair hangars	500	22	0.60	80
	Engine test areas	500	22	0.60	80
	Measuring areas in hangars	500	22	0.60	80
Railway installations	Covered platforms and passenger subways (underpasses)	100	–	0.40	40
	Fully enclosed platforms, large number of persons	200	–	0.50	60
	Pedestrian underpasses, small number of persons	50	28	0.50	40
	Pedestrian underpasses, large number of persons	100	28	0.50	40
	Ticket halls and concourses	200	28	0.50	40
	Ticket and luggage offices and counters	300	19	0.50	80
	Waiting rooms	200	22	0.40	80
	Entrance halls, station halls	200	–	0.40	80
	Signal boxes, technical rooms	200	28	0.40	60
	Access tunnels	50	–	0.40	20
	Maintenance and repair bays	300	22	0.50	60

Type of interior, task or activity

Sports facilities

The following details apply to competition class I (lower requirements apply to classes II and III)

$\bar{E}_m$ and R_a data according to European Standard EN 12193

General school sports data from EN 12464

An R_a level of 80 should be preferred

For lighting for training purposes, usually an UGR_L level of 22 should be observed

		$\bar{E}_m$	R_a
Sports facilities	Aerobics	500	60
	Archery	200	60
	Athletics (all disciplines)	500	60
	Badminton	750	60
	Basketball	750	60
	Billiards	750	80
	Boccia	300	60
	Boules	300	60
	Bowling	200	60
	Bowls	500	60
	Boxing (competition/training)	2000/300	80
	Climbing	500	60
	Cricket	750	60
	Cricket nets	1500	60
	Curling (target/playing areas)	300/200	60
	Cycling	750	60
	Dancing (fitness)	500	60
	Darts	200	60
	Fencing	750	60
	Figure skating	750	60
	Fistball	750	60
	Floorball	750	60
	Football (indoor)	750	60
	Gymnastics	500	60
	Gymnastics (floor exercises, apparatus work)	500	60
	Handball	750	60
	Hockey	750	60
	Ice hockey	750	60
	Ice speed skating (400 m and skating rink)	500	60
	Judo	750	60
	Kendo/Karate	750	60
	Netball	750	60
	Ninepins	200	60

Type of interior, task or activity

		$\bar{E}_m$	R_a
Sports facilities	Petanque	300	60
	Racketball	750	60
	Riding	500	60
	Roller skating	500	60
	Shooting	200	60
	School sports	750	60
	School sports (general use)	300	80
	Snooker	750	80
	Squash	750	60
	Swimming	500	60
	Swimming (school level)	300	80
	Table tennis	750	60
	Tennis	750	60
	Volleyball	750	60
	Weight lifting	750	60
	Wrestling	750	60

Type of outdoor workplace, task or activity

General circulation areas at outdoor workplaces		$\bar{E}_m$	R_a
	Walkways exclusively for pedestrians	5	20
	Traffic areas for slowly moving vehicles max. (10 km/h), e.g. bicycles, trucks and excavators	10	20
	Regular vehicle traffic (max. 40 km/h)	20	20
	Pedestrian passages, vehicle turning, loading and unloading points	50	20
Airports			
	Hangar aprons	20	20
	Terminal aprons	30	40
	Loading areas	50	40
	Fuel depots	50	40
	Aircraft maintenance stands	200	60
Building sites			
	Clearance, excavation and loading	20	20
	Construction areas, drain pipes mounting, transport, auxiliary and storage tasks	50	20
	Framework element mounting, light reinforcement work, wooden mould and framework mounting, electric piping and cabling	100	40
	Element jointing, demanding electrical, machine and pipe mountings	200	40
Fuel filling stations			
	Vehicle parking and storage areas	5	20
	Entry and exit driveways: dark environment (i.e. rural areas and suburbs)	20	20
	Entry and exit driveways: light environment (i.e. cities)	50	20
	Air pressure and water checking points and other service areas	150	20
	Meter reading areas	150	20
Industrial sites and storage areas			
	Short term handling of large units and raw materials, loading and unloading of solid bulk goods	20	20
	Continuous handling of large units and raw materials, loading and unloading of freight, lifting and descending location for cranes, open loading platforms	50	20
	Reading of addresses, covered loading platforms, use of tools, ordinary reinforcement and casting tasks in concrete plants	100	20
	Demanding electrical, machine and piping installations, inspection	200	60

Type of outdoor workplace, task or activity

Offshore facilities for gas and oil extraction		$\bar{E}_m$	R_a
	Sea surface below the platform	30	20
	Ladders, stairs, walkways	100	20
	Boat landing areas, transport areas	100	20
	Helicopter landing areas	100	20
	Drill towers	100	40
	Processing areas	100	40
	Piping depot/deck	150	40
	Test stations, shakers, drillheads	200	40
	Pump areas	200	20
	Lifeboat areas	200	20
	Drill floors, drill surfaces, platforms at drill tower	300	40
	Sludge chambers, sampling	300	40
	Crude oil pumps	300	40
	Facility areas	300	40
	Rotary tables	500	40
Parking areas			
	Light traffic, e.g. parking areas of shops, terraced and apartment houses; cycle parks	5	20
	Medium traffic, e.g. parking areas of department stores, office buildings, plants, sports and multipurpose building complexes	10	20
	Heavy traffic, e.g. parking areas of schools, churches, major shopping centres, major sports and multipurpose building complexes	20	20
Petrochemical and other hazardous industries			
	Handling of servicing tools, utilisation of manually regulated valves, starting and stopping motors, lighting of burners	20	20
	Filling and emptying of container trucks and wagons with risk free substances, inspection of leakage, piping and packing	50	20
	Filling and emptying of container trucks and wagons with dangerous substances, replacements of pump packing, general service work, reading of instruments	100	40
	Fuel loading and unloading sites	100	20
	Repair of machines and electric devices	200	60
Power, electricity, gas and heat plants			
	Pedestrian movements within electrically safe areas	5	20
	Handling of servicing tools, coal	20	20
	Overall inspection	50	20
	General servicing work and reading of instruments	100	40
	Wind tunnels: servicing and maintenance	100	40
	Repair of electric devices	200	60

Type of outdoor workplace, task or activity

Railways and tramways		$\bar{E}_m$	R_a
Railway areas including light railways, tramways, monorails, miniature rails, metro, etc.	Tracks in passenger station areas, including stabling	10	20
	Railway yards: flat marshalling, retarder and classification yards	10	20
	Hump areas	10	20
	Freight track, short duration operations	10	20
	Open platforms, rural and local trains, small number of passengers	15	20
	Walkways	20	20
	Level crossings	20	20
	Open platforms, suburban and regional trains with large number of passengers or inter-city services with small number of passengers	20	20
	Freight track, continuous operation	20	20
	Open platforms in freight areas	20	20
	Servicing trains and locomotives	20	40
	Railway yards handling areas	30	20
	Coupling areas	30	20
	Stairs, small and medium-size stations	50	40
	Open platforms, inter-city services	50	20
	Covered platforms, suburban or regional trains or inter-city services with small number of passengers	50	40
	Covered platforms in freight areas, short duration operations	50	20
	Covered platforms, inter-city services	100	40
	Stairs, large stations	100	40
	Covered platforms in freight areas, continuous operation	100	40
	Inspection pit	100	40
Saw mills			
	Timber handling on land and in water, sawdust and chip conveyors	20	20
	Sorting of timber on land or in water, timber unloading points and sawn timber loading points, mechanical lifting to timber conveyor, stacking	50	20
	Reading of addresses and markings of sawn timber	100	40
	Grading and packaging	200	40
	Feeding into stripping and chopping machines	300	40

Extracts from:

ÖNORM [Austrian standard] EN 12464-1
Light and lighting –
Lighting of workplaces – Part 1:
indoor workplaces (2011-07-01)

ÖNORM EN 12464 Part -2,
Light and lighting –
Lighting of workplaces – Part 2:
outdoor workplaces (2007-10-01)

ÖNORM EN 1246412193
Light and lighting –
Sports facility lighting (2008-04-01)

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Chapter 3
Lighting application

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What is lighting quality?

The ELI Ergonomic Lighting Indicator considers as many as five criteria of ergonomic quality.

Individual criteria are evaluated on the basis of specific checklists. The more individual aspects are fulfilled, the higher the rating. See chapter 9 – Checklists.

Three levels of lighting quality

Visual requirements

- Adequate visibility of details (visual acuity, contrast)
- Adequate visibility of shapes (three-dimensional)
- Adequate visibility of colours and colour variations
- Promptness of adequate visibility
- Adequate visibility over time/visual performance
- Guidance of attention
- Order, differentiability
- Physical safety
- Object safety

Emotional requirements

- Spatial orientation
- Keeping track of time
- Orientation about what is happening
- Privacy, communication
- Personal territory
- Self-representation, external representation
- Justice
- Sense of security
- Self check
- Mental stimulation
- Mental recovery
- Familiarity, surprise (no monotony)
- Structuring space according to shapes
- Structuring space according to rhythms (symmetries)
- Structuring space according to modules
- Enhancing the architecture's character and mood
- Emphasising special architectural (design) features

Biological requirements

- Physical stimulation
- Physical recovery
- Circadian rhythms
- Protection from radiation
- Physiological effect

Application area – Light for Offices and Communication

Working and feeling at ease	Examples
Making work easier	– Complying with standards (adjusting illuminance levels to tasks) – Avoiding glare by light
Creating an identity	– Lighting design in the overall architectural context – Taking CI into account
Promoting health	– Adjusting biologically effective light to the circadian day/night rhythm – Daylight as preferred source of light – Artificial lighting using Tunable White
Employees as a cost factor	– Staff cost analysis in comparison with investment and operating costs – Result: lighting solutions must be subject to people's demands – Light enhances people's performance and creativity
Technology and flexibility	
Creating different zones	– Structuring and orientation in space through lighting design for vertical surfaces, transit areas, pools of light etc. – Arranging groups using lighting management
Bolstering activity	– Adjustment through lighting management – Taking into account changing work media (such as tablets): no high luminance levels at steep angles
Preserving individuality	– Keeping demographic trends in mind – Higher illuminance levels at old age – Lighting management for individual control options
Being flexible	– Glare limitation at all angles for flexible utilisation of space – Lighting management: free-standing luminaire concepts and re-grouping of ceiling solutions

Effectiveness and efficiency	Examples
Sustainability	– Increases the value of buildings – Lighting management: daylight-based control or presence-based control – Efficient luminaires, lighting concepts
Integral approach	– All visual tasks and zones of the building – Integrating the lighting management system into higher-level building services
Rational refurbishment	– Short payback periods of new technologies – Wireless control technology
Added value thanks to LEDs	– Perfect integration into lighting management system – Unaffected by frequent switching and dimming – Life-cycle assessment shows benefits: reduced energy consumption, long service life, low maintenance effort

Lighting management as customer benefit

Lighting demands change with the user's age and specific visual tasks. A lighting management system meets all challenges to optimum extent.

Concentrated work and increasing communication place changing demands on the lighting situation. Additional, biologically effective components of artificial lighting that complement daylight at appropriate times of day work in harmony with our internal body clock and are invigorating.

Using time-based management, daylight-based control and presence-based control, the system achieves a high level of automation. This is associated with maximum energy savings and flexibility for adjustments.

Where staff members can individually control the lighting situation in their work environment, the technology is accepted most easily. This requires sufficient control options and small groups of luminaires with appropriately allocated responsibilities.

Application area – Light for Education and Science

Environmental aspects	Examples
Use of daylight	– Energy efficiency through lighting management
Efficient luminaires and intelligent control	– LED solutions are highly efficient – Frequent dimming and switching does not affect the LEDs' service life
Ergonomic compatibility	
Performance and concentration	– Standards cover basic visual requirements such as glare or illuminance – Emotional components enhance concentration – Open room ambience thanks to brightening up of ceiling and walls
Feeling at ease and health	– Feeling at ease enhances people's performance – Light stabilises the inner biological clock, measurably stimulates hormonal processes – Medical evidence shows that light enhances cognitive performance
Adjusting light to activities and visual tasks	– Blackboard lighting: high visual demands because of accommodation required from the eye for close and distant vision when reading and copying from the blackboard – Teamwork

New teaching methods	Examples
Mobility and communication	– Flexible seating arrangement – More teamwork and communication – Face recognition requires well-balanced direct/indirect components – Quickly retrievable, flexible luminaire grouping and scenes – Presence-based control in case of extensive periods of use (such as corridor zones at universities in the evening)
New learning methods and teaching materials	– Increasingly screen-based work, also on tablets: glare control at flat and steep angles
New technologies	
Variety and flexibility	– Lighting management: flexible use of rooms, dynamically changing light (daylight and artificial lighting) creates variety
Lighting scenes at the touch of a button	– Clearly laid out control units with selection of scenes

Lighting management as customer benefit

New teaching methods and media technologies require flexible room usage and frequent adjustment of lighting situations. These can be implemented by the press of a button using intuitive control units with predefined scenes – for working in small groups or teacher-centred teaching, a reduced level for data projector presentations or higher vertical illuminance levels for blackboard and flip charts.

Daylight is stimulating and enhances people's sense of well-being and performance. Using daylight-based control and presence-based control, maximum energy savings are achieved – without any compromises in terms of lighting quality.

Blinds control enhances the contrasts for presentation media and additionally increases room comfort, since glare and thermal output are minimised.

Application area – Light for Presentation and Retail

Setting the scene	Examples
Stimulating desires	– Guiding perception: direction of light, luminance levels and light colours rich in contrast matched to the goods on display
Brand communication	– Emotional lighting design through illumination of façades and shop windows

Authenticity	
Creating accents	– High-precision accent lighting – Excellent colour rendering: brilliance and authenticity
Directing the gaze	– Long-distance effect, orientation and enhanced room depth perception thanks to illuminated peripheral areas, vertical surfaces and shelf rear walls
Reducing lighting distances	– Presenting objects in greater detail – Miniaturised lighting systems focus people's attention on the goods displayed
Modelling objects	– Diffuse light to lend sleek lines to highly reflective objects – Presenting objects authentically with a three-dimensional effect: interplay of diffuse and directed light

Naturalness	
Emphasising freshness	– LED solutions with high colour rendering and matching colour temperature – Gentle illumination of fresh goods to boost sales
Adjusting colour temperature	– LED incorporating revolutionary Tunable Food and Tunable White technology – Choice of various colour temperatures in one luminaire – Formerly: filters and lamps had to be changed
Gentle illumination	– LED is virtually free from IR and UV radiation – No filters or protective devices

Sustainability	Examples
Increasing efficiency	– Linear LED solutions instead of fluorescent lamps – Vertical luminance levels prevail over horizontal lighting design
Reducing energy consumption	– LED combined with lighting management – Monitoring ancillary areas via presence detectors
Replacing the lighting system	– Comparing operating costs against investment costs – Increased lighting quality with higher efficiency possible (LED technology)

Lighting management as customer benefit

Lighting scenes are adjusted to various activities using intuitive control points – from task lighting at the POS terminals to gentle colour changes required for the lounge.

Thanks to increasing energy awareness, more and more dimmable luminaires are used in retail spaces. Positive material effects of goods and architecture are leveraged by possible changes in colour temperature combined with luminance levels (Tunable White).

Skilfully controlled lighting solutions are characterised by high levels of comfort and flexibility as well as low maintenance effort. For example, perfect adjustment of the light spectrum to the illuminated object is achieved without complicated replacement of filters. Using adequate control points, timelines or daylight-based control, ambient lighting is gently modified. The use of daylight not only helps to save energy, but makes room zones appear especially attractive.

Highly emotional illumination of goods and surprise effects can be achieved using static and dynamic lighting scenes.

Application area – Light for Hotels and Wellness

New technologies	Examples
Networking	– Lighting management system – Lighting scenes: multi-functional use of seminar rooms and conference halls
Flexible use of screens	– Glare control at steep angles for smartphones and tablets
Exacting design aspirations	
Enhancing architecture	– Illumination of façade and entrance area – Choice of luminaires reflecting the hotel's design language
Decorative luminaires	– New designs thanks to LED technology
Attractive control units	– Specially designed control units with intuitive lighting scenes and pictographs for hotels
Globalisation	
Variety of options	– Extensive product portfolio – Taking regional influences into account
Service on site and multi-cultural competence	– Global planning – Transnational distribution network – Regional adaptation – Knowledge of national regulations

Responsibility	Examples
Sustainable products	– Environmentally certified luminaires
Efficient luminaires and optimised lighting management	– Sufficient control options and central “off” of the entire unit next to the room door
Safety and security	– Integration of emergency lighting – Orientation in corridors and car parks
Spa and wellness	
Enhancing health and well-being, relaxation	– Gentle and dynamic changes in light colour – Creating specific pools of light and dark zones in the spa area

Lighting management as customer benefit

When it comes to hotel rooms, the guest’s individual wishes have top priority.
In terms of lighting, intuitive control units allow to create personal settings: using blinds control, artificial lighting and daylight can be conveniently adjusted to a variety of room requirements and visual demands – depending on whether the guest wants to watch TV, put on make-up or read.

Dynamic lighting scenes, flexibly defined via timelines or controlled according to weather situation and time of day, have an influence on the guests’ well-being – mainly in restaurants and wellness areas. Moreover, they optimise the adaptation conditions for the eye when entering the building, depending on the lighting situation outdoors, which provides security and orientation.

Predefined lighting scenes in conference areas allow for multiple changes in media, providing the right light at the press of a button. Integration of emergency lighting into the higher-level lighting management system allows central monitoring of the system.

Application area – Light for Art and Culture

Use of daylight	Examples
Enhancing architecture and promoting a sense of well-being	– Lighting management: utilising daylight to optimum effect
Lighting management for energy efficiency and gentle illumination of objects	– Presence-based control around the exhibits – Reduced radiation time
Creating scenes	
Diffuse low-shadow ambient lighting	– Linear luminaires with gently illuminating LEDs
Adjusting illuminance and colour temperatures	– Tunable White technology enhances the quality of perception and is gentle on the exhibits
Creating accents	
Directing people's gaze and creating exciting situations	– Selecting appropriate spectrum of light and optimum light distribution
High-precision accent lighting and modelling	– LED spotlights – Fibre-glass products
Illumination that is gentle on exhibits	– LED luminaires with marginal UV and IR radiation – The more reddish the LED's colour temperature (the lower the Kelvin values), the lower the burden on the exhibits
Setting the lighting stage	
Lighting art	– LED combined with lighting management

Lighting management as customer benefit

A lighting management system makes sure that exhibits which are sensitive to light are exposed only to the amount of light that is absolutely necessary: exactly that luminance level or light colour (Tunable White) that are required for good perception. Thanks to presence-based control, illumination is restricted to the time when visitors are present.

Times for switching on and off can be specified for particular times of day. Blinds management and daylight sensors allow just the amount of daylight that is absolutely necessary – as a balance between architecture, human well-being, gentle illumination of exhibits and energy costs.

Unobtrusively and with central monitoring, the emergency lighting system is integrated into the lighting management system, ensuring reliable visual conditions in an emergency.

Application area – Light for Health and Care

Health and activity	Examples
Quality for patients and persons in need of care	– Taking into account dementia patients – Avoiding mirror effects and reflections (delusions)
Feeling at ease and supporting the inner clock	– In many healthcare facilities, no daylight – an important means of stabilising the inner clock – is available – Little time is spent outdoors – Compensation by artificial lighting: well-adjusted changes in light colours and illuminance levels – High intensity in pools of light
Enhancing comfort and providing security	– Bedside lighting – Age-appropriate lighting scene concept in line with healthcare requirements

Reliability and functionality	
Visual comfort and security for patients and residents	– Emergency lighting – Providing orientation – Avoiding heavy shadows and dark zones – Pleasant corridor design using indirect light components on ceiling and walls
Supporting diagnosis and treatment	– Increase in illuminance levels: at the press of a button at the patient's bedside or via additional light components – High colour rendering index
Optimising doctors' and nurses' working conditions	– Individual settings, intuitive operation – Special illumination to meet high demands (operating theatres and intensive-care units) – Stimulation of night shift workers through high illuminance levels
Flexibility	– Modular lighting and medical supply units adapt flexibly to suit the way a room is being used

Eco-friendly and economically efficient	Examples
Added value for operators and investors	– Daylight-based control and lighting scenes that can be called up individually enhance comfort and increase efficiency
Optimising energy consumption	– Efficient luminaires and light sources – Corridor lighting with presence-based control and LED – unaffected by frequent switching and dimming
Enhancing the health and care facility’s image	– High-quality appearance of façade, parking spaces, entrance and waiting areas
Integral approach	– Central lighting control system with monitoring, including the emergency lighting system

Lighting management as customer benefit

Successful lighting solutions in residential care homes and hospitals offer intuitive age-appropriate control options that are also suitable for use by disabled persons. Using a lighting management system, a variety of lighting scenes required for residential and nursing purposes can be called up at the press of a button.

Due to age-related changes in the eye, the demand for light increases with age. For more sophisticated visual tasks, the artificial lighting can be individually adjusted by nursing staff and patients. As a result of processes of degradation in the eye, biologically highly effective bluish components are filtered out. The inner clock and the associated sleeping and resting patterns must therefore be supported by spending time outdoors or by biologically effective artificial lighting with high intensity levels or with a large bluish component at defined times of the day.

Timelines defined within the scope of the lighting management system make the interplay of artificial lighting and daylight perfect at any time of day.

Application area – Light for Industry and Engineering

Sustainability	Examples
Reducing energy consumption and CO_2 emissions	– Up to 24 working hours, often with little daylight, require highly efficient technologies – Primarily use of daylight, also to enhance well-being – Presence-based control of ancillary areas – Positioning companies as environmentally committed by obtaining certificates
Facilitating maintenance and replacing the lighting system	– Large-scale room dimensions result in high maintenance effort – Reduced effort thanks to durable and efficient LED solutions and lighting management systems
Productivity	
Empowerment and increased performance	– Taking into account not only the workstation, but also well-balanced luminance distribution in the room – Focussing the lighting design on special requirements for individual task areas – Individual lighting control enhances well-being – Variable production facilities require flexibility, quick adaptation of luminaires or luminaire groups
Cleanliness and security	– Low-maintenance luminaires that are easy to clean offer few surfaces on which dirt can settle – Materials resistant to cleaning agents and disinfectants – Explosion-proof luminaires – Sense of security: vertical luminance levels for opening up spaces – Special emphasis on dangerous zones

Functionality	Examples
Variety of options for rooms with high ceilings	– Uniform general lighting using linear fluorescent lamps or LEDs for typical room heights – Illumination of high bays: pinpointed high-pressure discharge lamps require compromises because of poor integration into the lighting management system (ignition and dimming behaviour) – Reduced uniformity – More shadows
Integral design using lighting management throughout the whole building	– Lighting solution on a one-stop basis, from the car park to workstations to storage facilities
Transparency and image	– More open architecture for creating brand identity – Clear arrangement of luminaires, in compliance with architectural zones, important for night-time effect – Façade lighting

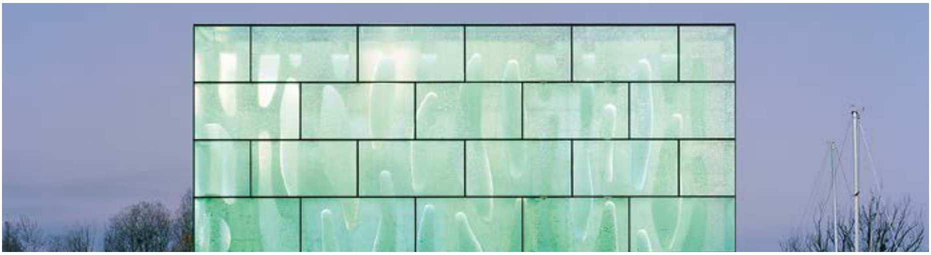
Lighting management as customer benefit

Especially in the industrial sector, the energysaving potential is very high, for because of shift and night-time working as well as in the absence of daylight, the lighting system is used extensively. Therefore investing in a lighting control system will pay for itself on a very short time-scale.

Lighting management perfectly complies with the required flexibility in production facilities. As maintenance factors must be taken into account, the design of new systems requires over-dimensioning. Functions such as daylight-based control or Maintenance Control counteract this additional energy consumption by continuously adjusting the lamp output depending on the daylight situation or service life.

Integral lighting solutions are created by close interlacing of the control system and the luminaire portfolio, as perfectly implemented in the TECTON continuous-row lighting system. Maintenance and monitoring are optimised in combination with integration of the emergency lighting system. In addition, interfaces with other building services ensure convenient and cost-efficient operation of buildings.

Application area – Light for Façades and Architecture



Façade lighting as a marketing factor	Examples
Setting the stage for cities	– Variety of LED luminaires: different night-time appearance – Accent lighting in compliance with master plans to enhance public spaces – Durable, highly efficient LED solutions
Promotion of the economy and tourism	– Promotion of corporate identity through night-time illumination of buildings has an influence on choice of site and residence – Tourists stay longer

Responsibility for nature, resources and the environment	
Sustainable lighting	– Intelligent lighting management – Night-time switch-off at specific times – Targeted direction of light to avoid spill light – Aim: balance between building illumination and environ-mental aspects – Integrated LED façade lighting or short distance from luminaire to façade for discreet energy efficiency
Security aspects	– Vertical luminance levels ensure orientation at night

Three approaches	Examples
Architectural: emphasis and structure	– Emphasis on façade elements – High-precision accent lighting for special architectural features – Adjustment of light colour to materials – Maintaining the façade's character 24/7 – Lighting scenario is subject to architecture
Emotional: drawing attention and making the architecture appear different	– Building looks different at night – Static or dynamic lighting scenarios using colours replace traditional accent lighting – Creative lighting patterns and textures reinforce emotional connection to the building
Communicative: creating brands and conveying information	– LED media façades produce a distinctive long-distance effect – LEDs can be used to convey information with unequivocal contents (images, text) – Interactivity: media façades respond to their environment

Lighting management as customer benefit

LED technology combined with lighting control resulted in a revolution in façade lighting.

Media façades are used to convey messages. In this respect, dynamic façade design in particular seeks to direct people's attention and convey information

From an environmental viewpoint, spill light at night is a hot issue. Much more important, however, seems to be the avoidance of unnecessary switch-on times by defining feasible operating hours. Ultimately, façade illumination interacts with people and should therefore be used only in the evening and morning hours with more public footfall.

This allows to emphasise the identity of companies and municipalities, to structure outdoor spaces at night and to support night-time perception, taking environmental goals into account.

Chapter 4
Technology

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LED technology

Functions and types of LEDs

An LED (light-emitting diode) is an electronic semiconductor component that emits light when a current flows through it. The wavelength of the light depends on the semiconductor material and its doping. The spectrum of LEDs offers a major benefit: only light (electromagnetic radiation in the visible range) and no ultraviolet or infrared radiation is emitted.

Basically, there are three types of LED:

- Standard through-hole LED: often used as indicator light source, although with low light output. Due to their shorter service life, higher probability of failure and sensitivity to UV radiation, they are not used in lighting technology.
- SMD (surface mounted device) LED: an LED that is reflow-soldered to the surface of a printed circuit board (using a reflow oven). Basically, it consists of an LED chip protected by silicon coating mounted in or on a housing or a ceramic plate with contacts.
- CoB (chip on board) LED: the LED chip is mounted directly on the printed circuit board. This allows a dense arrangement of chips close to each other.

LED features

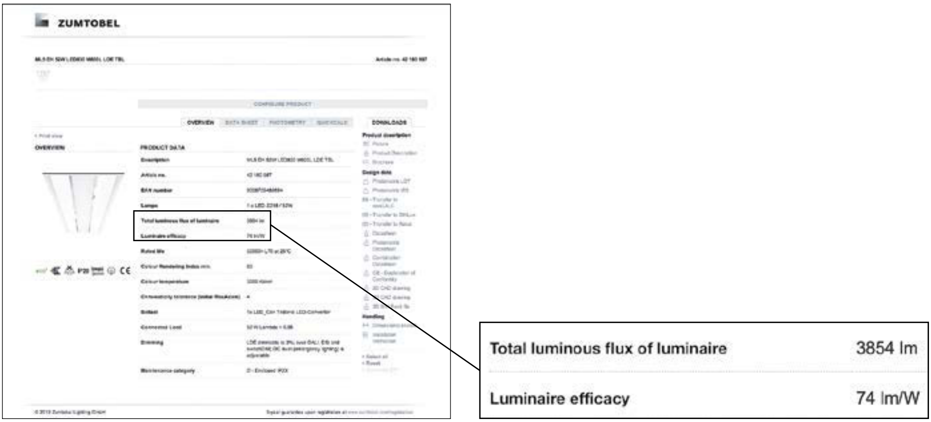
- Long service life (e.g. 50 000 hours at 70 % luminous flux)
- Light is emitted only in the visible range; i.e. no UV or infrared radiation
- Compact size
- High luminous efficiency (lm/W)
- Good to excellent colour rendering index (R_a)
- Luminous flux and service life highly temperature-sensitive
- No environmentally harmful materials (e.g. mercury)
- Resistant to vibrations and impact
- Saturated colours
- 100 % luminous flux after switching on
- No ignition, boosting or cooling time
- High-precision digital dimming via PWM (pulse-width modulation)
- No shifting of colour locations during dimming

Important LED key figures

Luminous flux and efficiency

A critical issue when comparing LED luminaires of various suppliers is the indication of luminous flux levels. In catalogues you will find details regarding the luminous flux and efficiency of individual LEDs at a junction temperature of 25 °C in the LED chip, details regarding the luminous flux levels of the LED boards used, or details regarding the luminous flux levels of luminaires and luminaire efficiency levels, including the power loss of ballasts and any potential loss of efficiency through lighting optics, such as lenses, reflectors or mixing chambers.

Zumtobel's catalogue data include the luminaire's overall luminous flux (lm) and system efficiency (lm/W). These figures indicate the actually available luminous flux emanating from the luminaire.



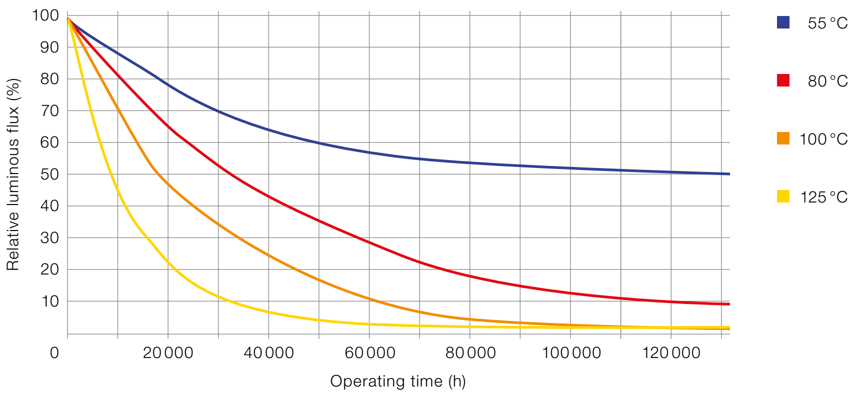
Temperature and service life

The luminous flux of an LED will decrease over time, like that of other lamps. This ageing process speeds up at higher temperatures. This is why the heat produced by an LED must be dissipated efficiently. Therefore, reliable thermal management is indispensable for an LED to have a long service life.

An LED's service life is determined taking this drop in luminous flux into account. As there is no standardised procedure in this respect, every manufacturer specifies the service life of its LEDs individually.

The prognostic methods are based on laboratory tests of varying duration and cannot be compared for the most part.

Usually, a luminous flux level of 70 % is assumed. However, some manufacturers also refer to 50 % or failure. These specific features should be observed when selecting and comparing products.



White light quality and binning

In the production of LED chips, LEDs of different production batches have different properties with respect to intensity, colour temperature, colour location, or with respect to forward voltage.

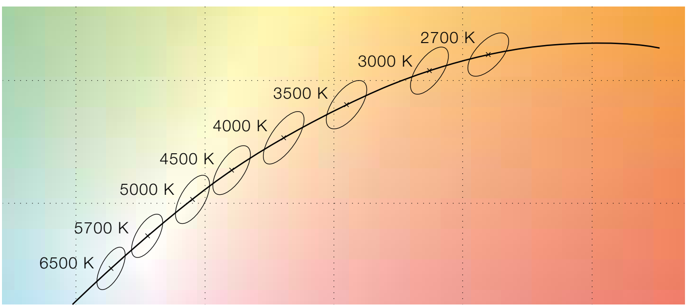
The properties of each individual LED are measured after manufacturing and allocated to a group showing the same features. These correspond to finely differentiated parameters which are divided into so-called bins. Depending on the application and the product, these features are weighted differently.

By using specific binning groups, colour and brightness tolerances – not just of the light emitted by individual luminaires, but also on visible luminous surfaces – are reduced to a minimum. Thus, illuminated surfaces and light emitting panels of luminaires are given a uniform appearance. This selection is especially important when it comes to "single LED" products and applications with maximum white light quality such as museums.

In practice, MacAdam ellipses are often used to give users an idea of how far individual LED modules differ with respect to colour perception.

MacAdam ellipses describe the colour distances on the xy coordinates in the standardised colour table. In theory, we talk about 1 MacAdam as soon as there is a visual difference with respect to colour perception.

A colour difference between individual LED modules of one luminaire and between individual LEDs, i.e. individual luminaires in case of spotlights, of 2 MacAdam ellipses is at present considered the maximum of technical feasibility. The colour difference between wide-angle luminaires with high luminous flux levels (replacing fluorescent lamps) is considered excellent at 4 MacAdam ellipses.



4 step MacAdam

Technology used in Zumtobel's LED modules

Colour temperature and CCT

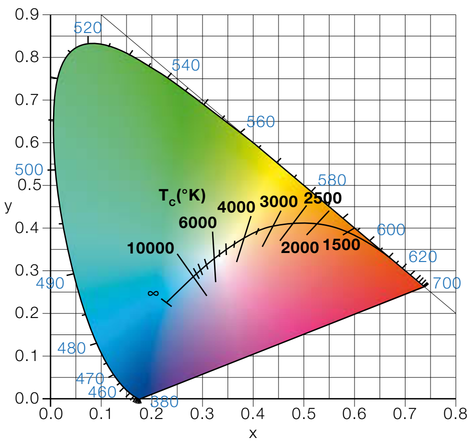
Colour temperature (CT)

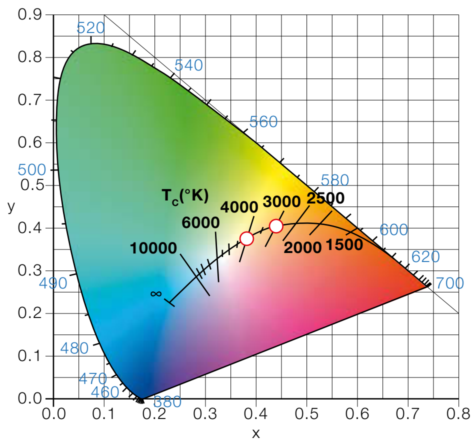
- Colour coordinates of the Planckian radiator (Planckian curve)
- Real light sources often deviate from this: correlated colour temperature (CCT)
- Judd straight lines: all points on these lines have the same correlated colour temperature. This means that different colour coordinates can have the same CCT.

Stable White

Invariable colour temperature

- Specific initial colour temperature (incl. tolerance range)
- Most frequent colour temperature at Zumtobel: 3000 K, 4000 K
- No readjustment in the course of the LED's service life
- Temperature-based readjustment to keep the colour temperature constant
- Constant colour temperature during dimming

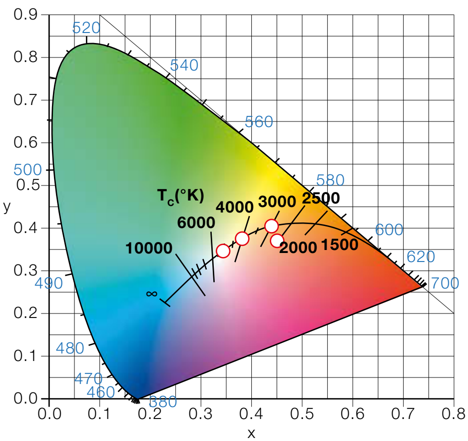


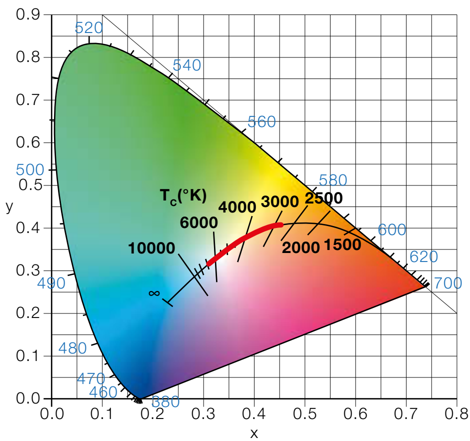


Selectable White
Colour coordinates to be selected
- Predefined, fixed colour coordinates or colour temperatures
- Steps adjustable using sliders

Use:
- Tunable Food: for illuminating food in supermarkets
- XPO: shelf lighting with selectable colour temperature (3000 K, 4000 K, 5000 K)

Tunable White
Tunable colour temperature
- Continuous alteration of the colour temperature between 2700 K and 6500 K
- Highly constant luminous flux across the entire colour temperature range
- Constant colour temperature during dimming
- Colour temperatures close to the Planckian curve
- Can be addressed statically or dynamically





Optics

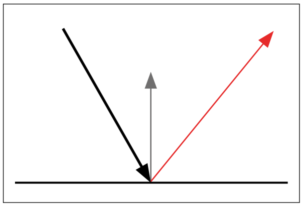
The direction of light is based on three fundamental principles: reflection, refraction and diffraction.

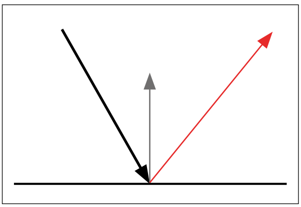
These principles are applied to define the photometric properties of luminaires in terms of lighting patterns.

High-precision light direction structures made of tried-and-tested as well as innovative materials extend the range with a view to both optics and design.

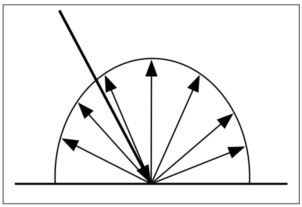
Reflection

In physics, reflection is the change in direction of a wavefront at an interface between two media with a differing refractive index so that the wavefront returns to the medium from which it originated.

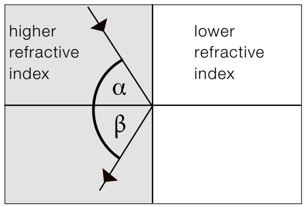




Specular reflection
Nearly all light is reflected according to the law of reflection (incident angle = reflected angle). The aim is to reflect as much light as possible, absorbing only little of it.



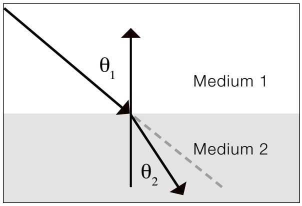
Lambertian reflectance
Nearly all light is reflected diffusely: light is reflected in all directions, in accordance with Lambert's law, so that the reflecting surface appears equally bright from any direction of view. Here, too, the aim is to reflect as much light as possible and absorb only little of it.

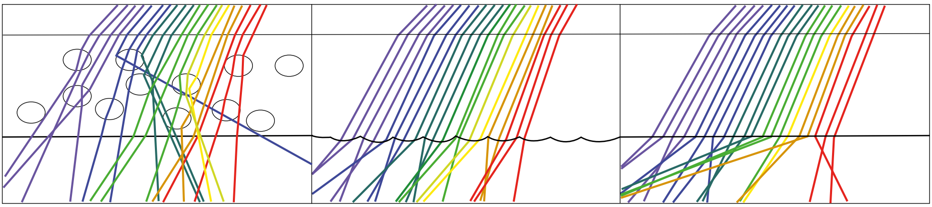


Total reflection
A beam of light coming from a medium with a higher refractive index that hits the boundary to a medium with a lower refractive index will be reflected away from the incident slot. If the incident angle is further increased, total reflection will occur at a critical angle. This means that the light beam does not pass out from the material with a higher refractive index, but is reflected back.

Refraction
Refraction indicates the change in direction of a wave due to a spatial change in its rate of propagation. For light waves in particular this phenomenon is described by the refraction index of a medium.

At the transition between two media with a differing refraction index, the beam therefore changes direction according to Snell's law of refraction.





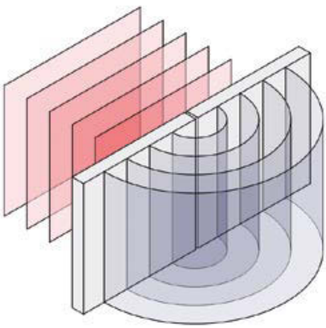
Light refraction in materials with different optical properties

Light refraction against structures such as microprisms or microlenses

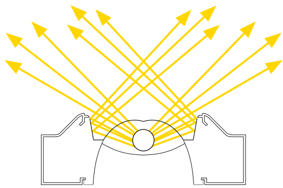
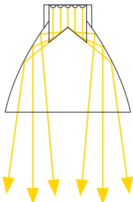
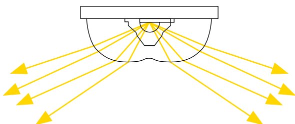
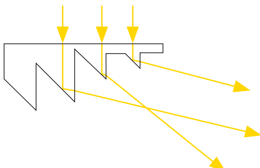
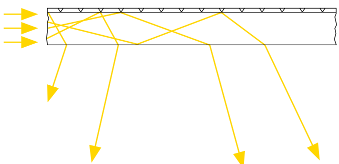
Light refraction against very fine structures for thorough mixing of light

Diffraction
If light encounters periodic structures with expansions in the wavelength of light, it is diffracted (see illustration).

Such structures may be transmission grids, reflection grids (phase grids) or holographic grids, for example. Diffraction of chromatic light results in an unfolding of the light spectrum.

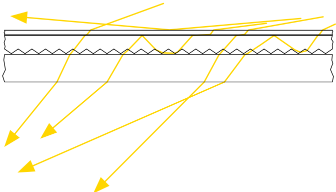
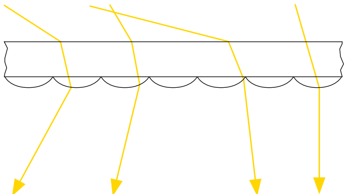
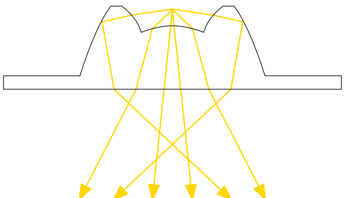
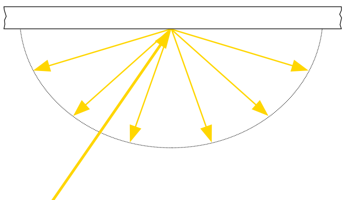


Technology and application in products

Technology	Illustration of the principle	Functional principle
Cross louvre		The combination of patented upper reflector and louvre directs the light beams to the ceiling crosswise.
Mixing-chamber lens system		The LEDs' spectral components are united in the mixing chamber to produce white light, focussed by the lens and directed to the high-precision reflector.
Reflector/lens system		The LED's narrow-beam light is emitted through a lens and a bi-symmetrical reflector so that a narrowly targeted beam pattern is produced.
Rotating lens		A cascading lens system redirects the vertical light beams, producing unilaterally asymmetrical distribution of light.
Lasered light guide panel		The texture applied on a transparent plastic panel using a laser results in refraction of the light injected. Thanks to the texture's varying density, the entire light guide panel can be uniformly illuminated.

Application in products	Application hints/benefits
 ELEEA	The structural design of the light control unit results in a light output ratio of the luminaire of up to 98 %. Wide-angle distribution of indirect light allows uniform illumination of the ceiling even at short suspension heights.
 IYON	The division into mixing chamber and optic results in high modularity when using various reflectors, and hence a variety of beam patterns – from narrow-beam to wide-angle.
 RESCLITE Escape	The special lighting technology allows luminaire spacings along the escape route of up to 23 m. Thanks to uniform floor illumination, perfect visual conditions are ensured even in emergency mode.
 ERI (Escape Route Illumination) in ONLITE CROSSIGN and ONLITE PURESIGN	With an installed load of only 0.5 W, the spot illuminates up to 12 m of escape route. The lens can be adjusted in increments of 90°. By using two lenses, escape route illumination can be doubled and even escape route illumination around the corner can be implemented. 
 ONLITE PURESIGN	This technology allows unilateral injection of light resulting in an increase in efficiency while at the same time ensuring perfect uniformity.

Technology and application in products

Technology	Illustration of the principle	Functional principle
Micro-pyramidal optic		The light is injected into the MPO panel laterally or from above. The light beams are precisely redirected resulting in defined distribution of light.
Micro-lens optic		The lens structure applied to a carrier film ensures parallelisation of incident light and thus produces linear light distribution.
Lens optic		The direction of light through the lens reduces the optic's volume and allows for uniform appearance of the luminaire even at varying beam angles.
Highly reflective plastic materials		Light chamber made of highly reflective high-purity plastic boasting a reflection factor of 98 %.

Application in products	Application hints/benefits
 AERO, MELLOW LIGHT V, LIGHT FIELDS	The luminance of the light source is reduced across the entire light emitting panel. The lamps are invisible at any angle, so that the luminaires can be flexibly arranged with respect to the workstation.
 MELLOW LIGHT V	A specific percentage of light emanates at a wider angle from the light emitting panel. The result is an increase in vertical illuminance and an improvement of face/object recognition and wall illumination as compared to louvre luminaires.
 TECTON LED	Thanks to high-precision direction of light, both horizontal and vertical illuminance levels can be optimised and spill light avoided. Hence, there is no need for additional reflectors.
 MELLOW LIGHT V	Homogenisation of the luminance curve and increase in the luminaire's optical light output ratio.

Chapter 5

Lamps

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Introduction – History of electric lighting, overview

History of electric lighting

Our ancestors had to make do with natural sunlight for many thousands of years. The story of how humans first learned to use light begins 500 000 years ago when they first tamed fire. It then became possible to use light and heat purposefully, and artificial lighting has extended the natural day length ever since.

Wood, tallow, fat and oil were burned to provide light for many years. It was industrialisation that brought really revolutionary changes in its wake: first gas, then electricity became the dominant method of distributing energy and producing light.

Artificial electric lighting has been an almost ubiquitous feature of everyday life for more than 130 years now. Our modern lifestyle is not viable without artificial lighting. We live in a 24-hour society and spend most of our time indoors. Even our outdoor environment is illuminated, either for traffic management purposes or to obtain decorative effects.

Demand for artificial lighting is therefore huge, and we have high expectations of it: we expect artificial lighting to be available any time, anywhere and in the required quality – and we expect it to be produced affordably and in eco-friendly ways.

Modern light sources are now highly efficient and produce good-quality light. Lighting in Europe nevertheless still accounts for 14 % of all energy consumption (and around 19 % of worldwide energy consumption).

Professional lighting accounts for approximately 80 % of this figure, and lighting in private homes accounts for roughly 20 %. That is equivalent to the emission of climate-relevant greenhouse gases amounting to roughly 600 million tonnes of CO_2 a year.

Saving energy that is used for lighting therefore also saves CO_2. The EU has set ambitious targets intended to limit global warming to no more than 2 °C compared with pre-industrial levels: –20 % by 2020 and –40 % by 2030 compared with 1990 emission levels.

The lighting industry has come up with a wide variety of different types of lamps since 1879 when Thomas Alva Edison invented the incandescent lamp and manufactured it on an industrial scale. Individual lamps differ in terms of their design and output and, especially, the way in which they produce light. The most important criteria for modern light sources are lighting quality and efficiency – low energy consumption and a long service life.

Light production
Light can be produced in a large number of different ways – naturally or artificially. Light is produced cost-effectively by using four main groups of light sources:

- Thermal light sources
- Low-intensity discharge lamps
- High-intensity discharge lamps
- Semiconductor light sources

Light production

- **Thermal radiation** — Thermal light sources
  - Incandescent lamps

    Standard, reflector, special types
  - Halogen incandescent lamps

    12 V 230 V
    Standard, reflector, cap at both ends
- **Gas discharge** — Discharge lamps
  - Low-intensity discharge lamps

    Fluorescent lamps, compact fluo-rescent lamps, “energy-saving lamps”
  - High-intensity discharge lamps

    Metal halide lamps, sodium dis-charge lamps, mercury dis-charge lamps
- **Electroluminescence** — Semiconductor light sources
  - Light emitting diodes

    LED lamps, LED modules, OLED

The most important light sources

QT12 QR-CBC QR111 QA60 QT-DE QPAR51 QPAR64

Halogen incandescent lamps

- Mains voltage or low voltage
- Service life and luminous efficiency better than incandescent lamps
- Dimmable
- Brilliant light
- Excellent colour rendering
- **Use: retail and domestic areas, hospitality and decorative applications**

Functional description
Current flows through a filament and heats it up in exactly the same way as in an incandescent lamp. This is why these lamps release relatively large amounts of heat. The halogen cycle boosts the efficiency and prolongs the service life of these lamps compared with conventional incandescent lamps.

Low-voltage lamps are very compact and therefore ideally suitable for directing light precisely, but they do need a transformer.

Due to European legislation, only the most energy-efficient versions of this lamp group are permitted.

More efficient alternatives include compact fluorescent lamps with built-in electronic ballasts or LED lamps.

T26 **T16** **T16-I** **T16-D** **T16-R(I)**

Fluorescent lamps

- High to very high luminous efficiency (especially T16 HE)
- Good to very good colour rendering
- Long service life
- Wide selection of standard ranges
- Dimmable
- **Use: efficient wide-area lighting**

Functional description
An alternating electrical field between two electrodes in the discharge tube produces invisible UV radiation. The tube's white fluorescent coating converts this radiation into high-quality, visible light.

These lamps need ignitors and current limiting; these functions are combined in an electronic ballast.

The luminous flux of fluorescent lamps is highly dependent on their operating position and ambient temperature. Lamps that use amalgam technology are optimised for use in environments where there are fluctuating temperatures (see page 94).

TC-SEL

TC-DEL

TC-TEL(I)

TC-L(I)

Compact fluorescent lamps

- Compact designs
- High luminous efficiency
- Excellent colour rendering
- Wide selection of standard ranges
- Dimmable
- **Use: commercial and prestigious areas, hospitality**

Functional description
These lamps are compact versions of tubular or toroidal fluorescent lamps and operate in a very similar way.

The luminous flux of these lamps is highly dependent on their operating position and ambient temperature. Lamps that use amalgam technology are optimised for use in environments where there are fluctuating temperatures (see page 99).

HIT-TC-CE HIT-CE HIT-DE-CE HIPAR HIE HIT

Metal halide lamps

- High luminous efficiency
- Good to very good colour rendering
- Good colour stability in case of lamps with ceramic discharge tubes
- Usually not dimmable
- **Use: industrial bays, spotlighting, floodlighting systems, retail areas**

Functional description
Metal halide lamps maintain an extremely compact electric arc in a discharge tube. Lighting quality is determined by the composition of the materials the lamp contains.

An ignitor is needed to start the lamp and the current must be limited by a ballast. Electronic ballasts can advantageously be used for low-power lamps.

Lamps with a ceramic discharge tube offer the best lighting quality, efficiency and service life.

HST-CRI **HSE** **HST** **HST-DE**

High-pressure sodium discharge lamps

- High luminous efficiency and long service life
- Satisfactory to poor colour rendering
- Yellowish light colour
- Can be dimmed in steps
- **Use: industrial bays, street lighting, outdoor illumination**

Colour-improved (Philips SDW):
- Warm, white light
- Excellent colour rendering
- **Use: retail areas**

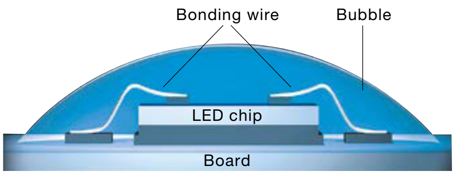
Functional description
Discharge in the elongated ceramic discharge tube is determined by sodium. The light therefore has a yellow hue and is only suitable for specific applications.

Philips colour-improved SDW produces very good quality white light and is a popular choice for lighting in retail spaces.

An ignitor is generally needed to start the lamp. The current must be limited by a ballast.

LED lamp

LED module



Light emitting diodes (LEDs)

– Very efficient light production
– Wide selection of standard ranges
– Can be switched and dimmed as required
– Very long service life
– Good to very good colour rendering
– Very good production of coloured light
– **Use: LEDs can be used for both functional and decorative lighting in indoor and outdoor locations.**

More information about LEDs can be found in Chapter 4 – Technology.

Functional description
Light emitting diodes are modern semiconductor devices. Their characteristics are determined by their materials, mechanical design and operating mode. The active semiconductor layer, in which radiation is produced, is sandwiched between a positive and a negative substrate inside the LED. Actual coloured light is produced, depending on which materials are chosen. Nowadays, high-quality white light is produced by blue LEDs with yellow luminescent substances. A mixture of RGB (red, green, blue) also produces white. The smallest LED chips have a side length of approx. 250 µm (1 micrometre = 1 one thousandth of a millimetre). As a rule, they are powered via appropriate DC converters. Their very long service life of over 10 000 hours demands optimised thermal management in order to prevent overheating.
Today, LEDs are already some of the most efficient light sources for general lighting. They are completely superseding traditional light sources in many applications.

Performance characteristics of light sources

Choosing the right lamp – an important first decision

Choosing the right lamp depends on what is required of the lighting (see Chapter 2).

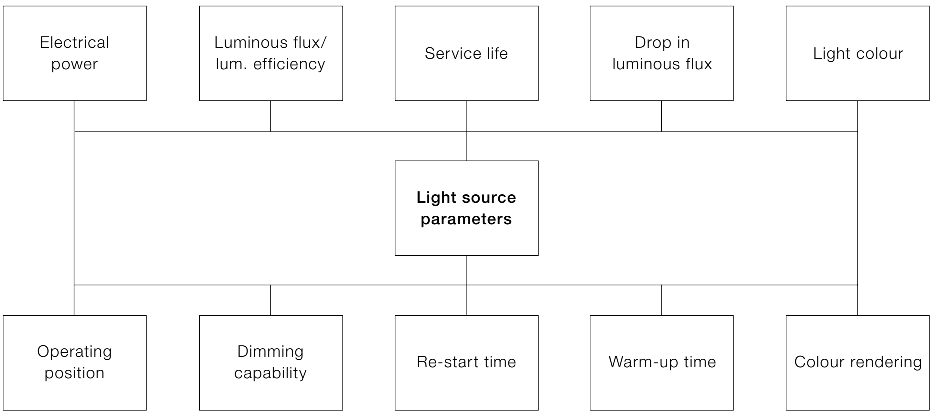
Incandescent lamps were highly popular for private domestic use for many years. Because of their poor efficiency and short service life, they are now being replaced by more environmentally compatible alternatives of higher quality such as LED lamps.

Discharge lamps are the perfect choice for professional applications thanks to their efficient operating mode.

LED light sources are taking over in all application areas because of their high luminous efficiency and long service life. They can legitimately be regarded as the light source of the future.

Thus it is part of the expertise of the lighting designer to find the most suitable lamp for a lighting task.

The performance characteristics of lamps are essentially defined by the following concepts:



Performance characteristics

Electric power
The electric power is the power consumed by a light source. The system power takes the power consumption of the control gear as well as that of the light source into account.

Luminous flux/luminous efficiency
Luminous flux defines the total quantity of light emitted from a light source. The unit used is the lumen [lm]. The ratio of luminous flux to the required electric power gives the luminous efficiency [lm/W]. The system luminous efficiency also takes the ballasts' losses into account.

Luminous efficiency describes the efficiency of a light source and is now one of the most important performance characteristics of all.

Service life
The average service life (mortality) is usually quoted; this is the time after which half of the lamps will statistically still be serviceable (in other words half of the lamps will have failed). This test is subject to standardised operating conditions. Lamp manufacturers display this failure rate by curves. In Chapter 8 – Technology, they are shown as maintenance factors (LSF).
Special service-life data apply to some light sources such as LEDs.

Drop in luminous flux
The initial luminous flux of a new lamp decreases over its time of operation (lumen maintenance), due to the ageing of its chemical and physical components. Lamp manufacturers display this drop in luminous flux by curves. In Chapter 8 – Technology, they are shown as maintenance factors (LLWF).

Colour code
The colour code is a three-digit numerical value (e.g. 840) that describes the lighting quality of a white light source. The first digit denotes colour rendering, the second and third digits denote colour temperature (light colour).

Example:
840 -> 8xx colour rendering index > 80
-> x40 colour temperature 4000 K

Light colour
The light colour describes the colour impression made by a white light source as relatively warm (ww = warm) or relatively cool (nw = intermediate, tw = cool). It is affected by the red and blue colour components in the spectrum.

Colour rendering

The spectral components of the light determine how well various object colours can be reproduced. The higher the colour rendering index (R_a or CRI), or the lower the colour rendering group number, the better the colour rendering in comparison with the optimum reference light. The maximum colour rendering index value is 100. Values in excess of 80 are considered to be very good.

Eight test colour samples (R_1 to R_8) are used for the general colour rendering index, and there are another 6 more vivid high-saturation colours (R_9 to R_{14}). The general colour rendering index is calculated for a light source relative to a “known” reference light source.

Colour fields can only convey an impression of the original reflection patterns.

R_1	Light greyish red	R_5	Light blueish green
R_2	Dark greyish yellow	R_6	Light blue
R_3	Strong yellow green	R_7	Light violet
R_4	Moderate yellowish green	R_8	Light reddish purple

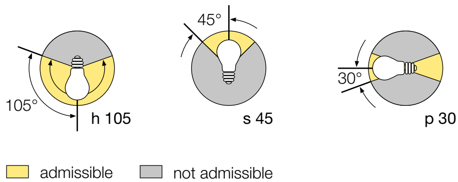
R_9	Strong red	R_{12}	Strong blue
a R_{10}	Strong yellow	R_{13}	Light yellowish pink
R_{11}	Strong green	R_{14}	Moderate olive green (leaf)

Warm-up time
Discharge lamps in particular need between 30 seconds and several minutes to warm up and output the full luminous flux.

Re-start
High-pressure discharge lamps need to cool down for several minutes before they can be started again.

Dimmability
As well as incandescent and halogen incandescent lamps, almost all fluorescent and compact fluorescent lamps can be dimmed as required nowadays. Most manufacturers' metal halide lamps continue to be incompatible with dimming because dimming may have uncontrolled effects on lighting quality and lamp service life. The new series of special models for indoor and outdoor applications constitute an exception. The output of sodium vapour lamps and high-pressure mercury lamps can be restricted in stages. LED light sources can be switched and dimmed as required.

Operating position
Manufacturers specify the permitted operating positions for their lamps. For some metal halide lamps, only certain operating positions are allowed so as to avoid unstable operating states. Compact fluorescent lamps may usually be used in any operating position; however, important properties such as the luminous flux vs. temperature curve may vary with the position.



Overview of light sources

Comparison of technical data of the most important lamp types

	Thermal light sources	Gas discharge lamps
		Low-pressure
	Incandescent lamps Halogen incandescent lamps	Fluorescent lamps Compact fluorescent lamps "Energy-saving lamps"
Applications	Private and semi-professional applications	Private and professional applications
Light production	Filament is heated until it glows	Current flows through conductive gas (contains mercury)
Output	Low, 15 to 400 W	Low to moderate, 5 to 80 W
Lamp voltage	230 V, 12 V	230 V, > 110 V
Cap	E27, E14, GY6,35, GU5,3, G9, R7s	E27, E14, G13, G5 G24/GX24-d/-q, 2G11 and others
Luminous flux	100 to 9000 lm	250 to 6150 lm
Luminous efficiency	10 to 25 lm/W	50 to ***100 lm/W***
Energy efficiency class	C, D, E, F	***A, B***
Service life	1000 to 5000 hours	10,000 to ***24000 hours***
Light colour	Warm approx. 2500 to 3000 K	Warm, intermediate, cool approx. 2500 to 8000 K
Colour rendering	Very good (CRI = ***100***)	Very good (CRI = 80 to ***95***)
Notes	Transformer is required in case of low-voltage lamps	Ballast is usually required

Italic = Best in class Grey = Worst in class

	Semiconductor light sources
High-pressure	
Mercury-vapour lamps Metal halide lamps High-pressure sodium discharge lamps	Light emitting diodes (individual LEDs) LED modules LED lamps
Professional applications	Private and professional applications
Electric arc in a conductive gas (contains mercury)	Photons are produced in a solid material (semiconductor)
Low to very high, 20 to 1000 W	Very low to high, 0.2 W (individual LED) to 100 W (LED module)
> 80 V	230 V, 12/24 V
E27, E40, G12, G8,5, GU6,5 and others	E27, E14 or without cap
1600 to 110,000 lm	Up to 5000 lm
40 to ***100 lm/W*** (sometimes ***> 120 lm/W***)	60 to ***140 lm/W***
Not defined	***A***
8000 to 15000 hours	***25000 to 50000 hours***
Warm, intermediate, cool approx. 2500 to 8000 K	Warm, intermediate, cool approx. 2700 to 6500 K
Poor to very good (CRI = < 40 to ***95***)	Good to very good (CRI = 70 to ***> 90***)
Ballast is required	Converter is required in case of modules

Application hints

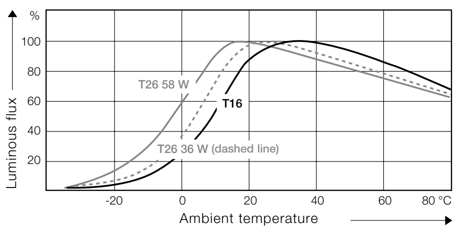
T16 fluorescent lamps

In comparison with thicker T26 lamps (diameter: 26 mm), modern T16 lamps (diameter: 16 mm) show several different properties that must be taken into account for application.

Luminous flux – temperature curve
As for all fluorescent lamps, the lamp's luminous flux is temperature-dependent. The maximum value is obtained at an optimum ambient temperature, with losses increasing at higher and lower temperatures. The T16 basically follows the same curve as the T26, but the maximum occurs not at an ambient temperature of 20 to 25 °C but at about 35 °C.

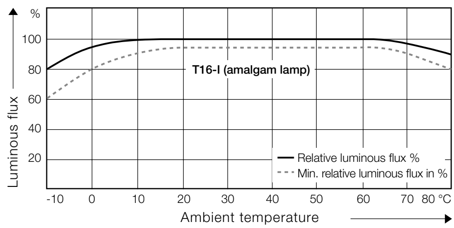
Reason: the cool spot of T16 is not located in the centre of the lamp, but typically at one end of the tube where the manufacturer has fixed its seal.

The rated luminous flux is generally specified for an ambient temperature of 25 °C. For the T16, the maximum value therefore lies above this rated value. Thus luminaire efficiencies may have levels greater than "1".



Amalgam technology
Special T16-I lamps with amalgam technology are available in order to ensure that the luminous flux is slightly less temperature dependent.

Adding amalgam (a mercury compound) makes it possible to compensate for the decrease in luminous flux at relatively high and low temperatures.



CSO – Cool Spot Optimizer

The photometric data of luminaires apply at a standard temperature of 25 °C. Where a different ambient temperature prevails, the lamps' luminous flux is also affected. In fluorescent lamps, the luminous flux declines in particular at lower temperatures.

In order to increase the efficiency of luminaires fitted with T16 lamps, the so-called Cool Spot Optimizer (CSO) may be used.

The CSO may only be used in conventional T16 28/54 W and 35/49/80 W lamps using cold-spot technology, and must be fitted at the lamp end (see picture).

The CSO produces a temperature increase on the lamp of roughly 10 to 20 °. This results in a corresponding shift to the left of the curve as shown in the diagram. At cooler temperatures, the lamp produces significantly more light than a lamp without a CSO.

Note: the CSO cannot be used in the case of amalgam lamps.

Example:

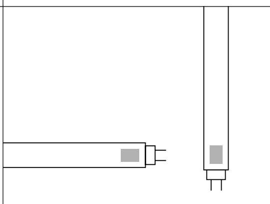
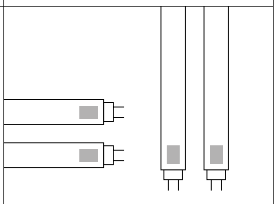
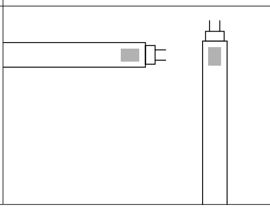
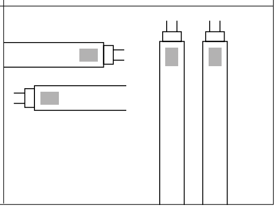
FZ 1/54 without CSO at 0 °C η_{LB} approx. 60 %
FZ 1/54 with CSO at 0 °C η_{LB} approx. 90 %

In this example, the luminous flux produced is therefore increased by 50 % and the number of luminaires required is reduced by one third, owing to the CSO.

For lighting design purposes, an appropriately adjusted planned luminous flux has to be calculated.

Lamp orientation

Due to the non-identical design of the two electrodes (tube ends) the way in which one or more T16 fluorescent lamps is/are fitted in luminaires makes a difference. Generally speaking, the seals, and hence the cool spots, must always be identically oriented. This means that side-by-side, multi-lamp luminaires, when used vertically, should ideally point downwards. It may be sensible to break this rule in cooler environments, depending on the type of luminaire.

	Single-lamp	Multi-lamp
Normal and higher ambient temperatures		
Cool ambient temperature		

= The grey rectangle denotes the lamp manufacturer’s seal and marks the position of the cool spot

Further details for TETRIS and continuous-row arrangements

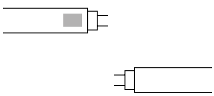
Particular attention is needed for special lamp arrangements like in TETRIS (TECTON or SLOT luminaires) or in continous-row lighting systems.

The so-called TETRIS arrangement provides for lamps overlapping several centimetres.

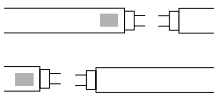
This enables to compensate for the dark zone at the lamp's ends. In order to provide for maximum uniformity, it is recommended to also align all lamps identically.

The last lamp/s, however, should be turned so as to make the lamp end head towards the centre of the luminaire.

TETRIS
single-lamp



TETRIS
twin-lamp

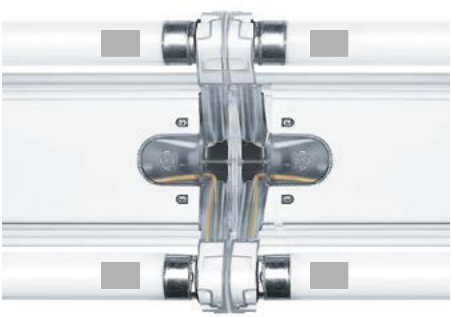


Differentiated features TETRIS T16 continuous-row luminaire, single lamp
- Single-lamp, diagonally overlapping arrangement
- Length of the single-lamp continuous-row luminaire consists of length of the luminaire (1096/1396 mm) x the number of luminaires + 75 mm

Differentiated features TETRIS T16 continuous-row luminaire, twin lamp
- Twin-lamp, parallel over-lapping arrangement
- Length of the twin-lamp continuous-row luminaire consists of length of the luminaire (1171/1471 mm) x the number of luminaires + 75 mm
- TETRIS twin-lamp, 28/54 W, cannot be installed using a feeder

In a continuous-row lighting system, the maximum total luminous flux is achieved if the lamp ends are placed next to each other, if possible.

For cool environments, here too it may make sense to arrange the lamp/s differently.



single- and twin-lamp

Compact fluorescent lamps

Amalgam technology

The luminous flux of compact fluorescent lamps strongly depends on ambient temperature.

Amalgam technology offers huge benefits because these lamps are often used in narrow and therefore very warm luminaires such as downlights.

In the same way as with T16-I lamps, using special lamps with amalgam technology makes the luminous flux somewhat less temperature dependent. Adding amalgam (a mercury compound) makes it possible to compensate for the decrease in luminous flux at relatively high temperatures in particular.

Amalgam lamps are available for both TC-LI and TC-TELI designs.

A luminous flux versus temperature curve for amalgam lamps is shown in the T16 section by way of example (see page 94).

In the case of compact fluorescent lamps it is not always easy to tell whether a lamp uses amalgam technology. The precise manufacturer's designation must be examined.

Lamp orientation

The luminous flux of compact fluorescent lamps is highly dependent on their operating position. The correct use of lamps in a luminaire can therefore maximise a luminaire's light output ratio.

Standard types have a cool spot in the exposed lamp bend, so that self-heating and convection may lead to a temperature rise here. In amalgam lamps, the cool spot lies in the lamp base.

In compact luminaires with horizontal lamp arrangement (e.g. downlights), it is therefore recommended to fit the lamps with electrodes uppermost wherever possible.

The marking of lamps does not allow for standard identification of the electrodes' position. This is why the lamp is fitted with that side facing upwards where adjacent tubes are not connected with each other – these are the two tube ends with the electrodes inside.

Initial operation of new fluorescent and compact fluorescent lamps

Brand-new fluorescent and compact fluorescent lamps must be carefully prepared prior to first-time use, especially in dimming systems, and before metrological testing.

Ageing
New lamps should be operated for 100 hours, i.e. roughly 4 days, at 100 % output (without dimming) and without switching them if possible. Lamps that have not been aged may fail prematurely in dimming systems.

Stabilisation
Lamps that have been aged must be allowed to burn in for at least 30 to 60 minutes without dimming or switching them before measuring the illuminance level and lighting quality of a lighting installation.

Lamps that have not been stabilised may exhibit poor starting behaviour, flicker and produce non-uniform brightness and light colours.

Metal halide lamps

Lamp start
Suitable ignitors are needed in order to generate an ignition voltage that is sufficient to start metal halide lamps. Modern ignitors also prevent cyclic attempts to start old lamps that are reluctant to start. These should be replaced without delay in order to prevent subsequent damage.

Glass covers
In general, metal halide lamps require a glass cover to protect people and property in the event of the lamp exploding. It is the manufacturer's responsibility to decide whether to permit individual lamp types to be used in uncovered luminaires.
The detailed information from the manufacturer must be observed without fail.

Service life behaviour
There are sometimes very significant differences in the average service life (lamp survival factor LSF) and decrease in luminous flux (lamp luminous flux maintenance factor LLWF) of different types of lamps, depending on their frequency of switching or operating position. The manufacturer's data also needs to be referred to. Some typical details can be found in the maintenance factor tables from page 246 onwards.

In the case of high-intensity discharge lamps in particular, it is especially important to replace lamps no later than by the end of their design service life (maintenance interval). Continued use may result in damage to lamps and control gear and consequently to luminaires!

Lamp designations

Various systems are used to designate lamps. Lamp manufacturers use their own product name for each lamp. And there are standards and non-proprietary documents that use general designations. The LBS* coding system, which was devised by the Central Association of German Electrical and Electronic Industries (ZVEI), provides an extremely useful overview. Every general lighting lamp can be precisely designated according to the LBS coding system by an abbreviation consisting of letters and numbers.

Many luminaire manufacturers use the LBS coding system to specify appropriate lamps for their luminaires regardless of the names used by lamp manufacturers. This makes sense because many lamps are standardised and are therefore interchangeable regardless of make. International standards use another system – ILCOS**.

The table below compares the designations used in various systems.

LBS (ZVEI)	ILCOS	OSRAM	PHILIPS	GE	SYLVANIA
A60	IAA	TR	CLASSIC TONE	A1	Normal
QR-CBC	HRGI	DECOSTAR S	MASTERline	Precise MR	Professional
QPAR	HEGPAR	HALOPAR	PAR	PAR	Hi-Spot
TC	FS	DULUX S	PL-S	BIAX S	Lynx CF-S
TC-T	FSM	DULUX T	PL-T	BIAX T	Lynx CF-T
TC-L	FSD	DULUX L	PL-L	BIAX L	Lynx CF-L
T16	FDH-G5-16	FH, FQ	TL’5 HE, HO	T5 XL	FHE, FHO
T26	FD-G13-26	L	TL’D	T8	F
HME	QE	HQL	HPL	H	HSL
HIT	MT	HQI-T, HCI-T	MHN/W-T, CDM-T	Arcstream T, Kolarc T, CMH	HSI-T, CMI-T
HST	ST, STM, XX	NAV-T	SON-T, SDW-T	Lucalox T	SHP-T

* **LBS** = Lampen-Bezeichnungs-System [Lamp Code System], a standardised system for designating electric lamps for general lighting (luminaire manufacturers)

** **ILCOS** = **I**nternational **L**amp **CO**ding **S**ystem (lamp manufacturers), Standard IEC TS 61231/DIN 49805

Example of general description of a fluorescent lamp using the LBS coding system:

The LBS lamp coding system makes it possible to designate a fluorescent lamp precisely.

T16 35 W/830

.30	=	Colour temperature **30**00 K (warm white)
8..	=	Colour rendering index **8**0 to **8**9
35 W	=	Nominal wattage 35 W
L..	=	Low-pressure discharge lamp
.M.	=	Mercury vapour
(LM)**T**	=	**T**ubular
16	=	**16** mm tube diameter

Redundant or unambiguous details may sometimes be omitted, for instance “LM” for “low-pressure mercury vapour discharge lamp” as in this example.

Besides this basic data, further details can be specified depending on the lamp:
bulb colour, clear or frosted,
radiation angle in case of reflector lamps,
description of cap/lampholder,
permissible voltage etc.

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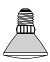
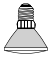
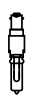
Technical data (lamp table)

	Designation (ZVEI/LBS)	Wattage [W]	Max. dimensions [mm]	Cap	Luminous flux levels [lm]	Luminous effic.** [lm/W]	Light col.***
Halogen incandescent lamps for 230 V (PAR lamps)			**Length x Ø**		**Max. lighting intensity [cd]**		
	QPAR16–36°	20	55 x 51	GU10	200	–	warm
	QPAR16–30°	28	55 x 51	GU10	570	–	warm
	QPAR16–35°	35	55 x 51	GU10	570	–	warm
	QPAR16–36°	35	55 x 51	GU10	400	–	warm
	QPAR16–25°	40	79–85 x 50	E14	950	–	warm
	QPAR16–25°	40	51 x 51	GU10	550	–	warm
	QPAR16–30°	40	55 x 51	GU10	900	–	warm
	QPAR16–50°	40	51 x 51	GU10	350	–	warm
	QPAR16–25°	50	53/55 x 51	GU10	1000–1300	–	warm
	QPAR16–35°	50	53 x 51	GU10	900	–	warm
	QPAR16–36°	50	55 x 51	GU10	600	–	warm
	QPAR16–50°	50	53/55 x 51	GU10	500–600	–	warm
	QPAR20–10°	50	88/91 x 65	E27	3000–4300	–	warm
	QPAR20–25°	50	88/91 x 65	E27	1000	–	warm
	QPAR20–30°	50	88/91 x 65	E27	1000–1100	–	warm
	QPAR20–25°	50	62 x 64	GU10	1500	–	warm
	QPAR20–30°	75	64 x 66	GU10	1900	–	warm
	QPAR-CB16–25°	50	53/55 x 51	GZ10	1000–1300	–	warm
	QPAR-CB16–35°	50	53 x 51	GZ10	900	–	warm
	QPAR-CB16–50°	50	53/55 x 51	GZ10	550–600	–	warm
	QPAR-CB20–10°	50	91 x 64.5	E27	3200	–	warm
	QPAR-CB20–30°	50	91 x 64.5	E27	1100	–	warm
	QPAR20–25°	75	62 x 64	GU10	2500	–	warm
	QPAR20–30°	75	61 x 64	GU10	1900	–	warm
	QPAR20–50°	75	62 x 64	GU10	1000	–	warm
	QPAR-CB20–25°	75	62 x 64	GZ10	2500	–	warm

* Core type ** (without control gear)

Colour temperatures [K]	Colour Rendering Index CRI/R_a	OSRAM	PHILIPS	SYLVANIA	GE
approx. 2700	100	–	–	–	Q20MR16/230/FL
approx. 2900	100	HALOPAR ECO 64819 FL	–	–	–
approx. 2900	100	HALOPAR 16 64820 FL	–	–	–
approx. 2700	100	–	–	–	Q35MR16/230/FL
approx. 2900	100	–	HalogenA PAR16	HI-SPOT 50/25°	40PAR16/230/FL
approx. 2900	100	–	TWISTline Alu 40 W	–	–
approx. 2900	100	HALOPAR ECO 64823 FL	–	–	–
approx. 2900	100	–	TWISTline Alu 40 W	–	–
approx. 2900	100	–	TWISTline Alu 50 W	HI-SPOT ES 50	Q50MR16/230/SP
approx. 2900	100	HALOPAR 16 64824FL	–	–	–
approx. 2700	100	–	–	–	Q50MR16/230/FL
approx. 2900	100	–	TWISTline Alu 50 W	HI-SPOT ES 50	Q50MR16/230/FL
approx. 2900	100	HALOPAR 20 64832 SP	PAR20 HalogenA PRO 50 W	HI-SPOT 63 50 W/ SP10°	50PAR20/230/SP
approx. 2900	100	–	PAR20 HalogenA PRO 50 W	HI-SPOT 63 50 W/ FL25°	–
approx. 2750–2900	100	HALOPAR 20 64832 FL	–	–	50PAR20/230/FL
approx. 2900	100	–	–	HI-SPOT ES 63	–
approx. 2900	100	HALOPAR 20 64830 FL	–	–	–
approx. 2900	100	–	TWISTline Dichro 50 W	HI-SPOT ESD 50	–
approx. 2900	100	HALOPAR 16 64826FL	–	–	–
approx. 2900	100	–	TWISTline Dichro 50 W	HI-SPOT ESD 50	
approx. 2900	100	HALOPAR 20 64836SP	–	–	–
approx. 2900	100	HALOPAR 20 64836FL	–	–	–
approx. 2900	100	–	–	HI-SPOT ES 63	–
approx. 2900	100	HALOPAR 16 64830FL	–	–	–
approx. 2900	100	–	–	HI-SPOT ES 63	
approx. 2900	100	–	–	HI-SPOT ESD 63	–

*** warm: up to 3300 K intermediate: 3300 to 5300 K cool: above 5300 K

	Designation (ZVEI/LBS)	Wattage [W]	Max. dimensions [mm]	Cap	Luminous flux levels [lm]	Luminous effic.** [lm/W]	Light col.***
Halogen incandescent lamps for 230 V (PAR lamps)			**Length x Ø**		**Max. lighting intensity [cd]**		
	QPAR-CB20–50°	75	62 x 64	GZ10	1000	–	warm
	QPAR-CB30–10°	75	91 x 97	E27	6900–7500	–	warm
	QPAR-CB30–30°	75	91 x 97	E27	2200–2400	–	warm
	QPAR-CB35–10°	75	110 x 70	GZ10	12000	–	warm
	QPAR-CB35–24°	75	110 x 70	GZ10	5000	–	warm
Halogen incandescent lamps for 230 V			**Length x Ø**		**Luminous flux levels [lm]**		
	QT14/c	20	43 x 14	G9	200	10	warm
	QT14/c	25	43 x 14	G9	250–260	–	warm
	QT14/c	28	43 x 14	G9	340	12	warm
	QT14/c	33	43 x 14	G9	460	14	warm
	QT14/c	40	43 x 14	G9	490	12	warm
	QT14/c	42	43 x 14	G9	630	15	warm
	QT14/c	48	43 x 14	G9	740	15	warm
	QT14/c	60	51 x 14	G9	820–980	16	warm
	QT18/c	40	67 x 18	B15d	590	15	warm
	QT18/c	53	86 x 18	B15d	850	16	warm
	QT18/c	60	67 x 18	B15d	980	16	warm
	QT18/c	60	86 x 18	B15d	980	16	warm
	QT18/c	70	86 x 18	B15d	1200	17	warm
	QT18/c	100	86 x 18	B15d	1800	18	warm
	QT18/c	105	86 x 18	B15d	1900	18	warm
	QT18/c	150	86 x 18	B15d	2870	19	warm

* Core type ** (without control gear)

Colour temperatures [K]	Colour Rendering Index CRI/R_a	OSRAM	PHILIPS	SYLVANIA	GE
approx. 2900	100	–	–	HI-SPOT ESD 63	
approx. 2900	100	HALOPAR 30 64845 SP	–	HI-SPOT 95 75 W/SP10° DIC	–
approx. 2900	100	HALOPAR 30 64845 FL	–	HI-SPOT 95 75 W/FL30° DIC	
2800	100	–	–	HI-SPOT ESD 111 (AG) 75 W/10°	–
2800	100	–	–	HI-SPOT ESD 111 (AG) 75 W/24°	–
2800–2900	100	HALOPIN ECO 66720	–	–	–
2800–2900	100	HALOPIN 66725	–	–	G9 25 W 230 V Clear
2800–2900	100	–	EcoHalogen Clickline 28 W	–	–
2800–2900	100	HALOPIN ECO 66733	–	–	–
2800–2900	100	HALOPIN 66740	–	–	G9 40 W 230 V Clear
2800–2900	100	–	EcoHalogen Clickline 42 W	–	–
2800–2900	100	HALOPIN ECO 66748	–	–	–
2800–2900	100	HALOPIN 66660, HALOPIN ECO 66760	–	–	G9 60W 230 V Clear
2800–2900	100	HALOLUX CERAM ECO 64491	–	–	–
2800–2900	100	–	Capsuleline ES 53 W	–	–
2800–2900	100	HALOLUX CERAM ECO 64492	–	–	–
2800–2900	100	HALOLUX CERAM ECO 64406	–	–	–
2800–2900	100	HALOLUX CERAM ECO 64494	Capsuleline ES 70 W	–	–
2800–2900	100	HALOLUX CERAM ECO 64496	Capsuleline PRO MV 100 W	–	–
2800–2900	100	–	Capsuleline 105 W	–	–
2800–2900	100	HALOLUX CERAM ECO 64499	–	–	–

*** warm: up to 3300 K   intermediate: 3300 to 5300 K   cool: above 5300 K

	Designation (ZVEI/LBS)	Wattage [W]	Max. dimensions [mm]	Cap	Luminous flux levels [lm]	Luminous effic.** [lm/W]	Light col.***
Halogen incandescent lamps for 230 V			**Length x Ø**				
	QT32/c	70	105 x 32	E27	1200	17	warm
	QT32/c	100	105 x 32	E27	1800	18	warm
	QT32/c	105	105 x 32	E27	1980	19	warm
	QT32/c	150	105 x 32	E27	2870	19	warm
	QT32/c	205	105 x 32	E27	4200	20	warm
			Length/ contact gap				
	QT-DE12	48	74.9	R7s	750–815	17	warm
	QT-DE12	80	74.9	R7s	1450	18	warm
	QT-DE12	100	74.9	R7s	1900	19	warm
	QT-DE12	120	74.9	R7s	2300	19	warm
	QT-DE12	120	114.2	R7s	2300–2800	19	warm
	QT-DE12	130	114.2	R7s	2440	19	warm
	QT-DE12	160	114.2	R7s	3100–3300	21	warm
	QT-DE12	200	114.2	R7s	4000–4200	20	warm
	QT-DE12	230/240	114.2	R7s	4900–5000	22	warm
	QT-DE12	330	114.2	R7s	7000	21	warm
Halogen incandescent lamps for 12 V (low voltage)			**Length x Ø**				
	QT-LP ax9/c	5	33 x 9	G4	60	12	warm
	QT-LP tr9/c	5	33 x 9.5	G4	60	12	warm
	QT-LP ax9/c	7	33 x 9.5	G4	107	15	warm
	QT-LP ax9/c	10	33 x 9–9.5	G4	120–140	12–14	warm
	QT-LP tr9/c	10	33 x 9.5	G4	140	14	warm
	QT-LP ax9/c	14	33 x 9.5	G4	240	17	warm
	QT-LP tr9/c	20	33 x 9.5	G4	320	16	warm
	QT-LP ax9/c	20	33 x 9–9.5	G4	300–320	15–16	warm
	QT-LP ax12/c	20	44 x 12	GY6,35	300–320	15–16	warm
	QT-LP ax12/c	25	44 x 12	GY6,35	500	20	warm

* Core type ** (without control gear)

Colour temperatures [K]	Colour Rendering Index CRI/R_a	OSRAM	PHILIPS	SYLVANIA	GE
approx. 2900	100	HALOLUX CERAM ECO 64400	EcoClassic30 70 W	–	–
approx. 2900	100	HALOLUX CERAM ECO 64401	–	–	–
approx. 2900	100	–	EcoClassic30 105 W	–	–
approx. 2900	100	HALOLUX CERAM ECO 64402	–	–	–
approx. 2900	100	HALOLUX CERAM ECO 64404	–	–	–
		HALOLINE	**PLUSline**		
approx. 3000	100	64684 ECO	ES 48 W	DE ECO 48 W	–
approx. 3000	100	64690 ECO	ES 80 W	DE ECO 80 W	–
approx. 3000	100	–	–	–	K12 C100 W R7S
approx. 3000	100	64695 ECO	ES 120 W	DE ECO 120 W	–
approx. 3000	100	64696 ECO	ES 120 W	DE ECO 120 W	–
approx. 3000	100	–	–	–	K11 C130 W R7s
approx. 3000	100	64698 ECO	ES 160 W	DE ECO 160 W	–
approx. 3000	100	–	–	–	K9 C200 W R7s
approx. 3000	100	64701 ECO	ES 230 W	DE ECO 230 W	–
approx. 3000	100	–	–	–	K1 C330 W R7s
		HALOSTAR			
approx. 3000	100	–	–	12 V/5 W LP UV-STOP 22165	–
approx. 3000	100	STARLITE 64405S	CAPSULEline Pro 5 W	–	–
approx. 3000	100	ECO 64417	–	–	–
approx. 3000	100	STARLITE 64415S	CAPSULEline Pro 5 W	12 V/10 W LP UV-STOP 22241	Q10T2.5/12 V G4 35705
approx. 3000	100	STANDARD 64415	–	–	–
approx. 3000	100	ECO 64423	–	–	–
approx. 3000	100	STANDARD 64425	–	–	–
approx. 3000	100	STARLITE 64425S	CAPSULEline Pro 20 W	12 V/20 W LP UV-STOP 22242	Q20T2.5/12 V G4 35710
approx. 3000	100	STARLITE 64427S	CAPSULEline Pro 20 W	–	Q20T3/12 V GY6,35 35696
approx. 3000	100	ECO 64429	EcoHalogen 20 W	–	–

*** warm: up to 3300 K intermediate: 3300 to 5300 K cool: above 5300 K

Designation (ZVEI/LBS)	Wattage [W]	Max. dimensions [mm]	Cap	Luminous flux levels [lm]	Luminous effic.** [lm/W]	Light col.***
Halogen incandescent lamps for 12 V (low voltage)		**Length x Ø**				
QT-LP ax12/c	35	44 x 12	GY6,35	600–860	17–25	warm
QT-LP tr12/c	35	44 x 12	GY6,35	600	17	warm
QT-LP ax12/c	50	44 x 12	GY6,35	800–1200	16–24	warm
QT-LP tr12/c	50	44 x 12	GY6,35	930	19	warm
QT-LP ax12/c	60	44 x 12	GY6,35	1650	28	warm
QT-LP ax12/c	75	44 x 12	GY6,35	1350–1575	18–21	warm
QT-LP ax12/c	90	44 x 12	GY6,35	1800	20	warm
QT-LP ax12/c	100	44 x 12	GY6,35	2550	26	warm
QT-tr9/c	5	31 x 9	G4	60	12	warm
QT-ax9/c	10	33 x 9	G4	140	14	warm
QT-tr9/c	10	31 x 9	G4	140	14	warm
QT-ax9/c	20	33 x 9	G4	350–400	18–20	warm
QT-ax9/c	35	33 x 9	G4	650	19	warm
QT-ax12/c	20	44 x 12	GY6,35	300	15	warm
QT-ax12/c	35	44 x 12	GY6,35	650	19	warm
QT-tr12/c	35	44 x 12	GY6,35	550	16	warm
QT-ax12/c	50	44 x 12	GY6,35	900–1000	18–20	warm
QT-tr12/c	50	44 x 12	GY6,35	850	17	warm
QT-ax12/c	75	44 x 12	GY6,35	1350–1600	18–21	warm
QT-tr12/c	75	44 x 12	GY6,35	1350	18	warm
QT-ax12/c	100	44 x 12	GY6,35	2150–2300	22–23	warm
QT-tr12/c	100	44 x 12	GY6,35	2100	21	warm
QT16 24 V	150	50 x 16	GY6,35	3200	21	warm
		Length x Ø		**Max. lighting intensity [cd]**		
QR-CBC51/10°	14	45 x 51	GU5,3	2800	–	warm

* Core type ** (without control gear)

Colour temperatures [K]	Colour Rendering Index CRI/R_a	OSRAM	PHILIPS	SYLVANIA	GE
		HALOSTAR			
approx. 3000	100	STARLITE 64432S, ECO 64432	CAPSULEline Pro 35 W, EcoHalogen 35 W	12 V/35 W LP UV-STOP 21021	Q35T3/12 V GY6,35 35699
approx. 3000	100	STANDARD 64432	–	–	–
approx. 3000	100	STARLITE 64440S, ECO 64440	CAPSULEline Pro 50 W	12 V/50 W LP UV-STOP 21022	Q50T3/12 V GY6,35 35700
approx. 3000	100	STANDARD 64440	–	–	–
approx. 3000	100	ECO 64447	–	–	–
approx. 3000	100	STARLITE 64450S	CAPSULEline Pro 75 W	–	Q75T3/12 V GY6,35 35701
approx. 3000	100	STARLITE 64458S	–	–	–
approx. 3000	100	–	CAPSULEline Pro 100 W	–	–
approx. 3000	100	–	–	–	M9 42959
approx. 3000	100	–	–	12 V/10 W 21990	–
approx. 3000	100	–	–	–	M11 34674
approx. 3000	100	–	–	12 V/20 W 21991	M47/Q20 G4 34715, M35/Q20 G4 34714
approx. 3000	100	–	–	12 V/35 W 21992	–
approx. 3000	100	–	–	–	M76/Q20/GY6,35 34712, M312/Q20/GY6,35 34713
approx. 3000	100	–	–	12 V/35 W 21920	–
approx. 3000	100	–	–	–	M95/Q35/GY6,35 34708
approx. 3000	100	–	–	12 V/50 W 21993	M74/Q50/GY6,35 34703
approx. 3000	100	–	–	–	M32/Q50/GY6,35 34702
approx. 3000	100	–	–	12 V/75 W 21994	M73/Q75/GY6,35 34683
approx. 3000	100	–	–	–	M313/Q75/GY6,35 34682
approx. 3000	100	–	–	12 V/100 W 21995	M180 34664
approx. 3000	100	–	–	–	M28/EVA/Q100/ GY6,35/12 34676
approx. 3000	100	24 V 64465U	–	–	–
		DECOSTAR 51			
approx. 3000	100	ECO 48855 SP	–	–	–

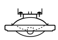
*** warm: up to 3300 K   intermediate: 3300 to 5300 K   cool: above 5300 K

	Designation (ZVEI/LBS)	Wattage [W]	Max. dimensions [mm]	Cap	Luminous flux levels [lm]	Luminous effic.** [lm/W]	Light col.***
Halogen incandescent lamps for 12 V (low voltage)			**Length x Ø**		**Max. lighting intensity [cd]**		
	QR-CBC51/36°	14	45 x 51	GU5,3	480	–	warm
	QR-CBC51/8°	20	45/51 x 51/50	GU5,3	6000–6500	–	warm
	QR-CBC51/10°	20	45/46 x 51	GU5,3	4000–6000	–	warm
	QR-CBC51/24°	20	45 x 51	GU5,3	1300–2300	–	warm
	QR-CBC51/36°	20	45/51 x 51/50	GU5,3	450–1000	–	warm
	QR-CBC51/38°	20	45 x 51	GU5,3	780–1000	–	warm
	QR-CBC51/60°	20	45 x 51	GU5,3	350–450	–	warm
	QR-CBC51/8°	30	51 x 50	GU5,3	11000	–	warm
	QR-CBC51/24°	30	51 x 50	GU5,3	3350	–	warm
	QR-CBC51/36°	30	51 x 50	GU5,3	1600	–	warm
	QR-CBC51/60°	30	51 x 50	GU5,3	750		warm
	QR-CBC51/8°	35	51 x 50	GU5,3	14000		warm
	QR-CBC51/10°	35	45 x 51	GU5,3	5400–12500		warm, inter-mediate
	QR-CBC51/24°	35	45/51 x 51/50	GU5,3	1700–4400		warm, inter-mediate
	QR-CBC51/36°	35	45/51 x 51/50	GU5,3	1000–2200	–	warm, inter-mediate
	QR-CBC51/60°	35	45/51 x 51/50	GU5,3	700–1100	–	warm
	QR-CBC51/8°	45	51 x 50	GU5,3	16000	–	warm
	QR-CBC51/24°	45	51 x 50	GU5,3	5450	–	warm

* Core type ** (without control gear)

Colour temperatures [K]	Colour Rendering Index CRI/R_a	OSRAM	PHILIPS	SYLVANIA	GE
		DECOSTAR 51			
approx. 3000	100	ECO 48855 FL	–	–	–
3000–3150	100	–	MASTERline ES 20 W	–	Precise Bright MR16 M268/ESX/CG
2925, 3100, 3200	100	STANDARD 44860 SP TITAN 46860 SP ECO 48860 SP	ACCENTline Pro 20 W BRILLIANTline Pro 50 mm 20 W MASTERline ES 20 W	Superia ESX	–
3000, 3200	100	ECO 48860 FL	BRILLIANTline Pro 50 mm 20 W	–	Precise Bright MR16 M269/FRA/CG
3000–3150	100	ECO 48860 WFL	ACCENTline Pro 20 W BRILLIANTline Pro 50 mm 20 W MASTERline ES 20 W	–	Precise Bright MR16 M269/BAB/CG
2925, 3100, 3200	100	STANDARD 44860 WFL TITAN 46860 WFL	–	Superia BAB	–
3100, 3200	100	STANDARD 44860 VWFL TITAN 46860 VWFL IRC 48860 VWFL	BRILLIANTline Pro 50 mm 20 W	–	–
3150	100	–	MASTERline ES 30 W	–	–
3150	100	–	MASTERline ES 30 W	–	–
3150	100	–	MASTERline ES 30 W	–	–
3150	100	–	MASTERline ES 30 W	–	–
3150	100	–	MASTERline ES 35 W	–	–
3100, 3200, 4100	100	STANDARD 44865 SP TITAN 46865 SP ECO 48865 SP	ACCENTline Pro 35 W BRILLIANTline Pro 50 mm 35 W DIAMONDline Pro 35 W	Superia FMT	–
3000, 3100, 3150, 3200, 4100	100	STANDARD 44865 FL TITAN 46865 FL ECO 48865 FL	BRILLIANTline Pro 50 mm 35 W MASTERline ES 35 W DIAMONDline Pro 35 W	–	Precise Bright MR16 M270/FRA/CG
3000-3200, 4100	100	STANDARD 44865 WFL TITAN 46865 WFL ECO 48865 WFL	ACCENTline Pro 35 W BRILLIANTline Pro 50 mm 35 W MASTERline ES 35 W DIAMONDline Pro 35 W	Superia FMW	Bright MR16 M281/ FMW/CG
3100, 3150, 3200	100	STANDARD 44865 VWFL TITAN 46865 VWFL ECO 48865 VWFL	BRILLIANTline Pro 50 mm 35 W MASTERline ES 35 W	–	–
3150	100	–	MASTERline ES 45 W	–	–
3150	100	–	MASTERline ES 45 W	–	–

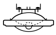
*** warm: up to 3300 K   intermediate: 3300 to 5300 K   cool: above 5300 K

	Designation (ZVEI/LBS)	Wattage [W]	Max. dimensions [mm]	Cap	Luminous flux levels [lm]	Luminous effic.** [lm/W]	Light col.***
Halogen incandescent lamps for 12 V (low voltage)			**Length x Ø**		**Max. lighting intensity [cd]**		
	QR-CBC51/36°	45	51 x 50	GU5,3	2850	–	warm
	QR-CBC51/60°	45	51 x 50	GU5,3	1300	–	warm
	QR-CBC51/8°	50	45 x 51	GU5,3	10100	–	warm
	QR-CBC51/10°	50	45 x 51	GU5,3	6400–15000	–	warm, inter-mediate
	QR-CBC51/24°	50	45 x 51	GU5,3	2700–5700	–	warm, inter-mediate
	QR-CBC51/36°	50	45 x 51	GU5,3	1200–2200	–	warm, inter-mediate
	QR-CBC51/60°	50	45 x 51	GU5,3	950–1430	–	warm
	QR-CBC51/15°	75	45 x 51	GU5,3	9800	–	warm
	QR-CBC51/25°	75	45 x 51	GU5,3	4600	–	warm
	QR-CBC51/42°	75	45 x 51	GU5,3	1950	–	warm
	QR111/4°	35	61 x 111	G53	45000	–	warm
	QR111/8°	30/35	57 x 111	G53	23000	–	warm
	QR111/24°	35	58 x 111	G53	2500–4500	–	warm
	QR111/4°	50	61 x 111	G53	50000	–	warm
	QR111/8°	45/50	57/63 x 111	G53	20000–35000	–	warm
	QR111/24°	45/50	58/63 x 111	G53	4000–5800	–	warm
	QR111/8°	60/65	57 x 111	G53	45000–48000	–	warm
	QR111/24°	60/65	58 x 111	G53	8500	–	warm
	QR111/45°	60/65	58 x 111	G53	2800	–	warm
	QR111/8°	75	57/63 x 111	G53	30000	–	warm
	QR111/24°	75	58/63 x 111	G53	5300	–	warm

* Core type ** (without control gear)

Colour temperatures [K]	Colour Rendering Index CRI/R_a	OSRAM	PHILIPS	SYLVANIA	GE
		DECOSTAR 51			
3150	100	–	MASTERline ES 45 W	–	–
3150	100	–	MASTERline ES 45 W	–	–
3000	100	–	–	–	Precise Bright MR16 M249/EXT/CG
3100, 3200, 4100	100	STANDARD 44870 SP TITAN 46870 SP ECO 48870 SP	ACCENTline Pro 50 W BRILLIANTline Pro 50 mm 50 W DIAMONDline Pro 50 W	Superia EXT	–
3000, 3100, 3200, 4100	100	STANDARD 44870 FL TITAN 46870 FL ECO 48870 FL	BRILLIANTline Pro 50 mm 50 W DIAMONDline Pro 50 W	Superia EXZ	Precise Bright MR16 M250/EXZ/CG
3000, 4100	100	STANDARD 44870 WFL TITAN 46870 WFL ECO 48870 WFL	ACCENTline Pro 50 W BRILLIANTline Pro 50 mm 50 W DIAMONDline Pro 50 W	Superia EXZ	Precise Bright MR16 M250/EXZ/CG
3000, 3100, 3200	100	STANDARD 44870 VWFL TITAN 46870 VWFL ECO 48870 VWFL	BRILLIANTline Pro 50 mm 50 W	Superia FNV	Precise Bright MR16 M280/FNV/CG
3050	100	–	–	–	Precise ConstantColor MR16 EYF/CG
3050	100	–	–	–	Precise ConstantColor MR16 EYJ/CG
3050	100	–	–	–	Precise ConstantColor MR16 EYC/CG
		HALOSPOT 111			
approx. 3000	100	41832 SSP	–	–	–
approx. 3000	100	48832 ECO SP	MASTERline111 30 W	–	AR111 35 W SP
approx. 3000	100	41832 FL, 48832 ECO FL	–	–	AR111 35 W FL
approx. 3000	100	41835 SSP	–	–	–
approx. 3000	100	41835 SP, 48835 ECO SP	ALUline PRO 50 W, MASTERline111 45 W	–	AR111 50 W SP
Approx. 3000	100	41835 FL, 48835 ECO FL	ALUline PRO 50 W, MASTERline111 45 W	–	AR111 50 W FL
approx. 3000	100	48837 ECO SP	MASTERline111 60 W	–	–
approx. 3000	100	48837 ECO FL	MASTERline111 60 W	–	–
approx. 3000	100	48837 ECO WFL	MASTERline111 60 W	–	–
approx. 3000	100	41840 SP	ALUline PRO 75 W	–	AR111 75 W SP
approx. 3000	100	41840 FL	ALUline PRO 75 W	–	AR111 75 W FL

*** warm: up to 3300 K   intermediate: 3300 to 5300 K   cool: above 5300 K

	Designation (ZVEI/LBS)	Wattage [W]	Max. dimensions [mm]	Cap	Luminous flux levels [lm]	Luminous effic.** [lm/W]	Light col.***
Halogen incandescent lamps for 12 V (low voltage)			**Length x Ø**		**Max. lighting intensity [cd]**		
	QR111/45°	75	55 x 111	G53	1700	–	warm
	QR111/8°	100	57/63 x 111	G53	48000	–	warm
	QR111/24°	100	58/63 x 111	G53	8500	–	warm
	QR111/45°	100	55 x 111	G53	2800	–	warm
Fluorescent lamps			**Length**		**Luminous flux levels [lm] ******		
	T16*	14	549	G5	1200–1250	86–89	warm, intermed.
	T16	14	549	G5	1100–1150	79–82	cool
	T16	14	549	G5	1080	77	cool
	T16*	21	849	G5	1900–1920	90–91	warm, intermed.
	T16	21	849	G5	1750–1775	83–85	cool
	T16	21	849	G5	1700	81	cool
	T16*	28	1149	G5	2600–2640	93–94	warm, intermed.
	T16	28	1149	G5	2400–2460	86–88	cool
	T16	28	1149	G5	2350	84	cool
	T16*	35	1449	G5	3300–3325	94–95	warm, intermed.
	T16	35	1449	G5	3050–3100	87–89	cool
	T16	35	1449	G5	3000	86	cool
	T16	24	549	G5	1400	58	inter-mediate
	T16	24	549	G5	1300–1400	54–58	cool
	T16*	24	549	G5	1700–1750	71–73	warm, intermed.
	T16	24	549	G5	1570–1650	65–69	cool
	T16	24	549	G5	1550	65–69	cool
	T16*	39	849	G5	3100–3220	79–83	warm, intermed.
	T16	39	849	G5	2850–2990	73–77	cool

***** Core type ****** (without control gear) ******** Rated values at 25 °C (maximum levels are achieved at approx. 35 °C)

Colour temperatures [K]	Colour Rendering Index CRI/R_a	OSRAM	PHILIPS	SYLVANIA	GE
		HALOSPOT 111			
approx. 3000	100	41840 WFL	–	–	AR111 75 W WFL
approx. 3000	100	41850 SP	ALUline PRO 100 W	–	AR111 100 W SP
approx. 3000	100	41850 FL	ALUline PRO 100 W	–	AR111 100 W FL
approx. 3000	100	41850 WFL	–	–	AR111 100 W WFL
		LUMILUX	**MASTER**	**T5 Luxline Plus**	**T5 LongLast**
2700, 3000, 3500, 4000	80...89	T5 HE 14 W/8..	TL5 HE 14 W/8..	FHE 14 W/8..	F14 W/T5/8../LL
6500	80...89	T5 HE 14 W/865 Cool Daylight	TL5 HE 14 W/865	FHE 14 W/865	F14 W/T5/865/LL
8000	80...89	T5 HE 14 W/880 SKYWHITE	–	–	–
2700, 3000, 3500, 4000	80...89	T5 HE 21 W/8..	TL5 HE 21 W/8..	FHE 21 W/8..	F21 W/T5/8../LL
6500	80...89	T5 HE 21 W/865	TL5 HE 21 W/865	FHE 21 W/865	F21 W/T5/865/LL
8000	80...89	T5 HE 21 W/880 SKYWHITE	–	–	–
2700, 3000, 3500, 4000	80...89	T5 HE 28 W/8..	TL5 HE 28 W/8..	FHE 28 W/8..	F28 W/T5/8../LL
6500	80...89	T5 HE 28 W/865	TL5 HE 28 W/865	FHE 28 W/865	F28 W/T5/865/LL
8000	80...89	T5 HE 28 W/880 SKYWHITE	–	–	–
2700, 3000, 3500, 4000	80...89	T5 HE 35 W/8..	TL5 HE 35 W/8..	FHE 35 W/8..	F35 W/T5/8../LL
6500	80...89	T5 HE 35 W/865	TL5 HE 35 W/865	FHE 35 W/865	F35 W/T5/865/LL
8000	80...89	T5 HE 35 W/880 SKYWHITE	–	–	–
4000, 5000	90...100	T5 HO 24 W/940 Cool White	TL5 HO 24 W/9.. de Luxe	–	–
6500	90...100	T5 HO 24 W/965 Cool Daylight	TL5 HO 24 W/965 de Luxe	–	–
2700, 3000, 3500, 4000	80...89	T5 HO 24 W/8..	TL5 HO 24 W/8..	FHO 24 W/8..	F24 W/T5/8../LL
6500	80...89	T5 HO 24 W/865	TL5 HO 24 W/865	FHO 24 W/865	F24 W/T5/865/LL
8000	80...89	T5 HO 24 W/880 SKYWHITE	–	–	–
2700, 3000, 3500, 4000	80...89	T5 HO 39 W/8..	TL5 HO 39 W/8..	FHO 39 W/8..	F39 W/T5/8../LL
6500	80...89	T5 HO 39 W/865	TL5 HO 39 W/865	FHO 39 W/865	F39 W/T5/865/LL

*** warm: up to 3300 K   intermediate: 3300 to 5300 K   cool: above 5300 K

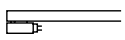
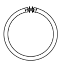
	Designation (ZVEI/LBS)	Wattage [W]	Max. dimensions [mm]	Cap	Luminous flux levels [lm]	Luminous effic.** [lm/W]	Light col.***
Fluorescent lamps			**Length**		**Luminous flux levels [lm] ******		
	T16	49	1449	G5	3450–3700	70–76	inter-mediate
	T16	49	1449	G5	3450–3750	70–77	cool
	T16*	49	1449	G5	4165–4300–4450	85–88–91	warm, intermed.
	T16	49	1449	G5	3950–4100	81–84	cool
	T16	49	1449	G5	4050–4100	83–84	cool
	T16	49	1449	G5	3700	76	cool
	T16	54	1149	G5	3550–3800	66–70	inter-mediate
	T16	54	1149	G5	3450–3800	64–70	cool
	T16*	54	1149	G5	4450	82	warm, intermed.
	T16	54	1149	G5	4050–4250	75–79	cool
	T16	54	1149	G5	4000–4250	74–79	cool
	T16	54	1149	G5	3800	70	cool
	T16*	80	1449	G5	6150–6550	77–82	warm, intermed.
	T16	80	1449	G5	5700–6300	71–79	cool
	T16	80	1449	G5	5550	69	cool
					Luminous flux levels [lm] *****		
	T16-I (amalgam)	24	549	G5	1900	79	warm, intermed.
	T16-I (amalgam)	39	849	G5	3400	87	warm, intermed.
	T16-I (amalgam)	54	1149	G5	4750–4850	88–90	warm, intermed.
	T16-I (amalgam)	49	1449	G5	4300–4650	88–95	warm, intermed.
	T16-I (amalgam)	80	1449	G5	6650–6800	83–85	warm, intermed.
	T16-D	14	582	G5	1200	86	w., interm.
	T16-D	21	882	G5	1900	90	w., interm.

* Core type ** (without control gear) **** Rated values at 25 °C (maximum levels are achieved at approx. 35 °C)

Colour temperatures [K]	Colour Rendering Index CRI/R_a	OSRAM	PHILIPS	SYLVANIA	GE
		LUMILUX	**MASTER**	**T5 Luxline Plus**	**T5 LongLast**
4000, 5000	90...100	T5 HO 49 W/940 Cool White	TL5 HO 49 W/9.. de Luxe	–	–
6500	90...100	T5 HO 49 W/965 Cool Daylight	TL5 HO 49 W/965 de Luxe	–	–
2700, 3000, 3500, 4000	80...89	T5 HO 49 W/8..	TL5 HO 49 W/8..	FHO 49 W/8..	F49 W/T5/8../LL
6500	80...89	T5 HO 49 W/865	TL5 HO 49 W/865	FHO 49 W/865	F49 W/T5/865/LL
8000	80...89	T5 HO 49 W/880 SKYWHITE	–	–	–
17000	80...89	–	TL5 HO ActiViva Active 49 W/817	–	–
4000, 5000	90...100	T5 HO 54 W/940 Cool White	TL5 HO 54 W/9.. de Luxe	–	–
6500	90...100	T5 HO 54 W/965 Cool Daylight	TL5 HO 54 W/965 de Luxe	–	–
2700, 3000, 3500, 4000	80...89	T5 HO 54 W/8..	TL5 HO 54 W/8..	FHO 54 W/8..	F54 W/T5/8../LL
6500	80...89	T5 HO 54 W/865	TL5 HO 54 W/865	FHO 54 W/865	F54 W/T5/865/LL
8000	80...89	T5 HO 54 W/880 SKYWHITE	–	–	–
17000	80...89	–	TL5 HO ActiViva Active 54 W/817	–	–
2700, 3000, 3500, 4000	80...89	T5 HO 80 W/8..	TL5 HO 80 W/8..	FHO 80 W/8..	F80 W/T5/8../LL
6000, 6500	80...89	T5 HO 80 W/865	TL5 HO 80 W/865	FHO 80 W/865	F80 W/T5/865/LL
8000	80...89	T5 HO 80 W/880 SKYWHITE	–	–	–
3000, 4000	80...89	T5 HO 24 W/8.. CONSTANT	–	–	–
3000, 4000	80...89	T5 HO 39 W/8.. CONSTANT	–	–	–
3000, 4000	80...89	T5 HO 54 W/8.. CONSTANT	TL5 HO TOP 54 W/840	–	–
3000, 4000	80...89	T5 HO 49 W/8.. CONSTANT	TL5 HO TOP 49 W/840	–	–
3000, 4000	80...89	T5 HO 80 W/8.. CONSTANT	TL5 HO TOP 80 W/840	–	–
3000, 4000	80...89	T5 HE 14 W/8.. SLS	–	–	–
3000, 4000	80...89	T5 HE 21 W/8.. SLS	–	–	–

***** Rated values at 25 °C (more than 90 % of rated luminous flux are achieved in the range between + 15 and + 60 °C)

*** warm: up to 3300 K intermediate: 3300 to 5300 K cool: above 5300 K

	Designation (ZVEI/LBS)	Wattage [W]	Max. dimensions [mm]	Cap	Luminous flux levels [lm]	Luminous effic.** [lm/W]	Light col.***
Fluorescent lamps			**Length**		**Luminous flux levels [lm] ******		
	T16-D	28	1182	G5	2600	93	w., interm.
	T16-D	24	582	G5	1750	73	w., interm.
	T16-D	39	882	G5	3100	79	w., interm.
	T16-D	54	1182	G5	4450	82	w., interm.
	T16-LL (long life)*	54	1149	G5	4450	82	w., interm.
	T16-LL (long life)	54	1149	G5	4100	76	cool
	T16-LL (long life)*	49	1449	G5	4310–4375	89	w., interm.
	T16-LL (long life)	49	1449	G5	4100	84	cool
	T16-LL (long life)*	80	1449	G5	6150–6240	77–78	w., interm.
	T16-LL (long life)	80	1449	G5	5700	71	cool
			Ø		**Luminous flux levels [lm]**		
	T16-R*	22	225	2GX13	1800–1900	82–86	w., interm.
	T16-R	22	225	2GX13	1800	82	cool
	T16-R*	40	300	2GX13	3300, 3400	83–85	w., interm.
	T16-R	40	300	2GX13	3300	83	cool
	T16-R*	55	300	2GX13	4200	76	w., interm.
	T16-RI (amalgam)*	55	300	2GX13	4200	76	w., interm.
	T16-R	55	300	2GX13	3990	73	cool
	T16-RI (amalgam)*	60	375	2GX13	5000	83	w., interm.
			Length		**Luminous flux levels [lm]**		
	T26	18	590	G13	900–950	50–53	inter-mediate
	T26	18	590	G13	1100–1200	50–56	w., interm., cool
	T26	18	590	G13	1150	48–56	cool
	T26*	18	590	G13	1350	75	warm, intermed.
	T26	18	590	G13	1300	72	intermed., cool
	T26	18	590	G13	1300	72	cool
	T26	30	895	G13	1920	64	warm

* Core type ** (without control gear) **** Rated values at 25 °C (maximum levels are achieved at approx. 35 °C)

Colour temperatures [K]	Colour Rendering Index CRI/R_a	OSRAM	PHILIPS	SYLVANIA	GE
		LUMILUX			
3000, 4000	80...89	T5 HE 28 W/8.. SLS	–	–	–
3000, 4000	80...89	T5 HO 24 W/8.. SLS	–	–	–
3000, 4000	80...89	T5 HO 39 W/8.. SLS	–	–	–
3000, 4000	80...89	T5 HO 54 W/8.. SLS	–	–	–
			MASTER		
2700, 3000, 4000	80...89	T5 HO 54 W/8.. XT	TL5 HO Xtra 54 W/8..	–	–
6500	80...89	T5 HO 54 W/865 XT	–	–	–
2700, 3000, 4000	80...89	T5 HO 49 W/8.. XT	TL5 HO Xtra 49 W/8..	–	–
6500	80...89	T5 HO 49 W/865 XT	–	–	–
2700, 3000, 4000	80...89	T5 HO 80 W/8.. XT	TL5 HO Xtra 80 W/8..	–	–
6500	80...89	T5 HO 80 W/865 XT	–	–	–
					T5 Circline
2700, 3000, 4000	80...89	T5 FC 22 W/8..	TL5 C 22 W/8..	–	FC22 W/T5/8..
6500	80...89	T5 FC 22 W/865 Cool Daylight	–	–	–
2700, 3000, 4000	80...89	T5 FC 40 W/8..	TL5 C 40 W/8..	–	FC40 W/T5/8..
6500	80...89	T5 FC 40 W/865 Cool Daylight	–	–	–
2700, 3000, 4000	80...89	T5 FC 55 W/8..	–	–	FC55 W/T5/8..
2700, 3000, 4000	80...89	–	TL5 C 55 W/8..	–	–
6500	80...89	T5 FC 55 W/865 Cool Daylight	–	–	–
3000, 4000	80...89	–	TL5 C 60 W/8..	–	–
5000, 6500	98	L 18 W/950 COLOR proof	TL-D 18 W/9.. Graphica	–	–
3000, 4000, 5000, 5400	90...100	DE LUXE L 18 W/9..	TL-D 18 W/9.. de Luxe	–	–
6500	90...100	DE LUXE L 18 W/965	TL-D 18 W/965 de Luxe	–	–
2700, 2950, 3000, 3400, 3500, 4000	80...89	L 18 W/8..	TL-D SUPER 80 18 W/8..	F18 W/8.. LUXLINE plus	F18 W/8.. Polylux XL
5000, 6000, 6300, 6500	80...89	L 18 W/860	TL-D SUPER 80 18 W/8..	F18 W/860 LUXLINE plus	F18 W/860 Polylux XL
8000	80...89	L 18 W/880 SKYWHITE	TL-D ActiViv Natural 18 W/880	–	–
3000	90...100	DE LUXE L 30 W/930	–	–	–

*** warm: up to 3300 K   intermediate: 3300 to 5300 K   cool: above 5300 K

	Designation (ZVEI/LBS)	Wattage [W]	Max. dimensions [mm]	Cap	Luminous flux levels [lm]	Luminous effic.** [lm/W]	Light col.***
Fluorescent lamps			**Length**				
	T26*	30	895	G13	2400–2450	80–82	warm, intermed.
	T26	30	895	G13	2300–2350	77–78	cool
	T26	30	895	G13	2350	78	cool
	T26-1m	36	970	G13	2600	72	cool
	T26-1m*	36	970	G13	3100	86	warm, intermed.
	T26	36	1200	G13	2100–2340	58–65	intermed., cool
	T26	36	1200	G13	2700–2900	61–67	w., interm., cool
	T26	36	1200	G13	2800–2850		cool
	T26*	36	1200	G13	3350	93	warm, intermed.
	T26	36	1200	G13	3250	90	intermed., cool
	T26	36	1200	G13	2900–3100	81–86	cool
	T26	58	1500	G13	3350–3670	58–63	intermed., cool
	T26	58	1500	G13	4350–4600	60–66	w., interm., cool
	T26	58	1500	G13	4550	78	cool
	T26*	58	1500	G13	5200	90	warm, intermed.
	T26	58	1500	G13	5000	86	intermed., cool
	T26	58	1500	G13	4900–5000	84–86	cool
	T26-LL (long life)	18	590	G13	1350	75	w., interm.
	T26-LL (long life)	18	590	G13	1250	69	cool
	T26-LL (long life)	18	590	G13	1350	75	w., interm.
	T26-LL (long life)	18	590	G13	1250	69	cool
	T26-LL (long life)	30	895	G13	2400	80	w., interm.
	T26-LL-1m (long life)	36	970	G13	3050	85	w., interm.

* Core type ** (without control gear)

Colour temperatures [K]	Colour Rendering Index CRI/R_a	OSRAM	PHILIPS	SYLVANIA	GE
		LUMILUX	**MASTER**		**T5 Circline**
2700, 2950, 3000, 3400, 4000	80...89	L 30 W/8..	TL-D SUPER 80 30 W/8..	F30 W/8.. LUXLINE plus	F30 W/8.. Polylux XL
6000, 6500	80...89	L 30 W/860	TL-D SUPER 80 30 W/865	F30 W/860 LUXLINE plus	–
8000	80...89	L 30 W/ 880 SKYWHITE	–	–	–
5400	90...100	DE LUXE L 36 W/954-1	–	–	–
2700, 3000, 4000	80...89	L 36 W/8..-1	TL-D SUPER 80 36 W-1/8..	–	–
5000, 6500	98	L 36 W/ 950 COLOR proof	TL-D 36 W/9.. Graphica	–	–
3000, 4000, 5000, 5400	90...100	DE LUXE L 36 W/9..	TL-D 36 W/9.. de Luxe	–	–
6500	90...100	DE LUXE L 36 W/965	TL-D 36 W/965 de Luxe	–	–
2700, 2950, 3000, 3400, 3500, 4000	80...89	L 36 W/8..	TL-D SUPER 80 36 W/8..	F36 W/8.. LUXLINE plus	F36 W/8.. Polylux XL
5000, 6000, 6300, 6500	80...89	L 36 W/860	TL-D SUPER 80 36 W/8..	F36 W/860 LUXLINE plus	F36 W/860 Polylux XL
8000	80...89	L 36 W/ 880 SKYWHITE	TL-D ActiViv Natural 36 W/880	–	–
5000, 6500	98	L 58 W/ 950 COLOR proof	TL-D 58 W/9.. Graphica	–	–
3000, 4000, 5000, 5400	90...100	DE LUXE L 58 W/9..	TL-D 58 W/9.. de Luxe	–	–
6500	90...100	DE LUXE L 58 W/ 965	TL-D 58 W/965 de Luxe	–	–
2700, 2950, 3000, 3400, 3500, 4000	80...89	L 58 W/8..	TL-D SUPER 80 58 W/8..	F58 W/8.. LUXLINE plus	F58 W/8.. Polylux XL
5000, 6000, 6300, 6500	80...89	L 58 W/860	TL-D SUPER 80 58 W/8..	F58 W/860 LUXLINE plus	F58 W/860 Polylux XL
8000	80...89	L 58 W/ 880 SKYWHITE	TL-D ActiViv Natural 58 W/880	–	–
			MASTER TL-D		
3000, 4000	80...89	L 18 W/8.. XT	TL-D Xtra 18 W/8..	–	–
6500	80...89	L 18 W/865 XT	TL-D Xtra 18 W/865	–	–
3000, 4000	80...89	L 18 W/8.. XXT	TL-D Xtreme 18 W/8..	–	–
6500	80...89	L 18 W/865 XXT	TL-D Xtreme 18 W/865	–	–
3000, 4000	80...89	–	TL-D Xtra 30 W/8..	–	–
3000, 4000	80...89	–	TL-D Xtra 1m 36 W/8..	–	–

*** warm: up to 3300 K   intermediate: 3300 to 5300 K   cool: above 5300 K

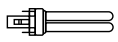
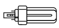
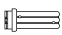
Designation (ZVEI/LBS)	Wattage [W]	Max. dimensions [mm]	Cap	Luminous flux levels [lm]	Luminous effic.** [lm/W]	Light col.***
Fluorescent lamps		**Length**				
T26-LL-1m (long life)	36	970	G13	3000	83	w., interm.
T26-LL (long life)	36	1200	G13	3300–3430	92–95	w., interm.
T26-LL (long life)	36	1200	G13	3200–3250	89–90	cool
T26-LL (long life)	36	1200	G13	3250–3300	90–92	cool
T26-LL (long life)	36	1200	G13	3150–3250	88–90	w., interm.
T26-LL (long life)	58	1500	G13	5200–5320	90–92	w., interm.
T26-LL (long life)	58	1500	G13	5000	86	cool
T26-LL (long life)	58	1500	G13	5150–5200	89–90	w., interm.
T26-LL (long life)	58	1500	G13	5000	86	cool
Compact fluorescent lamps (plug-in cap)		**Max. length acc. to IEC**				
TC-S	5	85	G23	250	50	w., interm.
TC-S	7	115	G23	400–425	57–61	w., interm.
TC-S	7	145	G23	425	61	cool
TC-S	9	145	G23	600	67	w., interm.
TC-S	9	145	G23	570–600	63–67	cool
TC-S	11	215	G23	900	82	w., interm.
TC-S	11	215	G23	900	82	cool
TC-SEL	5	85	2G7	250–265	50–53	w., interm.
TC-SEL	7	115	2G7	400–425	57–61	w., interm.
TC-SEL	9	145	2G7	600	67	w., interm.
TC-SEL	11	215	2G7	900	82	w., interm.
TC-SEL	11	215	2G7	900	82	cool
TC-D	10	95	G24d-1	600	60	warm, intermed.
TC-D	10	95	G24d-1	600	60	cool
TC-D	13	130	G24d-1	900	69	warm, intermed.
TC-D	13	130	G24d-1	900	69	cool
TC-D	18	150	G24d-2	1200	67	warm, intermed.
TC-D	18	150	G24d-2	1200	67	cool
TC-D	26	170	G24d-3	1800	69	warm, intermed.

* Core type ** (without control gear)

Colour temperatures [K]	Colour Rendering Index CRI/R_a	OSRAM	PHILIPS	SYLVANIA	GE
		LUMILUX	**MASTER TL-D**		
3000, 4000	80...89	–	TL-D Xtreme 1m 36 W/8..	–	–
3000, 4000	80...89	L 36 W/8.. XT	TL-D Xtra 36 W/8..	–	–
6500	80...89	L 36 W/865 XT	TL-D Xtra 36 W/865	–	–
6500	80...89	L 36 W/8.. XXT	TL-D Xtreme 36 W/8..	–	–
3000, 4000	80...89	L 36 W/865 XXT	TL-D Xtreme 36 W/865	–	–
3000, 4000	80...89	L 58 W/8.. XT	TL-D Xtra 58 W/8..	–	–
6500	80...89	L 58 W/865 XT	TL-D Xtra 58 W/865	–	–
3000, 4000	80...89	L 58 W/8.. XXT	TL-D Xtreme 58 W/8..	–	–
6500	80...89	L 58 W/865 XXT	TL-D Xtreme 58 W/865	–	–

		DULUX	**MASTER PL-S**	**Lynx**	**Biax**
2700, 3000, 4000	80...89	S 5 W/8..	2 pins 5 W/8..	S 5 W/8..	F5BX/8..
2700, 3000, 3500, 4000	80...89	S 7 W/8..	2 pins 7 W/8..	S 7 W/8..	F7BX/8..
6500	80...89	–	–	–	F7BX/865
2700, 3000, 3500, 4000	80...89	S 9 W/8..	2 pins 9 W/8..	S 9 W/8..	F9BX/8..
6500	80...89	S 9 W/865	–	–	F9BX/865
2700, 3000, 3500, 4000	80...89	S 11 W/8..	2 pins 11 W/8..	S 11 W/8..	F11BX/8..
6500	80...89	–	–	–	F11BX/865
2700, 4000	80...89	–	4 pins 5 W/8..	SE 5 W/8..	F5BX/8../4p
2700, 3000, 4000	80...89	S/E 7 W/8..	4 pins 7 W/8..	SE 7 W/8..	F7BX/8../4p
2700, 3000, 4000	80...89	S/E 9 W/8..	4 pins 9 W/8..	SE 9 W/8..	F9BX/8../4p
2700, 3000, 4000	80...89	S/E 11 W/8..	4 pins 11 W/8..	SE 11 W/8..	F11BX/8../4p
6500	80...89	–	–	–	F11BX/865/4p
			MASTER PL-C		
2700, 3000, 3500, 4000	80...89	D 10 W/8..	2 pins 10 W/8..	D 10 W/8..	F10DBX/8..
6500	80...89	–	–	–	F10DBX/865
2700, 3000, 3500, 4000	80...89	D 13 W/8..	2 pins 13 W/8..	D 13 W/8..	F13DBX/8..
6500	80...89	D 13 W/865	–	D 13 W/865	F13DBX/865
2700, 3000, 3500, 4000	80...89	D 18 W/8..	2 pins 18 W/8..	D 18 W/8..	F18DBX/8..
6500	80...89	D 18 W/865	–	D 18 W/865	F18DBX/865
2700, 3000, 3500, 4000	80...89	D 26 W/8..	2 pins 26 W/8..	D 26 W/8..	F26DBX/8..

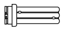
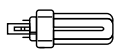
*** warm: up to 3300 K   intermediate: 3300 to 5300 K   cool: above 5300 K

	Designation (ZVEI/LBS)	Wattage [W]	Max. dimensions [mm]	Cap	Luminous flux levels [lm]	Luminous effic.** [lm/W]	Light col.***
Compact fluorescent lamps (plug-in cap)			**Max. length acc. to IEC**				
	TC-D	26	170	G24d-3	1710–1800	66–69	cool
	TC-D-LL (long life)	18	150	G24d-2	1200	67	w., interm.
	TC-D-LL (long life)	26	170	G24d-3	1800	69	w., interm.
	TC-DEL*	10	95	G24q-1	600	60	warm, intermed.
	TC-DEL	10	95	G24q-1	600	60	cool
	TC-DEL*	13	130	G24q-1	900	69	warm, intermed.
	TC-DEL	13	130	G24q-1	900	69	cool
	TC-DEL*	18	150	G24q-2	1200	67	warm, intermed.
	TC-DEL	18	150	G24q-2	1140	63	cool
	TC-DEL*	26	170	G24q-3	1800	69	warm, intermed.
	TC-DEL	26	170	G24q-3	1710	66	cool
	TC-DEL-LL (long life)	18	150	G24q-2	1200	67	w., interm.
	TC-DEL-LL (long life)	26	170	G24q-3	1800	69	w., interm.
	TC-T	13	90	GX24d-1	900	69	w., interm.
	TC-T	18	110	GX24d-2	1200	67	warm, intermed.
	TC-T	18	110	GX24d-2	1200	67	cool
	TC-T	26	130	GX24d-3	1800	69	warm, intermed.
	TC-T	26	130	GX24d-3	1800	69	cool
	TC-TI (amalgam)	13	116	GX24d-1	900	69	warm, intermed.
	TC-TI (amalgam)	18	110	GX24d-2	1200	67	warm, intermed.
	TC-TI (amalgam)	26	130	GX24d-3	1800	69	warm, intermed.
	TC-TEL	11	127	GR14q-1	810	74	w., interm.
	TC-TEL	13	90	GX24q-1	900	69	w., interm.
	TC-TEL	14	127	GR14q-1	1050	75	w., interm.
	TC-TEL	17	149	GR14q-1	1250	74	w., interm.
	TC-TEL	18	110	GX24q-2	1200	67	w., interm.
	TC-TEL	26	130	GX24q-3	1800	69	w., interm.
	TC-TEL	32	145	GX24q-3	2400	75	w., interm.

* Core type ** (without control gear)

Colour temperatures [K]	Colour Rendering Index CRI/R_a	OSRAM	PHILIPS	SYLVANIA	GE
		DULUX	MASTER PL-C	Lynx	Biax
6500	80...89	D 26 W/865	–	D 26 W/865	F26DBX/865
3000, 4000	80…90	–	2 pins 18 W/8.. Xtra	–	–
3000, 4000	80...89	–	2 pins 26 W/8.. Xtra	–	–
2700, 3000, 3500, 4000	80...89	D/E 10 W/8..	4 pins 10 W/8..	DE 10 W/8..	F10DBX/8../4p
6500	80…90	–	–	–	F10DBX/865/4p
2700, 3000, 3500, 4000	80...89	D/E 13 W/8..	4 pins 13 W/8..	DE 13 W/8..	F13DBX/8../4p
6000, 6500	80…90	–	–	DE 13 W/860	F13DBX/865/4p
2700, 3000, 3500, 4000	80...89	D/E 18 W/8..	4 pins 18 W/8..	DE 18W/8..	F18DBX/8../4p
6000, 6500	80…90	D/E 18 W/865	–	DE 18 W/860	–
2700, 3000, 3500, 4000	80...89	D/E 26 W/8..	4 pins 26 W/8..	DE 26W/8..	F26DBX/8../4p
6000, 6500	80…90	D/E 26 W/865	–	DE 26 W/860	F26DBX/865/4p
3000, 4000	80…90	D/E 18 W/8.. XT	4 pins 18 W/8.. Xtra	–	–
3000, 4000	80...89	D/E 26 W/8.. XT	4 pins 26 W/8.. Xtra	–	–
2700, 3000, 4000	80...89	T 13 W/8.. PLUS	2 pins 13 W/8..	–	–
2700, 3000, 3500, 4000	80...89	T 18 W/8.. PLUS	2 pins 18 W/8..	T 18 W/8..	–
6500	80...89	–	–	–	–
2700, 3000, 3500, 4000	80...89	T 26 W/8.. PLUS	2 pins 26 W/8..	T 26 W/8..	–
6500	80...89	–	–	–	–
2700, 3000, 3500, 4000, 6500	80...89	–	–	–	F13TBX/8../A/2p
2700, 3000, 3500, 4000	80...89	–	–	–	F18TBX/8../A/2p
2700, 3000, 3500, 4000	80...89	–	–	–	F26TBX/8../A/2p
3000, 4000	80...89	T/E 11 W/8.. HE	–	–	–
2700, 3000, 4000	80...89	T/E 13 W/8.. PLUS	4 pins 13 W/8..	–	–
3000, 4000	80...89	T/E 14 W/8.. HE	PL-R Eco 14 W/8../4P	–	–
3000, 4000	80...89	T/E 17 W/8.. HE	PL-R Eco 17 W/8../4P	–	–
2700, 3000, 4000	80...89	T/E 18 W/8.. PLUS	4 pins 18 W/8..	–	–
2700, 3000, 4000	80...89	T/E 26 W/8.. PLUS	4 pins 26 W/8..	–	–
2700, 3000, 4000	80...89	T/E 32 W/8.. PLUS	4 pins 32 W/8..	–	–

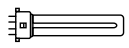
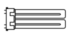
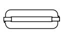
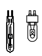
*** warm: up to 3300 K   intermediate: 3300 to 5300 K   cool: above 5300 K

	Designation (ZVEI/LBS)	Wattage [W]	Max. dimensions [mm]	Cap	Luminous flux levels [lm]	Luminous effic.** [lm/W]	Light col.***
Compact fluorescent lamps (plug-in cap)			**Max. length acc. to IEC**				
	TC-TEL	42	155	GX24q-4	3200	76	w., interm.
	TC-TEL	57	179	GX24q-5	4300	75	w., interm.
	TC-TELI (amalgam)	13	90	GX24q-1	900	69	warm, intermed.
	TC-TELI (amalgam)*	18	110	GX24q-2	1200	67	warm, intermed.
	TC-TELI (amalgam)*	26	130	GX24q-3	1800	69	warm, intermed.
	TC-TELI (amalgam)*	32	145	GX24q-3	2200–2400	69–75	warm, intermed.
	TC-TELI (amalgam)*	42	155	GX24q-4	3200	76	warm, intermed.
	TC-TELI (amalgam)*	57	181	GX24q-5	4300	75	w., interm.
	TC-TELI (amalgam)	70	219	GX24q-6	5200	74	w., interm.
	TC-QELI (amalgam)	57	179	GX24q-5	4300	75	w., interm., cool
	TC-QELI (amalgam)	70	219	GX24q-6	5200	74	w., interm., cool
	TC-TEL-LL (long life)	32	148	GX24q-3	2400	75	w., interm.
	TC-TEL-LL (long life)	42	155	GX24q-4	3200	76	w., interm.
	TC-TEL-LL (long life)	57	179	GX24q-5	4300	75	w., interm.
	TC-L*	16	317	2GX11	1500	94	w., interm.
	TC-L	18	225	2G11	950	53	w., interm., cool
	TC-L*	18	225	2G11	1200	67	warm, intermed.
	TC-L*	22	411	2GX11	2055	93	w., interm.
	TC-L	24	320	2G11	1500	63	w., interm., cool
	TC-L*	24	320	2G11	1800	75	warm, intermed.
	TC-L*	26	533	2GX11	2470	95	w., interm.
	TC-L*	28	565	2GX11	2700	96	w., interm.
	TC-L	36	415	2G11	2350	53–67	w., interm., cool
	TC-L*	36	415	2G11	2900	81	warm, intermed.
	TC-L	36	415	2G11	2750–2880	76–80	cool

* Core type ** (without control gear)

Colour temperatures [K]	Colour Rendering Index CRI/R_a	OSRAM	PHILIPS	SYLVANIA	GE
		DULUX	**MASTER PL-C**	**Lynx**	**Biax**
2700, 3000, 4000	80...89	T/E 42 W/8.. PLUS	4 pins 42 W/8..	–	–
2700, 3000, 4000	80...89	–	4 pins 57 W/8..	–	–
2700, 3000, 3500, 4000, 4100	80...89	–	–	–	F13TBX/8../A/4P
2700, 3000, 3500, 4000, 4100	80...89	–	4 pins 18 W/8.. TOP	TE 18 W/8..	F18TBX/8../A/4P
2700, 3000, 3500, 4000, 4100	80...89	T/E 26 W/8.. CONSTANT	4 pins 26 W/8.. TOP	TE 26 W/8..	F26TBX/8../A/4P
2700, 3000, 3500, 4000, 4100	80...89	T/E 32 W/8.. CONSTANT	4 pins 32 W/8.. TOP	TE 32 W/8..	F32TBX/8../A/4P
2700, 3000, 3500, 4000, 4100	80...89	T/E 42 W/8.. CONSTANT	4 pins 42 W/8.. TOP	TE 42 W/8..	F42TBX/8../A/4P/EOL
2700, 3000, 4000	80...89	–	4 pins 57 W/8.. TOP	–	–
3000, 4000	80...89	–	–	–	–
2700, 3000, 3500, 4000	80...89	–	–	–	F57QBX/8../A/4P/EOL
3000, 3500, 4000	80...89	–	–	–	F70QBX/8../A/4P/EOL
3000, 4000	80...89	T/E 32 W/8.. XT	4 pins 32 W/8.. Xtra	–	–
3000, 4000	80...89	–	4 pins 42 W/8.. Xtra	–	–
3000, 4000	80...89	–	4 pins 57 W/8.. Xtra	–	–
			MASTER PL-L		
3000, 4000	80...89	L 16 W/8.. HE	–	–	–
3000, 4000, 5400	90...100	DE LUXE L 18 W/9..	–	–	–
2700, 3000, 3500, 4000	80...89	L 18 W/8..	18 W/8../4P	L 18 W/8..	F18BX/8..
3000, 4000	80...89	L 22 W/8.. HE	–	–	–
3000, 4000, 5400	90...100	DE LUXE L 24 W/9..	–	–	–
2700, 3000, 3500, 4000	80...89	L 24 W/8..	24 W/8../4P	L 24 W/8..	F24BX/8..
3000, 4000	80...89	L 26 W/8.. HE	–	–	–
3000, 4000	80...89	L 28 W/8.. HE	–	–	–
3000, 4000, 5400	90...100	DE LUXE L 36 W/9..	–	–	–
2700, 3000, 3500, 4000	80...89	L 36 W/8..	36 W/8../4P	L 36 W/8..	F36BX/8..
6500	80...89	L 36 W/865	36 W/865/4P	–	–

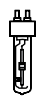
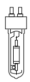
*** warm: up to 3300 K intermediate: 3300 to 5300 K cool: above 5300 K

	Designation (ZVEI/LBS)	Wattage [W]	Max. dimensions [mm]	Cap	Luminous flux levels [lm]	Luminous effic.** [lm/W]	Light col.***
Compact fluorescent lamps (plug-in cap)			**Max. length acc. to IEC**				
	TC-L	36	415	2G11	2600	72	cool
	TC-L	40	535	2G11	2950	74	cool
	TC-L*	40	535	2G11	3500	88	warm, intermed.
	TC-L	40	535	2G11	3325	83	cool
	TC-L	40	535	2G11	3150	79	cool
	TC-L	55	535	2G11	4000	73	w., interm., cool
	TC-L*	55	535	2G11	4800	87	warm, intermed.
	TC-L	55	535	2G11	4500–4550	82–83	cool
	TC-L	55	535	2G11	4300	78	cool
	TC-L*	80	565/568	2G11	6000–6500	75–81	w., interm.
	TC-LI (amalgam)	40	535	2G11	3500	88	inter-mediate
	TC-LI (amalgam)	55	535	2G11	4800	87	inter-mediate
	TC-LI (amalgam)	80	568	2G11	6500	81	inter-mediate
	TC-L-LL (long life)	18	225	2G11	1200	67	w., interm.
	TC-L-LL (long life)	24	320	2G11	1800	75	w., interm.
	TC-L-LL (long life)	36	415	2G11	2900	81	w., interm.
	TC-L-LL (long life)	40	535	2G11	3500	88	w., interm.
	TC-L-LL (long life)	55	535	2G11	4800	87	w., interm.
	TC-F*	18	122	2G10	1100	61	w., interm.
	TC-F*	24	165	2G10	1700	71	w., interm.
	TC-F*	36	217	2G10	2800	78	w., interm.
Induction lamps			**Length x width x height**		**Luminous flux levels [lm]**		
	LMT-SIHf	70	315 x 139 x 75	Osram	6500	93	w., interm.
	LMT-SIHf	100	315 x 139 x 75	Osram	8000	80	w., interm.
	LMT-SIHf	150	415 x 139 x 75	Osram	12000	80	w., interm.
Metal halide lamps			**Total length (OSRAM + PHILIPS)**		**Max. luminous fluxes on recommended ballast**		
	HIT-TC-CE	20	52–55	PGJ5	1650	83	warm
	HIT-TC-CE	20	51–57	GU6,5	1600–1800	80–90	warm

* Core type ** (without control gear)

Colour temperatures [K]	Colour Rendering Index CRI/R_a	OSRAM	PHILIPS	SYLVANIA	GE
		DULUX	**MASTER PL-L**	**Lynx**	**Biax**
8000	80...89	L 36 W/880	–	–	–
5400	90...100	DE LUXE L 40 W/954	–	–	–
2700, 3000, 3500, 4000	80...89	L 40 W/8..	40 W/8../4P	LE 40 W/8..	F40BX/8..
6500	80...89	L 40 W/865	–	–	–
8000	80...89	L 40 W/880	–	–	–
3000, 4000, 5400	90...100	DE LUXE L 55 W/9..	–	–	–
2700, 3000, 3500, 4000	80...89	L 55 W/8..	55 W/8../4P	LE 55 W/8..	F55BX/8..
6500	80...89	L 55 W/865	55 W/865/4P	–	F55BX/865
8000	80...89	L 55 W/880	–	–	–
2700, 3000, 4000	80...89	L 80 W/8..	80 W/8../4P	–	–
4000	80...89	L 40 W/840 CONSTANT	–	–	–
4000	80...89	L 55 W/840 CONSTANT	–	–	–
6500	80...89	L 80 W/840 CONSTANT	–	–	–
3000, 4000	80...89	L 18 W/8.. XT	–	–	–
3000, 4000	80...89	L 24 W/8.. XT	24 W/8../4P Xtra (Polar)	–	–
3000, 4000	80...89	L 36 W/8.. XT	36 W/8../4P Xtra (Polar)	–	–
3000, 4000	80...89	–	40 W/8../4P Xtra	–	–
3000, 4000	80...89	L 55 W/8.. XT	55 W/8../4P Xtra (Polar)	–	–
2700, 3000, 4000	80...89	F 18 W/8..	–	F 18 W/8..	–
2700, 3000, 4000	80...89	F 24 W/8..	–	F 24 W/8..	–
2700, 3000, 4000	80...89	F 36 W/8..	–	F 36 W/8..	–
		ENDURA			
3000, 4000	80...89	70 W/8..	–	–	–
3000, 4000	80...89	100 W/8..	–	–	–
3000, 4000	80...89	150 W/8..	–	–	–
		POWERSTAR/ POWERBALL	**MASTERcolour**		**ConstantColour**
3000	80...89	–	CDM-Tm Mini 20 W/830	–	–
3000	80...89	HCI-TF 20/830 WDL PB	CDM-Tm Mini GU6,5 20 W/830	–	CMH20/T/UVC/830/ GU6,5

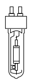
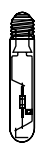
*** warm: up to 3300 K intermediate: 3300 to 5300 K cool: above 5300 K

	Designation (ZVEI/LBS)	Wattage [W]	Max. dimensions [mm]	Cap	Luminous flux levels [lm]	Luminous effic.** [lm/W]	Light col.***
Metal halide lamps			**Total length (OSRAM + PHILIPS)**		**Max. luminous fluxes on recommended ballast**		
	HIT-TC-CE	20	85	G8,5	2050	103	warm
	HIT-TC-CE	20	81–85	G8,5	1600–1800	80–90	warm
	HIT-CE	20	103	G12	2050	103	warm
	HIT-CE	20	88–103	G12	1650–1800	83–90	warm
	HIT-TC-CE	35	55	PGJ5	3000	86	warm
	HIT-TC-CE	35	52	GU6,5	3400	97	inter-mediate
	HIT-TC-CE	35	52–57	GU6,5	3300–3900	94–111	warm
	HIT-TC-CE	35	57	GU6,5	3400	97	warm
	HIT-TC-CE	35	81–85	G8,5	3000–3700	91–106	inter-mediate
	HIT-TC-CE	35	81–85	G8,5	2800	80	warm
	HIT-TC-CE	35	85	G8,5	4300	123	warm
	HIT-TC-CE	35	81	G8,5	3500–4000	100–114	warm
	HIT-TC-CE	35	81–85	G8,5	3100–3500	89–97	warm, intermed.
	HIT-CE	35	100–103	G12	3200–3800	94–109	inter-mediate
	HIT-CE	35	90–100	G12	2800–4000	80–114	warm
	HIT-CE	35	103	G12	4300	123	warm
	HIT-CE	35	100	G12	4000	114	warm
	HIT-CE*	35	88–103	G12	3150–3600	90–103	warm, intermed.
	HIT-TC-CE	50	85	G8,5	5000–5400	100–108	w., interm.
	HIT-CE	50	103	G12	5400	108	w., interm.
	HIT-CE	50	152–156	E27	4150–5350	83–100	warm
	HIT-CE	50	156	E27	4800	96	warm

* Core type ** (without control gear)

Colour temperatures [K]	Colour Rendering Index CRI/R_a	OSRAM	PHILIPS	SYLVANIA	GE
		POWERSTAR/ POWERBALL	**MASTERcolour**		**ConstantColour**
3000	90...100	–	CDM-TC Evolution 20 W/930	–	–
3000	80...89	HCI-TC 20 W/830 WDL PB	CDM-TC 20 W/830	–	CMH20/TC/ UVC/U/830/G8,5 Plus
3000	90...100	–	CDM-T Evolution 20 W/930	–	–
3000	80...89	–	CDM-T 20 W/830	–	CMH20/T/UVC/830/ G12 Plus
3000	80...89	–	CDM-Tm Mini 35 W/830	–	–
4200	90...100	–	–	–	CMH35/T/UVC/942/ GU6,5
3000	90...100	–	CDM-Tm Elite Mini 35 W/930 GU6,5	–	CMH35/T/UVC/930/ GU6,5 (Ultra)
3000	90...100	HCI-TF 35/930 WDL PB	–		–
4200	90...100	HCI-TC 35/942 NDL PB	CDM-TC 35 W/942, CDM-TC Elite 35 W/942	–	CMH35/TC/ UVC/U/942/G8,5
3000	90...100	HCI-TC 35/930 WDL PB Shoplight	–	–	–
3000	90...100	–	CDM-TC Evolution 35 W/930	–	–
3000	90...100	HCI-TC 35/930 WDL PB Plus	CDM-TC Elite 35 W/930	–	CMH35/TC/ UVC/U/930/G8,5 Ultra
3000, 4200	80...89	HCI-TC 35/830 WDL PB	CDM-TC 35 W/830	CMI-TC 35 W/WDL UVS	CMH35/TC/ UVC/U/8../G8,5 Plus
4200	90...100	HCI-T 35/942 NDL PB	CDM-T 35 W/942, CDM-T Elite 35 W/942	–	CMH35/T/UVC/U/942/ G12
3000	90...100	HCI-T 35/930 WDL PB Shoplight	CDM-T Elite 35 W/930	–	CMH35/T/UVC/U/930/ G12 Ultra
3000	90...100	–	CDM-T Evolution 35 W/930	–	–
3000	90...100	HCI-T 35/930 WDL PB Plus	–	–	–
3000, 4200	80...89	HCI-T 35/830 WDL PB	CDM-T 35 W/830	CMI-T 35 W/WDL UVS	CMH35/T/UVC/U/8../ G12 (Plus)
3000, 4200	90...100	–	CDM-TC Elite 50 W/9..	–	–
3000, 4200	90...100	–	CDM-T Elite 50 W/9..	–	–
2800, 3000	80...89	HCI-TT 50/830 WDL PB	CityWhite CDO-TT (Plus) 50 W/828	–	–
3000	70...79	–	–	–	CMH50/TTUVC/730/ E27 STREETWISE

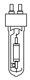
*** warm: up to 3300 K   intermediate: 3300 to 5300 K   cool: above 5300 K

	Designation (ZVEI/LBS)	Wattage [W]	Max. dimensions [mm]	Cap	Luminous flux levels [lm]	Luminous effic.** [lm/W]	Light col.***
Metal halide lamps			**Total length (OSRAM + PHILIPS)**		**Max. luminous fluxes on recommended ballast**		
	HIT-TC-CE	70	81–88	G8,5	5900–7400	84–106	inter-mediate
	HIT-TC-CE	70	81–85	G8,5	6300–7650	90–109	warm
	HIT-TC-CE	70	81	G8,5	6200–7800	92–111	warm
	HIT-TC-CE	70	81–85	G8,5	6200–6900	92–94	warm
	HIT-TC-CE	70	85	G8,5	6000	86	intermed.
	HIT-CE	70	100–103	G12	6300–7750	90–111	warm, intermed.
	HIT-CE*	70	100	G12	6400–7800	91–111	warm
	HIT-CE*	70	88–100–103	G12	5800–7500	83–107	inter-mediate
	HIT-CE*	70	88–100–103	G12	6200–7300	89–104	warm
	HIT-CE	70	103	G12	6000	86	intermed.
	HIT-CE	70	156	E27	6300	90	intermed.
	HIT-CE	70	150–156	E27	6000–7500	86–107	warm
	HIT-CE	70	156	E27	7800	111	warm
	HIT-CE	70	149	PG12-2	5800	83	intermed.
	HIT-CE	70	149	PG12-2	5800	83	warm
	HIT	70	76–90	G12	5200–5800	74–79	w., interm.
	HIT	70	90	G12	5200	74	warm
	HIT-CE	100	105	G12	9300	93	inter-mediate
	HIT-CE	100	110	G12	10500–11000	105–110	warm
	HIT-CE	100	105	G12	9500	95	warm
	HIT-CE	100	209–210	E40	8800–10700	88–107	warm
	HIT-CE	100	211	E40	10900	109	warm

* Core type   ** (without control gear)

Colour temperatures [K]	Colour Rendering Index CRI/R_a	OSRAM	PHILIPS	SYLVANIA	GE
		POWERSTAR/ POWERBALL	**MASTERcolour**		**ConstantColour**
4200	90...100	HCI-TC 70/942 NDL PB	CDM-TC 70 W/942, CDM-TC Elite 70 W/942 (Light Boost)	–	CMH70/TC/ UVC/U/942/G8,5
3000	90...100	HCI-TC 70/930 WDL PB Shoplight	CDM-TC Elite 70 W/930 (Light Boost)	–	–
2500, 3000	90...100	HCI-TC 70/930 WDL PB Plus	CDM-TC 70 W warm (925)	–	CMH70/TC/ UVC/U/930/G8,5 Ultra (White)
3000	80...89	HCI-TC 70/830 WDL PB	CDM-TC 70 W/830	CMI-TC 70 W/WDL UVS	CMH70/TC/ UVC/U/830/G8,5 Plus
4000	70...79	–	CDM-TC 70 W fresh (740)	–	–
3000, 4200	90...100	HCI-T 70/930 WDL PB Shoplight	CDM-T Elite 70 W/9.. (/930 Light Boost)	–	–
2500, 2950, 3000	90...100	HCI-T 70/930 WDL PB Plus	CDM-T 70 W warm (925)	–	CMH70/T/UVC/U/930/ G12 Ultra (White)
4200	90...100	HCI-T 70/942 NDL PB	CDM-T 70 W/942, CDM-T Elite 70 W/942 (Light Boost)	CMI-T 70 W/NDL UVS	CMH70/T/UVC/U/942/ G12
3000	80...89	HCI-T 70/830 WDL PB	CDM-T 70 W/830	CMI-T 70 W/WDL UVS	CMH70/T/UVC/U/830/ G12
4000	70...79	–	CDM-T 70 W fresh (740)	–	–
4200	90...100	–	CDM-TT 70 W/942	–	–
2800, 3000	80...89	HCI-TT 70/830 WDL PB	CityWhite CDO-TT 70 W/828	–	CMH70/TT/UVC/830/ E27
3000	70...79	–	–	–	CMH70/TTUVC/730/ E27 STREETWISE
4200	90...100	–	CDM-TP 70 W/942	–	–
3000	80...89	–	CDM-TP 70 W/830	–	–
3000, 4200	80...89	HQI-T 70/… UVS	–	HSI-T 70 W/... UVS	ARC70/T/U/842/G12
3000	70...79	–	–	–	ARC70/T/U/730/G12
4200	90...100	HCI-T 100/942 NDL PB	–	–	–
3000	90...100	–	CDM-T Elite 100 W/9..	–	–
3000	80...89	HCI-T 100/830 WDL PB	–	–	–
2800, 3000	80...89	HCI-TT 100/830 WDL PB	CityWhite CDO-TT Plus 100 W/828	–	CMH100/TT/UVC/830/ E40
3000	70...79	–	–	–	CMH100/TTUVC/730/ E27 STREETWISE

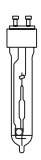
*** warm: up to 3300 K   intermediate: 3300 to 5300 K   cool: above 5300 K

	Designation (ZVEI/LBS)	Wattage [W]	Max. dimensions [mm]	Cap	Luminous flux levels [lm]	Luminous effic.** [lm/W]	Light col.***
Metal halide lamps			**Total length (OSRAM + PHILIPS)**		**Max. luminous fluxes on recommended ballast**		
	HIT-CE*	150	98–110	G12	12700–14500	85–87	inter-mediate
	HIT-CE	150	110	G12	15000	100	warm
	HIT-CE*	150	98–110	G12	13000–15000	90–100	warm
	HIT-CE	150	149	PGX12-2	13000	87	warm
	HIT-CE	150	149	PGX12-2	12000	80	intermed.
	HIT	150	76–84	G12	11500–13000	77–87	w., interm.
	HIT-CE	150	211	E40	12000	80	intermed.
	HIT-CE	150	209	E40	15000	100	inter-mediate
	HIT-CE	150	204–211	E40	13500–16500	90–110	warm, inter-mediate
	HIT-CE	150	211	E40	16300	109	warm
	HIT-CE	210	186	PGZ18	23000	110	inter-mediate
	HIT-CE	210	186	PGZ18	24150	115	warm
	HIT-CE	250	135	G12	23000	92	warm
	HIT-CE	250	175	G22(GY22)	25300	101	inter-mediate
	HIT-CE	250	175	G22(GY22)	26600	106	warm
	HIT-CE	250	135	G12	22000	88	inter-mediate
	HIT-CE*	250	260	E40	25000	100	inter-mediate
	HIT-CE	250	226–260	E40	20000–26000–28300	80–113	warm
	HIT	250	219–225–257	E40	19000–20000	76–80	intermed., cool
	HIT	250	257	E40	20000	80	intermed.
	HIT	250	220	E40	21000	84	intermed.
	HIT	250	246–257	E40	20500–21000	82–84	inter-mediate

* Core type ** (without control gear)

Colour temperatures [K]	Colour Rendering Index CRI/R_a	OSRAM	PHILIPS	SYLVANIA	GE
		POWERSTAR/ POWERBALL	**MASTERcolour**		**ConstantColour**
4200	90...100	HCI-T 150/942 NDL PB	CDM-T 150 W/942 CDM-SA/T 150 W/942	CMI-T 150 W/NDL UVS	CMH150/T/ UVC/U/942/G12
3000	90...100	–	CDM-T Elite 150 W/930	–	–
3000	80...89	HCI-T 150/830 WDL PB	CDM-T 150 W/830	CMI-T 150 W/WDL UVS	CMH150/T/ UVC/U/830/G12
3000	80...89	–	CDM-TP 150 W/830	–	–
4200	90...100	–	CDM-TP 150 W/942	–	–
3000, 4000, 4200	80...89	HQI-T 150/…	–	HSI-T 150 W/... UVS	ARC150/T/U/8../G12
4200	90...100	–	CDM-TT 150 W/942	–	–
4200	90...100	–	–	–	CMH150//UVC O/T/U/942/E40
3000, 4200	80...89	HCI-TT 150/830 WDL PB	CityWhite CDO-TT Plus 150 W/828	–	CMH150/UVC/ T/U/842/E40 CMH150/TT/UVC/ 830/E40 CMH150//UVC O/T/U/830/E40
3000	70...79	–	–	–	CMH150/TTUVC/730/ E40 STREETWISE
4200	90...100	–	CDM-TMW Elite 210 W/942	–	–
3000	90...100	–	CDM-TMW Elite 210 W/930	–	–
3000	80...89	–	CDM-T 250 W/830 G12	–	–
4200	90...100	HCI-TM 250/942 NDL MD/HR PB	–	–	–
3000	90...100	HCI-TM 250/930 WDL MD/HR PB	–	–	–
4200	90...100	–	CDM-T 250 W/942 G12	–	–
4200	90...100	–	–	–	CMH250/TT/UVC/ 942/E40
2800, 3000	80...89	HCI-TT 250/830 WDL PB	CityWhite CDO-TT Plus 250 W/828	–	CMH250/TT/UVC/ 830/E40, KRC250/CMH/830/ T/H/E40
5200, 5400, 6000	90...100	HQI-T 250/D PRO	–	HSI-T 250 W/D	ARC250/T/.../960/E40
4500	90...100	–	–	HSI-THX 250 W	–
4200	70...79	–	–	–	ARC250/T/H/742/E40
4000, 4500, 4600	60...69	–	MASTER HPI-T PLUS 250 W/645	HSI-TSX 250 W	–

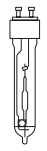
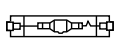
*** warm: up to 3300 K intermediate: 3300 to 5300 K cool: above 5300 K

	Designation (ZVEI/LBS)	Wattage [W]	Max. dimensions [mm]	Cap	Luminous flux levels [lm]	Luminous effic.** [lm/W]	Light col.***
Metal halide lamps			**Total length (OSRAM + PHILIPS)**		**Max. luminous fluxes on recommended ballast**		
	HIT-CE	315	186	PGZ18	35500	113	inter-mediate
	HIT-CE	400	175	G22(GY22)	43000	108	inter-mediate
	HIT-CE	400	175	G22(GY22)	43000	108	warm
	HIT-CE	400	278	E40	41000	103	warm
	HIT	400	270	E40	36000	90	inter-mediate
	HIT	400	270–285	E40	31500–35000	79–88	cool
	HIT	400	270	E40	25000–28000	63–70	cool
	HIT	400	260	E40	35000	88	intermed.
	HIT	400	270–286	E40	32000–40000	80–100	inter-mediate
	HIT	600	180	G22(GY22)	58000	97	cool
	HIT	1000	382	E40	81000	81	intermed.
	HIT	1000	180	G22(GY22)	97000	97	cool
	HIT	1000	340	E40	85000	85	cool
	HIT	1000	345–382	E40	85000–110000	85–110	intermed.
	HIT	2000	430	E40	180000	90	cool
	HIT	2000	430	E40	180000	90	cool
	HIT	2000	430	E40	189000–210000	95–105	intermed.
	HIT	2000	430	E40	190000	95	intermed.
	HIT	2000	430	E40	240000	120	inter-mediate
			Length x diameter				
	HIT-CE	45	132 x 19	PGZ12	4455–4950	99–110	warm
	HIT-CE*	60	132 x 19	PGZ12	6420–7020	107–117	inter-mediate
	HIT-CE	60	132 x 19	PGZ12	6780–7200	113–120	warm
	HIT-CE*	90	143 x 19	PGZ12	9450–10350	105–115	inter-mediate
	HIT-CE	90	143 x 19	PGZ12	10000–10450	111–116	warm

* Core type ** (without control gear)

Colour temperatures [K]	Colour Rendering Index CRI/R_a	OSRAM	PHILIPS	SYLVANIA	GE
		POWERSTAR/ POWERBALL	**MASTERcolour**		**ConstantColour**
4200	90...100	–	CDM-TMW Elite 315 W/942	–	–
4200	90...100	HCI-TM 400/942 NDL (HR) PB	–	–	–
3000	90...100	HCI-TM 400/930 WDL (HR) PB	–	–	–
3000	80...89	–	–	–	CMH400/TT/UVC/830/ E40
4200	90...100	–	–	HSI-THX 400 W	–
5500, 5900	90...100	HQI-BT 400/D PRO	–	HSI-T 400 W/D	–
6000	90...100	–	–	–	KRC400/T/.../960/E40
4200	70...79	–	–	–	ARC400/T/H/742/E40
3500, 4000, 4200, 4300, 4500	60...69	HQI-T 400/N	MASTER HPI-T PLUS 400 W/645	HSI-TSX 400 W	–
6100	90...100	HQI-TM 600/D (HR) PB	–	–	–
4000	90...100	–	–	HSI-T 1000 W/4K	–
6100	90...100	HQI-TM 1000/D (HR) PB	–	–	–
7250	90...100	HQI-T 1000/D	–	–	–
3500, 4300	65	HQI-T 1000/N	HPI-T 1000 W/643	–	–
7250	90...100	HQI-T 2000/D	–	–	–
7250	90...100	HQI-T 2000/D/I	–	–	–
4200, 4600	60...69	HQI-T 2000/N	HPI-T 2000 W/64.	–	–
4400	60...69	HQI-T 2000/N 230 V	–	–	–
4400	60...69	HQI-T 2000/N/E SUPER	–	–	–
2800	60–66	–	CosmoWhite CPO-TW Xtra 45 W/728	–	–
4000	81–83	–	CosmoWhite CPO-TW 60 W/840	–	–
2800	67–73	–	CosmoWhite CPO-TW Xtra 60 W/728	–	–
4000	72–77	–	CosmoWhite CPO-TW 90 W/840	–	–
2800	58–66	–	CosmoWhite CPO-TW Xtra 90 W/728	–	–

*** warm: up to 3300 K intermediate: 3300 to 5300 K cool: above 5300 K

	Designation (ZVEI/LBS)	Wattage [W]	Max. dimensions [mm]	Cap	Luminous flux levels [lm]	Luminous effic.** [lm/W]	Light col.***
Metal halide lamps			**Total length (OSRAM + PHILIPS)**		**Max. luminous fluxes on recommended ballast**		
	HIT-CE*	140	150 x 19	PGZ12	15120–16100	108–115	inter-mediate
	HIT-CE	140	150 x 19	PGZ12	16500	118	warm
			Length/ contact gap				
	HIT-DE-CE	35	114.2	RX7s	3400	97	warm
	HIT-DE-CE	70	114.2	RX7s	5800–6700	83–96	inter-mediate
	HIT-DE-CE*	70	114.2	RX7s	5800–7000	83–97	warm
	HIT-DE	70	114.2	RX7s	5100–6500	73–93	w., interm., cool
	HIT-DE	70	114.2	RX7s	5500–6200	79–89	warm, intermed.
	HIT-DE-CE	150	132	RX7s-24	12000–14400	80–96	inter-mediate
	HIT-DE-CE*	150	132	RX7s-24	13000–14800	88–97	warm, intermed.
	HIT-DE	150	132–138	RX7s-24	11000–13500	73–90	w., interm., cool
	HIT-DE	150	132–138	RX7s-24	12000–13800	80–92	warm, intermed.
	HIT-DE	250	162	Fc2	21500	86	intermed.
	HIT-DE	250	162	Fc2	20000–22000	80–88	warm, intermed.
	HIT-DE	400	206	Fc2	31000–37000	78–93	cool
	HIT-DE	400	206	Fc2	36000	90	intermed.
	HIT-DE	1000	187	Cable	90000	90	cool
	HIT-DE	1000	187	Cable	90000	90	intermed.
	HIT-DE	1000	294	Cable	90000	90	cool
	HIT-DE	1000	294	Cable	100000	100	inter-mediate
	HIT-DE	1800	364	Cable	155000	86	cool
	HIT-DE	2000	369	Cable	200000	100	cool

* Core type ** (without control gear)

Colour temperatures [K]	Colour Rendering Index CRI/R_a	OSRAM	PHILIPS	SYLVANIA	GE
			MASTERcolour		
4000	75–80	–	CosmoWhite CPO-TW 140 W/840	–	–
2800	66	–	CosmoWhite CPO-TW 140 W/728	–	–
		POWERSTAR/ POWERBALL			**ConstantColour**
3000	80...89	–	–	–	CMH35/TD/UVC/830/ RX7s
4200	90...100	HCI-TS 70/942 NDL PB	CDM-TD 70 W/942	CMI-TD 70 W/NDL	CMH70/TD/UVC/942/ RX7s
3000	80...89	HCI-TS 70 /830 WDL PB	CDM-TD 70 W/830	CMI-TD 70 W/WDL	CMH70/TD/UVC/830/ RX7s
3000, 4000, 4200, 5200, 5600, 6500	80...89	HQI-TS 70/… EXCELLENCE	–	HSI-TD 75 W/… UVS	–
3000, 3500, 4200, 4300	70...79	–	–	–	ARC70/TD(UVC)/7../ RX7s
4200	90...100	HCI-TS 150 /942 NDL PB	CDM-TD 150 W/942	CMI-TD 150 W/NDL	CMH150/TD/UVC/942/ RX7s-24
3000, 4200	80...89	HCI-TS 150 /830 WDL PB	CDM-TD 150 W/8.. (Essential)	CMI-TD 150 W/WDL	CMH150/TD/UVC/830/ RX7s-24
3000, 4200, 5600, 6500	80...89	HQI-TS 150/… EXCELLENCE	–	HSI-TD 150 W/… UVS	–
3000, 3200, 3500, 4200	70...79	–	–	–	ARC150/TD(UVC)/7../ RX7s-24
5500	90...100	HQI-TS 250/D (PRO)	–	–	–
3200, 4000, 4200, 5200	80...89	HQI-TS 250/… UVS	MHN-TD 250 W/842	HSI-TD 250 W/… .K (UVS)	ARC250/TD/8../Fc2
5500-6000	90...100	HQI-TS 400/D (PRO)	–	–	–
4200	80...89	HQI-TS 400/NDL	–	–	–
6100	90...100	HQI-TS 1000/D/S (PRO)	–	–	–
4400	80...89	HQI-TS 1000/NDL/S	–	–	–
5600	90...100	–	MASTER MHN-LA 1000 W/956 XWH	–	–
4200	80...89	–	MASTER MHN-LA 1000 W/842 XWH	–	–
5600	90...100	–	MASTER MHN-SA 1800 W/956 (P)SFC	–	–
5600	90...100	–	MASTER MHN-SA 2000 W/956 400 V XW	–	–

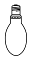
*** warm: up to 3300 K intermediate: 3300 to 5300 K cool: above 5300 K

	Designation (ZVEI/LBS)	Wattage [W]	Max. dimensions [mm]	Cap	Luminous flux levels [lm]	Luminous effic.** [lm/W]	Light col.***
Metal halide lamps			**Length/ contact gap**		**Max. luminous fluxes on recommended ballast**		
	HIT-DE	2000	187	Cable	210000–230000	105–115	cool
	HIT-DE	2000	364	Cable	190000	95	cool
	HIT-DE	2000	187	Cable	225000	113	inter-mediate
	HIT-DE	2000	274–364	Cable	205000–220000	103–110	intermed., cool
	HIT-DE	2000	274	Cable	230000	115	intermed.
			Length x Ø		**Max. luminous fluxes on recommended ballast**		
	HIE-CE-P	35	138 x 54	E27	3200	91	warm
	HIE-CE-P	50	138 x 54	E27	4000	80	warm
	HIE-CE	50	156 x 71	E27	4900	98	warm
	HIE-CE	70	156 x 71	E27	6000–7230	86–103	warm
	HIE-CE-P	70	138 x 54	E27	6700	96	warm
	HIE-P	70	141 x 55	E27	6200–6600	89–94	inter-mediate
	HIE-P	70	141 x 55	E27	6200–6600	89–94	warm
	HIE	70	138 x 54	E27	5000	71	warm
	HIE-CE-P	100	138 x 54	E27	8500	85	warm
	HIE-CE	100	186 x 76	E40	8700–9400	87–94	warm
	HIE-P	100	141 x 55	E27	7300–7700	73–77	inter-mediate
	HIE-P	100	141 x 55	E27	7300–7700	73–77	warm
	HIE	100	138 x 54	E27	8100	81	warm
	HIE-CE-P	150	138 x 54	E27	13700	91	warm
	HIE-CE	150	227 x 91	E40	12300–15100	82–101	warm

* Core type ** (without control gear)

Colour temperatures [K]	Colour Rendering Index CRI/R_a	OSRAM	PHILIPS	SYLVANIA	GE
		POWERSTAR/ POWERBALL	MASTERcolour		ConstantColour
6100–6200	90...100	HQI-TS 2000/D/S (High Flux)	–	–	–
5600	90...100	–	MASTER MHN-LA 2000 W/956 400 V XWH	–	–
4400	80…89	HQI-TS 2000/NDL/S	–	–	–
4200, 5400	80...89	–	MASTER MHN-LA 2000 W/842 400 V XWH	–	–
4200	60…69	HQI-TS 2000/N/L	–	–	–
3000	80...89	HCI-E/P 35/830 WDL PB coated	–	–	–
3000	80...89	HCI-E/P 50/830 WDL PB coated	–	–	–
2800	89	–	CityWhite CDO-ET Plus 50/828	–	–
2900, 3000	80…89	–	CityWhite CDO-ET Plus 70/828	–	CMH70/E/UVC/U/830/ E27/C/D
3000	80...89	HCI-E/P 70/830 WDL PB coated	–	–	–
–	80...89	HQI-E/P 70/NDL clear/coated	–	–	–
–	70...79	HQI-E/P 70/WDL clear/coated	–	–	–
3000	70...79	–	–	HSI-MP 75 W/CO U-E27	–
3000	80...89	HCI-E/P 100/830 WDL PB coated	–	–	–
2830, 3000	80…89	–	CityWhite CDO-ET Plus 100/828	–	CMH100/E/ UVC/U/830/E27/C/D
4200	80...89	HQI-E/P 100/NDL clear/coated	–	–	–
3000	70...79	HQI-E/P 100/WDL clear/coated	–	–	–
3000	70...79	–	–	HSI-MP 100 W/CO U-E27	–
3000	80...89	HCI-E/P 150/830 WDL PB coated	–	–	–
2830, 3000	80…89	–	CityWhite CDO-ET Plus 150/828	–	CMH150/E/ UVC/U/830/E27/C/D

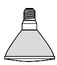
*** warm: up to 3300 K   intermediate: 3300 to 5300 K   cool: above 5300 K

	Designation (ZVEI/LBS)	Wattage [W]	Max. dimensions [mm]	Cap	Luminous flux levels [lm]	Luminous effic.** [lm/W]	Light col.***
Metal halide lamps			**Length x Ø**		**Max. luminous fluxes on recommended ballast**		
	HIE-P	150	141 x 55	E27	11400–12000	76–80	inter-mediate
	HIE-P	150	141 x 55	E27	11400–12000	76–80	warm
	HIE	150	138 x 54	E27	12500	83	warm
	HIE (-P)*	250	226 x 90	E40	17000–19000	68–76	intermed., cool
	HIE*	250	227 x 90	E40	23500	94	warm
	HIE	250	227 x 91	E40	19500	78	intermed.
	HIE (-P)*	250	211/226 x 90	E40	18000–25500	72–102	intermed., cool
	HIE (-P)*	400	290 x 120	E40	23000–31000	58–78	cool
	HIE*	400	282 x 120	E40	39000	98	warm
	HIE	400	285 x 120	E40	40000–42000	100–105	inter-mediate
	HIE (-P)*	400	284–290 x 122	E40	30000–42500	75–106	w., interm., cool
	HIE	1000	380 x 165	E40	100000	100	intermed.
			Length x Ø		**Max. lighting intensity [cd]**		
	HIPAR16/12°*	20	55 x 51	GX10	9000	–	warm
	HIPAR16/25°*	20	55 x 51	GX10	2900	–	warm
	HIPAR16/40°*	20	55 x 51	GX10	1500	–	warm
	HIPAR16/12°*	35	55 x 50	GX10	16000	–	warm, inter-mediate
	HIPAR16/15°*	35	65 x 50	GX10	12000	–	inter-mediate
	HIPAR16/25°*	35	65 x 50	GX10	5500	–	warm, inter-mediate

* Core type ** (without control gear)

Colour temperatures [K]	Colour Rendering Index CRI/R_a	OSRAM	PHILIPS	SYLVANIA	GE
		POWERSTAR/ POWERBALL	**MASTERcolour**		**ConstantColour**
4200	80...89	HQI-E/P 150/NDL clear/coated	–	–	–
3000	70...79	HQI-E/P 150/WDL clear/coated	–	–	–
3000	70...79	–	–	HSI-MP 150 W/CO U-E27	–
5200, 6000	90...100	HQI-E(/P) 250/D (PRO/coated)	–	–	ARC250/D/.../960/E40
3000	80…89	–	–	–	CMH250/E/U/830/E40
4000	70...79	–	–	–	ARC250/D/H/740/E40
3700, 3800, 4300, 6700	60...69	–	MASTER HPI PLUS 250 W/7.. BU(-P)	HSI-SX 250 W/CO	–
5000, 6000	90...100	HQI-E(/P) 400/D coated	–	–	KRC400/D/.../960/E40
3000	80…89	–	–	–	CMH400/E/U/830/E40
3800–4000	60…69	HQI-E 400/N (clear/coated)	–	–	–
3000, 3700, 4300, 4500, 6700	60...69	–	MASTER HPI PLUS 400 W/7 BU(-P)	HSI-SX 400 W/CO	–
3800	60...69	HQI-E 1000/N	–	–	–
3000	80…89	–	–	–	CMH20/MR16/UVC/830/ GX10/SP
3000	80…89	–	–	–	CMH20/MR16/UVC/830/ GX10/FL
3000	80…89	–	–	–	CMH20/MR16/UVC/830/ GX10/WFL
3000, 4000	90...100	–	–	–	CMH35/MR16/UVC/930/ GX10/SP (ULTRA), CMH35/MR16/UVC/942/ GX10/SP
4200	90...100	–	CDM-Rm Mini 35 W/942 GX10 15°	–	–
3000, 4200	90...100	–	CDM-Rm Mini 35 W/942 GX10 25°	–	CMH35/MR16/V60// UVC/930/GX10/FL (ULTRA), CMH35/MR16/V60// UVC/942/GX10/FL

*** warm: up to 3300 K intermediate: 3300 to 5300 K cool: above 5300 K

	Designation (ZVEI/LBS)	Wattage [W]	Max. dimensions [mm]	Cap	Luminous flux levels [lm]	Luminous effic.** [lm/W]	Light col.***
Metal halide lamps			**Length x Ø**		**Max. lighting intensity [cd]**		
	HIPAR16/40°*	35	55 x 50	GX10	3000	–	warm, inter-mediate
	HIPAR16/40°*	35	65 x 50	GX10	2800	–	inter-mediate
	HIPAR16/25°*	50	65 x 50	GX10	11500	–	warm
	HIPAR16/40°*	50	65 x 50	GX10	7000	–	warm
	HIPAR16/60°*	50	65 x 50	GX10	3000	–	warm
	HIPAR20/10°*	20	92 x 64	E27	13000	–	warm
	HIPAR20/25°*	20	92 x 64	E27	3750	–	warm
	HIPAR20/10°	35	95 x 65	E27	16000–21500	–	inter-mediate
	HIPAR20/25°*	35	95 x 65	E27	6950	–	inter-mediate
	HIPAR20/30°	35	95 x 65	E27	4000–5000	–	inter-mediate
	HIPAR20/10°	35	95 x 65	E27	22000–23000	–	warm
	HIPAR20/25°*	35	95 x 65	E27	7500	–	warm
	HIPAR20/30°	35	95 x 65	E27	5000–5400	–	warm
	HIPAR30/10°*	20	124 x 95	E27	19800	–	warm
	HIPAR30/25°*	20	124 x 95	E27	4900	–	warm
	HIPAR30/10°	35	125 x 97	E27	36000–36700	–	inter-mediate
	HIPAR30/25°*	35	125 x 97	E27	10200	–	inter-mediate
	HIPAR30/30°	35	125 x 97	E27	7000	–	inter-mediate
	HIPAR30/10°	35	120 x 95	E27	52000	–	warm
	HIPAR30/30°	35	120 x 95	E27	7800	–	warm

* Core type ** (without control gear)

Colour temperatures [K]	Colour Rendering Index CRI/R_a	OSRAM	PHILIPS	SYLVANIA	GE
		POWERSTAR/ POWERBALL	**MASTERcolour**		**ConstantColour**
3000, 4200	90...100	–	–	–	CMH35/MR16/V60/ UVC/930/GX10/WFL (ULTRA), CMH35/MR16/V60/ UVC/942/GX10/WFL
4200	90...100	–	CDM-Rm Mini 35 W/942 GX10 40°	–	–
3000	90...100	–	CDM-Rm Elite Mini 50 W/830 GX10 25°	–	–
3000	90...100	–	CDM-Rm Elite Mini 50 W/830 GX10 40°	–	–
3000	90...100	–	CDM-Rm Elite Mini 50 W/830 GX10 60°	–	–
3000	80…89	–	–	–	CMH20/PAR20/ UVC/830/E27/SP
3000	80…89	–	–	–	CMH20/PAR20/ UVC/830/E27/FL
4200	90...100	HCI-PAR20 35/942 NDL PB SP 10D	CDM-R 35 W/942 PAR20 10°	–	CMH35/PAR20/ UVC/942/E27/SP10
4200	90...100	–	–	–	CMH35/PAR20/ UVC/942/E27/FL25
4200	90...100	HCI-PAR20 35/942 NDL PB FL 30D	CDM-R 35 W/942 PAR20 30°	–	–
3000	80...89	HCI-PAR20 35/830 WDL PB SP 10D	CDM-R 35 W/830 PAR20 10°	–	CMH35/PAR20/ UVC/830/E27/SP
3000	80...89	–	–	–	CMH35/PAR20/ UVC/830/E27/FL
3000	80...89	HCI-PAR20 35/830 WDL PB FL 30D	CDM-R 35 W/830 PAR20 30°	–	–
3000	80…89	–	–	–	CMH20/PAR30/ UVC/830/E27/SP10
3000	80…89	–	–	–	CMH20/PAR30/ UVC/830/E27/FL25
4200	90...100	HCI-PAR30 35/942 NDL PB SP 10D	–	–	CMH35/PAR30/ UVC/942/E27/SP10
4200	90...100	–	–	–	CMH35/PAR30/ UVC/942/E27/FL25
4200	90...100	HCI-PAR30 35/942 NDL PB FL 30D	–	–	–
3000	90...100	–	CDM-R Elite 35 W/930 PAR30L10°	–	–
3000	90...100	–	CDM-R Elite 35 W/930 PAR30L30°	–	–

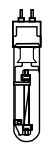
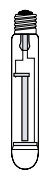
*** warm: up to 3300 K intermediate: 3300 to 5300 K cool: above 5300 K

	Designation (ZVEI/LBS)	Wattage [W]	Max. dimensions [mm]	Cap	Luminous flux levels [lm]	Luminous effic.** [lm/W]	Light col.***
Metal halide lamps			**Length x Ø**		**Max. lighting intensity [cd]**		
	HIPAR30/10°	35	125 x 97	E27	39600–45000	–	warm
	HIPAR30/25°*	35	125 x 97	E27	11000	–	warm
	HIPAR30/30°	35	125 x 97	E27	7400–8000	–	warm
	HIPAR30/10°	70	125 x 97	E27	63000–70000	–	inter-mediate
	HIPAR30/15°*	70	124 x 95	E27	33500	–	inter-mediate
	HIPAR30/30°	70	125 x 97	E27	13000	–	inter-mediate
	HIPAR30/40°	70	120 x 95	E27	9000	–	inter-mediate
	HIPAR30/10°	70	120 x 95	E27	60000–70000	–	warm
	HIPAR30/30°	70	120 x 95	E27	12000–15000	–	warm
	HIPAR30/30°	70	120 x 95	E27	10000	–	warm
	HIPAR30/10°	70	125 x 97	E27	68000	–	warm
	HIPAR30/15°*	70	124 x 95	E27	43000	–	warm
	HIPAR30/30°	70	125 x 97	E27	13500	–	warm
	HIPAR30/40°	70	125 x 97	E27	8900–10000		warm
			Length x Ø		**Luminous flux levels [lm]**		
	HIPAR64/6°	1000	175 x 207	G38	76000	63	inter-mediate
			Length x Ø		**Luminous flux levels [lm]**		
	HIR	150	93 x 95	AMP	5200 (25 mm)	35	inter-mediate
	HIR-CE	150	106 x 95	AMP	5000 (25 mm)	33	inter-mediate
High-pressure sodium discharge lamps			**Length x Ø**		**Luminous flux levels [lm]**		
	HST-CRI*	35	149 x 32	PG12-1	1300	37	warm
	HST	35	135 x 32	E27	2000	57	warm

* Core type ** (without control gear)

Colour temperatures [K]	Colour Rendering Index CRI/R_a	OSRAM	PHILIPS	SYLVANIA	GE
		POWERSTAR/ POWERBALL	**MASTERcolour**		**ConstantColour**
3000	80...89	HCI-PAR30 35/830 WDL PB SP 10D	CDM-R 35 W/830 PAR30L10°	–	CMH35/PAR30/ UVC/830/E27/SP10
3000	80…89	–	–	–	CMH35/PAR30/ UVC/830/E27/FL25
3000	80...89	HCI-PAR30 35/830 WDL PB FL 30D	CDM-R 35 W/830 PAR30L30°	–	–
4200	80...89	HCI-PAR30 70/942 NDL PB SP 10D	CDM-R 70 W/942 PAR30L10°	–	–
4200	90...100	–	–	–	CMH70/PAR30/ UVC/942/E27/SP
4200	80...89	HCI-PAR30 70/942 NDL PB FL 30D	CDM-R 70 W/942 PAR30L30°	–	–
4200	90...100	–	CDM-R 70 W/942 PAR30L40°	–	CMH70/PAR30/ UVC/942/E27/FL
3000	90...100	HCI-PAR30 70/830 WDL PB SP 10D	CDM-R Elite 70 W/930 PAR30L10°	–	–
3000	90...100	HCI-PAR30 70/830 WDL PB FL 30D	CDM-R Elite 70 W/930 PAR30L30°	–	–
3000	90...100	–	CDM-R Elite 70 W/930 PAR30L40°	–	–
3000	80...89	–	CDM-R 70 W/830 PAR30L10°	–	–
3000	80…89	–	–	–	CMH70/PAR30/ UVC/830/E27/SP
3000	80...89	–	CDM-R 70 W/830 PAR30L30°	–	–
3000	80...89	HCI-PAR30 70/830 WDL PB WFL 40D	CDM-R 70 W/830 PAR30L40°	–	CMH70/PAR30/ UVC/830/E27/FL
4000	80	–	–	–	CSI1000/PAR64/../G38 (29333, 29336)
4200	85	HQI-R 150 W/ NDL/FO	–	–	–
4200	96	–	CDM-SA/R 150 W/942	–	–
			MASTER		
2500	83	–	SDW-T 35 W	–	–
2050	< 40	–	–	SHP-TS 35 W E27	–

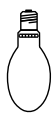
*** warm: up to 3300 K intermediate: 3300 to 5300 K cool: above 5300 K

	Designation (ZVEI/LBS)	Wattage [W]	Max. dimensions [mm]	Cap	Luminous flux levels [lm]	Luminous effic.** [lm/W]	Light col.***
High-pressure sodium discharge lamps			**Length x Ø**				
	HST-CRI	100	96 x 19	GX12-1	4900	49	warm
	HST-CRI*	100	149 x 32	PG12-1	5000	50	warm
	HST-CRI	50	96 x 19	GX12-1	2400	48	warm
	HST-CRI*	50	149 x 32	PG12-1	2300	46	warm
	HST-MF	50	156 x 37	E27	4000–4400	80–88	warm
	HST	50	156 x 39	E27	3400–4000	68–80	warm
	HST-MF	70	156 x 37	E27	6300–6500–6600	90–93–94	warm
	HST	70	156 x 37	E27	5300–6000	76–86	warm
	HST-MF	100	211 x 46	E40	8800–10700	88–107	warm
	HST	100	211 x 48	E40	9000–9600	90–96	warm
	HST	150	211 x 46	E40	14500–15300	97–102	warm
	HST-CRI	150	211 x 47	E40	13000	87	warm
	HST-MF	150	211 x 46	E40	15000–18000	100–120	warm
	HST-CRI	250	257 x 47	E40	23000	92	warm
	HST-MF	250	257 x 46	E40	28000–33300	112–133	warm
	HST	250	257 x 46	E40	27000–29000	108–116	warm
	HST-CRI	400	283 x 47	E40	37000–38000	93–95	warm
	HST-MF*	400	285 x 46	E40	53000–55500–56500	133–139–141	warm
	HST	400	285 x 46	E40	48000–50000	120–125	warm
	HST-MF	600	285 x 52	E40	85000–90000	142–150	warm
	HST	1000	355–400 x 65	E40	130000	130	warm

* Core type ** (without control gear)

Colour temperatures [K]	Colour Rendering Index CRI/R_a	OSRAM	PHILIPS	SYLVANIA	GE
		VIALOX	**MASTER**		
2500	80...89	–	SDW-TG Mini 100 W	–	–
2550	83	–	SDW-T 100 W	–	–
2500	80...89	–	SDW-TG Mini 50 W	–	–
2500	83	–	SDW-T 50 W	–	–
1900, 1950, 2000	< 40	NAV-T 50 SUPER 4Y	SON-T PIA Plus/APIA Plus Xtra 50 W	–	LU50/85/HO/T27
2000, 2050	< 40	NAV-T 50	–	SHP-TS 50 W CL/E (Twinarc)	LU50/90/(SBY/)T/27
1900, 1950, 2000, 2100	< 40	NAV-T 70 SUPER 4Y	SON-T PIA Plus/APIA Plus Xtra 70 W	–	LU70/90/HO/T27
2000, 2050	< 40	NAV-T 70 (4Y)	–	SHP-TS 70 W CL/E (Hg-free/Twinarc)	LU70/90/(SBY/)T12/27
1950, 2000, 2050, 2100	< 40	NAV-T 100 SUPER 4Y	SON-T PIA Plus/APIA Plus Xtra 100 W	SHP-TS 100 W E40 (Hg-free/Twinarc)	LU100/100/HO/T/40
2000	< 40	NAV-T 100	–	–	LU100/100/(SBY/)T/40
1900, 2000, 2050	< 40	NAV-T 150 (4Y)	–	SHP-T 150 W E40	LU150/100/(SBY/T/)40
2150, 2200	60...69	–	SON-T COMFORT 150 W/621	–	LU150/CL-DL/T/40
1950, 2000, 2050, 2100, 2150	< 40	NAV-T 150 SUPER 4Y	SON-T PIA 150 W Hg free SON-T PIA Plus/APIA Plus Xtra 150 W	SHP-TS 150 W E40 (Hg-free/Twinarc)	LU150/150/HO/T/40
2150, 2200	60...69	–	SON-T COMFORT 250 W/621	–	LU250/CL-DL/T/40
1950, 2000, 2050, 2100, 2150	< 40	NAV-T 250 SUPER 4Y	SON-T PIA 250 W Hg free SON-T PIA Plus/APIA Plus Xtra 250 W	SHP-TS 250 W E40 (Hg-free/Twinarc)	LU250/CL-DL/T/40
1950, 2000, 2050, 2100	< 40	NAV-T 250 (4Y)	–	SHP-T 250 W E40	LU250/(SBY/)T/40
2150, 2200	60...69	–	SON-T COMFORT 400 W/621	–	LU400/CL-DL/T/40
1950, 2000, 2050, 2100	< 40	NAV-T 400 SUPER 4Y	SON-T PIA Plus/APIA Plus Xtra 400 W	SHP-TS 400 W E40 (Hg-free/Twinarc)	LU400/HO/T/40
1950, 2000, 2050	< 40	NAV-T 400 (4Y)	SON-T PIA 400 W Hg free	SHP-T 400 W E40	LU400/(SBY/)T/40
1950, 2000, 2050, 2100	< 40	NAV-T 600 SUPER 4Y	SON-T PIA Plus 600 W	SHP-TS 600 W E40	LU600/HO/T/40
2000, 2050	< 40	NAV-T 1000	SON-T 1000 W	SHP-T 1000 W E40	LU1000/110/T/40

*** warm: up to 3300 K   intermediate: 3300 to 5300 K   cool: above 5300 K

	Designation (ZVEI/LBS)	Wattage [W]	Max. dimensions [mm]	Cap	Luminous flux levels [lm]	Luminous effic.** [lm/W]	Light col.***
High-pressure sodium discharge lamps			**Length/ contact gap**				
	HST-DE-MF	70	114.2	RX7s	6600	94	warm
	HST-DE-MF	150	132	RX7s-24	15000	100	warm
	HST-DE*	250	206	Fc2	28000	112	warm
	HST-DE	250	191	RX7s ?	23000	92	warm
	HST-DE*	400	206	Fc2	49000	123	warm
	HST-DE	400	256	RX7s ?	43000	108	warm
	HST-DE	1000	334	RX7s ?	137000	137	warm
			Length x Ø				
	HSE	35	165 x 72	E27	1800	51	warm
	HSE	50	156x70–165x72	E27	3400–3600	68–72	warm
	HSE	50	156x70–165x72	E27	3300–4000	66–80	warm
	HSE	70	156x70–165x72	E27	5000–5900	71–84	warm
	HSE	70	152x70–165x72	E27	5600–6300	80–90	warm
	HSE	100	184 x 76	E27	9500	95	warm
	HSE-MF	100	186 x 75	E40	8000–10400	80–104	warm
	HSE	100	186 x 76	E40	8500–9200	85–92	warm
	HSE-CRI	150	227 x 91	E40	12000–12500	80–83	warm
	HSE-MF	150	226 x 90	E40	14500–17500	97–117	warm
	HSE	150	226 x 90	E40	14000–15000	93–100	warm
	HSE-CRI	250	226 x 91	E40	22000	88	warm
	HSE-MF*	250	226 x 90	E40	27000–32000	108–128	warm
	HSE	250	226 x 90	E40	25000–28800	100–115	warm
	HSE-CRI	400	290 x 122	E40	36000–37000	90–93	warm

* Core type ** (without control gear)

Colour temperatures [K]	Colour Rendering Index CRI/R_a	OSRAM	PHILIPS	SYLVANIA	GE
		VIALOX	**MASTER**		
2000	< 40	NAV-TS 70 SUPER 4Y	–	–	–
2000	< 40	NAV-TS 150 SUPER 4Y	–	–	–
2000	< 40	NAV-TS 250	–	–	–
2000	< 40	–	–	–	LU250/TD
2000	< 40	NAV-TS 400	–	–	–
2000	< 40	–	–	–	LU400/TD
2000	< 40	–	–	–	LU1000/TD
2050	< 40	–	–	SHP-S 35 W/E27	–
1900, 2000, 2050	< 40	NAV-E 50(/E) 4Y	SON 50 W	SHP-S 50 W/E27 (Twinarc)	–
1950, 2000, 2050	< 40	NAV-E 50 SUPER 4Y	SON PIA 50 W, SON PIA Plus/ APIA Plus Xtra 50 W	SHP 50 W/CO/E/E27	LU50/90/(SBY/)D/27
1900, 2000, 2050	< 40	NAV-E 70(/E) 4Y	SON 70 W	SHP-S 70 W/E27 (Hg-free/Twinarc)	–
1950, 2000, 2050	< 40	NAV-E 70 SUPER 4Y	SON PIA 70 W, SON PIA Plus/ APIA Plus Xtra 70 W	SHP 70 W/CO/E/E27	LU70/90/(SBY/)D/27
2050	< 40	–	–	SHP-S 100W/E27	–
1950, 2000, 2050	< 40	NAV-E 100 SUPER 4Y	SON PIA Plus/ APIA Plus Xtra 100 W	SHP-S 100 W/E40 (Hg-free/Twinarc)	LU100/100/HO/D/40
2050	< 40	NAV-E 100	–	–	LU100/100/(SBY/)D/40
2150, 2200	60...69	–	SON COMFORT 150 W/621	–	LU150/CL-DL/D/40
1950, 2000, 2050	< 40	NAV-E 150 SUPER 4Y	SON PIA 150 W Hg free, SON PIA Plus/ APIA Plus Xtra 150 W	SHP-S 150 W/E40 (Hg-free/Twinarc)	LU150/100/HO/D/40
1900, 2000, 2050	< 40	NAV-E 150 (4Y)	–	SHP 150 W/E40	LU150/100/(SBY/)D/40
2150, 2200	60...69	–	SON COMFORT 250 W/621	–	LU250/CL-DL/D/40
1950, 2000, 2050	< 40	NAV-E 250 SUPER 4Y	SON PIA 250 W Hg free, SON PIA Plus/ APIA Plus Xtra 250 W	SHP-S 250 W/E40 (Hg-free/Twinarc)	LU250/HO/D/40
1950, 2000, 2050	< 40	NAV-E 250 (4Y)	–	SHP 250 W/E40	LU250/(SBY/)D/40
2150, 2200	60...69	–	SON COMFORT 400 W/621	–	LU400/CL-DL/D/40

*** warm: up to 3300 K intermediate: 3300 to 5300 K cool: above 5300 K

	Designation (ZVEI/LBS)	Wattage [W]	Max. dimensions [mm]	Cap	Luminous flux levels [lm]	Luminous effic.** [lm/W]	Light col.***
High-pressure sodium discharge lamps			**Length x Ø**				
	HSE-MF*	400	290 x 120	E40	48000–56500	120–141	warm
	HSE	400	290 x 120	E40	47000–48000	118–125	warm
	HSE	1000	400 x 165	E40	120000–130000	120–130	warm

* Core type ** (without control gear)

Colour temperatures [K]	Colour Rendering Index CRI/R_a	OSRAM	PHILIPS	SYLVANIA	GE
		VIALOX	MASTER		
1950, 2000, 2050, 2100	< 40	NAV-E 400 SUPER 4Y	SON PIA 400 W Hg free, SON PIA Plus/ APIA Plus Xtra 400 W	SHP-S 400 W/E40 (Hg-free/Twinarc)	LU400/HO/D/40
2000, 2050	< 40	NAV-E 400 (4Y)	–	SHP 400 W/E40	LU400/(SBY/)D/40
2000, 2100	< 40	NAV-E 1000	SON 1000 W	–	LU1000/D/40

*** warm: up to 3300 K   intermediate: 3300 to 5300 K   cool: above 5300 K

Chapter 6

Lighting control and control gear

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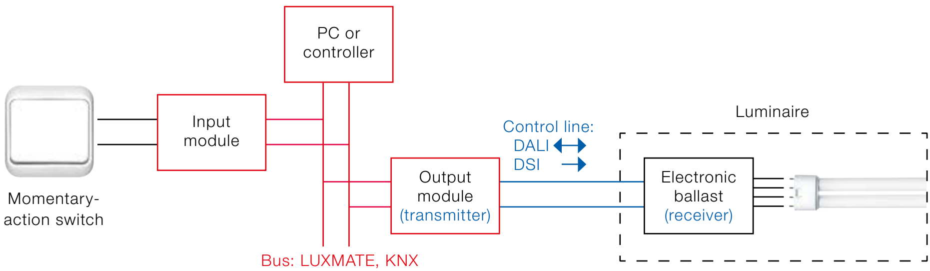
Terminology and circuit diagram

- A **bus** is a system for transferring data between **several** participants via a joint transmission path.
- In electronic engineering, a **control line** is a connection (cable, wire) between **one** transmitter and one receiver. Via this connection the receiver is switched to a different operating mode. Communication is either **bidirectional** (DALI) or just **unidirectional** (DSI).
- A **communication protocol** is an agreement according to which data transfer between two or more participants is carried out. In its most simple form, a protocol can be defined as the rules determining the structure, meaning and synchronisation of communication.



DALI: General information

– The term DALI stands for “Digital Addressable Lighting Interface”.
– DALI is not a building management bus system, but a protocol **for digital addressing of technical lighting control gear.**
– DALI is a standard defined by several manufacturers of luminaires and electronic ballasts: IEC 60929 allows the combination of devices of various manufacturers. However, the standard defines only output devices (control gear), not input devices such as sensors or control units. Hence, input devices with DALI connection are addressed in a manufacturer-specific way!
– IEC 62386 specifies requirements placed on control gear allocated to specific types of device.

DALI: Features

– Usable data transmission rate: 1200 bit/s
– Max. **64 control units** per control circuit
– Max. **16 groups** per control gear can be assigned
– Max. **16 scenes** per control unit can be programmed
– Bidirectional: reports information such as faulty lamps, dimming levels etc.
– Max. **system current of 250 mA** from central interface supply (each electronic ballast takes up a maximum of 2 mA of current load)
– Two-wire control line (potential-free, polarity-free, unshielded, no terminal resistors)
– Voltage drop between transmitter and receiver **must not be more than 2 V**
– Application: general lighting (small number of lighting points, static light)

DALI: Device type

IEC subcommittee SC 34C is in charge of the IEC 62386 “Digital addressable lighting interface” series of standards.

IEC 62386-1xx	**Parts 1xx: General requirements**
IEC 62386-101:2009-06	Part 101: System
IEC 62386-102:2009-06	Part 102: Control devices
IEC 62386-2xx	**Parts 2xx: Particular requirements for control gear**
IEC 62386-201:2009-06	Part 201: Fluorescent lamps (device type 0)
IEC 62386-202:2009-06	Part 202: Emergency lighting with separate battery (device type 1)
IEC 62386-203:2009-06	Part 203: Discharge lamps (except fluorescent lamps) (device type 2)
IEC 62386-204:2009-06	Part 204: LV halogen lamps (device type 3)
IEC 62386-205:2009-06	Part 205: Supply voltage controllers for incandescent lamps (device type 4)
IEC 62386-206:2009-06	Part 206: Conversion from digital signal into D. C. voltage (device type 5)
IEC 62386-207:2009-06	Part 207: Particular requirements for control gear – LED modules (device type 6)
IEC 62386-208:2009-06	Part 208: Switching function (device type 7)
IEC 62386-209:2011-06	Part 209: Colour/colour temperature control (device type 8)
IEC 62386-210:2011-04	Part 210: Sequencer (device type 9)

DSI: General information

- The term DSI stands for “Digital Serial Interface”.
- DSI is not a building management bus system, but a protocol **for digital addressing of technical lighting control gear.**
- DSI is a manufacturer-specific interface defined by Zumtobel.
- DSI is the predecessor of DALI with the main goal of replacing analogue addressing (1–10 V) of control gear with digital addressing.
- Devices with DSI and DALI connection are not compatible and cannot be used jointly in one control circuit.

DSI: Features

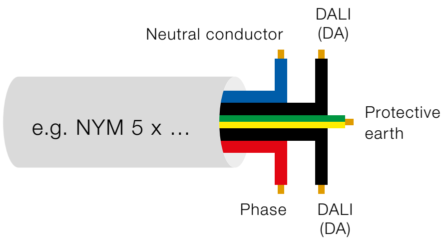
- Usable data transmission rate: 1200 bit/s
- Depending on the output module: **10 to 100 control units** per control circuit
- Max. **20 scenes** per control unit can be programmed
- Unidirectional: reports only faulty lamps (depending on the technical design of the electronic ballast)
- Two-wire control line (potential-free, polarity-free, unshielded, no terminal resistors)
- Application: general lighting (small number of lighting points, static light)

Differences between DALI and DSI

- Each DALI control unit may have different intensity levels, while all DSI (and 1–10 V) control units always have the same intensity level.
- With DSI, units are allocated to groups by wiring; with DALI, group allocation is performed via software.
- With DSI (and 1–10 V), only a unidirectional flow of information (from the controller to the controlled unit) is possible.
- DSI and DALI units cannot be operated jointly in one control circuit.

DALI and DSI: Control line

– Any type of insulated line for mains voltage is admissible if the voltage drop is not more than 2 V at 250 mA.
– DALI components are usually powered via a separate mains power supply.
– The insulation of the digital interface complies with basic insulation requirements; verification is effected in accordance with the IEC 60 928 standard. Thus, SELV (Safety Extra Low Voltage) is not guaranteed.
– The cables connecting the digital interface with the mains power supply lines (e.g. 230 V) may be relocated if the insulation conditions (2 x basic insulation) are maintained. The two "free" wires of a 5 x 1.5 mm² NYM cable are frequently used as control lines (together with the other wires for phase, neutral and protective ground conductors).



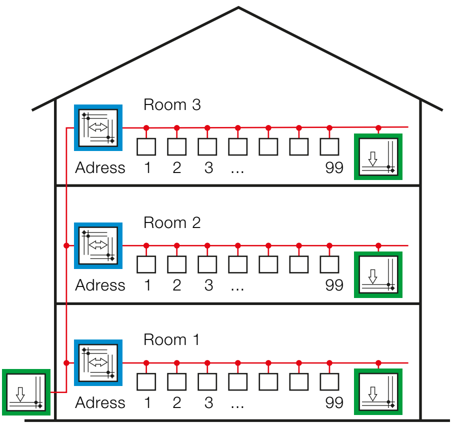
Cross-section	Length
2 x 0.50 mm²	116 m
2 x 0.75 mm²	174 m
2 x 1.00 mm²	232 m
2 x 1.50 mm²	300 m

LUXMATE bus: General information

- Proprietary bus developed by Zumtobel, so that a combination of devices by different manufacturers is **not** possible
- **Bus domain**, the smallest logical unit
  - Max. **99 rooms**
  - Max. **99 addresses** per room
  - Max. **99 groups** per room
  - Max. **500 devices** connected to bus coupler (max. 100 devices per bus power supply)

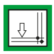
LUXMATE bus: Features

- Usable data transmission rate: 2400 bit/s
- Max. **20 scenes** per control unit can be programmed
- Bidirectional: reports information
- Two-wire control line (potential-free, polarity-free, unshielded, no terminal resistors)
- **Loop resistance** for entire line within one bus domain must not exceed **11 ohms**
- Total length of line: max. **1000 m** (with 2 x 1.5 mm²)
- Dimming range 1 to 100 %
- Application: general lighting (large number of lighting points, static light)



LUXMATE bus:
Bus domain and bus power supply

- **Bus domain**
  - Smallest logical unit
  - Max. 99 rooms
  - Max. 99 addresses per room
  - Max. 500 devices connected with bus coupler
- **Bus power supply**
  - LM-BV: maximum of 100 modules
  - LM-BVS35: maximum of 35 modules

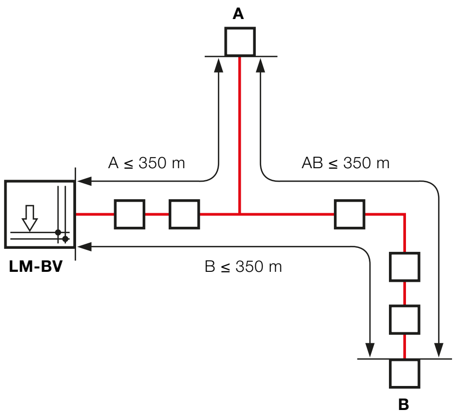

LM-BV (LM-BVS35) bus power supply


LM-BK bus coupler

LUXMATE bus: Bus line and cable lengths

Bus line
- Twisted two-core line (1 lay each 5 metres) for low-voltage installation

Cable lengths
- Overall length for one bus power supply: max. 1000 m
- Between LUXMATE devices (AB):
  - Max. 350 m with 2 x 0.75 mm²
  - Max. 500 m with 2 x 1.5 mm²
- From bus power supply to the most distant LUXMATE device (A,B):
  - Max. 350 m with 2 x 0.75 mm²
  - Max. 500 m with 2 x 1.5 mm²



Cable length test report
LUXMATE PROFESSIONAL

Voltage measurement (VOLT): measurement between B1 and B2 – D. C. voltage

Current measurement (AMPERE): measurement at B1 or B2 – measured value must not exceed 150 mA

Loop resistance (OHM): 1) disconnect LM-BV from power, 2) establish wire bridge at LM-BV between B1 and B2, 3) perform measurement at the last actuator of the bus line between B1 and B2.

The loop resistance measured must not exceed 11 ohms!

If a loop resistance between 14 and 16 ohms is measured, the service report must indicate that the bus line is too long; electrician must be informed!

If the loop resistance measured is 16 ohms or higher, commissioning will be terminated!

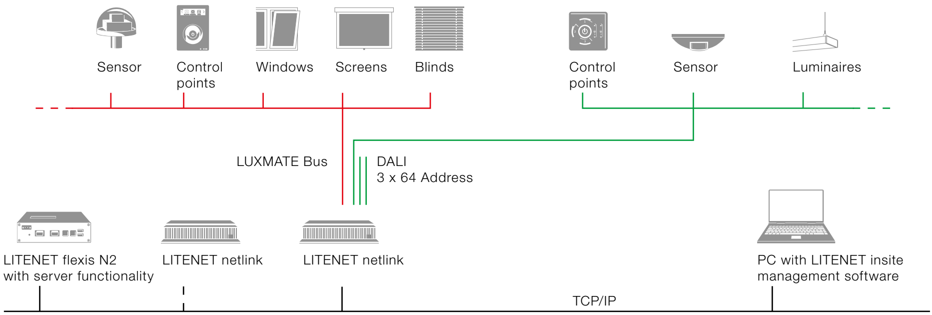
The cable length is calculated as follows:
Cable length = loop resistance x rho x cross-section/ divided by two
L = R x rho x A / : 2
A = cross-section/rho = 56 for copper

LUXMATE guidelines:
1.5 mm² cross-section = max. bus line of 500 m
1.0 mm² cross-section = max. bus line of 300 m/ with 2 x 2 x 0.8 cable, both pairs must be connected
0.75 mm² cross-section = max. bus line of 250 m
0.5 mm² cross-section = max. bus line of 150 m

- **Loop resistance** in a bus circuit must not exceed **11 ohms** (applies to all components of the bus power supply).
- Bus and mains in one cable (5 x 1.5 mm²) are admissible only for 5 m stub lengths each.
- For tracks/trunking: bus lines should be cross-linked at least every 7 m.

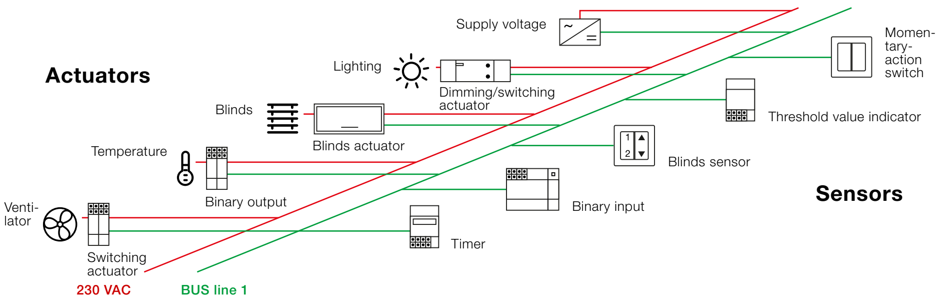
Cross-section	Length
2 x 0.50 mm²	150 m
2 x 0.75 mm²	250 m
2 x 1.00 mm²	300 m
2 x 1.50 mm²	500 m

Comparison: LUXMATE bus – KNX (EIB)



LUXMATE

- Standard cables are used for installation
- Protected against reversed polarity!
- General operation immediately after installation (installation test)
- Easy addressing from each location within the building



KNX

- A specially shielded EIB cable must be used for installation
- Not protected against reversed polarity (+/–)
- No operation possible without addressing (no installation test)
- Addressing only directly on the luminaire and via control points using special ETS software

DMX: General information

DMX was developed in the United States for stage equipment in 1986. Previously, the slider settings for spotlights were converted to analogue voltage levels between 1 and 10 V. Subsequently these voltages were transmitted in parallel to the dimmers via one control line for each spotlight.

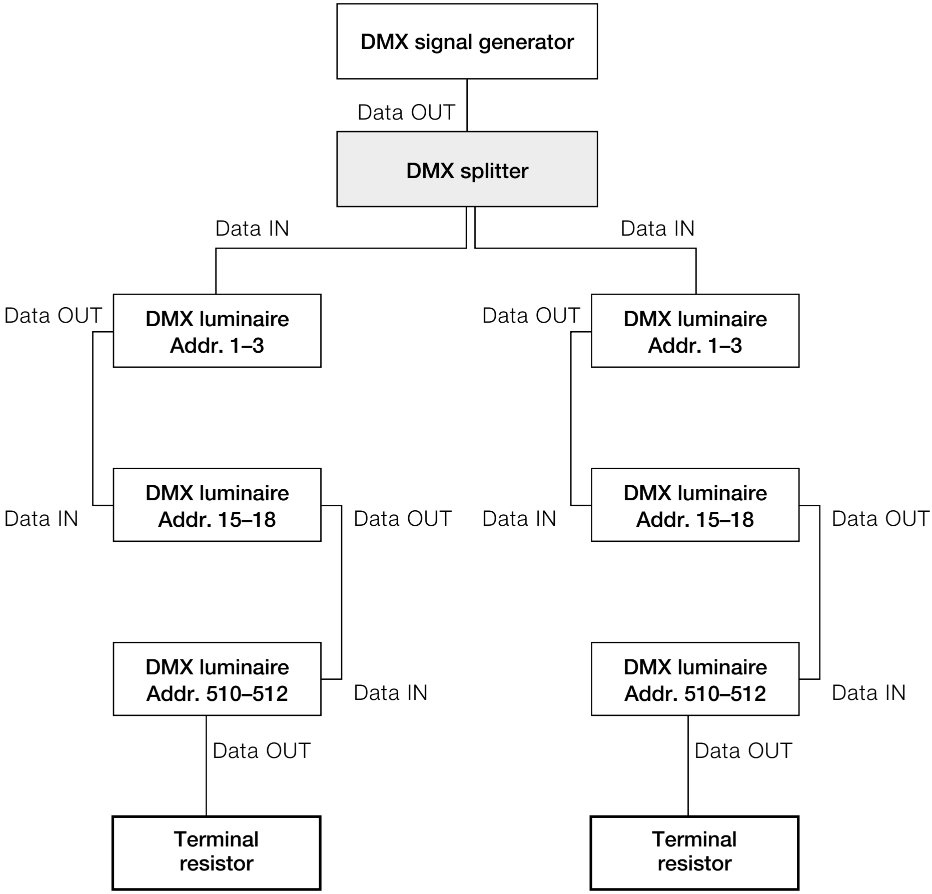
This analogue dimming worked well with a small number of spotlights. However, stages and shows became bigger and bigger. The cabling included a large number of parallel 1–10 V control lines became too complex and inflexible.

DMX was developed, with the slider positions being converted into digital values. ALL dimming levels are then transmitted one after the other via ONE joint control line.

DMX: Features

- Usable data transmission rate: 250 000 bit/s
- Refresh rate: 30 times per second
- Max. 512 channels (addresses) per universe (control circuit)
- Max. of 32 luminaires directly one after the other; for more luminaires, a splitter is required
- Unidirectional: no information is reported
- Two-wire control line (shielded, terminal resistance)
- Application: illumination of façades (large number of lighting points, dynamic light)

DMX: System design

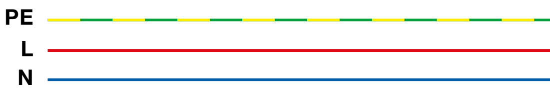


max. 32 receivers in case of standard DMX connection

LUXMATE: Simple dimming

switchDIM
Dimming for individual or multiple luminaires

CIRCLE KIT
Lighting scenes for luminaire groups



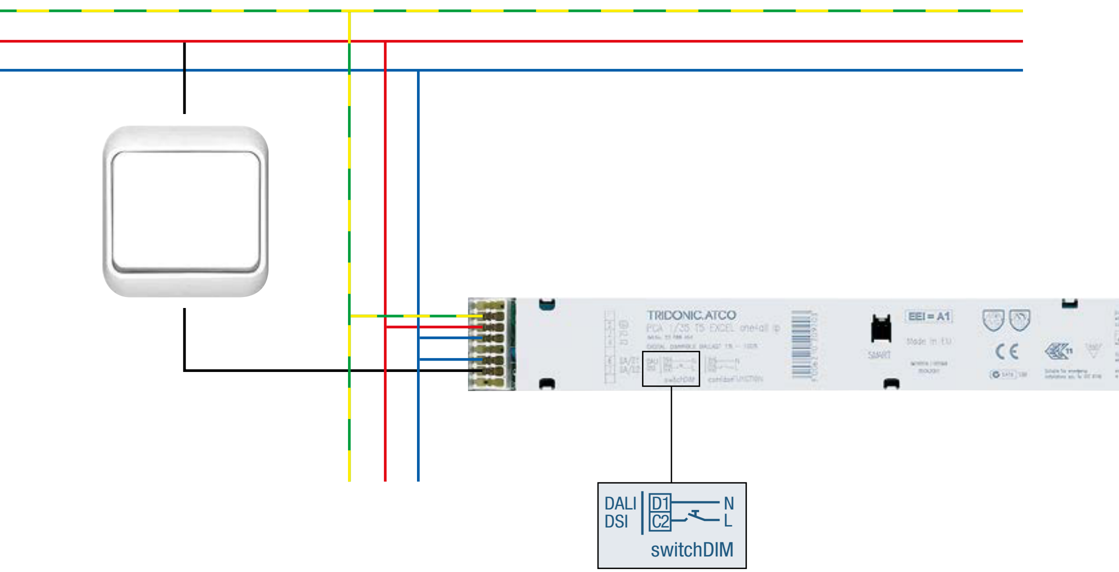
switchDIM: General information

Benefits

- Easiest way of dimming an **individual luminaire** or a small group of **luminaires**
- Only a conventional **momentary-action switch** is required
- No addressing necessary

Features

- Function:
  - Switching by pressing the button briefly
  - Dimming by pressing the button longer
- Asynchronous dimming: switching time (approx. 0.2 seconds) depends on the timer in the control unit. Due to component tolerances, there is no exact switching point for several luminaires within a group. Asynchronicity may occur.
- Recommendation: use switchDIM for no more than 2 luminaires. If more luminaires are involved, a controller such as DIMLITE single is feasible.
- Works only with a momentary-action switch, not with a regular switch!



Wiring of electronic ballast with switchDIM function.

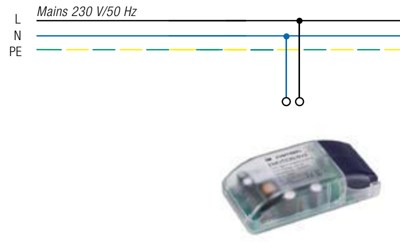
CIRCLE KIT and CIRCLEtune KIT: General information

Benefits
– CIRCLE KIT: easiest way of applying **lighting scenes**
– CIRCLEtune KIT: easiest way of using **colour temperature control**
– Commissioning and operation via CIRCLE CSx control point
– Several CIRCLE control points can be connected in parallel
– Bus power supply already included in the package

Features
– 3 lighting scenes can be individually programmed
– Dimming of 2 luminaire groups
– Bus power supply for up to 64 DALI-dimmable luminaires
– One CIRCLE control point covers 3 DALI loads
– Control point available in white and silver

CIRCLE KIT: Wiring scheme

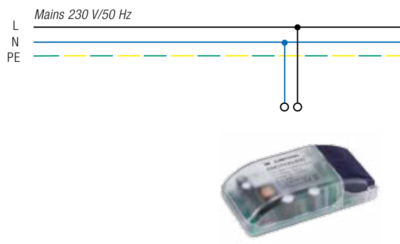
Control devices



EMOTION BV2
bus power supply

CIRCLEtune KIT: Wiring scheme

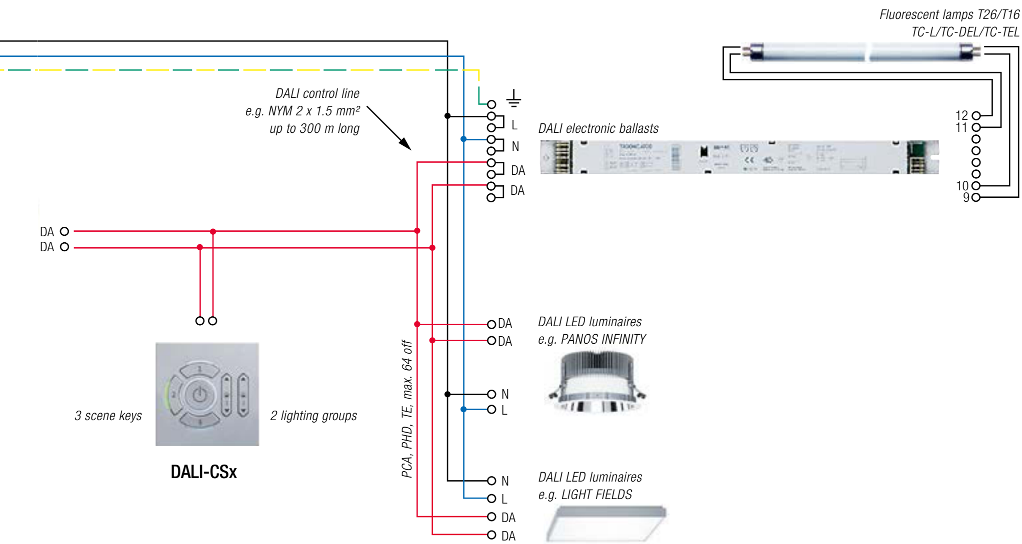
Control devices



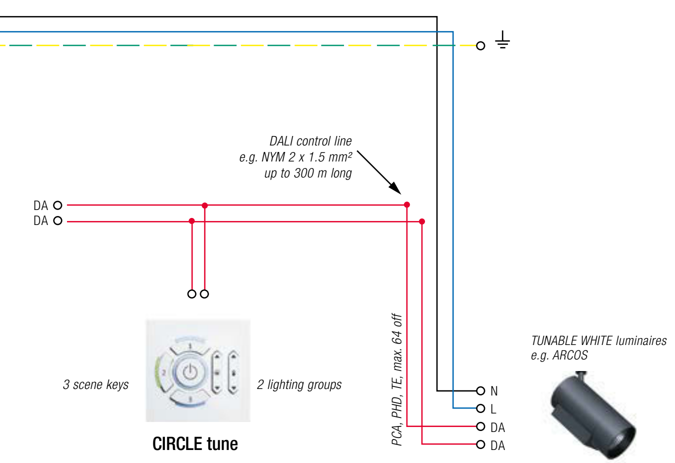
EMOTION BV2
bus power supply

L phase
N neutral
PE protective earth
D control line
⏚ earth
≈ AC voltage

Control units | Lamp control gear | Lamps

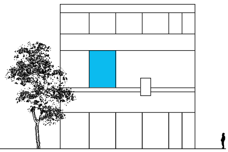


Control units | Lamp control gear/Lamps

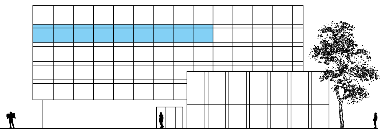


LUXMATE: Overview of lighting control systems

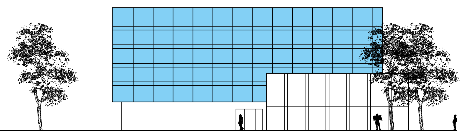
LUXMATE DIMLITE
Lighting management for individual rooms



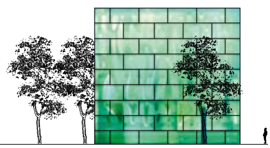
LUXMATE EMOTION
Lighting management for several rooms



LUXMATE LITENET / PROFESSIONAL
Lighting management for buildings
with lighting and blinds control



DMX lighting management
Dynamic lighting scenarios for outer façades



LUXMATE DIMLITE: General information

Benefits
- Synchronous dimming
- AUTO detect: DALI and DSI outputs with automatic identification (mixed operation not admissible)
- AUTO setup: automatic initialisation, no addressing necessary
- Reduction of stand-by losses: automatic power disconnection of lighting actuators via integrated relay
- Operation using all conventional 230 V momentary-action light switches; several momentary-action switches can be connected in parallel

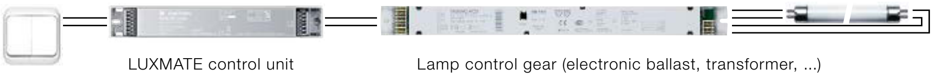
Features
- 2 models: for installation in switch cabinet for 2 or 4 luminaire groups, and for installation in luminaire or recessed into ceiling for 2 or 4 luminaire groups, including strain relief
- Up to 3 lighting scenes, of which scene 1 features daylight-based control (depending on additional devices)
- Modular range of functions, to be individually combined:
  - daylight-based control
  - presence detector (ONLY OFF, ON/OFF, CORRIDOR with 10 % dimming level)
  - IR remote control
  - CIRCLE comfort control point (2 groups, 3 scenes)
  - scene or group module

LUXMATE DIMLITE: Overview

	Size of system			Functions			Components to be integrated			
DIMLITE basic module	Number of groups	Number of DALI/dim²save luminaires	Number of DSI/dim²save luminaires	Dimming	Lighting scene	Control by momentary-action switch	Presence detector	Daylight-based control	Convenience control point	Remote control
DIMLITE single*	1	25	25	•	•	•	•			
DIMLITE daylight*	2	50	50	•	•	•	•	•		
DIMLITE multifunction 2ch**	2	50	100	•	•	•	•	•	•	•
DIMLITE multifunction 4ch**	4	100	200	•	•	•	•	•	•	•

* for installation in luminaire or recessed into ceiling
** for installation in switch cabinet (DIN rail mounted device)

LUXMATE DIMLITE: Selection according to control gear and functionality



LUXMATE control unit   Lamp control gear (electronic ballast, transformer, ...)

1. Select appropriate lamp control gear

Lamps	Dimming range	All control gear with DALI/DSI control input
GLS lamps	0–100 %	Phase dimmer: 500–1000–5000 VA
PAR lamps	0–100 %	Phase dimmer: 500–1000–5000 VA
HV halogen incandescent lamps	0–100 %	Phase dimmer: 500–1000–5000 VA
LV halogen incandescent lamps	0–100 %	electronic dimmable transformer: 105 VA + 150 VA
Fluorescent lamps	1–100 %	electronic dimmable ballast
LED	0–100 %	electronic dimmable LED converter 1 ch./3 ch.

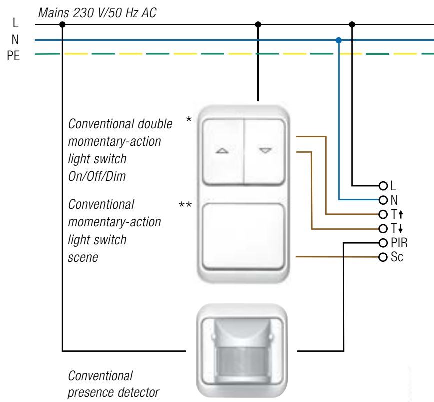
2. Select control function required

Function	Control	Module name for DSI/DALI/dim²save
1-channel dimming, lighting scene, presence	momentary-action switch, presence detector	DIMLITE single
2-channel dimming, daylight, presence	momentary-action switch, presence detector, light sensor	DIMLITE daylight
2- or 4-channel multifunction	momentary-action switch, Circle, light sensor, presence detector, IR remote control unit	DIMLITE 4ch* (4-channel)

All modules available for installation in luminaire or recess into ceiling
* only available as housing for installation in switch cabinet

LUXMATE DIMLITE basic wiring:
Dimming via momentary-action switch using

Control units



* Saving the pre-set lighting level

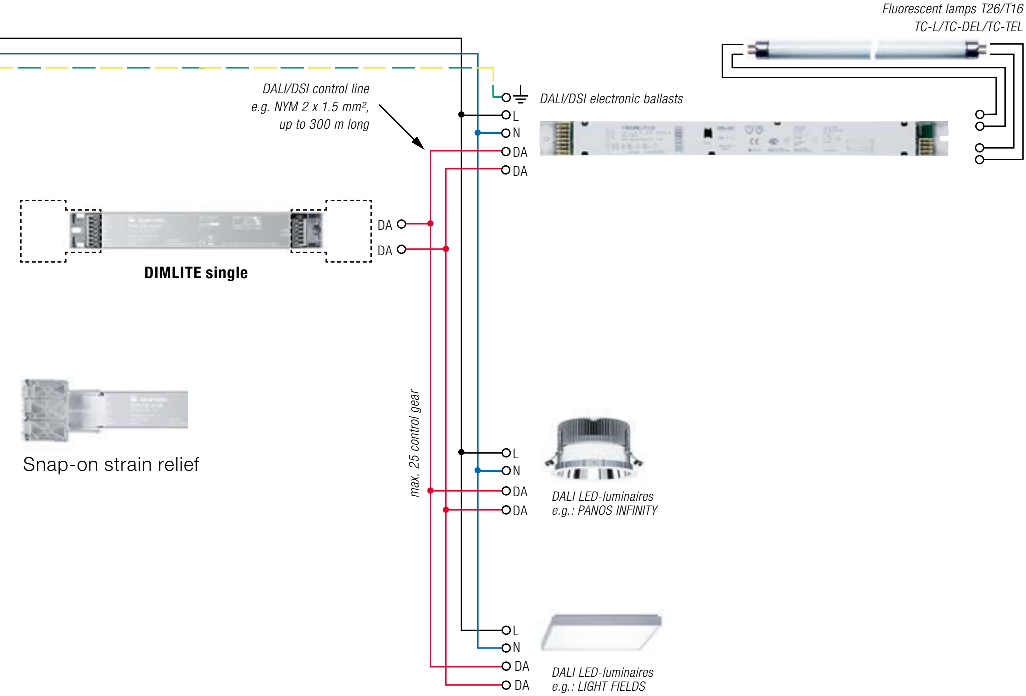
** Alternative:
When using a single momentary-action switch, fit jumper on terminal “T↑” und “T↓”

L	phase
N	neutral
PE	protective earth
T	momentary-action switch input
D	control line
⏚	earth
≈	AC voltage

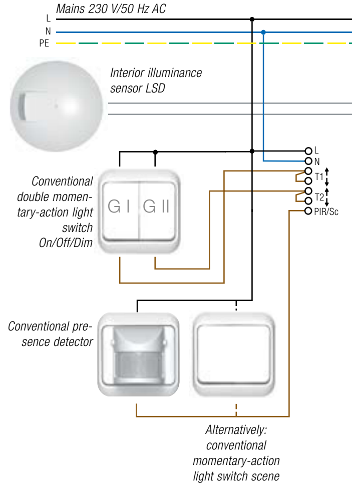
Control devices

Lamp control gear

Lamps



LUXMATE DIMLITE basic wiring: Daylight-based dimming using



L phase

N neutral

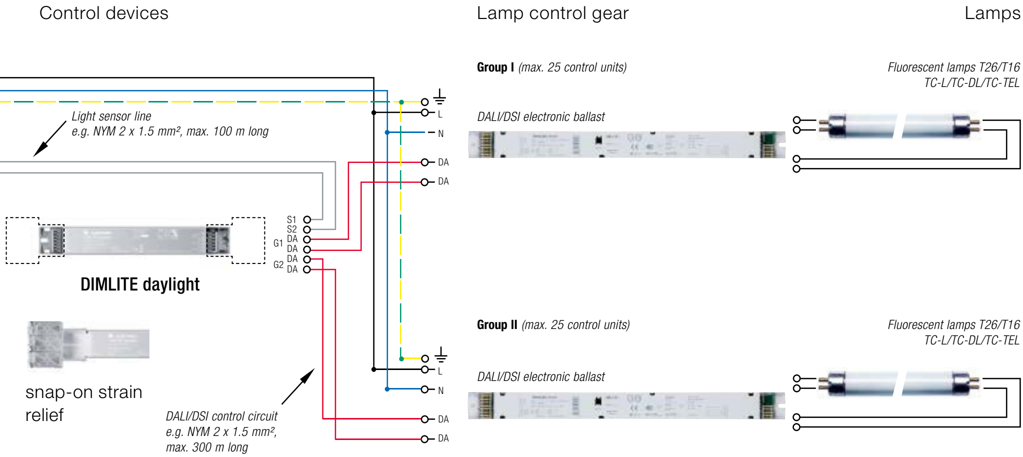
PE protective earth

T momentary-action switch input

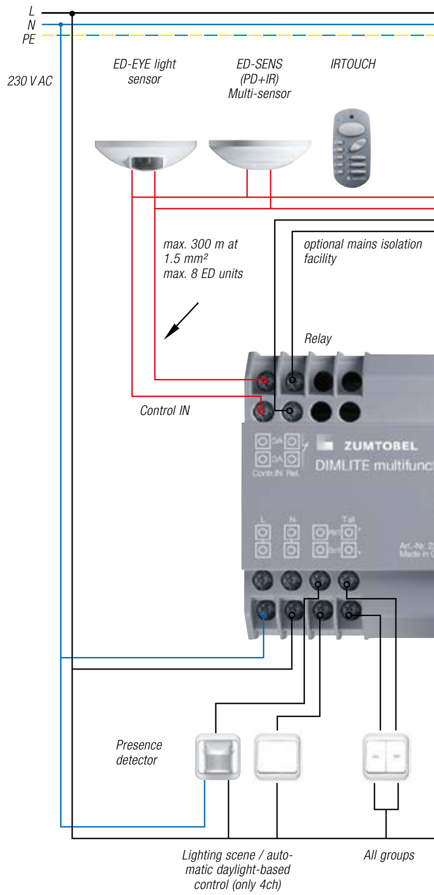
D control line

⏚ earth

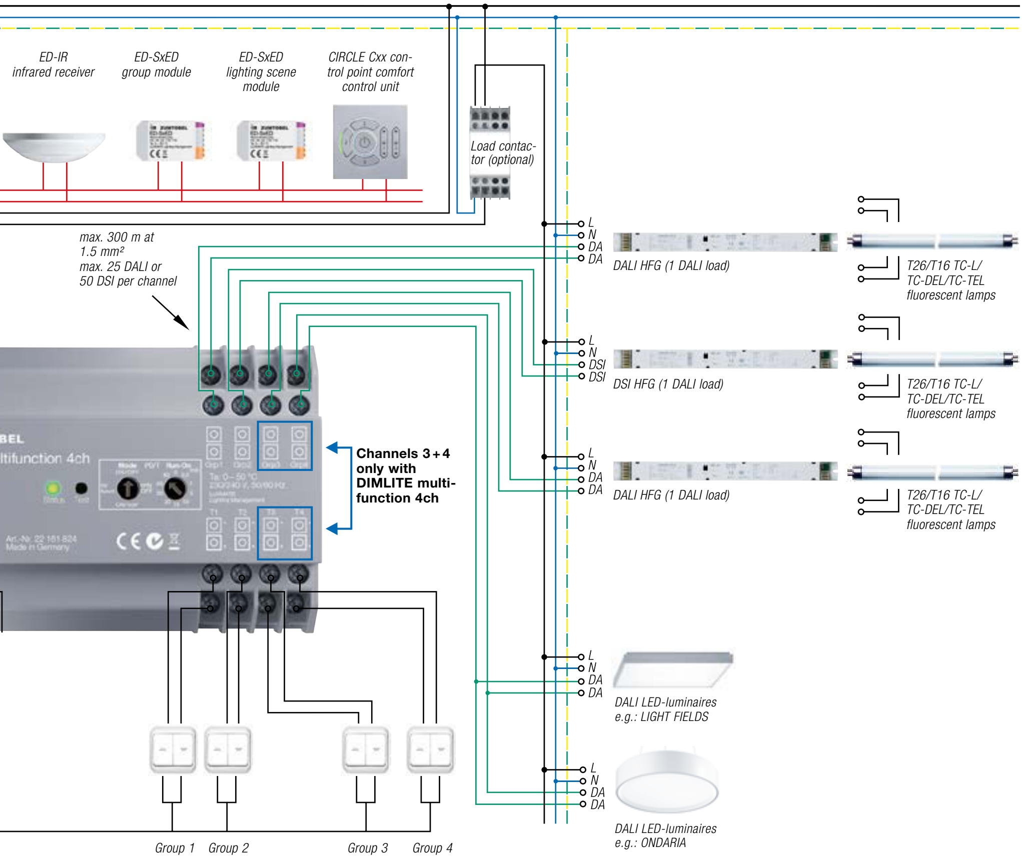
≈ AC voltage


Control devices
Lamp control gear
Lamps
Group I (max. 25 control units)
Fluorescent lamps T26/T16
TC-L/TC-DL/TC-TEL
Light sensor line
e.g. NYM 2 x 1.5 mm², max. 100 m long
L
N
DA
DA
DALI/DSI electronic ballast
S1
S2
G1
DA
DA
G2
DA
DA
DIMLITE daylight
snap-on strain relief
Group II (max. 25 control units)
Fluorescent lamps T26/T16
TC-L/TC-DL/TC-TEL
DALI/DSI electronic ballast
L
N
DA
DA
DALI/DSI control circuit
e.g. NYM 2 x 1.5 mm²,
max. 300 m long

LUXMATE DIMLITE basic wiring: Multifunctional lighting control



L phase
N neutral
PE protective earth
D control line


ED-IR
infrared receiver
ED-SxED
group module
ED-SxED
lighting scene
module
CIRCLE Cxx con-
trol point comfort
control unit
Load contac-
tor (optional)
max. 300 m at
1.5 mm²
max. 25 DALI or
50 DSI per channel
Channels 3+4
only with
DIMLITE multi-
function 4ch
L
N
DA
DA
DALI HFG (1 DALI load)
T26/T16 TC-L/
TC-DEL/TC-TEL
fluorescent lamps
L
N
DSI
DSI
DSI HFG (1 DALI load)
T26/T16 TC-L/
TC-DEL/TC-TEL
fluorescent lamps
L
N
DA
DA
DALI HFG (1 DALI load)
T26/T16 TC-L/
TC-DEL/TC-TEL
fluorescent lamps
L
N
DA
DA
DALI LED-luminaires
e.g.: LIGHT FIELDS
L
N
DA
DA
DALI LED-luminaires
e.g.: ONDARIA
Group 1
Group 2
Group 3
Group 4

LUXMATE EMOTION: General information

Benefits

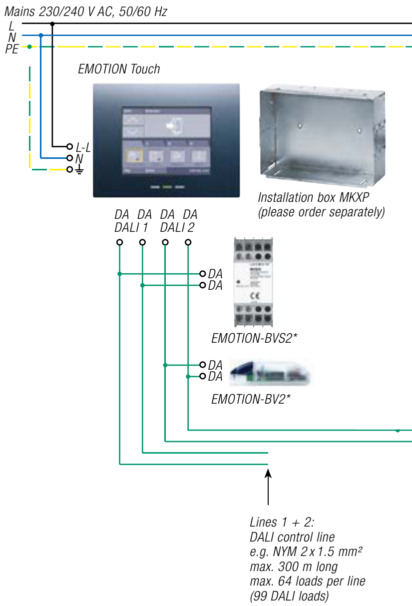
– All in one: operation, control, commissioning
– Lighting scenes can be static (scene) or dynamic (show)
– Extremely easy integration of special luminaires: colour luminaires (RGB), colour temperature, Balanced Light (direct/indirect)
– Extremely low programming effort: large number of preprogrammed technical lighting functions where only parameters must be entered
– Extensive energy-saving options: daylight, presence, automated timing

Features

– Max. 16 rooms
– Max. 32 groups per room
– Max. 16 scenes per room
– max. 128 luminaires (2 DALI control circuits with max. 64 actuators)
– max. 100 DALI loads (1 DALI load = 2 mA) per DALI control circuit

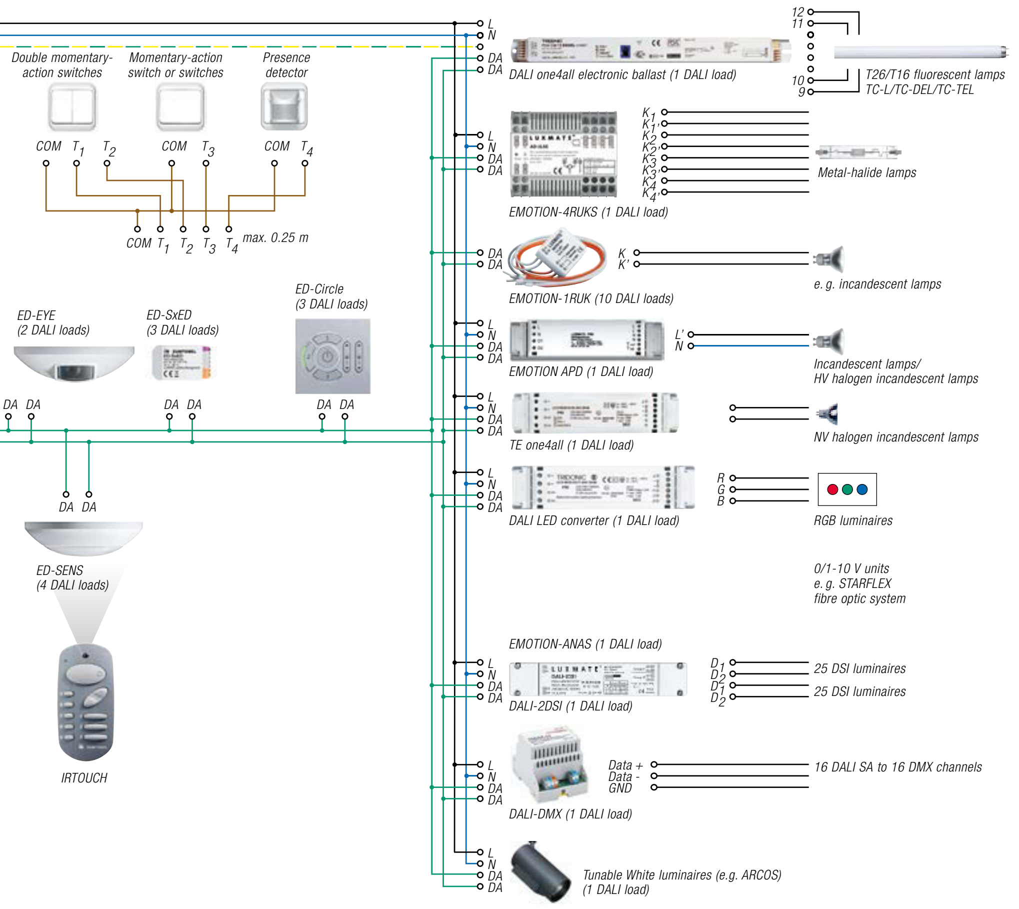
Wiring overview

Operation/Power Supply



L phase
N neutral
PE protective earth
T momentary-action switch input
D control line
⏚ earth

Lighting


L
N
DA
DA
Double momentary-action switches
Momentary-action switch or switches
Presence detector
COM T1 T2
COM T3
COM T4
COM T1 T2 T3 T4
max. 0.25 m
DALI one4all electronic ballast (1 DALI load)
12
11
10
9
T26/T16 fluorescent lamps TC-L/TC-DEL/TC-TEL
K1 K1' K2 K2' K3 K3' K4 K4'
Metal-halide lamps
EMOTION-4RUKS (1 DALI load)
K K'
e. g. incandescent lamps
EMOTION-1RUK (10 DALI loads)
ED-EYE (2 DALI loads)
ED-SxED (3 DALI loads)
ED-Circle (3 DALI loads)
L' N
EMOTION APD (1 DALI load)
Incandescent lamps/ HV halogen incandescent lamps
TE one4all (1 DALI load)
NV halogen incandescent lamps
R G B
DALI LED converter (1 DALI load)
RGB luminaires
ED-SENS (4 DALI loads)
0/1-10 V units e. g. STARFLEX fibre optic system
EMOTION-ANAS (1 DALI load)
D1 D2 D1 D2
DALI-2DSI (1 DALI load)
25 DSI luminaires
25 DSI luminaires
IRTOUCH
Data + Data - GND
16 DALI SA to 16 DMX channels
DALI-DMX (1 DALI load)
Tunable White luminaires (e.g. ARCOS) (1 DALI load)

LUXMATE LITENET: General information

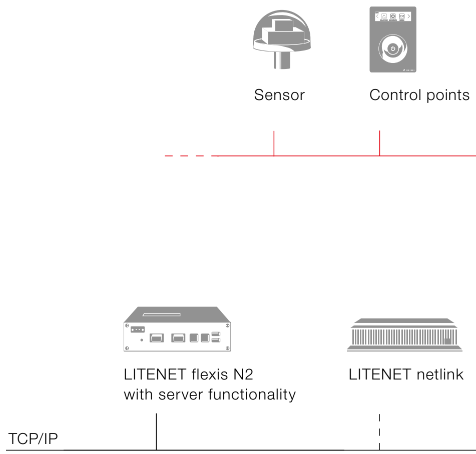
Benefits

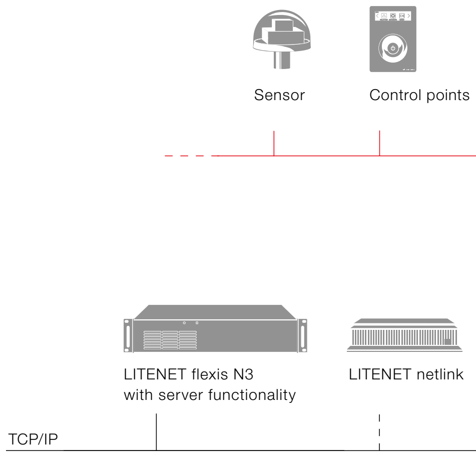
- Maximum flexibility: use of floor space (room and group addresses can be configured via software), flexibility of use (room profiles with basic functions for specific room utilisation), modular solution packages ranging from 500 to 10,000 luminaires
- Daylight-based blinds management with central daylight sensor
- Integration of the latest technologies: Tunable White for LED colour temperature luminaires, enocean for wireless key switches, control via web browser (LITENET incontrol)
- Maximum of energy-saving options: daylight, presence, automated timing, Maintenance Control (constant light control)
- Software interfaces to building management system: OPC, BACnet

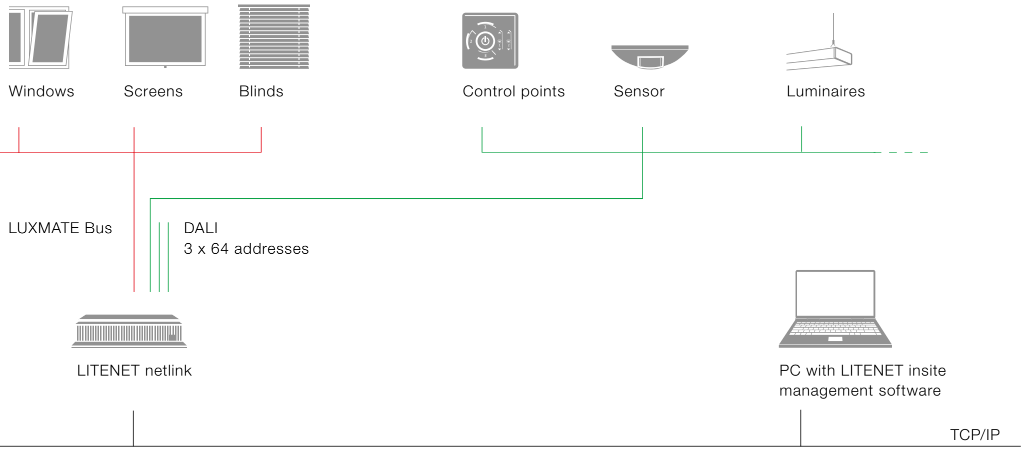
Features

- Field technology is based on LUXMATE Professional with LUXMATE bus and optional integration of DALI and DSI control circuits
- Data exchange from PC (LITNET Flexis, LITENET, server) to gateway (LITENET netlink) via network technology (TCPIP protocol)
- Gateway (LITENET netlink) allows easy integration of modules in the field area (3 DALI control circuits, 1 LUXMATE bus link; incl. power supply) (1 DALI load = 2 mA) per DALI control circuit

Wiring overview

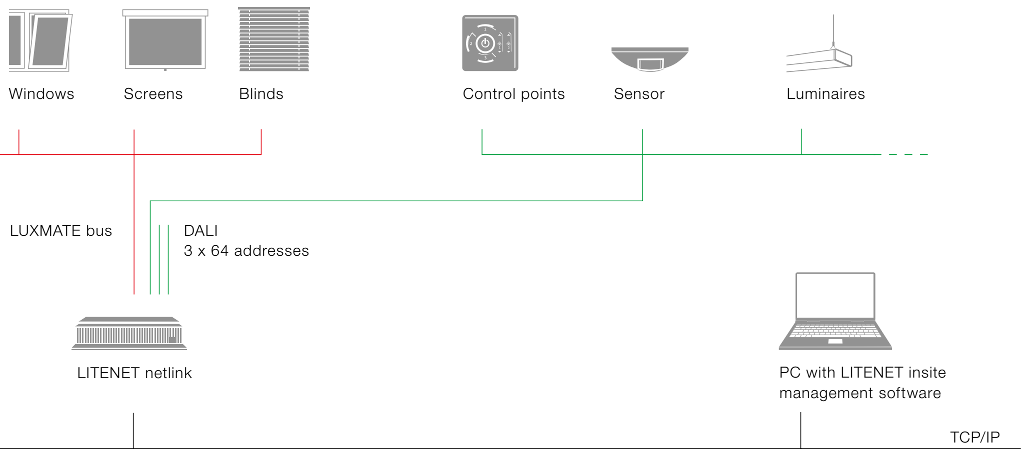






LITENET economy

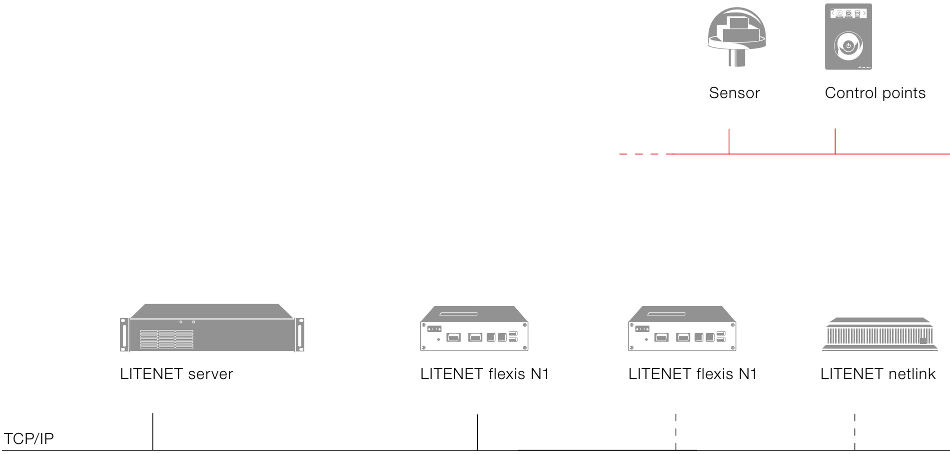
- up to 500 output addresses
- no server required
- LITENET flexisN2 without rotating parts (wear-free)
- optional LITENET incontrol operating software

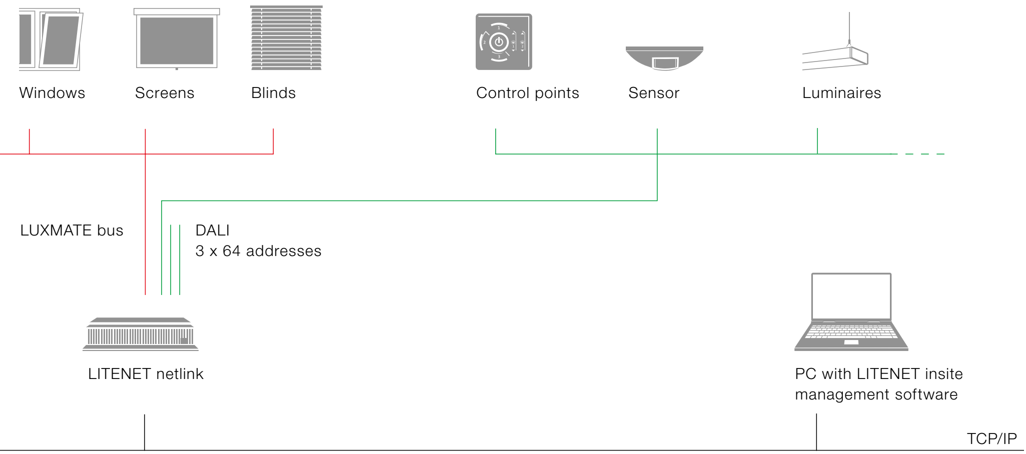


LITENET compact

- up to 2000 output addresses
- no server required
- LITENET flexis N3 in 19" rack
- fail-safe thanks to RAID1
- optional LITENET incontrol operating software
- optional BACnet and OPC interfaces

LUXMATE LITENET: Wiring overview





LITENET flexibel

- up to 10 000 output addresses (or more upon request)
- can be cascaded as required
- LITENET flexis N1 installed in switch cabinet
- LITENET server extremely fail-safe thanks to RAID1
- optional LITENET incontrol operating software
- optional BACnet and OPC interfaces

LUXMATE lighting management:
Overview | Functions | Product ranges

Functions – Lighting	DIMLITE	EMOTION	LITENET
Manual switching and dimming	•	•	•
Presence-based switching	•	•	•
Daylight-based control	•	•	•
Synchronisation with daylight	•	•	•
Active lighting control		•	•
Time-based switching		•	•
Dynamic switching and dimming		•	•
Linked/conditional switching		•	•
Radio-controlled switching and dimming			•
Infrared remote control	•	•	•
Connection of regular switches and momentary-action switches	•	•	•
Call-up of static lighting scenes	•	•	•
Call-up of dynamic lighting scenes		•	•
Colour control		•	•
Colour temperature control		•	•
Switching actuators	•	•	•
Standard phase/reverse phase control	•	•	•
Control via DALI	•	•	•
Control via DSI	•	•	•
Control via DMX		•	•
Control via LUXMATE bus			•
Grouping of luminaires	•	•	•
Corridor function	•	•	•

Functions – Blinds	**EMOTION**	**LITENET**
Manual positioning		•
Presence-based positioning		•
Daylight-based positioning		•
Time-based positioning		•
Linked/conditional positioning		•
Security functions (wind, rain, frost)		•

Functions – Windows		
Manual opening/closing		•
Presence-based opening/closing		•
Time-based opening/closing		•
Linked/conditional opening/closing		•
Security functions (wind, rain, frost)		•

Central functions		
Fault indication	•	•
CAD plan-based visualisation		•
Failure reports via SMS, e-mail		•
Emergency lighting functions		•
Remote maintenance		•
Burning life management		•
Maintenance Control		•
Adaptation to room configurations	•	•

Functions – Integration with other building services		
TCP/IP text-based		•
BACnet		•
OPC		•

LUXMATE lighting management: Differentiation between DALI (EMOTION, LITENET) and DMX (E:cue, VCU)

		LUXMATE EMOTION	LUXMATE LITENET	E:cue Butler XT	VCU
Lighting solution	architectural	•	•	(•)	–
	emotional	•	–	•	(•)
	communicative	–	–	(•)	•
Speed	static/switching or dimming	•	•	–	–
	slow/gentle transitions	•	•	•	(•)
	fast changes in colour or brightness	–	–	•	•
	video speed	–	–	–	•
Effect	lighting	•	•	•	–
	colour	•	•	•	•
	diagram	–	–	(•)	•
	text	–	–	•	•
	video	–	–	(•)	•
Miscellaneous	sensors	•	•	–	–
	time-based control	•	•	–	–
	dimming of luminaires	•	•	•	•
	driving other motors	–	•	•	–
	shows	•	•	•	(•)
	playing back videos	–	–	(•)	•
	addresses/channels	128	10 000	1024	5400***
	addressing	via system	via system	on luminaire	on luminaire

• = applicable
(•) = partly applicable
– = not applicable

* server-based
** special solutions for up to 50 000 using server structure
*** 1800 RGB pixels; using master/slave structure (no special solution), open-ended

Functions overview

Function	DALI	DSI	1–10 V	Heavy-duty electr. ballast	Electronic ballast
Can be switched at zero power (digital control signal)	•	•			
Dimmability (via additional control lines)	•	•	•		
Dimming range (1 to 100 %)	•	•	•		
DALI addressable (individual addressing, max. 64 addresses per control line)	•				
Can be configured (limitation of dimming levels, start level, fault level)	•				
Status reporting (dimming level, switching status, service readiness)	•				
Fault reporting (faulty lamp, device failure)	•				
Dimming automatically disabled in DC mode (dimming and switching signals are not accepted)	•				
Adjustable emergency lighting level (parameters ranging from 1 to 70 %, factory setting: 70 %)	•				
DC mode suitable for emergency lighting (DC mode in line with VDE 0108, operating voltage 176–280 V DC)	•	•	•	•	•
Critical operating conditions (ambient temperature: up to 70 °C, service life: 100,000 h)				•	

Chapter 7

Emergency lighting

ONLITE local – emergency lighting system with separate battery supply		196
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ONLITE local – emergency lighting system with separate battery supply

SB 128 Controller

Controlling an emergency lighting system is much more convenient and safe if it is networked via a DALI control line and an SB 128 Controller is connected.

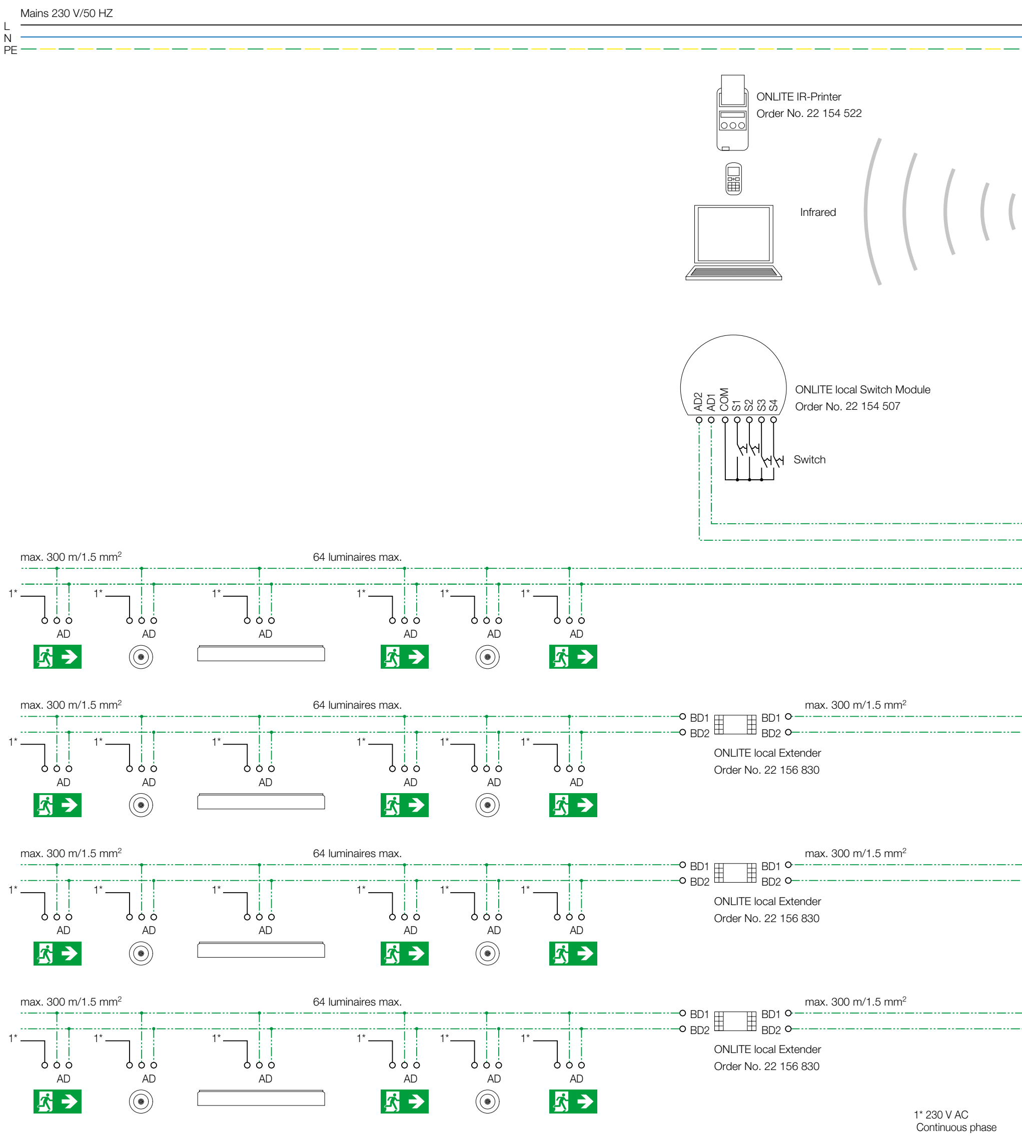
The status of all the luminaires is displayed on the Controller, all notifications such as lamp faults or battery malfunctions are captured in a central location and logged in the test logbook. By doing this, the Controller takes on full responsibility for the emergency lighting system.

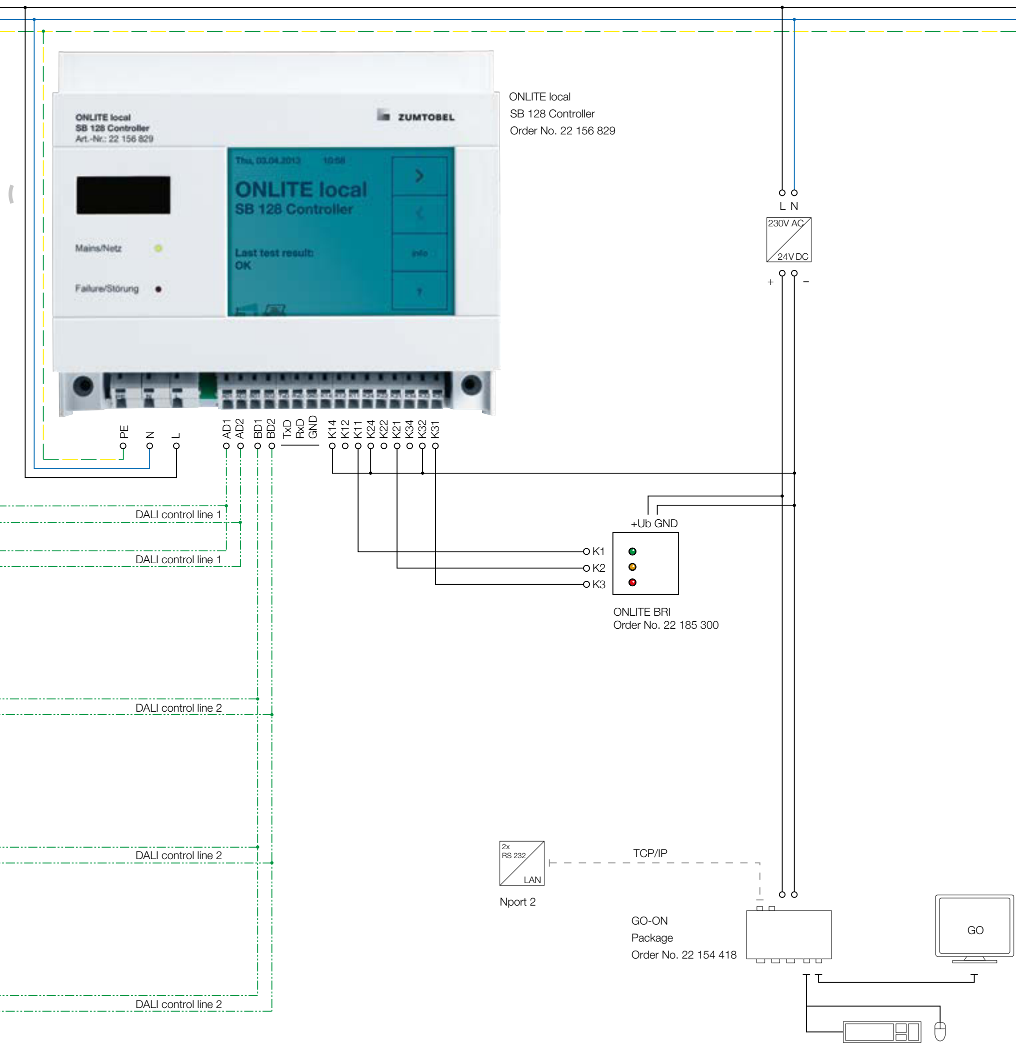
Easy operation
- Very easy commissioning and addressing of the entire emergency lighting installation – requires just one person
- Easy touch-screen operation
- Clearly laid-out, logical menu prompting
- Can monitor 128 luminaires, can be expanded to take 256 luminaires by fitting extenders

Automatic tests and test logs
- Test logbook with central logging of test results for at least three years
- Clock and calendar function for user-programmable test cycles
- Facility to manually trigger test functions on Controller

High level of functionality
- Display of all luminaires, configuration with description and addressing
- Mode can be selected individually for every ONLITE luminaire
- User-programmable signalling contacts and audible failure notification
- Installation can be disabled to allow servicing work

Control test system topology





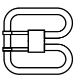
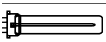
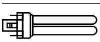
ONLITE local
SB 128 Controller
Art.-Nr.: 22 156 829
ZUMTOBEL
Thu, 03.04.2013 10:58
ONLITE local
SB 128 Controller
Last test result:
OK
info
Mains/Netz
Failure/Störung
ONLITE local
SB 128 Controller
Order No. 22 156 829
PE
N
L
AD1
AD2
BD1
BD2
TxD
RxD
GND
K14
K12
K11
K24
K22
K21
K34
K32
K31
L N
230V AC
24V DC
+
–
+Ub GND
K1
K2
K3
ONLITE BRI
Order No. 22 185 300
DALI control line 1
DALI control line 1
DALI control line 2
DALI control line 2
DALI control line 2
2x
RS 232
LAN
Nport 2
TCP/IP
GO-ON
Package
Order No. 22 154 418
GO

ONLITE local emergency sets for separate battery supply

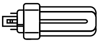
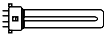
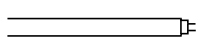
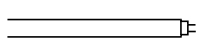
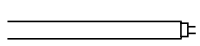
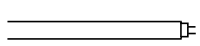
Zumtobel's luminaires are supplied ready to use with separate battery supply (emergency sets) for emergency lighting integrated into general lighting systems. Compliance to standards is guaranteed here compared to luminaires converted by the operator. The emergency sets are connected via DALI and an ONLITE local SB 128 Controller.

The emergency lighting consists of a control unit and battery. In contrast to the RESCLITE emergency set, the light source of the general lighting luminaire is used for emergency lighting. The ONLITE local emergency sets are available for backup of one or three hours.

Overview ONLITE local emergency sets

			1 hour			3 hours		
			4 cells	5 cells	6 cells	4 cells	5 cells	6 cells
			EM 14 PRO EZ-3	EM 15 PRO EZ-3	EM 16 PRO EZ-3	EM 34 PRO EZ-3	EM 35 PRO EZ-3	EM 36 PRO EZ-3
			NT1-TR 14	NT1-TR 15	NT1-TR 16	NT3-TR 14	NT3-TR 15	NT3-TR 16
Symbol	**Lamp**	**W**	**BLF in emergency lighting mode in % for rated service life**					
	TC-DD	10	33.0			33.0		
		16	24.0			24.0		
		21	17.0			17.0		
		28	14.0			14.0		
		38			7.5			7.5
		55			5.2			5.2
	TC-SEL	7	24.0			24.0		
		9	28.0			28.0		
		11	31.0			31.0		
	TC-DEL	10	30.0			30.0		
		13	26.0			26.0		
		18	17.0			17.0		
		26	14.4			14.4		

Overview ONLITE local emergency sets – continued

			1 hour			3 hours		
			4 cells	5 cells	6 cells	4 cells	5 cells	6 cells
			EM 14 PRO EZ-3	EM 15 PRO EZ-3	EM 16 PRO EZ-3	EM 34 PRO EZ-3	EM 35 PRO EZ-3	EM 36 PRO EZ-3
			NT1-TR 14	NT1-TR 15	NT1-TR 16	NT3-TR 14	NT3-TR 15	NT3-TR 16
Symbol	**Lamp**	**W**	**BLF in emergency lighting mode in % for rated service life**					
	TC-TEL[1]	13	26.0			26.0		
		18	17.5/16.0	–/20.5 (GE)		17.5/16.0	–/20.5 (GE)	
		26[2]	11.5/10.4	–/15.0	–/14.0	11.5/10.4	–/15.0	–/14.0
		32[2]		14.0/5.0	–/8.0		14.0/5.6	–/8.0
		42			7.4/7.3			7.4/7.3
		57			5.1/5.2			5.1/5.2
	TC-F	18	18.0			18.0		
		24		21.0			21.0	
		36		13.0			13.0	
	TC-L	18	18.0			18.0		
		24		17.0			17.0	
		36		12.0			12.0	
		40		8.8			8.8	
		55			4.5			4.5
	T16 FH	14	22.0			22.0		
		21		17.0			17.0	
		28			14.0			14.0
		35			10.5			10.5
	T16 FQ	24	12.3			12.3		
		39			8.3			8.3
		49			6.4			6.4
		54			5.7			5.7
		80			4.7			4.7
	T16 C	22	11.5			11.5		
		40			6.0			6.0
		55			5.5			5.5
	T16	6	35.0			35.0		
		8	36.0			36.0		
		13	22.0			22.0		
	T26	15	16.5			16.5		
		18	16.5			16.5		
		30	9.5			9.5		
		36	8.0			8.0		
		38		10.5			10.5	
		58		6.5			6.5	
		70			3.7			3.7

[1] The first figure refers to non-amalgam lamps, the second figure to amalgam lamps (e.g. 14/9.5).
[2] For optimum operation of 26 W and 32 W TC lamps, in particular for lamps with an amalgam filling, we recommend the use of EM 36 PRO EZ-3 and EM 16 PRO EZ-3, respectively.

ONLITE central eBox – central emergency power supply system

System overview

ONLITE central eBox is perfectly adjusted, convenient and flexible: for each application, there is the right basic housing in a functional design. The main station is modular and still boasts a compact size for easy assembly. Extremely small SUB stations enable the devices to be used next to the final circuits in any recess, small as it may be. With the optional external modules at the system bus, the functions of each ONLITE central eBox system can be extended individually.

Features

- Total output in emergency mode up to 2730 W for 1 hour emergency operation
- Total output in mains operation up to 5000 VA
- 30 final circuits (OCM)
- 4 external SUB stations (SUB)
- 36 switch inputs (BSIM)
- 9 bus phase detectors (BPD)
- 1 remote display (BRI)
- Web browser interface for up to 10 000 luminaires and 100 systems

	eBox MS 1700 **Main station**	**eBox MS 1200** **Main station**
Circuits (max. 20 luminaires)	30 overall (6 internal, 24 external for SUB each with 3 double circuits)	30 overall (6 internal, 24 external for SUB each with 3 double circuits)
Maximum number of luminaires depending on the available battery capacity [1]	600 overall 120 internal 120 per SUB external	600 overall 120 internal 120 per SUB external
Mains connection	3-pole (L / N / PE) 230 / 240 V ± 10 % max. 5500 VA output in case of full capacity	3-pole (L / N / PE) 230 / 240 V ± 10 % max. 5500 VA output in case of full capacity
System Bus connection	two core cable min. 2 x 0.75 mm^2	two core cable min. 2 x 0.75 mm^2
Mains operation Total AC output power	5000 VA per SCM 1000 VA	5000 VA per SCM 1000 VA
Emergency operation e.g. 1 h duration Battery output DC total [1]	2730 W at 24 Ah [2] accommodated in the cabinet max. per SCM 750 W / 200 W per circuit	1215 W at 12 Ah [2] accommodated in the cabinet max. per SCM 750 W / 200 W per circuit

[1] **Battery power in W depending on nominal duration of battery-powered operation**

Battery type	System voltage	Max. DC system output including 25 % ageing reserve as prescribed by the standard (EN 50 171 – 6.12.4)					
ONLITE central eBox Accu PB / 12	[V]	8 h	5 h	3 h	2 h	1 h	0.5 h
7.2 Ah	216	131	178	274	381	656	1085
12.0 Ah	216	233	324	487	640	1215	1993
24.0 Ah	216	479	697	1040	1490	2730	3750

[2] **Battery voltage 216 V nominal (189–249 V)**

[3] **DC output power depends on the available battery capacity**

eBox SUB E60 Fireproof substation	**eBox SUB IP65 Substation**	**eBox SUB IP20 Substation**
3 OCM modules with 2 outputs circuits per module	3 OCM modules with 2 outputs circuits per module	3 OCM modules with 2 outputs circuits per module
120 pcs	120 pcs	120 pcs
5-pole (from the main station L / N / PE / B+ / B-)	5-pole (from the main station L / N / PE / B+ / B-)	5-pole (from the main station L / N / PE / B+ / B-)
two core cable to main station	two core cable to main station	two core cable to main station
1000 VA per SUB 420 VA per OCM	1000 VA per SUB 420 VA per OCM	1000 VA per SUB 420 VA per OCM
max. 750 W per SUB [3] max. 200 W per circuit	max. 750 W per SUB [3] max. 200 W per circuit	max. 750 W per SUB [3] max. 200 W per circuit

SCM and OCM

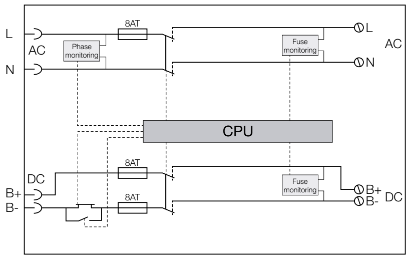
ONLITE central eBox SCM

SCM Switch Connection Module

One ONLITE central eBox SCM is included in the standard scope of supply. If several SUB stations are used, one ONLITE central eBox SCM per SUB station must be ordered separately.

Output power AC	1000 VA
Output power DC	750 W
Fuses (6 x 32 mm)	3 x 8 A
Output voltage AC	230 / 240 V ± 10 %
Max. number of luminaires	120

SCM
Switchover and fuse module

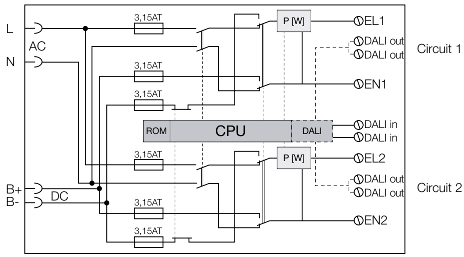


ONLITE central eBox OCM

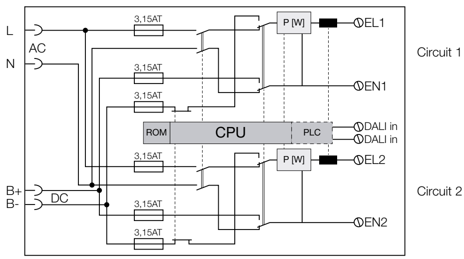
OCM Output Circuit Modules

Up to three ONLITE central eBox OCMs per system can be used as an option. In this context, the different functions of the modules may also be mixed. Each circuit is separately protected by a 3.15 A 6 x 32 mm fuse. In the battery circuit, there is 2-pole fusing, in the mains network 1-pole fusing. The total output of the three double-circuit modules must not exceed 1000 VA and 750 W.

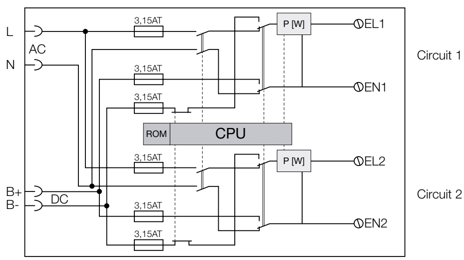
Output power per circuit AC	420 VA
Output power per circuit DC	200 W
Fuses (6 x 32 mm)	6 x 3.15 A
Output voltage AC	230 / 240 V ± 10 %
Output voltage DC (nominal)	216 V (189–249 V)



OCM-NDA
Double-circuit module
DALI communication



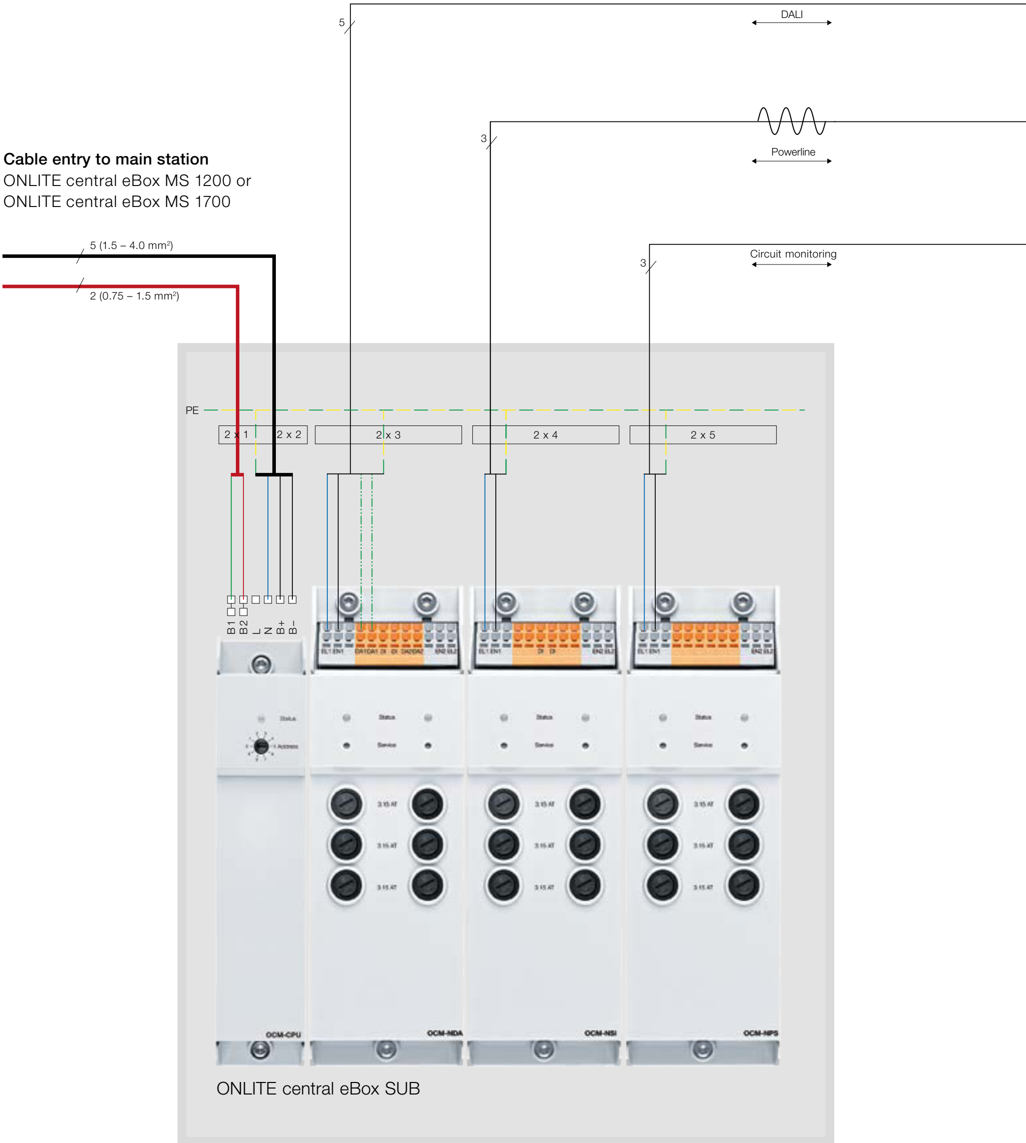
OCM-NSI
Double-circuit module
Powerline communication

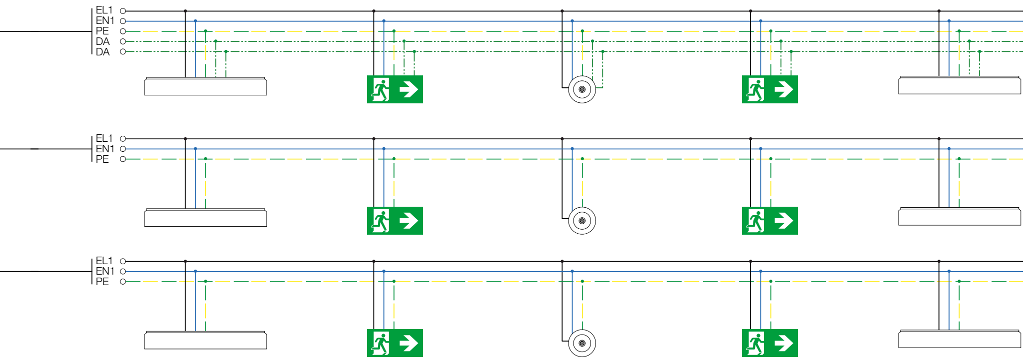


OCM-NPS
Double-circuit module
with circuit monitoring

SUB stations

Cable entry to main station
ONLITE central eBox MS 1200 or
ONLITE central eBox MS 1700





Cable entry from substation to main station ONLITE central eBox

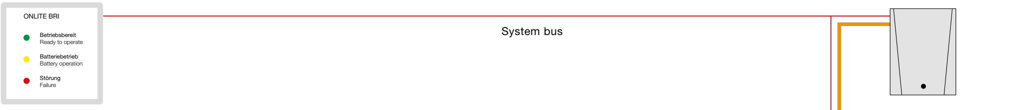
The 5-pole power cable must be installed in a FP cable up to the place of installation of the ONLITE central eBox SUB station of the respective fire compartment. If several fire compartments are supplied from the ONLITE central eBox SUB E60, the power cable must be installed in a fireproof manner up to the cabinet, and the final circuits up to the fire compartments to be supplied in each case.

The system bus may be executed in a linear manner or in a star topology. Fireproof installation is not required, since the monitoring of the bus is ensured through heartbeat control. If on account of an interruption or short-circuit, any logging data arrive late or not at all, AC emergency operation of all luminaires is activated at the final circuit.

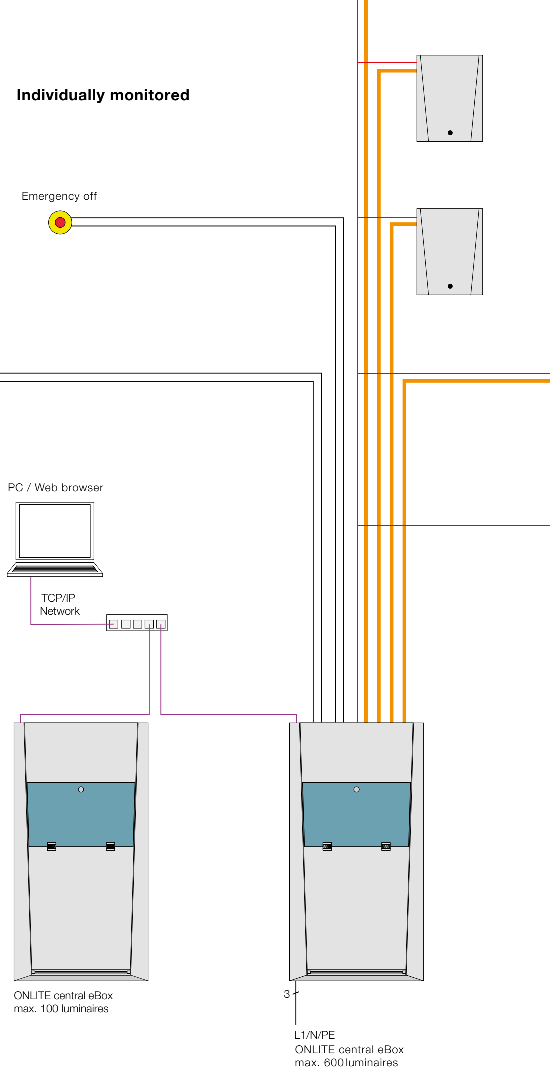
Three SUB stations are available

- ONLITE central eBox SUB E60
  Standard SUB station is used if final circuits in different fire compartments are served
- ONLITE central eBox SUB E00
  Standard SUB station in E00 IP20 to supply final circuits without crossing any fire compartment
- ONLITE central eBox SUB IP65
  Standard SUB station in E00 IP65 to supply final circuits without crossing any fire compartment for rough environments such as industry, car parks or underground parking

System topology



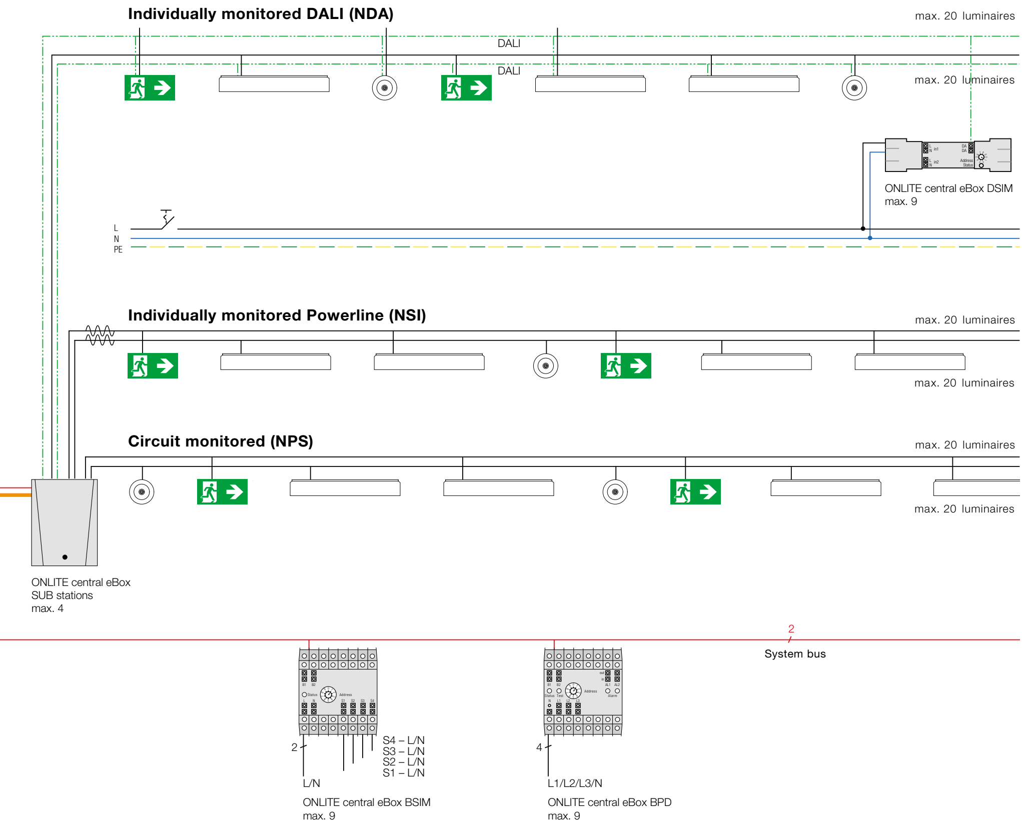
ONLITE BRI remote display
The module is a remote display for the operational status of an emergency lighting system. This is required in every installation under EN 50172. The remote display is installed at a superordinate location within the building, in order to show the status of the system at any time.



Status-LED*

Green	System is ready for operation
Yellow	System in battery mode
Red	Too many faulty light sources in the system
Red, periodically on/off every 0.5 s	error in the system
All, off	break-down of the system bus
All, periodically on/off every 0.5 s	error at the system bus or main station failure

* Use with ONLITE central eBox

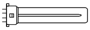
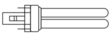
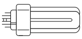
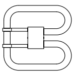

Individually monitored DALI (NDA)
max. 20 luminaires
DALI
DALI
max. 20 luminaires
ONLITE central eBox DSIM
max. 9
L
N
PE
Individually monitored Powerline (NSI)
max. 20 luminaires
max. 20 luminaires
Circuit monitored (NPS)
max. 20 luminaires
max. 20 luminaires
ONLITE central eBox
SUB stations
max. 4
2
System bus
2
S4 – L/N
S3 – L/N
S2 – L/N
S1 – L/N
L/N
ONLITE central eBox BSIM
max. 9
4
L1/L2/L3/N
ONLITE central eBox BPD
max. 9

Ballast/lumen factor table

Emergency lighting level	Light source	Wattage	AC power [100 %] 230 V/50 Hz [VA]	DC [W] 5 %	DC [W] 10 %	DC [W] 15 %	DC [W] 20 %	DC [W] 30 %	DC [W] 40 %	DC [W] 50 %	DC [W] 60 %
LED	LED		3.7		1.6	1.6	1.7	1.7	1.8	1.9	
			3.7		1.7	1.8	1.8	1.9	2.0	2.1	
			5.0		3.5	3.6	3.7	3.8	4.0	4.1	
			5.0		3.4	3.5	3.6	3.7	3.8	4.0	
			5.0		3.4	3.5	3.6	3.7	3.8	4.0	
			6.0		4.4	4.5	4.6	4.7	4.8	5.0	
			6.5		4.4	4.5	4.6	4.7	4.8	5.0	
			11.0		8.1	8.4	8.7	9.1	9.4	9.7	
			2.9		1.6	1.6	1.7	1.7	1.8	1.9	
			6.0		2.0	2.2	2.4	2.8	3.2	3.6	
			11.0		8.3	8.4	8.5	8.6	8.8	9.0	
			5.0		3.5	3.6	3.7	3.8	4.0	4.1	
			5.0		3.5	3.6	3.7	3.8	4.0	4.1	
			5.4		1.5	1.7	1.9	2.3	2.6	3.0	
			8.2		2.1	2.4	2.7	3.3	4.0	4.6	
	T16	14 W	17.9	6.9	7.9	8.6	9.2	10.3	12.0	13.0	14.1
		2/14 W	33.0	11.1	13.4	15.2	16.3	18.8	21.4	23.7	25.6
		21 W	24.8	7.9	9.3	10.5	11.3	13.7	15.9	17.7	19.3
		2/21 W	47.2	12.9	15.7	17.8	20.0	24.5	28.7	32.3	35.4
		28 W	32.5	9.4	11.6	13.3	14.9	17.5	20.4	23.0	25.0
		2/28 W	61.8	15.4	19.3	22.9	26.3	31.6	37.6	42.6	46.9
		35 W	41.0	10.5	12.9	16.3	17.1	21.0	24.9	27.6	30.4
		2/35 W	77.4	16.6	21.6	26.0	29.6	37.7	45.2	51.1	56.7
		24 W	27.5	8.7	9.8	11.9	13.0	15.4	17.7	19.8	21.1
		2/24 W	51.7	14.8	18.1	21.2	24.4	28.9	33.4	37.6	41.1
		39 W	43.8	10.3	13.8	16.2	18.1	22.9	26.7	33.3	33.0
		2/39 W	86.5	17.5	23.7	28.9	34.0	42.5	51.4	58.1	64.5
		49 W	55.6	12.4	16.4	20.2	23.2	28.5	33.5	38.0	42.1
		2/49 W	110.3	20.6	28.2	35.9	41.6	52.5	62.8	73.0	80.9
		54 W	57.5	14.8	19.3	23.1	26.7	31.8	36.8	41.2	44.2
		2/54 W	117.0	26.3	35.0	43.5	49.8	61.7	73.8	82.2	90.5
		80 W	90.9	17.3	24.7	30.9	36.3	45.0	53.9	61.3	67.8
		2/80 W	178.3	31.8	45.6	59.7	70.1	90.1	106.3	122.1	134.5
	T26	1/18 W	19.8	7.1	8.1	9.2	10.3	11.6	13.6	15.0	15.9
		2/18 W	37.3	11.8	14.3	16.4	18.1	21.4	24.4	27.2	29.3
		1/36 W	37.6	9.0	11.1	13.2	15.3	19.0	22.5	25.1	27.4
		2/36 W	69.8	16.5	21.2	25.1	28.6	35.6	42.0	48.1	53.2
		1/58 W	54.3	12.1	16.1	19.5	22.3	27.6	32.7	36.9	41.1
		2/58 W	107.8	21.2	28.5	35.8	42.0	52.1	63.0	72.4	79.4
	TC-L/F	1/18 W	18.0	7.9	8.2	9.7	10.7	11.6	12.9	14.2	14.9
		2/18 W	33.4	13.1	15.1	16.0	18.0	20.9	24.0	25.9	28.0
		1/24 W	24.9	8.4	10.1	11.5	12.2	14.4	16.5	18.2	19.3
		2/24 W	47.3	13.0	16.5	19.6	21.9	26.4	30.3	34.0	37.0
		1/36 W	36.4	10.3	12.4	14.9	16.4	19.7	23.2	25.5	27.7
		2/36 W	71.0	16.1	21.2	25.8	30.0	36.6	43.6	48.6	53.8
		1/40 W	46.0	8.8	12.0	14.9	17.4	22.2	26.6	30.5	33.6
		2/40 W	88.7	17.3	23.4	29.4	34.6	43.8	53.1	60.4	67.1
		1/55 W	64.9	14.5	19.5	24.0	27.0	33.3	39.2	44.9	49.0
		2/55 W	125.6	25.8	35.8	44.7	51.2	64.4	75.8	86.1	94.8

DC [W] **70 %**	DC [W] **100 %**	Control gear/luminaire
2.4	3.2	EMpowerX LED NSI / ARTSIGN C EW
2.4	3.2	EMpowerX LED NSI / ARTSIGN C ED
4.3	4.5	EMpowerX LED NSI / COMSIGN 150
4.2	4.5	EMpowerX LED NSI / CROSSIGN 110
4.2	4.5	EMpowerX LED NSI / CROSSIGN 110 ERI
5.2	5.5	EMpowerX LED NSI / CROSSIGN 160
5.2	5.5	EMpowerX LED NSI / CROSSIGN 160 ERI
10.1	10.5	EMpowerX LED NSI / CUBESIGN 210
2.1	2.4	EMpowerX LED NSI / ERGOSIGN LED
4.5	5.5	EMpowerX LED NSI / ECOSIGN LED IP 65
9.5	10.5	EMpowerX LED NSI / FREESIGN 300
4.3	4.5	EMpowerX LED NSI / PURESIGN 150
4.3	4.5	EMpowerX LED NSI / PURESIGN 150 ERI
3.8	4.9	EMpowerX LED NSI / RESCLITE C
5.8	7.7	EMpowerX LED NSI / SQUARESIGN 300
15.3	17.4	PCA 1 x 14/24 T5 EXCEL one4all lp xitec II
28.1	32.6	PCA 2 x 14/24 T5 EXCEL one4all lp xitec II
20.8	24.3	PCA 1 x 21/39 T5 EXCEL one4all lp xitec II
39.1	46.7	PCA 2 x 21/39 T5 EXCEL one4all lp xitec II
27.2	32.0	PCA 1 x 28/54 T5 EXCEL one4all lp xitec II
51.4	61.4	PCA 2 x 28/54 T5 EXCEL one4all lp xitec II
33.3	40.4	PCA 1 x 35/49/80 T5 EXCEL one4all lp xitec II
62.6	77.1	PCA 2 x 35/49 T5 EXCEL one4all lp xitec II
22.8	27.1	PCA 1 x 14/24 T5 EXCEL one4all lp xitec II
44.7	51.5	PCA 2 x 14/24 T5 EXCEL one4all lp xitec II
35.8	43.8	PCA 1 x 21/39 T5 EXCEL one4all lp xitec II
71.6	86.3	PCA 2 x 21/39 T5 EXCEL one4all lp xitec II
46.3	55.1	PCA 1 x 35/49/80 T5 EXCEL one4all lp xitec II
89.6	110.2	PCA 2 x 35/49 T5 EXCEL one4all lp xitec II
48.4	57.0	PCA 1 x 28/54 T5 EXCEL one4all lp xitec II
99.8	117.1	PCA 2 x 28/54 T5 EXCEL one4all lp xitec II
74.4	90.6	PCA 1 x 35/49/80 T5 EXCEL one4all lp xitec II
147.9	178.0	PCA 2 x 80 T5 EXCEL one4all lp xitec II
17.3	19.4	PCA 1 x 18 T8 EXCEL one4all lp xitec II
32.2	37.0	PCA 2 x 18 T8 EXCEL one4all lp xitec II
32.8	35.3	PCA 1 x 36 T8 EXCEL one4all lp xitec II
58.6	69.6	PCA 2 x 36 T8 EXCEL one4all lp xitec II
44.6	54.1	PCA 1 x 58 T8 EXCEL one4all lp xitec II
88.0	108.5	PCA 2 x 58 T8 EXCEL one4all lp xitec II
15.7	17.7	PCA 1 x 18/24 TCL EXCEL one4all c xitec II
30.6	33.1	PCA 2 x 18/24 TCL EXCEL one4all c xitec II
20.8	24.6	PCA 1 x 18/24 TCL EXCEL one4all c xitec II
40.6	47.1	PCA 2 x 18/24 TCL EXCEL one4all c xitec II
30.0	36.3	PCA 1 x 21/39 T5 EXCEL one4all lp xitec II
59.5	70.9	PCA 2 x 21/39 T5 EXCEL one4all lp xitec II
37.0	46.1	PCA 1 x 21/39 T5 EXCEL one4all lp xitec II
74.5	89.0	PCA 2 x 21/39 T5 EXCEL one4all lp xitec II
53.7	64.4	PCA 1 x 35/49/80 T5 EXCEL one4all lp xitec II
105.2	125.4	PCA 2 x 80 T5 EXCEL one4all lp xitec II

Ballast/lumen factor table

Emergency lighting level	Light source	Wattage	AC power [100 %] 230 V/50 Hz [VA]	DC [W] **5 %**	DC [W] **10 %**	DC [W] **15 %**	DC [W] **20 %**	DC [W] **30 %**	DC [W] **40 %**	DC [W] **50 %**	DC [W] **60 %**
	TC-S/E	1/11 W	15.7	6.4	7.5	8.2	8.6	9.8	11.2	12.4	13.0
		2/11 W	27.6	8.7	10.4	11.7	13.1	15.3	17.3	19.6	21.1
	TC-D/E	1/13 W	15.5	6.4	7.5	7.8	8.5	10.2	11.2	11.9	13.1
		2/13 W	28.2	9.1	11.0	12.6	14.0	16.3	18.1	21.0	21.0
	TC-D/T	1/18 W	20.7	7.0	8.5	10.0	11.1	12.8	14.2	15.6	16.8
		2/18 W	38.9	11.1	13.6	16.4	18.1	22.2	25.3	28.2	30.7
		1/26 W	28.4	8.7	10.5	12.4	13.6	15.9	18.5	20.4	22.2
		2/26 W	53.1	14.1	17.4	21.0	23.7	28.5	33.0	37.4	40.7
	TC-T/E	1/32 W	33.6	9.4	12.1	14.1	16.0	19.0	22.3	25.0	26.4
		2/32 W	58.4	14.5	19.7	24.5	28.1	34.4	40.0	44.6	47.9
		1/42 W	40.7	10.4	13.0	15.6	18.5	22.9	27.7	31.4	35.0
		2/42 W	75.4	15.4	21.8	27.4	31.8	40.5	48.5	55.6	60.1
	TC-DD	1/28 W	31.0	8.9	10.6	12.6	13.9	16.6	18.9	21.6	23.6

DC [W] **70 %**	DC [W] **100 %**	Control gear/luminaire
14.4	15.3	PCA 1 x 11/13 TC EXCEL one4all xitec II
23.0	27.0	PCA 2 x 11/13 TC EXCEL one4all xitec II
13.9	15.0	PCA 1 x 11/13 TC EXCEL one4all xitec II
24.1	27.8	PCA 2 x 11/13 TC EXCEL one4all xitec II
18.0	20.2	PCA 1 x 18 TC EXCEL one4all xitec II
33.5	37.5	PCA 2 x 18 TC EXCEL one4all xitec II
24.0	27.7	PCA 1 x 26-57 TC EXCEL one4all xitec II
45.0	52.7	PCA 2 x 26/32/42 TC EXCEL one4all xitec II
29.0	32.4	PCA 1 x 26-57 TC EXCEL one4all xitec II
51.7	58.3	PCA 2 x 26/32/42 TC EXCEL one4all xitec II
37.1	44.9	PCA 1 x 26-57 TC EXCEL one4all xitec II
65.2	74.5	PCA 2 x 26/32/42 TC EXCEL one4all xitec II
25.8	30.5	PCA 1 x 28 TC-DD EXCEL one4all xitec II

ONLITE central CPS – central battery system

System overview

Every ONLITE central CPS offers full functionality in order to comprehensively meet the requirements placed on a central battery system using as few components as possible.

No additional software or modules are needed. There is no need to fit any separate components in the luminaire because every DALI luminaire can be used as an emergency luminaire which can be individually monitored and controlled. This also reduces effort on commissioning, inspecting and maintaining the system.

A large removable Touch PC is the core of the system. For example, it enables straightforward commissioning by one person or neatly laid out, easily manageable visualisation of the system's status.

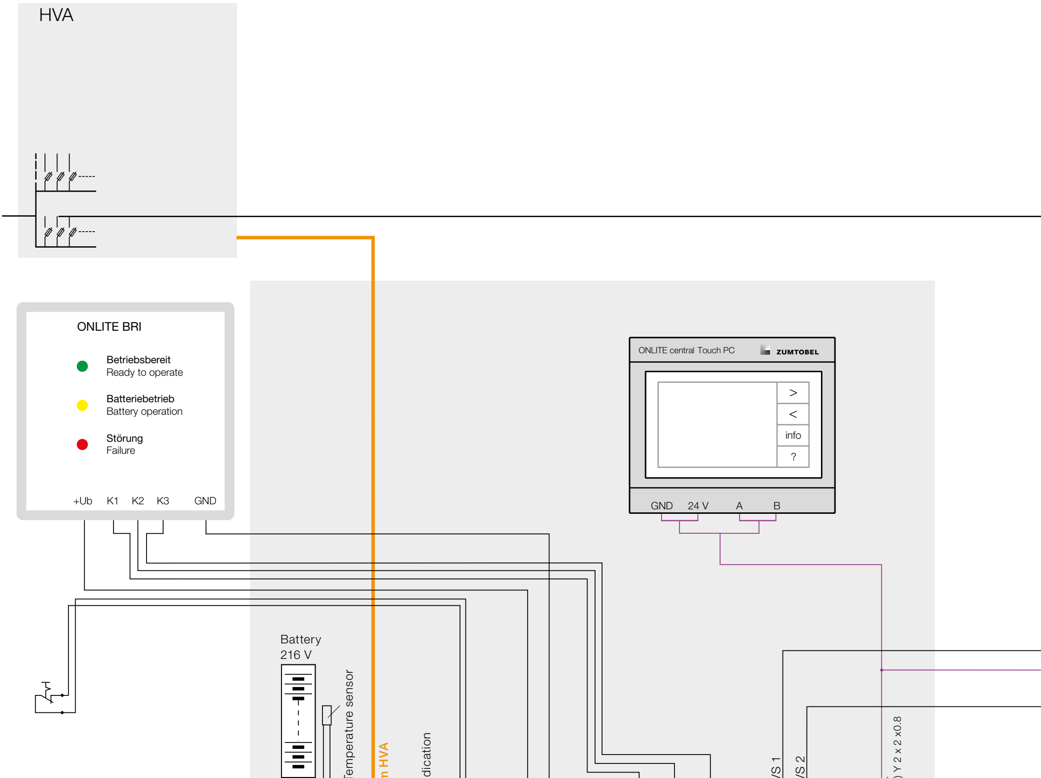
	CPS K Compact station	CPS H Main station
Circuits (up to 20 luminaires)	1) Up to 40 internal + 20 external 2) Up to 20 internal + 140 external	up to 60 internal + 240 external
Maximum number of luminaires	1) 1200 pcs * 2) 3200 pcs *	6000 pcs *
Mains connection	5-pole 3 x 400 V	5-pole 3 x 400 V
Mains operation		
Total AC output power	7–30 kVA	30 kVA
Max. AC output power per circuit	1300 VA	1300 VA
AC output power per 20 circuits (per UVS)	4700 VA	4700 VA
Emergency mode		
Total DC output power	7.6 kW [1 h]* 3.3 kW [3 h]*	22.7 kW [1 h]* 10 kW [3 h]*
Max. DC output power per circuit	1300 W	1300 W
DC output power per 20 circuits (per UVS)	4700 W	4700 W
Standby operating time 1–8 h	18 x 12 V / 7–75 Ah accommodated in combined cabinet	18 x 12 V up to 200 Ah accommodated in separate battery cabinet or battery rack

Features
- Power in emergency mode 1–30 kW
- Up to 300 circuits, each for 20 emergency luminaires (The maximum numbers are exclusively based on the technical specifications. All locally applicable laws, standards and regulations must be taken into account.)
- Up to 12 external substations per main station (CPS H)
- Mixed operation within one circuit is possible
- Up to 240 (optional) freely assignable switching inputs
- Web browser-based user interface

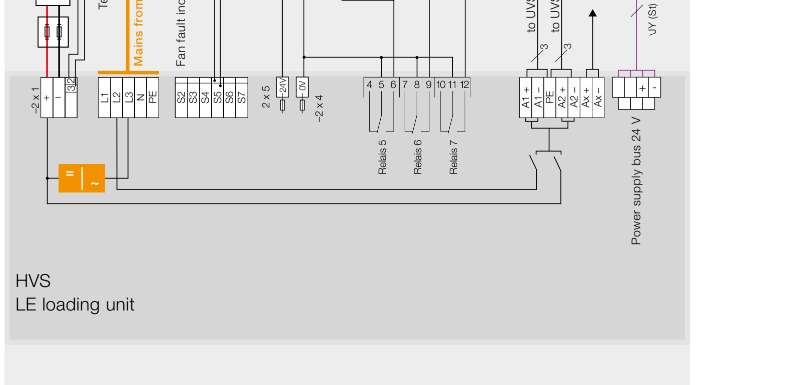
CPS U E60 Fire-resistant substation	CPS U E00 Substation
20	20
4700 VA	4700 VA
1300 VA	1300 VA
4700 VA	4700 VA

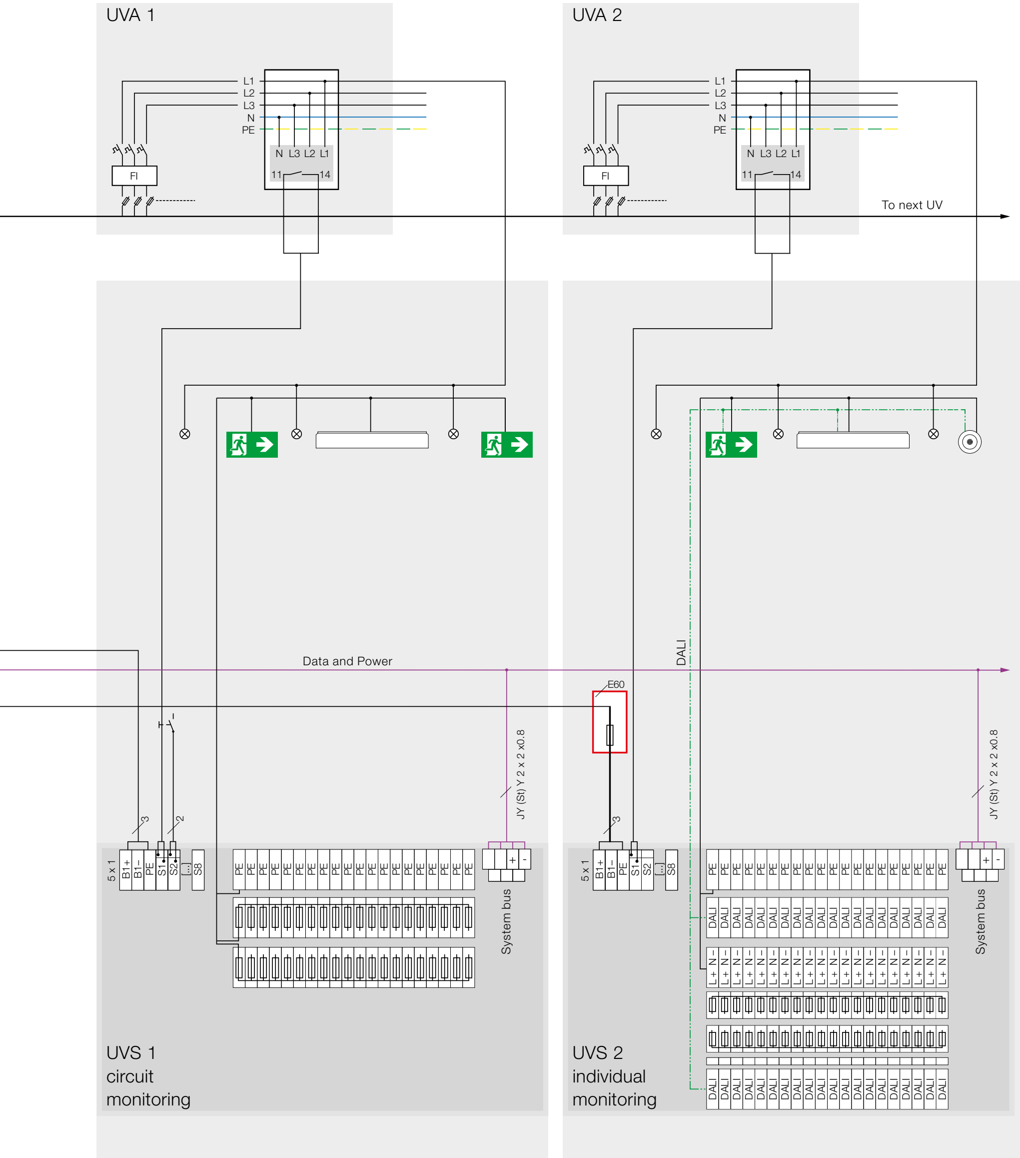
* Including 25 % reserve capacity (battery ageing)

ONLITE central CPS system topology



Emergency-off
By pressing the emergency-off button, the complete ONLITE central CPS system (including all substations) is disconnected from power supply. This ensures that emergency forces can safely do their job. The internal +24 V supply is carried via an NC switch (emergency-off) and connected to the S5 terminal (2 x 1 terminal strip at the main station), while the configuration is adjusted to the emergency-off function using the Touch PC.





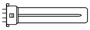
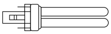
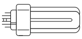
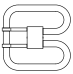
UVA 1
UVA 2
L1
L2
L3
N
PE
FI
N L3 L2 L1
11
14
To next UV
Data and Power
DALI
E60
JY (St) Y 2 x 2 x0.8
System bus
5 x 1
B1+
B1–
PE
S1
S2
[...]
S8
UVS 1
circuit
monitoring
UVS 2
individual
monitoring

Ballast/lumen factor table

Emergency lighting level	Light source	Wattage	AC power [100 %] 230 V/50 Hz [VA]	DC [W] 5 %	DC [W] 10 %	DC [W] 15 %	DC [W] 20 %	DC [W] 30 %	DC [W] 40 %	DC [W] 50 %	DC [W] 60 %
LED	LED		3.2		1.6	1.6	1.7	1.7	1.8	1.9	
			3.2		1.7	1.8	1.8	1.9	2.0	2.1	
			4.5		3.5	3.6	3.7	3.8	4.0	4.1	
			4.5		3.4	3.5	3.6	3.7	3.8	4.0	
			4.5		3.4	3.5	3.6	3.7	3.8	4.0	
			5.5		4.4	4.5	4.6	4.7	4.8	5.0	
			6.0		4.4	4.5	4.6	4.7	4.8	5.0	
			10.5		8.1	8.4	8.7	9.1	9.4	9.7	
			2.4		1.6	1.6	1.7	1.7	1.8	1.9	
			5.5		2.0	2.2	2.4	2.8	3.2	3.6	
			10.5		8.3	8.4	8.5	8.6	8.8	9.0	
			4.5		3.5	3.6	3.7	3.8	4.0	4.1	
			4.5		3.5	3.6	3.7	3.8	4.0	4.1	
			4.9		1.5	1.7	1.9	2.3	2.6	3.0	
			7.7		2.1	2.4	2.7	3.3	4.0	4.6	
	T16	14 W	17.4	6.9	7.9	8.6	9.2	10.3	12.0	13.0	14.1
		2/14 W	32.5	11.1	13.4	15.2	16.3	18.8	21.4	23.7	25.6
		21 W	24.3	7.9	9.3	10.5	11.3	13.7	15.9	17.7	19.3
		2/21 W	46.7	12.9	15.7	17.8	20.0	24.5	28.7	32.3	35.4
		28 W	32.0	9.4	11.6	13.3	14.9	17.5	20.4	23.0	25.0
		2/28 W	61.3	15.4	19.3	22.9	26.3	31.6	37.6	42.6	46.9
		35 W	40.5	10.5	12.9	16.3	17.1	21.0	24.9	27.6	30.4
		2/35 W	76.9	16.6	21.6	26.0	29.6	37.7	45.2	51.1	56.7
		24 W	27.0	8.7	9.8	11.9	13.0	15.4	17.7	19.8	21.1
		2/24 W	51.2	14.8	18.1	21.2	24.4	28.9	33.4	37.6	41.1
		39 W	43.3	10.3	13.8	16.2	18.1	22.9	26.7	33.3	33.0
		2/39 W	86.0	17.5	23.7	28.9	34.0	42.5	51.4	58.1	64.5
		49 W	55.1	12.4	16.4	20.2	23.2	28.5	33.5	38.0	42.1
		2/49 W	109.8	20.6	28.2	35.9	41.6	52.5	62.8	73.0	80.9
		54 W	57.0	14.8	19.3	23.1	26.7	31.8	36.8	41.2	44.2
		2/54 W	116.5	26.3	35.0	43.5	49.8	61.7	73.8	82.2	90.5
		80 W	90.4	17.3	24.7	30.9	36.3	45.0	53.9	61.3	67.8
		2/80 W	177.8	31.8	45.6	59.7	70.1	90.1	106.3	122.1	134.5
	T26	1/18 W	19.3	7.1	8.1	9.2	10.3	11.6	13.6	15.0	15.9
		2/18 W	36.8	11.8	14.3	16.4	18.1	21.4	24.4	27.2	29.3
		1/36 W	37.1	9.0	11.1	13.2	15.3	19.0	22.5	25.1	27.4
		2/36 W	69.3	16.5	21.2	25.1	28.6	35.6	42.0	48.1	53.2
		1/58 W	53.8	12.1	16.1	19.5	22.3	27.6	32.7	36.9	41.1
		2/58 W	107.3	21.2	28.5	35.8	42.0	52.1	63.0	72.4	79.4
	TC-L/F	1/18 W	17.5	7.9	8.2	9.7	10.7	11.6	12.9	14.2	14.9
		2/18 W	32.9	13.1	15.1	16.0	18.0	20.9	24.0	25.9	28.0
		1/24 W	24.4	8.4	10.1	11.5	12.2	14.4	16.5	18.2	19.3
		2/24 W	46.8	13.0	16.5	19.6	21.9	26.4	30.3	34.0	37.0
		1/36 W	35.9	10.3	12.4	14.9	16.4	19.7	23.2	25.5	27.7
		2/36 W	70.5	16.1	21.2	25.8	30.0	36.6	43.6	48.6	53.8
		1/40 W	45.5	8.8	12.0	14.9	17.4	22.2	26.6	30.5	33.6
		2/40 W	88.2	17.3	23.4	29.4	34.6	43.8	53.1	60.4	67.1
		1/55 W	64.4	14.5	19.5	24.0	27.0	33.3	39.2	44.9	49.0
		2/55 W	125.1	25.8	35.8	44.7	51.2	64.4	75.8	86.1	94.8

DC [W] **70 %**	DC [W] **100 %**	Control gear/luminaire
2.4	3.2	EMpowerX LED DALI / ARTSIGN C EW
2.4	3.2	EMpowerX LED DALI / ARTSIGN C ED
4.3	4.5	EMpowerX LED DALI / COMSIGN 150
4.2	4.5	EMpowerX LED DALI / CROSSIGN 110
4.2	4.5	EMpowerX LED DALI / CROSSIGN 110 ERI
5.2	5.5	EMpowerX LED DALI / CROSSIGN 160
5.2	5.5	EMpowerX LED DALI / CROSSIGN 160 ERI
10.1	10.5	EMpowerX LED DALI / CUBESIGN 210
2.1	2.4	EMpowerX LED DALI / ERGOSIGN LED
4.5	5.5	EMpowerX LED DALI / ECOSIGN LED IP 65
9.5	10.5	EMpowerX LED DALI / FREESIGN 300
4.3	4.5	EMpowerX LED DALI / PURESIGN 150
4.3	4.5	EMpowerX LED DALI / PURESIGN 150 ERI
3.8	4.9	EMpowerX LED DALI / RESCLITE C
5.8	7.7	EMpowerX LED DALI / SQUARESIGN 300
15.3	17.4	PCA 1 x 14/24 T5 EXCEL one4all lp xitec II
28.1	32.6	PCA 2 x 14/24 T5 EXCEL one4all lp xitec II
20.8	24.3	PCA 1 x 21/39 T5 EXCEL one4all lp xitec II
39.1	46.7	PCA 2 x 21/39 T5 EXCEL one4all lp xitec II
27.2	32.0	PCA 1 x 28/54 T5 EXCEL one4all lp xitec II
51.4	61.4	PCA 2 x 28/54 T5 EXCEL one4all lp xitec II
33.3	40.4	PCA 1 x 35/49/80 T5 EXCEL one4all lp xitec II
62.6	77.1	PCA 2 x 35/49 T5 EXCEL one4all lp xitec II
22.8	27.1	PCA 1 x 14/24 T5 EXCEL one4all lp xitec II
44.7	51.5	PCA 2 x 14/24 T5 EXCEL one4all lp xitec II
35.8	43.8	PCA 1 x 21/39 T5 EXCEL one4all lp xitec II
71.6	86.3	PCA 2 x 21/39 T5 EXCEL one4all lp xitec II
46.3	55.1	PCA 1 x 35/49/80 T5 EXCEL one4all lp xitec II
89.6	110.2	PCA 2 x 35/49 T5 EXCEL one4all lp xitec II
48.4	57.0	PCA 1 x 28/54 T5 EXCEL one4all lp xitec II
99.8	117.1	PCA 2 x 28/54 T5 EXCEL one4all lp xitec II
74.4	90.6	PCA 1 x 35/49/80 T5 EXCEL one4all lp xitec II
147.9	178.0	PCA 2 x 80 T5 EXCEL one4all lp xitec II
17.3	19.4	PCA 1 x 18 T8 EXCEL one4all lp xitec II
32.2	37.0	PCA 2 x 18 T8 EXCEL one4all lp xitec II
32.8	35.3	PCA 1 x 36 T8 EXCEL one4all lp xitec II
58.6	69.6	PCA 2 x 36 T8 EXCEL one4all lp xitec II
44.6	54.1	PCA 1 x 58 T8 EXCEL one4all lp xitec II
88.0	108.5	PCA 2 x 58 T8 EXCEL one4all lp xitec II
15.7	17.7	PCA 1 x 18/24 TCL EXCEL one4all c xitec II
30.6	33.1	PCA 2 x 18/24 TCL EXCEL one4all c xitec II
20.8	24.6	PCA 1 x 18/24 TCL EXCEL one4all c xitec II
40.6	47.1	PCA 2 x 18/24 TCL EXCEL one4all c xitec II
30.0	36.3	PCA 1 x 21/39 T5 EXCEL one4all lp xitec II
59.5	70.9	PCA 2 x 21/39 T5 EXCEL one4all lp xitec II
37.0	46.1	PCA 1 x 21/39 T5 EXCEL one4all lp xitec II
74.5	89.0	PCA 2 x 21/39 T5 EXCEL one4all lp xitec II
53.7	64.4	PCA 1 x 35/49/80 T5 EXCEL one4all lp xitec II
105.2	125.4	PCA 2 x 80 T5 EXCEL one4all lp xitec II

Ballast/lumen factor table

Emergency lighting level	Light source	Wattage	AC power [100 %] 230 V/50 Hz [VA]	DC [W] **5 %**	DC [W] **10 %**	DC [W] **15 %**	DC [W] **20 %**	DC [W] **30 %**	DC [W] **40 %**	DC [W] **50 %**	DC [W] **60 %**
	TC-S/E	1/11 W	15.2	6.4	7.5	8.2	8.6	9.8	11.2	12.4	13.0
		2/11 W	27.1	8.7	10.4	11.7	13.1	15.3	17.3	19.6	21.1
	TC-D/E	1/13 W	15.0	6.4	7.5	7.8	8.5	10.2	11.2	11.9	13.1
		2/13 W	27.7	9.1	11.0	12.6	14.0	16.3	18.1	21.0	21.0
	TC-D/T	1/18 W	20.2	7.0	8.5	10.0	11.1	12.8	14.2	15.6	16.8
		2/18 W	38.4	11.1	13.6	16.4	18.1	22.2	25.3	28.2	30.7
		1/26 W	27.9	8.7	10.5	12.4	13.6	15.9	18.5	20.4	22.2
		2/26 W	52.6	14.1	17.4	21.0	23.7	28.5	33.0	37.4	40.7
	TC-T/E	1/32 W	33.1	9.4	12.1	14.1	16.0	19.0	22.3	25.0	26.4
		2/32 W	57.9	14.5	19.7	24.5	28.1	34.4	40.0	44.6	47.9
		1/42 W	40.2	10.4	13.0	15.6	18.5	22.9	27.7	31.4	35.0
		2/42 W	74.9	15.4	21.8	27.4	31.8	40.5	48.5	55.6	60.1
	TC-DD	1/28 W	30.5	8.9	10.6	12.6	13.9	16.6	18.9	21.6	23.6

DC [W] **70 %**	DC [W] **100 %**	Control gear/luminaire
14.4	15.3	PCA 1 x 11/13 TC EXCEL one4all xitec II
23.0	27.0	PCA 2 x 11/13 TC EXCEL one4all xitec II
13.9	15.0	PCA 1 x 11/13 TC EXCEL one4all xitec II
24.1	27.8	PCA 2 x 11/13 TC EXCEL one4all xitec II
18.0	20.2	PCA 1 x 18 TC EXCEL one4all xitec II
33.5	37.5	PCA 2 x 18 TC EXCEL one4all xitec II
24.0	27.7	PCA 1 x 26-57 TC EXCEL one4all xitec II
45.0	52.7	PCA 2 x 26/32/42 TC EXCEL one4all xitec II
29.0	32.4	PCA 1 x 26-57 TC EXCEL one4all xitec II
51.7	58.3	PCA 2 x 26/32/42 TC EXCEL one4all xitec II
37.1	44.9	PCA 1 x 26-57 TC EXCEL one4all xitec II
65.2	74.5	PCA 2 x 26/32/42 TC EXCEL one4all xitec II
25.8	30.5	PCA 1 x 28 TC-DD EXCEL one4all xitec II

Chapter 8

Technology and tables

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Protection classes

Protection classes describe measures providing protection against touch-sensitive voltages. These measures are set out in the EN 61140 standard and marked with symbols in compliance with IEC 60417.

Zumtobel luminaires are classified into the following classes of protection:

⏚ = **Protection class I**

⧈ = **Protection class II**

= **Protection class III**

Class I luminaires
The luminaire is designed for connection to a protective conductor.

Protection class I is not identified by a symbol. The symbol indicating the protective earth ⏚ is often used.

Unless specified otherwise, all luminaires by Zumtobel comply at least with protection class I.

Class II luminaires
Class II luminaires have total insulation but no protective earth terminal.

The Zumtobel range includes protection class II luminaires, for instance moisture-proof batten luminaires and moisture-proof diffuser luminaires.

Class III luminaires
Class III identifies luminaires that are intended for operation with protective extra low voltage (50 V max.).

Architectural luminaires such as 2LIGHT MINI and MICROS-S are protection class III luminaires.

Degrees of protection

Degrees of protection indicate the following properties of equipment:

– the quality of its protection against direct contact
– its sealing against ingress of solid foreign bodies (dust, stones, sand, etc.)
– its sealing against the ingress of water

The type of protection is defined by two degrees of protection in accordance with IEC 529:

– degree of shock-hazard protection and protection against ingress of solid foreign bodies (1st digit)
– degree of protection against the ingress of water (2nd digit)

For example IP23:

IP

INGRESS PROTECTION

2

Protection against ingress of solid foreign bodies having Ø > 12 mm (medium-sized solid bodies), insertion of fingers or objects.

3

Protection against ingress of water falling at any angle up to 60° from vertical. There must be no adverse effect (spray water).

Degrees of protection for technical luminaires

Protection against ingress of solid foreign bodies as per first digit

IP0X	Unprotected against ingress of solid foreign bodies
IP1X	Protection against solid bodies > 50 mm
IP2X	Protection against solid bodies > 12 mm
IP3X	Protection against solid bodies > 2.5 mm
IP4X	Protection against solid bodies > 1 mm
IP5X	Dust-protected (limited ingress of dust)
IP6X	Dust-tight (no ingress of dust)

Protection against moisture as per second digit

IPX**0**	No special protection
IPX**1**	Drip-proof – protection against water drops
IPX**2**	Protection against water drops up to 15° from the vertical
IPX**3**	Rainproof – protection against spray water up to 60°
IPX**4**	Splash-proof – protection against spray water from all directions
IPX**5**	Jet-proof – protection against jets of water
IPX**6**	Protection against heavy seas (conditions on ship decks)
IPX**7**	Watertight – protection against immersion (pressure and time specified)
IPX**8**	Protection against immersion under pressure (with instructions from manufacturer)

Applications for luminaires with increased protection

Damp locations

Bakeries	**IPX1**	The following generally applies:
Manure sheds	**IPX1**	IPX5: for cleaning using water jets
Animal-feed preparation facilities	**IPX1**	IPX4: in rinsing areas
Industrial kitchens	**IPX1**	
Boiler rooms	**IPX1**	
Commercial workshops	**IP20**	
Granaries	**IPX1**	
(Deep-freeze) cold storage	**IPX1**	
Pump houses	**IPX1**	
Sculleries	**IPX1**	
Laundries	**IPX1**	

Wet locations

Beer or wine cellars	**IPX4**	The following generally applies:
Shower cubicles	**IPX4**	IPX5: for cleaning using water jets
Meat processing facilities	**IPX5**	
Electroplating facilities	**IPX4**	
Greenhouses	**IPX4**	
Dairies	**IPX4**	
Workshops using wet processes	**IPX4**	
Car wash areas	**IPX4**	

Agricultural facilities

Beer or wine cellars	**IP44**	The following generally applies:
Shower cubicles	**IP44**	IPX5: for cleaning using water jets
Stores, storerooms for hay, straw, feedstuff	**IP44**	IP54+FF: when increased fire risk
Intensive stock farming	**IP44**	
Animal sheds	**IP44**	
Adjoining rooms of animal sheds	**IP44**	

Facilities with increased fire risk

Workrooms	**IP50**
Woodworking	**IP50**
Sawmills	**IP50**
Paper processing	**IP50**
Textile processing	**IP50**
Treatment and fabrication	**IP50**

Gymnasia and sports halls

Badminton courts	**IP20**	ballproof luminaires
Squash courts	**IP20**	ballproof luminaires with
Indoor tennis courts	**IP20**	all-round cover;
Gymnasia and sports halls	**IP20**	maximum mesh size 60 mm

Fire protection

Luminaire identification marking
The following criteria must be taken into account:
– position of normal use
– fire behaviour of environment and mounting surfaces
– minimum clearance from combustible substances and materials

Luminaires marked with ▽D
This symbol indicates the surface temperature of luminaire. External surfaces where highly flammable materials such as dust or fibres may accumulate, even in case of use according to purpose, must not exceed specific temperatures.

The ▽F▽F luminaire mark was withdrawn in 1999. A period of transition was agreed that allowed the ▽F▽F mark to be applied until 01/08/2005. Since 01/08/1998, the ▽D mark introduced by EN 60598 has been applied.

The ▽D mark limits the temperature to 90 °C max. on horizontal surfaces during normal operation and to 115 °C in the event of a ballast fault. On vertical surfaces, 150 °C must not be exceeded.

Luminaires with the ▽M mark
Luminaires which carry the ▽M mark are intended for installation in furniture. They are designed so that in the event of a ballast fault, flame-retardant and normally flammable materials as specified in DIN 4102 cannot be ignited, e.g. in corners of wooden furniture. The materials may be painted, veneered or varnished.

Luminaires with the ▽M▽M mark
Luminaires which carry the ▽M▽M mark are intended for mounting in or on furniture made of materials whose flammability is not known. They are designed so that in normal operation any mounting surface or other adjacent furniture surfaces do not exceed a temperature of 95 °C.

Fire protection: Place of use – Mark – Requirements

Place of use	Luminaire mark	Requirements for luminaires with discharge lamps
Building parts made of non-combustible building materials according to DIN 4102 Part 1		as specified in EN 60598-1
Building parts made of flame-retardant building materials according to DIN 4102 Part 1	F	as specified in EN 60598-1 on the mounting surface **Mounting surface** / **Operation** < 130 °C – abnormal < 180 °C – ballast fault
Facilities with increased fire risk according to DIN VDE 0100 Part 720	D **IP5X**	as specified in EN 60598-2-24 luminaire surfaces **horizontal** / **vertical** / **Operation** < 90 °C – < 150 °C – normal < 115 °C – < 150 °C – abnormal/ ballast fault
Agricultural facilities with increased fire risk according to DIN VDE 0100 Part 720 DIN VDE 0100 Part 705 VDS 8/83 Form 2033	D **IP54** Installation marking	as specified in EN 60598-2-24 luminaire surfaces **horizontal** / **vertical** / **Operation** < 90 °C – < 150 °C – normal < 115 °C – < 150 °C – abnormal/ ballast fault
Installation objects whose fire behaviour is specified as flame retardant or normally flammable in DIN 4102 Part 1	M Permissive location markings	as per DIN VDE 0710 Part 14 on the mounting surface and adjacent surfaces **Mounting surface** / **Operation** < 130 °C – abnormal < 180 °C – ballast fault
Installation objects with unknown fire behaviour	M M Permissive location markings	as per DIN VDE 0710 Part 14 on the mounting surface and adjacent surfaces **Mounting surface** / **Operation** < 95 °C – normal < 130 °C – abnormal < 130 °C – ballast fault

Explosion-proofness

Flammable gases, vapours and mists

Zone 0 A hazardous explosive atmosphere is present continuously or long term.

Zone 1 A hazardous explosive atmosphere can be expected to occur occasionally.

Zone 2 A hazardous explosive atmosphere can be expected to occur only rarely and, if any, short term.

Combustible dusts

Zone 20 includes areas in which there is a permanent, long-term or frequent explosive atmosphere consisting of dust-air mixtures.

Zone 21 includes areas in which an explosive atmosphere consisting of dust-air mixtures can be expected to occur occasionally and short term.

Zone 22 includes areas in which an explosive atmosphere cannot be expected to occur due to disturbance of deposited dust. If an explosive atmosphere should nevertheless occur, this will most probably happen only rarely and short term.

Directive 94/9/EC

Directive 94/9/EC specifies the requirements for all devices and protection systems for use in explosion-prone areas. Over and above this, this Directive now directly includes the “Basic safety requirements” for explosion-proof equipment.

Manufacturers of explosion-proof equipment have to provide evidence of a quality assurance system to be tested by a “notified body”.

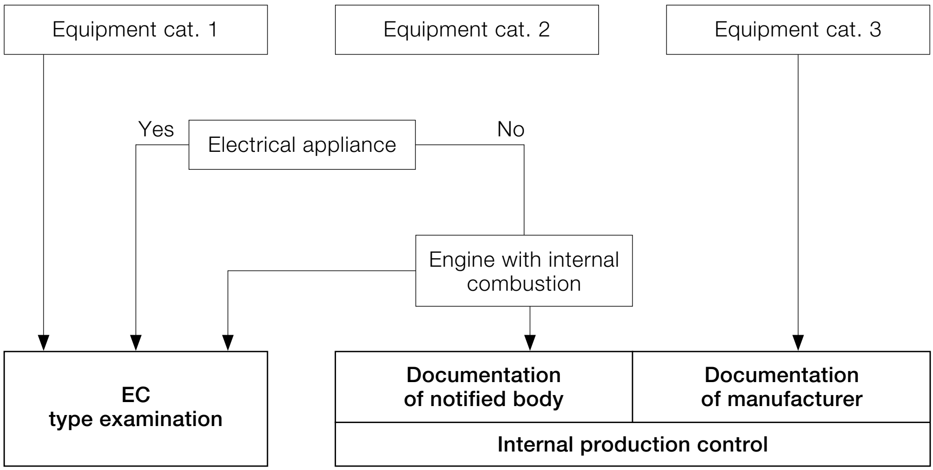
Directive 99/92 EC (Workplace Directive)

Also important is the description of hazard areas in explosion-prone workplaces, and a resulting graded safety profile for the “equipment” used.

As this Directive was drafted according to the EC’s “new approach”, the manufacturer’s declaration of conformity, combined with CE marking of the products, was introduced for explosion-proof equipment as well.

A detailed commentary on Directive 94/9/EC is included in the “Directive 94/9/EC by the European Parliament and the Council of 23 March 1994” section. Since 1 July 2003, it has superseded all directives on explosion protection previously effective at European level.

Equipment of Group 2 including potential ignition source



Basic safety and health requirements

Classification of max. surface temperatures in electrical equipment of Class 2

Temperature class	Max. permissible surface temperature of equipment in °C	Ignition temperatures of flammable substances in °C
T1	450	> 450
T2	300	> 300 ≥ 450
T3	200	> 300 ≥ 200
T4	135	> 200 ≥ 135
T5	100	> 100 ≥ 135
T6	85	> 85 ≥ 100

Ball-proofness

Luminaires for sports halls must be ball-proof according to DIN VDE 0710-13.

Balls hitting luminaires must not damage them so as to cause luminaire parts to fall down. In a test conforming with the relevant standard, the luminaire has to withstand 36 hits from three directions at a maximum impact speed of 60 km/h, the ball used having the size of a handball.

When choosing the luminaires, the rod guard's grid width must be matched to the sport played in the hall: it must always be considerably smaller than the balls used, never of the same size, as balls may get stuck in the guard.

Ballproof luminaires offered by Zumtobel include the MIREL T16 recessed luminaire and the MIRAL T16 surface-mounted luminaire as well as the VALUEA and GRAFT high-bay luminaires.

Cleanroom technology

Cleanroom compatibility tested
CLEAN Advanced and CLEAN Supreme have been tested and assessed by the Fraunhofer Institute in Stuttgart (Germany) with respect to
– cleanroom compatibility for cleanrooms (particle emission behaviour of the luminaires) and
– cleanliness compatibility (disinfectability, electrostatic behaviour and chemical resistance).

Details on cleanroom compatibility
The German VDI 2083 Guideline specifies a standardised procedure for all equipment used in a cleanroom.

The common criterion for the cleanroom compatibility of luminaires and all other equipment is their particle emission behaviour. "Airborne particle emission" is used as a classification criterion in all international standards. The relevant maximum value for the permissible concentration of particles of a specific particle size constitutes the class limit.

Test setup
A defined volume of air is aspirated by an air sampling probe and fed into a test chamber. The particles inside this test chamber are monitored and recorded appropriately.

Exceeding the relevant limit values is decisive in order to classify the luminaires. If a limit value is not exceeded with a certainty of at least 95 %, the respective item of equipment may be regarded as suitable for use in this air cleanliness class.

Details on cleanliness compatibility
In order to be able to confirm **cleanliness compatibility**, as well as, quantities reflecting cleanroom compatibility that can be detected by metrological methods, additional expert assessments and parameters were included in the tests conducted by the Fraunhofer Institute IPA.

Cleanliness compatibility covers a large number of **sector-based cleanliness requirements** such as resistance to chemicals, surface quality, flow behaviour or electrostatic charge characteristics. These are defined in the following **standards and codes of practice**, among others:

Standardisation

General:
- classification of air cleanliness – cleanrooms and associated controlled environments according to DIN EN ISO 14644-1 (Federal Standard 209 has been withdrawn)
- cleanroom technology and cleanroom compatibility of equipment VDI 2083
- EHEDG (European Hygienic Engineering & Design Group)

Industrial application areas:
- GMP Guidelines (Good Manufacturing Practice) – pharmaceuticals
- FDA (Food and Drug Administration) – pharmaceuticals and foodstuffs
- Medicinal Product Law
- EU Pharmaceutical Regulation – Good manufacturing practices Volume 4 – (Medicinal products for human and veterinary use)
- Hazard Analytical Control Point (HACCP) Regulations – foodstuffs

Hospital application areas:
- VDI 2167 Building services in hospitals
- DIN 1946-4 Ventilation and air conditioning Part 4 (Ventilation in hospitals)

Airflow systems in cleanrooms
One of the basic criteria for the requirements placed on equipment in cleanrooms is the nature of the airflow system. The CLEAN luminaire has been designed for use in all cleanroom classes with a **turbulent mixed airflow**. In this commonly encountered airflow system, air enters the room with a turbulent flow, thereby causing continuous dilution and “cleaning”. According to GMP (Good Manufacturing Practice) classification, cleanroom Classes C to E and ISO Classes 6 to 9 can be achieved using this airflow system.

Cleanrooms with **low-turbulence displacement flow**, which are more expensive to build, allow air to initially enter the cleanroom with low turbulence. The design of laminar flow cleanrooms precludes the use of any luminaires other than extremely slim batten luminaires which disrupt the directional flow of air as little as possible. The laminar flow system minimises contamination, and any contaminant is quickly eliminated. Cleanrooms in ISO Classes 1 to 6 and GMP Classes A and B are areas where this airflow system is used.

Fusing and rating of circuits

Tripping values of line circuit-breakers

Tripping characteristics	Tripping current
B (quick-acting)	3 to 5-fold rated current
C	5 to 10-fold rated current

For the operation of luminaires, automatic circuit breakers with C characteristics are recommended. In case of multipolar circuit breakers, the values specified by the manufacturer must be reduced by 20 %. The levels indicated in the table refer to simultaneous switch-on at the mains voltage peak with U_N = 230 V.

Please note: the values given in the table are intended as reference values only and may deviate in individual cases. The specific range and type, as well as, the actual number of ballasts per luminaire must be taken into account. In case of metal halide lamps, the switch-on current is increased by ignition time shunting. In case of connection to circuit breakers with B characteristics, transformers should not be loaded above rating in order to avoid false tripping.

Loading of automatic circuit breakers for metal halide lamps – maximum recommended number of electronic ballasts per automatic circuit breaker

Electronic ballasts for HIT/HIT-DE/HIE and HIT-CE/HIT-TC-C²E/HIT-DE-CE/HIE-CE metal halide lamps, non-dimmable (TRIDONIC PCI range):

	C10	**C13**	**C16**	**C20**	**B10**	**B13**	**B16**	**B20**
mm^2	1.5	1.5	1.5	2.5	1.5	1.5	1.5	2.5
1/20 W HI	24	33	42	48	12	15	19	19
1/35 W HI	16	22	28	32	8	10	13	13
1/70 W HI	10	18	26	30	6	10	13	13
1/150 W HI	7	14	20	20	4	6	7	7

Loading of automatic circuit breakers for electronic ballasts for fluorescent and compact fluorescent lamps – maximum recommended number of electronic ballasts per automatic circuit breaker

Electronic ballasts for T16 fluorescent lamps, not dimmable (TRIDONIC PC T5 PRO range):

	C10	C13	C16	C20	B10	B13	B16	B20
mm²	1.5	1.5	1.5	2.5	1.5	1.5	1.5	2.5
1/14 W T16	46	80	80	140	23	40	40	70
2/14 W T16	46	80	80	140	23	40	40	70
3/14 W T16	30	46	50	64	15	23	25	32
4/14 W T16	30	46	50	64	15	23	25	32
1/21 W T16	46	80	86	98	23	40	43	49
2/21 W T16	46	78	80	100	23	39	40	50
1/28 W T16	44	78	80	90	22	39	40	45
2/28 W T16	18	28	30	36	9	14	15	18
1/35 W T16	46	80	80	140	23	40	40	70
2/35 W T16	20	30	30	44	10	15	15	22
1/24 W T16	46	80	80	140	23	40	40	70
2/24 W T16	30	50	50	64	15	25	25	32
1/39 W T16	30	40	50	60	15	20	25	30
2/39 W T16	18	28	30	36	9	14	15	18
1/54 W T16	30	46	50	80	15	23	25	40
2/54 W T16	14	20	24	30	7	10	12	15
1/49 W T16	30	46	50	58	15	23	25	29
2/49 W T16	18	28	30	36	9	14	15	18
1/80 W T16	18	28	30	36	9	14	15	18

Electronic ballasts for T16 fluorescent lamps, Basic dimmable/DALI-dimmable (TRIDONIC PCA T5 ECO/PCA T5 EXCEL one4all ranges):

	C10	C13	C16	C20	B10	B13	B16	B20
mm^2	1.5	1.5	1.5	2.5	1.5	1.5	1.5	2.5
1/14 W T16	30	50	70	80	15	25	35	40
2/14 W T16	22	32	44	50	11	16	22	25
3/14 W T16	16	26	34	42	8	13	17	21
4/14 W T16	16	24	34	38	8	12	17	19
1/21 W T16	30	50	70	76	15	25	35	38
2/21 W T16	22	32	44	50	11	16	22	25
1/28 W T16	32	50	72	80	16	25	36	40
2/28 W T16	16	22	30	34	8	11	15	17
1/35 W T16	32	50	70	80	16	25	35	40
2/35 W T16	16	22	30	34	8	11	15	17
1/24 W T16	22	32	44	50	11	16	22	25
2/24 W T16	22	32	46	52	11	16	23	26
1/39 W T16	22	32	44	50	11	16	22	25
2/39 W T16	14	22	28	34	7	11	14	17
1/54 W T16	22	32	44	50	11	16	22	25
2/54 W T16	14	22	28	34	7	11	14	17
1/80 W T16	10	20	30	30	5	10	15	15

Electronic ballasts for T26 fluorescent lamps, non-dimmable (TRIDONIC PC E011/PC T8 PRO ranges):

	C10	C13	C16	C20	B10	B13	B16	B20
mm^2	1.5	1.5	1.5	2.5	1.5	1.5	1.5	2.5
1/18 W T26	46/46	80/80	104/140	110/140	23/23	40/40	52/70	55/70
2/18 W T26	30/44	46/80	68/140	84/140	15/22	23/40	34/70	42/70
3/18 W T26	32/–	46/–	66/–	80/–	16/–	23/–	33/–	40/–
4/18 W T26	20/–	30/–	40/–	44/–	10/–	15/–	20/–	22/–
1/36 W T26	32/46	48/80	70/140	84/140	16/23	24/40	35/70	42/70
2/36 W T26	20/20	30/30	40/42	44/44	10/10	15/15	20/21	22/22
1/58 W T26	32/32	46/46	66/66	80/80	16/16	23/23	33/33	40/40
2/58 W T26	14/14	20/20	26/26	30/30	7/7	10/10	13/13	15/15

Electronic ballasts for T26 fluorescent lamps, Basic dimmable/DALI-dimmable (TRIDONIC PCA T8 ECO/PCA T8 EXCEL one4all ranges):

	C10	C13	C16	C20	B10	B13	B16	B20
mm^2	1.5	1.5	1.5	2.5	1.5	1.5	1.5	2.5
1/18 W T26	30	50	80	80	15	25	40	40
2/18 W T26	20	30	40	46	10	15	20	23
3/18 W T26	12	18	24	30	6	9	12	15
4/18 W T26	12	16	24	28	6	8	12	14
1/30 W T26	30	50	70	76	15	25	35	38
2/30 W T26	10	20	30	30	5	10	15	15
1/36 W T26	30	50	70	76	15	25	35	38
2/36 W T26	10	20	30	30	5	10	15	15
1/58 W T26	20	30	40	46	10	15	20	23
2/58 W T26	10	20	30	30	5	10	15	15

Electronic ballasts for TC-L compact fluorescent lamps, Basic dimmable/DALI-dimmable (TRIDONIC PCA TCL ECO/PCA TCL EXCEL one4all ranges):

	C10	C13	C16	C20	B10	B13	B16	B20
mm^2	1.5	1.5	1.5	2.5	1.5	1.5	1.5	2.5
1/18 W TC-L	52	56	64	96	26	28	32	48
2/18 W TC-L	52	56	64	96	26	28	32	48
1/24 W TC-L	52	56	64	96	26	28	32	48
2/24 W TC-L	20	26	32	40	10	13	16	20
1/36 W TC-L	30	50	70	76	15	25	35	38
2/36 W TC-L	10	20	30	30	5	10	15	15
1/40 W TC-L	30	50	70	76	15	25	35	38
2/40 W TC-L	10	20	30	30	5	10	15	15
1/55 W TC-L	20	30	40	46	10	15	20	23
2/55 W TC-L	10	14	18	20	5	7	9	10
1/80 W TC-L	10	20	30	30	5	10	15	15

Electronic ballasts for TC-L compact fluorescent lamps, non-dimmable (TRIDONIC PC PRO FSD ranges):

	C10	C13	C16	C20	B10	B13	B16	B20
mm^2	1.5	1.5	1.5	2.5	1.5	1.5	1.5	2.5
1/18 W TC-L	30	50	80	80	15	25	40	40
2/18 W TC-L	30	50	80	80	15	25	40	40
1/24 W TC-L	30	50	80	80	15	25	40	40
2/24 W TC-L	30	50	80	80	15	25	40	40
1/36 W TC-L	80	80	80	100	40	40	40	50
2/36 W TC-L	20	30	40	40	10	15	20	20
1/40 W TC-L	30	50	80	80	15	25	40	40
2/40 W TC-L	14	20	26	30	7	10	13	15
1/55 W TC-L	20	30	40	40	10	15	20	20
2/55 W TC-L	10	14	20	22	5	7	10	11
1/80 W TC-L	18	28	30	36	9	14	15	18

Loading of automatic circuit breakers for electronic ballasts for fluorescent and compact fluorescent lamps – maximum recommended number of electronic ballasts per automatic circuit breaker

Electronic ballasts for TC-DEL/TEL fluorescent lamps, non-dimmable (TRIDONIC PC PRO range):

	C10	C13	C16	C20	B10	B13	B16	B20
mm^2	1.5	1.5	1.5	2.5	1.5	1.5	1.5	2.5
1/13 W TC-DEL/TC-TEL	80	80	80	100	40	40	40	50
2/13 W TC-DEL/TC-TEL	80	80	80	100	40	40	40	50
1/18 W TC-DEL/TC-TEL	80	80	80	100	40	40	40	50
2/18 W TC-DEL/TC-TEL	30	50	80	80	15	25	40	40
1/26 W TC-DEL/TC-TEL	30	50	80	80	15	25	40	40
2/26 W TC-DEL/TC-TEL	32	50	80	80	16	25	40	40
1/32 W TC-TEL	30	50	80	80	15	25	40	40
2/32 W TC-TEL	16	22	30	44	8	11	15	22
1/42 W TC-TEL	30	50	80	80	15	25	40	40
2/42 W TC-TEL	16	22	30	44	8	11	15	22
1/57 W TC-TEL	20	30	30	44	10	15	15	22

Electronic ballasts for TC-DEL/TEL compact fluorescent lamps Basic dimmable/DALI-dimmable (TRIDONIC PCA ECO/PCA EXCEL one4all ranges):

	C10	C13	C16	C20	B10	B13	B16	B20
mm^2	1.5	1.5	1.5	2.5	1.5	1.5	1.5	2.5
1/13 W TC-DEL/TC-TEL	40	60	80	80	20	30	40	40
2/13 W TC-DEL/TC-TEL	28	40	60	64	14	20	30	32
1/18 W TC-DEL/TC-TEL	30	50	70	76	15	25	35	38
2/18 W TC-DEL/TC-TEL	22	32	46	68	11	16	23	34
1/26 W TC-DEL/TC-TEL	30	50	70	76	15	25	35	38
2/26 W TC-DEL/TC-TEL	22	32	46	56	11	16	23	28
1/32 W TC-TEL	26	38	50	58	13	19	25	29
2/32 W TC-TEL	10	18	24	28	5	9	12	14
1/42 W TC-TEL	26	38	50	58	13	19	25	29
2/42 W TC-TEL	10	18	24	28	5	9	12	14

Loading of automatic circuit breakers for low-voltage halogen incandescent lamps – maximum recommended number of transformers per automatic circuit breaker

Magnetic transformers for QT/QR/QR-CB(C) halogen incandescent lamps (TRIDONIC TMBx/OMTx ranges):

Power	**C10**	**C16**	**B10**	**B16**
20 W	58	93	29	46
35 W	41	65	20	32
50 W	21	35	10	17
70 W	15	24	7	12
80 W	14	22	7	11
105 W	8	13	4	6
150 W	4	6	2	3
210 W	2–3	4–5	1	2
300 W	1–2	2–3	n.r.	1

n.r. = not recommended

Magnetic transformers for QT/QR/QR-CB(C) halogen incandescent lamps (TRIDONIC OGT range):

Power	**C10**	**C16**	**B10**	**B16**
250 W	3–4	5–6	1–2	2–3
300 W	2	3–4	1	1–2
500 W	1	1–2	n.r.	n.r.

n.r. = not recommended

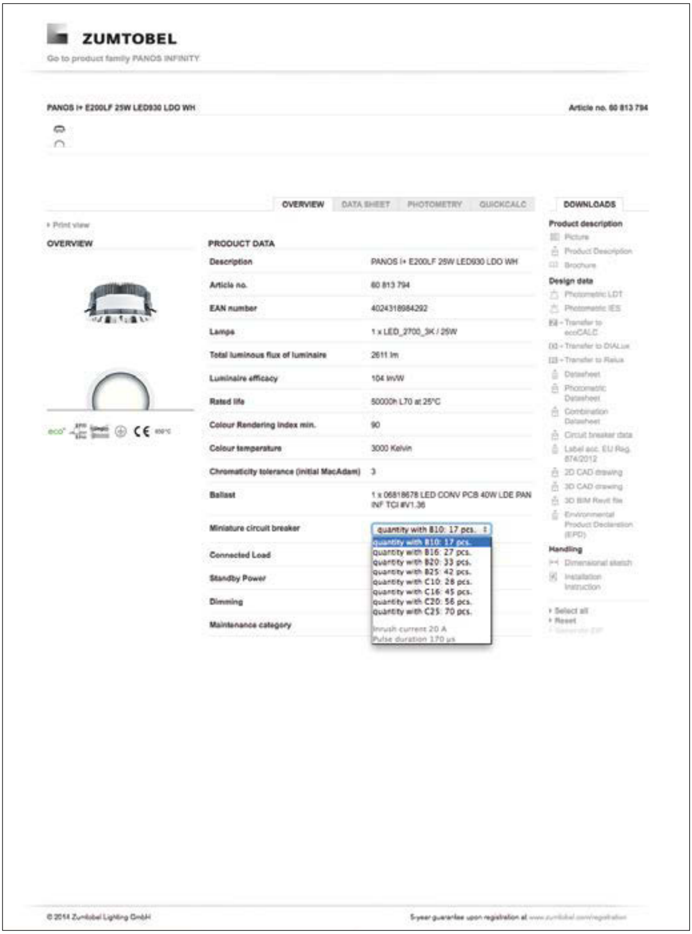
Magnetic transformers for QT/QR/QR-CB(C) halogen incandescent lamps (TRIDONIC TMAx/TMDx ranges):

Power	**C10**	**C16**	**B10**	**B16**
20 W	42	67	21	33
35 W	35	56	17	28
40 W	26	43	13	21
50 W	23	37	11	18
60 W	21	33	10	16
70 W	16	26	8	13
80 W	13	21	6	10
105 W	9	14	4	7

Line circuit breaker ratings for LED downlights and spotlights – maximum number of DL recommended per line circuit breaker

The type of automatic circuit breakers and the corresponding maximum number of luminaires are specified in Zumtobel's online catalogue. Moreover, the LED luminaire's switch-on current and pulse width are also indicated at the bottom of the table.

Information about line circuit breakers is available at the respective product page under:
zumtobel.com/com-en/products



Impact on materials

No material is resistant to all chemical influences.

This is not really surprising, as there are so many chemicals and so many effects; in fact, they fill whole volumes with resistance tables.

When assessing potential hazards, the degree of saturation of chemical substances and the ambient temperature must be taken into account.

The accompanying tables therefore only provide a brief overview of frequently encountered applications and chemical impact.

If you are unsure or have specific questions, your Zumtobel adviser will be happy to assist.

Excellent properties

	PC	PMMA	CHEMO	Polyester
IK code	08	03	07	03
UV resistance	+ **	++	++	++
Shock resistance	6 Nm	0.2 Nm	4 Nm	0.35 Nm
Resistance to ageing	+ *	++	++	++
Silicone-free	Yes	Yes	Yes	Yes
Halogen-free	Yes	Yes	Yes	Yes
International Food Standards (IFS) certification	Yes	Yes	Yes	Yes
Glow-wire tested	850 °C	650 °C	850 °C	850 °C
Heat resistance of luminaire plastics	130 °C	90 °C*	122 °C	
Flammability acc. to UL94 (ISO 60695)	V2	HB	HB	HB
UV transmittance	89 %	91 %	89 %	

* limited UV stability of PC ** UV stabilised

Recommendations according to application area

	PC	PMMA	CHEMO
Damp locations			
Bake houses	•	•	•
Damp cellars	–	•	••
Fodder kitchens	•	•	•
Large-scale catering establishments	•	•	•

•• highly recommended • suitable – unsuitable

-> to be continued on the next page

* with plastic catches and special ceiling brackets (available on request)

	PC	PMMA	CHEMO
Wet locations			
Beer and wine cellars	•	•	•
Breweries	–	•	••
Wine cellars (using sulphur to steam out barrels)	–	••	••
Damp pump rooms	•	•	•
Meat-processing facilities	–	•	••
Electroplating plants (caution: do not use V2A)	–	• *	• *
Conservatories	•	•	•
Cheese dairies	–	••	••
Dairies	–	•	•
Washing bays/car washes (motor vehicles)	–	•	•
Rooms or areas in bathhouses or laundries	•	•	•
Bathrooms/shower rooms	•	•	•
Thermal spas and brine baths	•	•	•
Agricultural premises			
Fodder preparation	•	•	•
Greenhouses	•	•	•
Storage areas/storerooms for hay, straw, fodder, fertilisers	••	•	•
Areas for animal husbandry (stables)	–	••	•
Locations exposed to fire hazards (only version with electronic ballast is fire resistant)			
Woodworking	•	•	•
Paper processing	–	••	•
Textile processing plants	–	••	•
Theatre workshops	•	•	•
Drying rooms	•	•	•
Garages	•	•	•
Underground garages	•	•	•
Car parks	•	•	•
Private garages	•	•	•
Vehicle depots	•	•	•
Outdoor facilities			
Facilities on ramps (canopied)	•	•	•
Gateways (canopied)	•	•	•
Canopied railway platforms	•	•	•
Canopied petrol stations	•	•	•
Canopy roofs	•	•	•

Chemical resistance of materials

	PC	PMMA	CHEMO	Polyester
Acetic acid up to 5 %	•	•	•	•
Acetic acid up to 30 %	•	–	–	•
Acetone	–	–	•	–
Aliphatic hydrocarbons	•	•	•	•
Ammonia 25 %	–	•	•	•
Aniline	–	–	–	–
Aromatic hydrocarbons	–	–	•	•
Battery acid	•	•	•	•
Beer	•	•	•	•
Benzene	–	–	•	–
Blood	•	•	•	•
Bromic acid	–	–	–	–
Carbon dioxide	•	•	•	•
Carbon monoxide	•	•	•	•
Carbon tetrachloride	–	–	•	•
Caustic potash solution 30 %	–	•	•	–
Chloroform	–	–	•	–
Chlorophenol	–	–	–	–
Cleaner’s naphtha (solvent)	•	•	•	•
Cresol	–	–	–	–
Dichloromethane	–	–	•	–
Diesel fuel	–	•	•	•
Diesel oil, crude oil	•	•	•	•
Dimethyl benzene	–	–	•	–
Dioxane	–	–	•	•
Ethanol < 30 %	•	•	•	•
Ethanol > 30 %	•	–	•	•
Ether	–	–	•	•
Ethyl acetate	–	–	•	–
Fats: animal	–	•	•	•
Fats: mineral	–	•	•	•
Fats: vegetable	–	•	•	•
Four-star petrol	–	–	•	•
Fuel oil	–	•	•	•
Glycerol	•	•	•	•

• resistant
– not resistant

	PC	PMMA	CHEMO	Polyester
Glycol	•	•	•	•
Glysantin®	•	•	•	•
Hydrochloric acid (HCl) < 20 %	•	•	•	•
Hydrochloric acid (HCl) > 20 %	•	•	–	•
Hydrogen peroxide over 40 %	•	–	•	–
Hydrogen peroxide up to 40 %	•	•	•	–
Hydrogen sulphide	•	•	•	•
Isopropyl alcohol	•	–	•	•
Ketones	–	–	•	–
Methyl alcohol	–	–	•	–
Milk of lime	•	•	•	•
Nitric acid over 20 %	–	–	–	–
Nitric acid up to 10 %	•	•	–	•
Nitric acid up to 20 %	•	•	–	•
Petroleum ether	•	•	•	•
Phenol	–	–	–	–
Pyridine	–	–	•	–
Regular petrol	•	–	•	•
Seawater	•	•	•	•
Silicone oil	•	•	•	•
Soapsuds	•	•	•	•
Soda	•	•	•	•
Sodium hydroxide solution 2 %	–	•	•	•
Sodium hydroxide solution 10 %	–	•	•	–
Solution of sodium chloride	•	•	•	•
Spirit of turpentine	•	•	•	•
Sulphuric acid (H_2SO_4) < 50 %	•	•	•	•
Sulphuric acid (H_2SO_4) < 70 %	•	•	–	•
Sulphuric acid (H_2SO_4) > 70 %	–	–	–	–
Sulphuric acid (H_2SO_4) > 98 %	–	–	–	–
Sulphurous acid up to 5 %	–	•	•	•
Synthetic detergent solution	•	•	•	•
Toluene	–	–	•	–
Trichloroethane	–	–	•	•
Water up to 60 °C	•	•	•	•

- • resistant
- – not resistant

The information given is valid under the following conditions: the chemical substance listed in the table is a basic material and not part of a chemical compound. The ambient temperature is 22 °C.

Maintenance of lighting systems

Today, the maintenance of lighting installations is a decisive factor in an installation's balance of costs.

According to the formula below (1), a lighting level required of E_m = 500 lx at a standard maintenance factor of MF = 0.67 implies a new illuminance level of E_{new} = 750 lx.

E_m: maintained illuminance = maintenance value of illuminance

(1) $\mathbf{E_m = E_{neu} \times MF}$

Benefit of a high MF
– lower luminaire investment costs
– reduced energy costs

Benefit of a low MF
– low maintenance costs
– longer maintenance intervals

Please note: at a lower maintenance factor, illuminance may be constantly dimmed to the maintenance value to save energy (maintenance control).

The maintenance factor includes 4 components

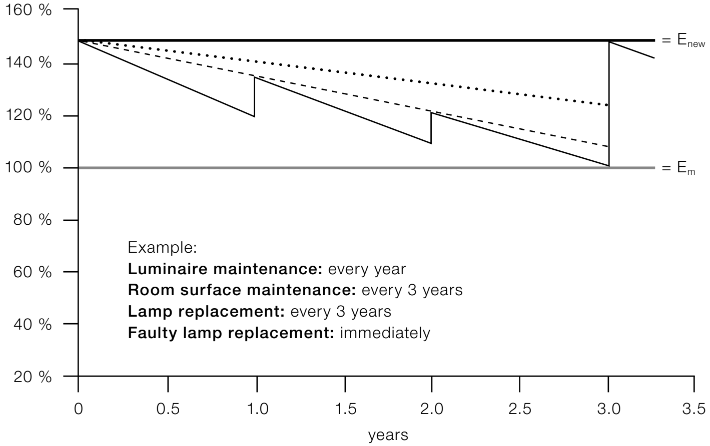
(2) **MF = LLMF x LSF x LMF x RMF**

All these factors describe the decrease in illuminance. The maximum in each case is 1, corresponding to the new value. At the respective time of maintenance, the various causes of the decrease in illuminance must be identified.

Maintenance factor components
– Lamp luminous flux mainten. factor LLMF
– Lamp survival factor LSF
– Luminaire maintenance factor LMF
– Room maintenance factor RMF

Causes of illuminance decrease
– Ageing of lamps
– Failure of lamps
– Soiling of luminaire
– Soiling of room

Options for improving the maintenance factor
– lamp replacement already before the lamp service life ends (LLMF/LSF↗)
– immediate replacement of lamps in case of failure (LSF = 1)
– use of closed luminaires (LWF7↗)
– more frequent room cleaning (RWF7↗)



Environmental conditions

In case you are not familiar with the application, the following standard values apply; however, the tables below will help you calculate the accurate maintenance factor according to formula (2).

Ambient condition	Maintenance interval recommended	Working areas	Reference maintenance factor
Very Clean (**VC**)	3 years	Cleanrooms, data centres, assembly workstations for electronic components	0.80
Clean (**C**)	3 years	Offices Schools	0.67
Normal (**N**)	2 years	Shops Laboratories Restaurants Warehouses Assembly bays	0.57
Soiled (**S**)	1 year	Steel works Chemical plants Foundries Welding shops Grinding shops Wood processing	0.50

According to CIE – volume 97,
“Maintenance of indoor electric lighting systems”, as at 2005

Lamp luminous flux maintenance factor (LLMF) and lamp survival factor (LSF)

Lamps		Service life given in hours						
		100	500	1000	1500	2000	4000	6000
Halogen incandescent lamp CIE97:2005	LLMF	1.00	0.99	0.97		0.95		
	LSF	1.00	1.00	0.78		0.50		
T26 (low-loss ballast) triple-band fluor. lamp ZVEI 2005	LLMF	1.00	0.99	0.98	0.97	0.96	0.95	0.94
	LSF	1.00	1.00	0.99	0.99	0.98	0.98	0.97
T26 (electronic ballast) triple-band fluor. lamp ZVEI 2005/CIE97:2005	LLMF	1.00	0.99	0.98	0.97	0.96	0.95	0.94
	LSF	1.00	1.00	1.00	1.00	1.00	0.99	0.99
T26 (el. ballast) triple-band fluor. lamp, long-life Philips MASTER TL-D Xtreme (long life)	LLMF	1.00	0.99	0.99	0.98	0.98	0.98	0.97
	LSF	1.00	1.00	1.00	1.00	1.00	1.00	1.00
T26 (el. ballast) triple-band fluor. lamp, long-life AURA Ultimate LL (long life)	LLMF	1.00	1.00	1.00	1.00	0.98	0.98	0.97
	LSF	1.00	1.00	1.00	1.00	1.00	1.00	1.00
T16 (electronic ballast) triple-band ZVEI 2005	LLMF	1.00	0.99	0.98	0.97	0.96	0.95	0.94
	LSF	1.00	1.00	1.00	1.00	1.00	0.99	0.99
T16 (el. ballast) triple-band fluor. lamp, long-life AURA SUPREME T5 HO LL (long life)	LLMF	1.00	1.00	0.99	0.99	0.98	0.96	0.95
	LSF	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Compact fluorescent lamp CIE97:2005	LLMF	1.00	0.98	0.97		0.94	0.91	0.89
	LSF	1.00	0.99	0.99		0.98	0.97	0.94
TC-S, TC-D, TC-T 5–26 W (low-loss ballast) **Compact fluorescent lamp** ZVEI 2005	LLMF	1.00	0.98	0.97	0.95	0.93	0.86	0.83
	LSF	1.00	1.00	1.00	0.99	0.98	0.97	0.95
TC-SEL, TC-TEL 5–42 W (electronic ballast) **Compact fluorescent lamp** ZVEI 2005	LLMF	1.00	0.98	0.96	0.94	0.93	0.87	0.84
	LSF	1.00	1.00	0.99	0.99	0.99	0.98	0.97
TC-DEL 10–26 W (electronic ballast) **Compact fluorescent lamp** ZVEI 2005	LLMF	1.00	0.98	0.96	0.94	0.92	0.87	0.85
	LSF	1.00	1.00	1.00	0.99	0.99	0.98	0.97
TC-L 18–36 W (low-loss ballast) **Compact fluorescent lamp** ZVEI 2005	LLMF	1.00	0.99	0.98	0.97	0.96	0.92	0.90
	LSF	1.00	1.00	1.00	1.00	1.00	1.00	0.99
TC-L 18–80 W (electronic ballast) **Compact fluorescent lamp** ZVEI 2005	LLMF	1.00	0.99	0.98	0.97	0.97	0.94	0.93
	LSF	1.00	1.00	1.00	1.00	1.00	0.99	0.99

Values acc. to specifications by lamp manufacturers, January 2008, acc. to CIE97:2005
Technical report “Guide on the Maintenance of Indoor Electric Lighting Systems” 2nd edition, and ZVEI publication “Service life behaviour of discharge lamps for lighting” of November 2005.
For data of lamps by other manufacturers or other lamp types, please contact the respective manufacturer directly.
The use of state-of-the-art ballast technology is a prerequisite.
The switching frequency has a major influence on lamp survival.
Most data are based on the standardised 3-hour switching rhythm acc. to IEC (2.75 h ON, 0.25 h OFF).

8000	10000	12000	14000	16000	18000	20000	22000	24000	30000	35000	40000	45000
0.93	0.92	0.92	0.91									
0.95	0.93	0.83	0.60									
0.93	0.92	0.92	0.91	0.90	0.90	0.90						
0.98	0.98	0.97	0.95	0.90	0.75	0.50						
0.96	0.95	0.95	0.94	0.94	0.93	0.93	0.93	0.92	0.91	0.90	0.90	0.90
1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.98	0.90	0.70
0.97	0.97	0.96	0.95	0.95	0.94	0.94	0.94	0.93	0.92	0.91	0.91	0.91
1.00	1.00	1.00	1.00	1.00	1.00	0.99	0.99	0.99	0.99	0.99	0.99	0.99
0.93	0.92	0.92	0.91	0.90	0.90	0.90	0.90	0.89				
0.98	0.98	0.98	0.97	0.97	0.96	0.91	0.80	0.50				
0.94	0.93	0.92	0.91	0.90	0.90	0.90	0.90	0.89	0.89	0.88	0.88	0.88
1.00	1.00	1.00	1.00	0.99	0.99	0.99	0.99	0.99	0.99	0.98	0.98	0.98
0.87	0.85											
0.86	0.50											
0.80	0.78											
0.81	0.60											
0.82	0.80	0.79										
0.93	0.76	0.55										
0.82	0.80	0.79	0.78									
0.96	0.91	0.80	0.60									
0.89	0.88	0.88	0.88									
0.98	0.95	0.86	0.62									
0.91	0.90	0.90	0.90	0.90	0.90	0.89						
0.98	0.98	0.96	0.95	0.90	0.75	0.50						

Lamp luminous flux maintenance factor (LLMF) and lamp survival factor (LSF)

Lamps		Service life given in hours						
		100	500	1000	1500	2000	4000	6000
Metal halide lamp Ceramic (50–150 W) CIE97:2005	LLMF	1.00	0.95	0.87		0.75	0.72	0.68
	LSF	1.00	0.99	0.99		0.98	0.98	0.98
Metal halide lamp Ceramic Philips CDM-T 70 W/Elite	LLMF	1.00	0.99	0.98	0.96	0.95	0.91	0.87
	LSF	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Metal halide lamp Ceramic Osram HCI-T 150 W/WDL PB	LLMF	1.00	0.93	0.88	0.87	0.86	0.80	0.77
	LSF	1.00	1.00	1.00	1.00	0.99	0.99	0.98
Metal halide lamp Ceramic Osram HCI 250 W PB	LLMF	1.00	0.96	0.92	0.91	0.90	0.87	0.84
	LSF	1.00	0.99	0.98	0.98	0.97	0.94	0.90
Metal halide lamp Quartz (250/400 W) CIE97:2005	LLMF	1.00	0.98	0.95		0.90	0.87	0.83
	LSF	1.00	0.99	0.99		0.98	0.97	0.92
Metal halide lamp Quartz Osram HQI-E 250 W/D	LLMF	0.99	0.98	0.92	0.88	0.85	0.80	0.75
	LSF	1.00	0.99	0.98	0.97	0.95	0.91	0.86
Metal halide lamp Quartz Osram HQI-E 400 W/D	LLMF	1.00	0.97	0.93	0.88	0.85	0.80	0.78
	LSF	1.00	0.99	0.98	0.97	0.95	0.91	0.86
Metal halide lamp Quartz Osram HQI-BT 400 W/N	LLMF	1.00	0.97	0.92	0.87	0.83	0.77	0.73
	LSF	1.00	0.99	0.98	0.97	0.95	0.91	0.86
Metal halide lamp Quartz Philips HPI-T Plus 250/400 W	LLMF	1.00	0.98	0.96	0.93	0.92	0.86	0.83
	LSF	1.00	1.00	0.99	0.99	0.99	0.98	0.96
Sodium vapour lamp 50/70 W ZVEI 2005	LLMF	1.00	0.99	0.98	0.97	0.96	0.93	0.90
	LSF	1.00	1.00	0.99	0.99	0.98	0.97	0.96
Sodium vapour lamp 150–400 W (standard luminous flux level) ZVEI 2005	LLMF	1.00	0.99	0.98	0.97	0.96	0.93	0.92
	LSF	1.00	1.00	0.99	0.98	0.98	0.97	0.97
Sodium vapour lamp 150–400 W (increased luminous flux level) ZVEI 2005	LLMF	1.00	0.99	0.99	0.98	0.97	0.96	0.95
	LSF	1.00	1.00	1.00	1.00	0.99	0.98	0.98
Sodium vapour lamp Philips SON(-T) PIA Plus 100–400 W	LLMF	1.00	0.99	0.99	0.98	0.98	0.97	0.97
	LSF	1.00	1.00	1.00	1.00	1.00	1.00	0.99

Values acc. to specifications by lamp manufacturers, January 2008, acc. to CIE97:2005
Technical report “Guide on the Maintenance of Indoor Electric Lighting Systems” 2nd edition, and ZVEI publication “Service life behaviour of discharge lamps for lighting” of November 2005.
For data of lamps by other manufacturers or other lamp types, please contact the respective manufacturer directly.
The use of state-of-the-art ballast technology is a prerequisite.
The switching frequency has a major influence on lamp survival.
Most data are based on the standardised 3-hour switching rhythm acc. to IEC (2.75 h ON, 0.25 h OFF).

8000	10000	12000	14000	16000	18000	20000	22000	24000	30000	35000	40000	45000
0.64	0.60	0.56										
0.95	0.80	0.50										
0.85	0.81	0.80										
0.98	0.90	0.50										
0.73	0.71	0.69										
0.96	0.88	0.70										
0.81	0.80	0.75										
0.85	0.75	0.62										
0.79	0.65	0.63	0.60	0.56	0.53	0.50						
0.86	0.80	0.73	0.68	0.63	0.55	0.50						
0.70	0.69	0.65										
0.79	0.70	0.61										
0.74	0.71	0.69										
0.79	0.70	0.61										
0.72	0.70	0.69										
0.79	0.70	0.61										
0.80	0.78	0.76	0.74	0.73	0.72	0.71						
0.93	0.89	0.84	0.75	0.66	0.59	0.50						
0.89	0.88	0.88	0.87	0.87	0.87	0.86	0.85					
0.93	0.92	0.89	0.84	0.79	0.72	0.63	0.50					
0.91	0.90	0.89	0.88	0.88	0.88	0.88	0.87	0.87				
0.96	0.95	0.93	0.92	0.90	0.88	0.84	0.79	0.70				
0.94	0.93	0.92	0.92	0.91	0.91	0.90	0.90	0.90				
0.97	0.97	0.95	0.93	0.92	0.90	0.86	0.81	0.73				
0.96	0.95	0.95	0.94	0.94	0.93	0.93	0.92	0.92	0.90	0.89		
0.98	0.97	0.96	0.93	0.92	0.88	0.86	0.82	0.77	0.55	0.43		

Lamp luminous flux maintenance factor (LLMF) and lamp survival factor (LSF)

LED luminous flux classes* with the following specific values		Service life given in hours							
		1000	**5000**	**10000**	**15000**	**20000**	**25000**	**30000**	**35000*** **
L95 @ 50,000 h	LLMF	1.00	1.00	0.99	0.99	0.98	0.98	0.97	0.97
	LSF	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
L90 @ 50,000 h	LLMF	1.00	0.99	0.98	0.97	0.96	0.95	0.94	0.93
	LSF	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
L85 @ 50,000 h	LLMF	1.00	0.99	0.97	0.96	0.94	0.93	0.91	0.90***
	LSF	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
L80 @ 50,000 h	LLMF	1.00	0.98	0.96	0.94	0.92	0.90	0.88	0.86
	LSF	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
L75 @ 50,000 h	LLMF	1.00	0.98	0.95	0.93	0.90	0.88	0.85	0.83
	LSF	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
L70 @ 50,000 h	LLMF	0.99	0.97	0.94	0.91	0.88	0.85	0.82	0.79
	LSF	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
L65 @ 50,000 h	LLMF	0.99	0.97	0.93	0.90	0.86	0.83	0.79	0.76
	LSF	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
L60 @ 50,000 h	LLMF	0.99	0.96	0.92	0.88	0.84	0.80	0.76	0.72
	LSF	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
L55 @ 50,000 h	LLMF	0.99	0.96	0.91	0.87	0.82	0.78	0.73	0.69
	LSF	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
L50 @ 50,000 h	LLMF	0.99	0.95	0.90	0.85	0.80	0.75	0.70	0.65
	LSF	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

* An LED luminous flux class is characterised by the useful service life Lx (basis selected: 50000 h) at a drop in luminous flux to x % (initial level = 100 %) and an ambient temperature of 25 °C.
Example: the LED luminous flux class at “L80 @ 50000 h” describes a drop in luminous flux to 80 % (LLWF = 0.80) at a useful service life of 50000 h.

The maintenance factor values specified for an LED luminous flux class are intended to facilitate planning. They indicate the prospective luminous flux changes over the course of time.

The maintenance factors for an assumed service life are available for planning purposes.

Please note: the known lamp maintenance factors LLWF and LSF are applied to LED modules, although these are not lamps in the proper meaning of the term. LSF is assumed to be 1, as a total breakdown of the complete LED module can be neglected for planning purposes.

The levels specified are in line with the drafts for IEC 62717 that have not yet been completed at the time of going to press.

40000	45000	50000	55000	60000	65000	70000	75000**	80000	85000	90000	95000	100000
0.96	0.96	0.95	0.95	0.94	0.94	0.93	0.93	0.92	0.92	0.91	0.91	0.90
1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
0.92	0.91	0.90	0.89	0.88	0.87	0.86	0.85	0.84				
1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00				
0.88	0.87	0.85***	0.84	0.82	0.81	0.79	0.78	0.76				
1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00				
0.84	0.82	0.80**	0.78	0.76	0.74	0.72	0.70**					
1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00					
0.80	0.78	0.75	0.73	0.70	0.68	0.65	0.63					
1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00					
0.76	0.73	0.70	0.67	0.64	0.61	0.58	0.55					
1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00					
0.72	0.69	0.65	0.62	0.58								
1.00	1.00	1.00	1.00	1.00								
0.68	0.64	0.60	0.56	0.52								
1.00	1.00	1.00	1.00	1.00								
0.64	0.60	0.55										
1.00	1.00	1.00										
0.60	0.55	0.50										
1.00	1.00	1.00										

LED luminaires can be compared by finding the matching “LLWF and service life” pair of values for the “Lx @ 50 000 h” class in the same line, with LLWF x 100 corresponding to the luminous flux component (in %).

Example: ** L80 @ 50 000 h corresponds to L70 @ 75 000 h
*** L90 @ 35 000 h corresponds to L85 @ 50 000 h

Table for luminaire maintenance factor (LMF)

Luminaire cleaning interval in years	0.5				1.0				1.5	
Environment type	**SC**	**C**	**N**	**S**	**SC**	**C**	**N**	**S**	**SC**	**C**
Luminaire type										
Batten lum. with open light distribution	0.98	0.95	0.92	0.88	0.96	0.93	0.89	0.83	0.95	0.91
Reflector exposed above (self-cleaning effect)	0.96	0.95	0.91	0.88	0.95	0.90	0.86	0.83	0.94	0.87
Reflector enclosed above (no self-cleaning effect)	0.95	0.93	0.89	0.83	0.94	0.89	0.81	0.72	0.93	0.84
Enclosed IP2X	0.94	0.92	0.87	0.83	0.94	0.88	0.82	0.77	0.93	0.85
Dust-proof IP5X	0.94	0.96	0.93	0.91	0.96	0.94	0.90	0.86	0.92	0.92
Indirect luminaires	0.94	0.92	0.89	0.85	0.93	0.86	0.81	0.74	0.91	0.81

From CIE publication 97 “Maintenance of indoor electric lighting systems”, dated 2005, ICBN 3 900 734 34 8
Ambient conditions: VC = very clean, C = clean, N = normal, S = soiled

Table for room surface maintenance factor (RSMF)

Luminaire cleaning interval in years					
Illumination type	**Environment type**	**0**	**0.5**	**1.0**	**1.5**
Direct	**VC**	1.00	0.98	0.97	0.97
	C	1.00	0.96	0.95	0.94
	N	1.00	0.92	0.91	0.90
	S	1.00	0.87	0.86	0.86
Direct/Indirect	**VC**	1.00	0.97	0.96	0.95
	S	1.00	0.93	0.91	0.91
	N	1.00	0.87	0.84	0.84
	S	1.00	0.77	0.75	0.75
Indirect	**VC**	1.00	0.95	0.93	0.92
	C	1.00	0.89	0.86	0.85
	N	1.00	0.77	0.73	0.72
	S	1.00	0.60	0.56	0.55

From CIE publication 97 “Maintenance of indoor electric lighting systems”, dated 2005, ISBN 3 900 734 34 8
The figures in the table above apply to reflection factors 70/50/20 and a medium-sized room (k = 2.5)
Ambient conditions: VC = very clean, S = clean, N = normal, V = soiled

1.5		2.0				2.5				3.0			
N	S	SC	C	N	S	SC	C	N	S	SC	C	N	S
0.87	0.80	0.94	0.89	0.84	0.78	0.93	0.87	0.82	0.75	0.92	0.85	0.79	0.73
0.83	0.79	0.92	0.84	0.80	0.75	0.91	0.82	0.76	0.71	0.87	0.79	0.74	0.68
0.74	0.64	0.91	0.80	0.69	0.59	0.89	0.77	0.64	0.84	0.87	0.74	0.61	0.52
0.79	0.73	0.91	0.83	0.77	0.71	0.90	0.81	0.75	0.68	0.89	0.79	0.73	0.65
0.88	0.83	0.93	0.91	0.86	0.81	0.92	0.90	0.85	0.80	0.92	0.90	0.84	0.79
0.73	0.65	0.77	0.88	0.66	0.57	0.86	0.73	0.60	0.51	0.85	0.70	0.55	0.45

2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0
0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97
0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86
0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91
0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83
0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84
0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72
0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55

Table of burning hours

Working mode/ shift type	Switch-on period Days in use/year	Hours/day	Daylight-based control	Burning hours per lamp and year in hours
24-h shift working,	365	24 h	No	8760 h
Process monitoring/ control	365	24 h	Yes	7300 h
Double shift,	310	16 h	No	4960 h
6 days/week	310	16 h	Yes	3720 h
Single shift,	310	10 h	No	3100 h
6 days/week	310	10 h	Yes	1760 h
Single shift,	258	10 h	No	2580 h
5 days/week	258	10 h	Yes	1550 h

Daylight-based control: the lamps switch on automatically when there is too little daylight available.
Data is based on the assumption that there is sufficient available daylight for half the year.

From CIE publication 97 “Maintenance of indoor electric lighting systems”, dated 2005

Chapter 9

Checklists

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General information – The five steps of lighting design

The five steps of lighting design = help for structuring the lighting design scheme

– Determine lighting REQUIREMENTS
– SELECT lamps, luminaires and lighting management
– Calculate NUMBER of luminaires required
– POSITION luminaires and lighting control
– ANALYSE the results

From experience we know that usually Step 1 = Determine lighting requirements, is not taken into account sufficiently.

The checklist below should help the user to consider key questions for clarifying basic requirements.

Accordingly, requirements are broken down as follows:

- **general conditions**
- **lighting quality requirements**
  - **visual performance**
  - **vista**
  - **visual comfort**
  - **vitality**
  - **empowerment**

The lighting quality criteria are in line with those set by the EU. ELI (Ergonomic Lighting Indicator) was developed in collaboration with ETH Zurich and TU Ilmenau (Prof. Dr. Schierz).

Understanding this task will allow for proper development of a well thought-out lighting solution based on the quality characteristics of lighting (page 10) and project-specific requirements.

Analysis includes the assessment of lighting quality. In the process, the requirement criteria are taken into account. The formulations for assessment differ from the requirements (ELI assessment).

Requirements placed on lighting

Underlying conditions	checked ✓
Utilisation of rooms	☐
Size and height of room	☐
Ceiling structure	☐
Reflection factors	☐
Window areas	☐
Doors, passageways, circulation areas	☐
Multi-task areas	☐
Arrangement and material of furniture	☐
Protection types (foreign bodies and humidity)	☐
Protection classes (electrical installations)	☐
Influence by chemicals	☐
Fire protection	☐
Emergency lighting	☐
Energy consumption limits (kWh/year)	☐
Maximum power requirement (W/m^2)	☐
Budget for initial installation	☐

Checklist 1: Lighting quality requirements (ELI requirements)

Criterion A – Visual performance

How well should the visual task be recognised?
Explanation: Lighting in conformity with relevant standards is decisive for ensuring that the visual task can be identified and the related activities can be carried out. Consideration of the traditional quality characteristics of lighting has a major impact on visual task performance.

At the workstations, …					
… standard visual tasks have to be performed.	-2	-1	0*	1	2
… visual tasks are the same across the whole area.	-2	-1	0	1	2
… colour distinction is required to a common extent.	-2	-1	0	1	2
… no extraordinary changes of viewing direction occur.	-2	-1	0	1	2
Within the visual task area, …					
… hard shadows must be avoided.	-2	-1	0	1	2
… the field of vision should be free from sources of glare.	-2	-1	0	1	2
… reflections must be avoided.	-2	-1	0	1	2

* Minimum criterion, corresponds to values specified in the standards

Mean value Visual task

Criterion B – Vista

How do you want to experience the lighting solution in your environment?
Explanation: In prestigious buildings, for example, light is not only needed for seeing but also enhances the looks of the interior. Light can provide guidance and create a favourable first visual impression of a room.

In the project planned, …					
… the lighting concept should blend in smoothly with the interior design.	1	2	3	4	5
… the lighting concept should be properly geared towards expectations.	1	2	3	4	5
… the lighting concept should facilitate orientation in the room.	1	2	3	4	5
In the project planned, …					
… the first visual impression will be decisive.	1	2	3	4	5
… the perceptible quality of the luminaire will be of major importance.	1	2	3	4	5
… the cleanliness of the room and the lighting will be of major importance.	1	2	3	4	5

1 = does not apply at all; 5 = applies completely

Mean value Vista

Criterion C – Visual comfort

How much visual comfort is required in the room?
Explanation: Light is needed not only in the visual task area, but also for perception in the room. Rooms should be illuminated with uniform brightness and lighting balance.

In the project planned, …					
… users must be particularly protected from annoying sources of glare.	-2	-1	0*	1	2
… it will be particularly important to identify three-dimensional structures in the room.	-2	-1	0	1	2
… the room should provide a bright and inviting impression.	-2	-1	0	1	2
… daylight must be taken into account.	-2	-1	0	1	2
… there must be no flickering light.	-2	-1	0	1	2
… larger dark areas should be avoided.	-2	-1	0	1	2
In the area around the visual task, the room should be illuminated uniformly.	-2	-1	0	1	2

* Minimum criterion, corresponds to values specified in the standards

Mean value Visual comfort

Criterion D – Vitality

How positive should the light's influence be on people?
Explanation: Light significantly influences people's activity and sense of wellbeing. Moreover, it has a positive impact on their health and may even enhance or influence biological processes.

The lighting concept …					
… should make people feel good.	1	2	3	4	5
… should stimulate people.	1	2	3	4	5
In the project planned, …					
… it should be possible, in particular, to adjust the lighting to the brightness level required.	1	2	3	4	5
… the effect to be created should be as natural as possible.	1	2	3	4	5
… people's circadian rhythm should be particularly taken into account.	1	2	3	4	5
In the project planned, special emphasis is put on protection against sources of annoyance or adverse health effects.	1	2	3	4	5

1 = does not apply at all; 5 = applies completely

Mean value Vitality

Criterion E – Empowerment

To what extent should the lighting adjust to my personal requirements?
Explanation: Varying visual requirements, visual tasks or periods of use call for options to individually influence one's lighting situation. Sensors and control systems help users adjust the lighting situation to their personal needs.

In the project planned, …					
… the user should be able to personally influence the lighting situation.	1	2	3	4	5
… a variety of tasks must be taken into account.	1	2	3	4	5
The lighting should be switched automatically.	1	2	3	4	5
Artificial lighting should be controlled by daylight sensors.	1	2	3	4	5
The lighting should be controlled on the basis of time.	1	2	3	4	5
Any future layout changes should be taken into account.	1	2	3	4	5

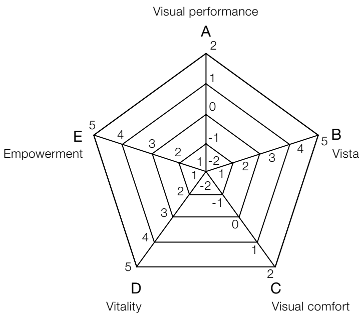
1 = does not apply at all; 5 = applies completely

Mean value Empowerment

ELI – LENI requirements

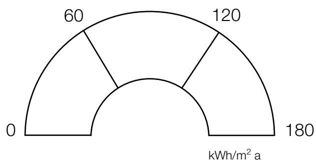
Application: the mean values of the individual criteria are entered on the centre lines of the spider chart.

ELI



LENI

Calculation see page 23



Selection of lamps, luminaires and lighting management	Checked ✓
Lamp type	☐
Luminaire range and model	☐
Lighting management range and modules	☐

Calculate number of luminaires required	Checked ✓
Rough calculation (Quickplan/Quickcalc)	☐
Detailed calculation (Dialux/Relux)	☐
Planning conditions (maintenance, reflection)	☐

Positioning of luminaires and lighting control	Checked ✓
Positioning the luminaires	☐
– structural situation	☐
– orientation (avoid reflections and glare)	☐
– spacings between luminaires (regular patterns)	☐
– peripheries	☐
– alignment	☐
Technical infrastructure (distribution cabinet, clamping compartment, …)	☐
Position of control gear	☐
Emergency lighting	☐

Checklist 2: Lighting quality analysis (ELI assessment)

Criterion A – Visual performance

How well can the visual task be recognised?
Explanation: Lighting in conformity with relevant standards is decisive for ensuring that the visual task can be identified and the related activities can be carried out. Consideration of the traditional quality characteristics of lighting has a major impact on visual task performance.

In the main visual task area, the lighting …					
… complies with the maintenance value of illuminance.	-2	-1	0*	1	2
… provides uniformity of illuminance.	-2	-1	0	1	2
… complies with the colour rendering index.	-2	-1	0	1	2
In the area around the visual task, the illuminance level required is achieved.	-2	-1	0	1	2
In the lighting installation as it exists at present, …					
… annoying hard shadows,	-2	-1	0	1	2
… irritating direct glare	-2	-1	0	1	2
… and annoying reflections are avoided.	-2	-1	0	1	2

* Minimum criterion, corresponds to values specified in the standards

Mean value Visual task

Please note: EN 12464 specifies standard values; values may be lower only if visual tasks are modified. Where there are several task areas, calculate and assess the mean value for all of them.

Criterion B – Vista

How do you experience the lighting solution in your environment?
Explanation: In prestigious buildings, for example, light is not only needed for seeing but also enhances the looks of the interior. Light can provide guidance and create a favourable first visual impression of a room.

The lighting concept …					
… enhances interior design features.	1	2	3	4	5
… fulfils my personal expectations.	1	2	3	4	5
… takes passageways, circulation areas and activity zones into consideration.	1	2	3	4	5
… creates a hierarchy of perception (lighting focuses).	1	2	3	4	5
The luminaires make a high-quality impression.	1	2	3	4	5
The luminaires are neither soiled nor affected by other foreign substances.	1	2	3	4	5

1 = does not apply at all; 5 = applies completely

Mean value Vista

Criterion C – Visual comfort

How much visual comfort is provided in the room?
Explanation: Light is needed not only in the visual task area, but also for perception in the room. Rooms should be illuminated with uniform brightness and lighting balance.

The lighting solution produces no glare (UGR).	-2	-1	0*	1	2
The lighting components are balanced and matched to the room.	-2	-1	0	1	2
The ceiling and walls are pleasantly bright.	-2	-1	0	1	2
The lighting solution …					
… takes daylight into account and uses it.	-2	-1	0	1	2
… does not flicker.	-2	-1	0	1	2
… does not allow major dark areas in the room.	-2	-1	0	1	2
The task area environment is uniformly illuminated.	-2	-1	0	1	2

* Minimum criterion, corresponds to values specified in the standards

Mean value Visual comfort

Criterion D – Vitality

How positive is the light's influence on the people?
Explanation: Light significantly influences people's activity and sense of wellbeing. Moreover, it has a positive impact on their health and may even enhance or influence biological processes.

The lighting …					
… is one of the factors that make me feel good.	1	2	3	4	5
… has a stimulating effect.	1	2	3	4	5
… adjusts to the brightness level required.	1	2	3	4	5
The lighting creates a natural, pleasant effect.	1	2	3	4	5
The lighting stabilises/enhances the users' circadian rhythm.	1	2	3	4	5
There are no sources of annoyance or adverse health effects.	1	2	3	4	5

1 = does not apply at all; 5 = applies completely

Mean value Vitality

Criterion E – Empowerment

To what extent does the lighting adjust to my personal requirements?
Explanation: Varying visual requirements, visual tasks or periods of use call for options to individually influence one's lighting situation. Sensors and control systems help users adjust the lighting situation to their personal needs.

The installation can be switched or dimmed.	1	2	3	4	5
A variety of lighting scenes can be called up.	1	2	3	4	5
Presence detectors make sure that the lighting switches automatically.	1	2	3	4	5
Thanks to daylight sensors, the artificial lighting adjusts to daylight changes over the course of the day.	1	2	3	4	5
Automated, dynamic scenes are available.	1	2	3	4	5
Luminaires and switches can be rearranged flexibly.	1	2	3	4	5
The luminaires are arranged to allow for flexible changes in the room utilisation without major effort.	1	2	3	4	5

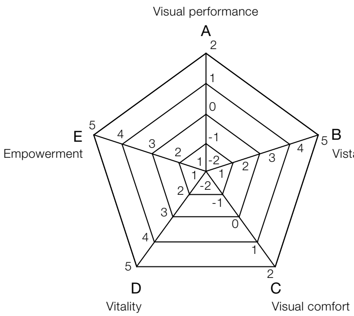
1 = does not apply at all; 5 = applies completely

Mean value Empowerment

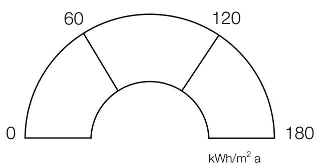
ELI – LENI assessments

Application: the mean values of the individual criteria are entered on the centre lines of the spider chart.

ELI



LENI
Calculation see page 23



Other analyses

Situation regarding standards	
Economic efficiency	
Budget	

Documentation	
Methods of presentation	

General information – Refurbishment of lighting systems

The following list provides clues for discussion with the customer. The potentials stated draw a comparison between contemporary lighting solution options available today with the technology approx. 15 years ago. In a project, viable savings must be accurately calculated in the design stage.

The savings apply only on a case-by-case basis. If several measures are taken, they will complement each other without the levels adding up.

1. Saving energy, CO_2 and costs

Pros	**Potential savings**
1. Advanced materials Today's reflectors and innovative surface finishes provide for more efficient luminaires.	up to –30 %
2. Use of daylight The LUXMATE daylight-based lighting control system provides for high energy savings where sufficient daylight is available.	up to –60 %
3. Improvement of lamps and control gear Innovations in the electronic control of lamps, optimised temperatures and improvements of the lamps' physical properties provide for extensive savings.	up to –40 %
4. Taking ageing into account The balance between the new value and minimum illuminance can be saved by dimmable control (Maintenance Control).	up to –17 %
5. Taking room utilisation into account Using presence detectors or a time-based control system, the lighting can be adjusted precisely to the time/s of use.	up to –25 %

2. Improved ergonomic compatibility

Pros	Potential savings
1. Increased productivity According to various studies, an individual's productivity can be significantly improved by an upgraded lighting solution (e.g. research by TU Ilmenau, AIF no. 9955).	↗
2. Fewer errors According to various studies, people's error rate can be minimised by an upgraded lighting solution (e.g. research by TU Ilmenau, AIF no. 9955).	↗
3. Increased alertness The human physiology is decoded step-by-step, allowing to perfectly adjust the lighting to the individual (e.g. doctoral thesis by Susanne Fleischer, ETH Zürich).	↗
4. Enhanced sense of wellbeing Pleasant brightness levels and personal control can have a positive impact on an individual's sense of wellbeing (e.g. Light Right Consortium).	↗

Please note: It is difficult to provide exact and generally applicable figures; however, measurable increases were achieved in individual cases. Minor increases already result in high economic benefits.

3. Improved maintenance conditions (employment of staff for cleaning, maintenance and monitoring)

Pros	Potential savings
1. Extension of maintenance cycle Over recent years, the service life of lamps has been significantly extended (e.g. AURA SUPREME).	up to +50 %
2. Reduction in maintenance costs Contemporary luminaires frequently come in a closed design, allowing for easy cleaning (e.g. MELLOW LIGHT IV, LIGHTFIELDS, PERLUCE).	up to –30 %
3. Automatic monitoring of installations Today, the facility management tools allow for automatic, central monitoring of installations (e.g. in emergency lighting/ONLITE).	up to –80 %
4. Energy savings Easy cleaning luminaires and extension of the maintenance cycle result in a reduced number of luminaires required, and thus energy savings (e.g. TECTON I IP).	up to –20 %

4. Additional arguments

Pros

1. **Improvements in environmental factors**
   Today, WEEE and RoHS provide the basis for manufacturing luminaires. Environmental impact has been reduced (e.g. lead/cadmium).

2. **State-of-the-art**
   The latest lighting solutions reflect the state-of-the-art and an improved situation in terms of lighting standards.

Collecting data for lighting refurbishment

The following forms are intended to help you collect all relevant data required for evaluating the situation in terms of existing lighting installations. They provide the basis for comparing technical lighting features and for calculating costs.

Checklist 3: Refurbishment of lighting systems

Project	Contact
Address	Tel.
	Fax

Activities in room

	Old system	Option 1	Option 2
Luminaire type A			
Number of luminaires			
Number of lamps per luminaire			
Type of ballast			
System power per luminaire incl. ballast (W)			
Illuminance			
Luminaire type B			
Number of luminaires			
Number of lamps per luminaire			
Type of ballast			
System power per luminaire incl. ballast (W)			
Illuminance			

Total installed load in kW			
ON period each day (h)			
Working days per year			
Annual ON period (h)			
Power consumption in kWh/a			
Annual savings in kWh			
Basic power price kWh/year			
Power costs per kWh			
Annual power costs in kWh			
Annual savings			

Room length		Reflection: wall	%
Room width		ceiling	%
Room height		floor	%

Uniformity

$$g = \frac{E_{min}}{E_{mean}} = \_\_\_\_\_\_\_\_\_\_$$

E_{mean} = lx

E_{min} = lx

Room sketch:

Costs	**Old system**	**Option 1**	**Option 2**
Cleaning per luminaire/year			
Lamp replacement (incl. lamp)			

Checklist 4: Diagnosis in the event of malfunctions in luminaires

1. Fundamental analysis in luminaires with electronic ballast or dimmable electronic ballast:

Error occurring	Possible cause
Luminaire was recently installed but cannot be switched on.	Faulty circuit-breaker/mains fuse
	Faulty cable leading to luminaire
	Ballast power down
	With 3-phase through-wiring in particular, overvoltages (400 V) may have occurred. – N conductor has been confused with L conductor – directly earthed conductor interrupted – unbalanced load
Luminaire worked but suddenly cannot be switched on again.	No re-ignition after lamp replacement
	Faulty lamp
	Wrong lamp
	Faulty lampholder contact

2. Additional tests for luminaires with dimmable electronic ballast:

Error occurring	Possible cause
Dimmable luminaire already worked but suddenly cannot be switched on again.	Ballast power down in switchDIM installations
	Ballast power down in LM and/or DALI bus installations
	Problems with signal line and/or bus line (faulty bus)

Possible solution	Note	Checked ✓
After checking, perhaps install new circuit-breaker/fuse.		☐
Measure voltage at luminaire terminal. Fix wiring at input end.	230 V ± 10 %	☐
Use mains fuse to briefly switch off luminaire power, then switch on again.	Power reset	☐
Visually check electronic ballasts if there are any burn marks at mains input. Replace all units affected.		☐
Use mains fuse to briefly switch off luminaire power, then switch on again.	Power reset	☐
Check cause: replace lamp/s for working lamp/s from adjacent luminaire. Fit new lamp/s if cause has been confirmed. In multi-lamp luminaires, all lamps have to be replaced (make voltage reset).		☐
Check compatibility with ballast. Details on ballast label must conform with details printed on lamp.		☐
Check by rotating lamp several times to left and right (approx. 180°).		☐

Possible solution	Note	Checked ✓
Use mains fuse to briefly switch off power. Activate momentary-action switch at switchDIM input (switching on/off).	Power reset with switchDIM	☐
Intermit signal in bus line (B1, B2 or DALI) (disconnect line). Use mains fuse to briefly switch off power. Then reconnect bus line and try to switch luminaire via control gear installed (LM or DALI).	Power reset with bus signal	☐
Measure power at bus.	Specified values: DALI: 9 to 15 V = LM: 13 to 15 V = DSI: no power measured	☐

3. Additional test for HID luminaires (high-pressure lamps such as HIT, HST, etc.):

Error occurring	Possible cause
After relamping, luminaire does not work any more.	No contact in lampholder thread

4. Analysis of partial function of luminaires with electronic ballast (poor lighting quality of fluorescent lamp)

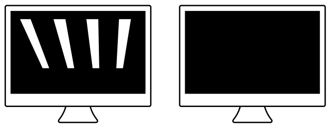
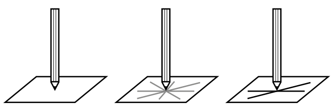
Error occurring	Possible cause
Lamp start delayed	No earth connection in luminaires with protection class 1
Poor dimming quality	Poor earth connection
Poor luminous efficiency/dimming behaviour	Ambient temperature of lamp too low/too high
	Cool spot neglected
	Increasing migration of dark spots along fluorescent lamp

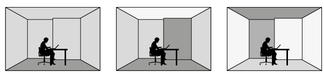
Possible solution	Note	Checked ✓
– screw-fasten lamp as deeply as possible – check contact between lamp solder point and cap tab – remove oxidation from lamp solder point, if necessary		☐

Possible solution	Note	Checked ✓
Connect luminaire earth.		☐
Use high-resistance voltmeter to measure power between phase and earth, and between neutral conductor and earth.		☐
Check for heat buildup underneath high ceilings or at workplaces with very high temperatures. Too low temperatures outside, or heavy air flow (e.g. air-conditioning system).	Common temperature range: $-15\,°C < T < 35\,°C$	☐
Do not operate lamps in positions unprovided for.	Cool Spot	☐
In order to achieve an appropriate lighting quality, new lamps should always be operated at 100 % for the first 100 hours of operation.		☐

Checklist 5: Offices

Potential for conflicts with regard to “Lighting of workplaces”

Assessment criterion	Point score	Sum of points
Does the mean illuminance on the task level (h = 0.75 m, measuring grid ≈ 0.5 m) comply with specifications (for instance, a minimum of 500 lx are specified for office areas)?	● no … yes ○	
Is illuminance distributed uniformly ($E_{min}/E_{mean} > 0.67$)?	● no … yes ○	
The left screen symbolically shows reflections or mirror effects that are so severe that text can no longer be deciphered. The right screen symbolically stands for full readability of characters and symbols. What is the situation like in the workplace?	● … ○ 	
At a level of 1.2 m, measure horizontal illuminance and vertical illuminance in all four directions. Use the formula below for calculation. Is the level between 0.3. and 0.7? $S = \frac{E_{v1} + E_{v2} + E_{v3} + E_{v4}}{4 \cdot E_H}$	● no … yes ○	
Do visible reflections occur on the screens which may irritate or distract users?	① no ② yes ③	
Are the displays arranged in parallel to the window frontages?	① no ② yes ③	
Can flickering caused by the lighting be perceived in the room?	① no ② yes ③	
Place a pencil in upright position on the desktop. Which of the opposite pictograms resembles the shadow image most closely?	③ ② ① ② ③ 	

Assessment criterion	**Point score**	**Sum of points**
Are there any irritating shadows in the room (cast e.g. by furniture, people, plants)?	① no ② yes ③	
Does the room create a pleasant impression in terms of lighting effect?	③ no ② yes ①	
Can the lighting be individually adjusted to the room?	③ no ② yes ①	
Can the lighting be intuitively controlled by all the users (employees, cleaning staff, security guards)?	③ no ② yes ①	
Place a high-gloss pad on the desktop. Do high-gloss phenomena occur on this pad? If so, do they bother you when reading?	① no ② yes ③ ① ② ③	
What are the contrasts on room peripheries like?	③ ② ① ② ③ 	
Does the lighting generate noticeable heat?	① no ② yes ③	
Have blinds been installed at the windows?	③ no ② yes ①	
Do the windows allow for visual contact towards the outside?	③ no ② yes ①	
	Total score	

How to read the score

● – If the first 4 questions are marked with a black dot, basic specifications in the standard are not being complied with.

13–17 – According to the criteria checked, it may be assumed that the lighting solution in the room complies with the state of the art.

18–23 – The lighting system includes several critical aspects. It must be checked which of the lighting installation's criteria can be adjusted at reasonable effort and expense.

24–39 – The lighting system has deficiencies that must be remedied by all means. It is highly probable that working in this room permanently will affect the users' sense of wellbeing and health.

Chapter 10

Design tools

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Design process and tools

Design process

Communication	Attention to products and concepts
↓	
Requirement	Define requirements, determine basic situation
↓	
Planning	– **Blueprint planning:** work out a concept – **Detailed planning:** calculation, optimise – **Documentation**
↓	
Implementation	Implementation, testing, maintenance

Design tools

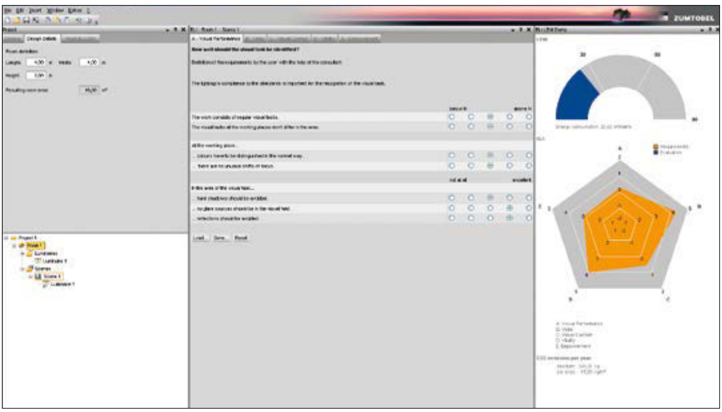
Communication	Product catalogue, brochures, Map of Light, ads and press work, trade fairs, conferences, events, roadshows, Light Forums
↓	
Requirement	ELI-LENI Calculator, VIVALDI Reference Library, research projects, studies
↓	
Planning	Online catalogue, QuickCalc, system configurators, LM Energy
↓	
Implementation	DIALux, Relux, ecoCALC, ELI-LENI Calculator, VIVALDI visualisation, VIVALDI optimisation

ELI-LENI Calculator

The ELI-LENI Calculator is our tool for evaluating a lighting solution's energy efficiency and lighting quality.

For more information and downloads, please refer to: **zumtobel.com/com-en/service.html#programms**

– Easy calculation of energy efficiency in compliance with EN 15193 and graphic illustration of LENI in a diagram
– Definition of a requirement profile for the lighting solution according to the following quality criteria:
  A: Visual performance
  B: Vista
  C: Visual comfort
  D: Vitality
  E: Empowerment
– Evaluation of lighting quality according to the quality criteria using checklists
– Clearly structured comparison and visualisation of the results in an ELI-LENI stamp
– Support of communication between those involved in the design process
– All solutions can be evaluated independently of the manufacturer

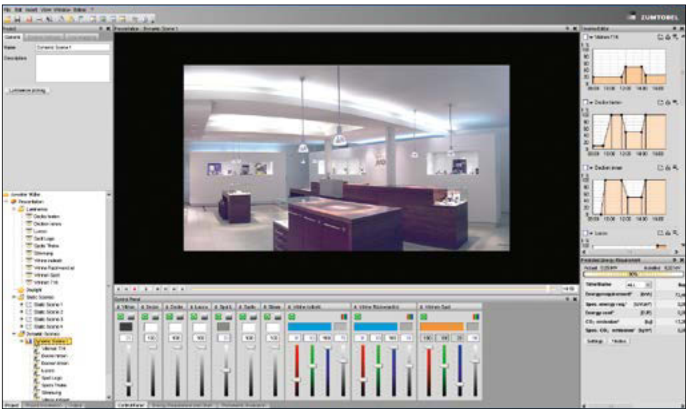


VIVALDI

VIVALDI is our interactive tool for designing lighting scenes and designing dynamic lighting concepts.

For further information, simply refer to:
zumtobel.com/com-en/service.html#programms

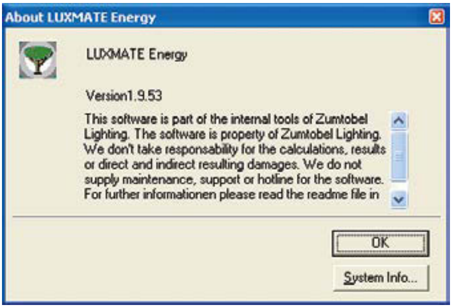
- VIVALDI uses photos, sketches or images from lighting calculation programs
- Individual light sources can be intuitively controlled in intensity and colour using sliders
- As regards images from calculation programs, details on illuminance and luminance levels as well as on energy consumption are given in real time
- Changes in lighting scenes are displayed in real time
- Dynamic sequences within the scenes are interactively controlled via timelines
- Daylight sequences can be taken into account so that daylight and artificial lighting can be dynamically adjusted over the course of the day

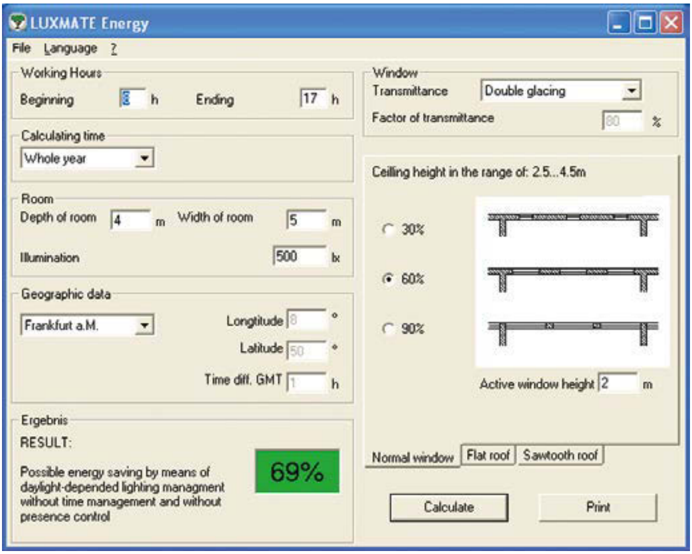


LM Energy

The “LM Energy” program calculates the energy-saving potential to be expected for interior lighting controlled by daylight-based lighting management systems.

For more information, please refer to **zumtobel.com/com-en/service.html#programms**





ecoCALC

ecoCALC is Zumtobel's tool for analysing the costs of a lighting solution throughout its service life.

For more information and downloads, please refer to: **zumtobel.com/com-en/service.html#programms**

- Maintenance cycles and the dimensions of the lighting solution are optimised so that lighting quality will be guaranteed at all times with maximum cost efficiency.
- Evaluation of static or dynamically controlled lighting solutions with individual timelines for all luminaires
- A variety of utilisation and control scenarios over the course of a year can be evaluated
- Database including defined dimming characteristics and details regarding lamp and ballast changes throughout their service life
- Variable electricity rates and rise in electricity rates can be defined
- Existing installations can be analysed and all luminaires – independent of the manufacturer – can be entered
- Easy to operate and control thanks to wizard mode

Online product information

Online catalogue
Under the “Download” tab, the online catalogue provides a list of all product data available for a specific product.

Quick access with URL/article reference:
zumtobel.com/42176750

Available product information:
– Product data sheet incl. maintenance category
– Photometric data sheets incl. UGR tables
– Photometric data formats Eulumdat, IES
– Drag & drop data for DIALux and Relux
– Brochures
– Installation instructions
– CE certificates
– 3D BIM Revit file
– CAD data: 2D and 3D
– Environmental product declaration (EPD)
– Line circuit breaker data
– Label in compliance with EU-VO 874/2012

Mobile online catalogue

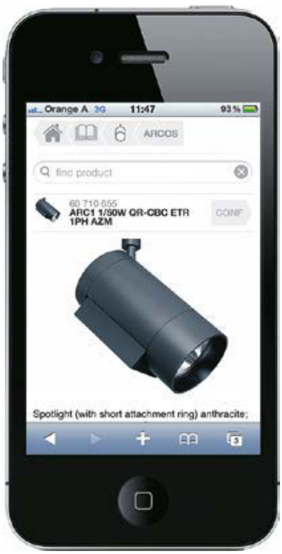
Zumtobel's online product catalogue has been optimised for access via mobile devices, enabling users to directly access information on the complete product range anywhere and at any time, by means of smart phones and tablets.

To this end, all you need to do is go to **http://mobile.zumtobel.com** (or the page of the respective country, e.g. http://mobile.zumtobel.co.uk) via the mobile device's browser. As this is not an app, no software needs to be installed, and access is possible from various devices.

The system supports iPhones, iPads as well as Android-based mobile phones and tablets. Access is, however, also possible using Blackberry devices OS 6 and higher, as well as other current smart phones, such as the Nokia S60, for instance.

In the mobile version, too, products can be accessed directly via a quicklink.
To do so, all you need to do is enter http://mobile.zumtobel.com followed by the respective order number.

For article number 42918319, for example, this would be
http://mobile.zumtobel.com/42918319



QR code

A so-called QR (Quick Response) code is printed on all cardboard packaging for Zumtobel luminaires of the standard range. This code is similar to a bar code and makes it easy to quickly access information on a specific product, even when you are not at the office.

If you have installed free QR reading software on your smart phone, all you need to do is focus your mobile phone's camera onto this black-and-white square; you will then be automatically directed to the respective product in Zumtobel's online catalogue.

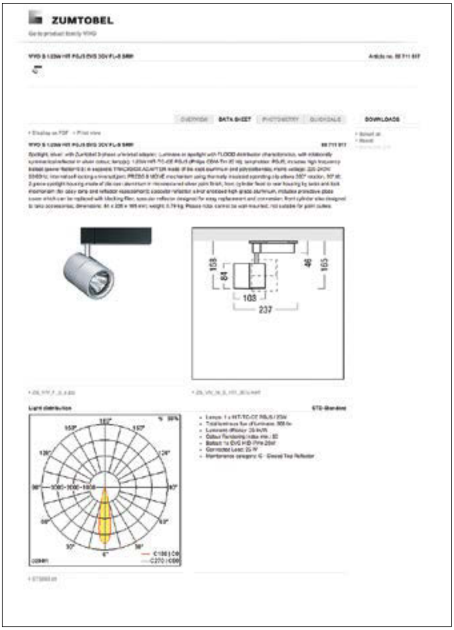
All information available on the product, such as installation instructions, data sheets and product details, can be conveniently retrieved from the product catalogue. In order to make it really easy to navigate the catalogue using a mobile phone as well, the whole online catalogue has been optimised for mobile devices.

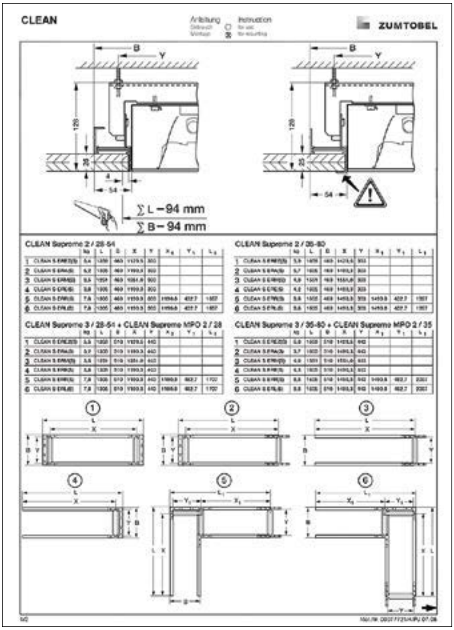
Product data sheets and installation instructions available online

Any product information required can be selected from the online catalogue and summarised in the form of a data sheet. Additionally, all installation instructions for the respective product are available in PDF format.

For more product information, please refer to:
zumtobel.com/com-en/products

- Complete product information in PDF format, up to date and country-specific: figures, charts, images
- Compilation of the product information selected in the form of a data sheet (ZIP file)
- Photometric data sheets
- Data sheets with connecting instructions for LUXMATE products
- Quick dispatch of any part of the catalogue by e-mail





2D CAD data

Note: The complete library can be called up on the homepage under “Services”.

Access via: **zumtobel.com/com-en/downloads.html#2D-CAD**

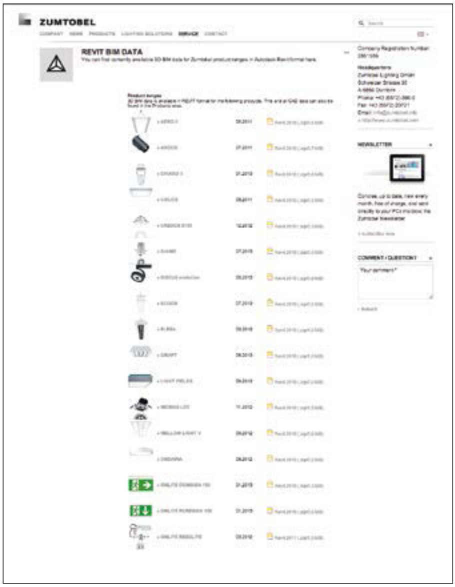
3D/REVIT CAD data

3D CAD data for Zumtobel’s product ranges are available for downloading also in Autodesk REVIT format. The first product ranges can already be downloaded from the website’s Service Center under menu item “REVIT BIM DATA”. Other product ranges will be added to the collection on an ongoing basis.

3D CAD data are also available in the online product catalogue. In addition to other CAD data in DWG format (2D/3D), the REVIT files for a product – if already available for this product range – can be found in the product’s downloading section.

Note: The complete library can be called up on the homepage under “Services”.

Access via: **zumtobel.com/com-en/downloads.html#revit**



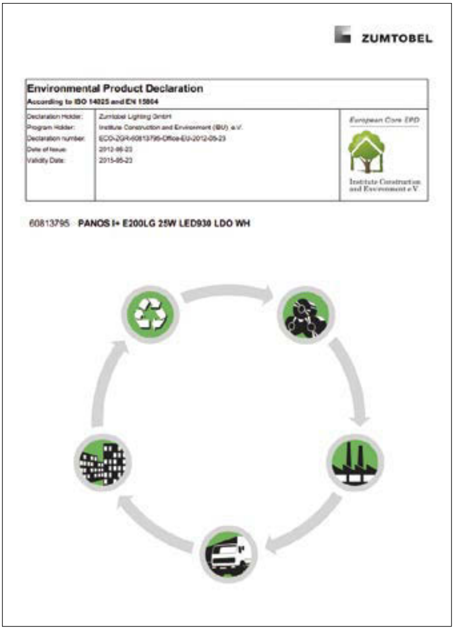
Environmental product declaration (EPD)
The environmental product declaration (EPD) according to ISO 14025 describes the specific environmental impact of a product.

The declaration is based on the product category rules (PCR) for “luminaires, lamps and components for luminaires” set out according to EN 15804. The life cycle assessment (LCA) was prepared in compliance with ISO 14040.

For more product information, please refer to:
zumtobel.com/com-en/products

The product described serves as a declared unit. An EPD includes a product description, data on material composition, manufacture, transport, period of use, disposal and recycling as well as the results of the life cycle assessment. It is subjected to independent testing according to ISO 14025.

EPDs of building products can be compared only if life cycle assessments have been calculated according to the same PCRs. This EPD refers to the IBU master EPD for the Zumtobel Group and can be called up at **http://bau-umwelt.de/hp4234/Luminaires-lamps.htm**


ZUMTOBEL

Environmental Product Declaration
According to ISO 14025 and EN 15804

Declaration Holder:	Zumtobel Lighting GmbH
Program Holder:	Institute Construction and Environment (IBU) e.V.
Declaration number:	ECO-ZGR-60813795-Office-EU-2012-05-23
Date of Issue:	2012-05-23
Validity Date:	2015-05-23

European Core EPD
Institute Construction and Environment e.V.

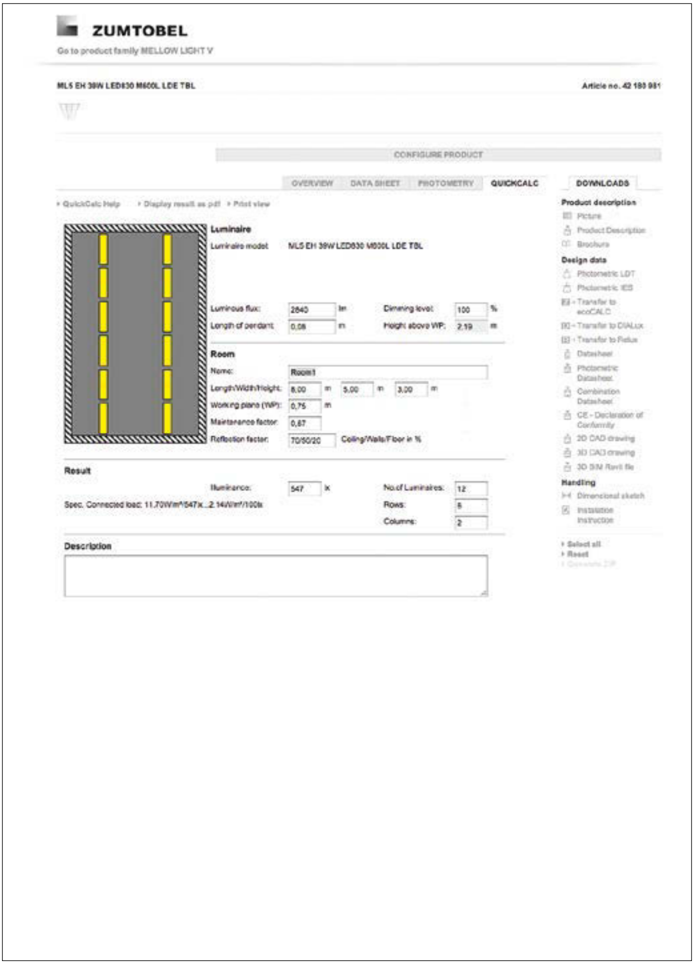
60813795 **PANOS I+ E200LG 25W LED930 LDO WH**

QuickCalc

QuickCalc provides a quick, approximate determination of the number of luminaires required to achieve a defined illuminance level according to the light output ratio method – or vice versa: to determine the illuminance level necessary for a defined number of luminaires.

In the Zumtobel online catalogue, QuickCalc is available for products with calculation data under the “QuickCalc” tab.

You find QuickCalc at the respective product under:
zumtobel.com/com-en/products



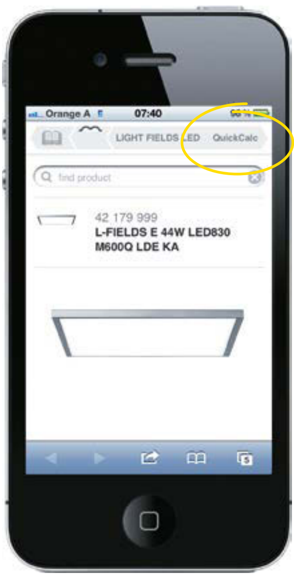
QuickCalc mobile

The mobile version of QuickCalc makes this intuitive lighting calculation program available at any time, anywhere.

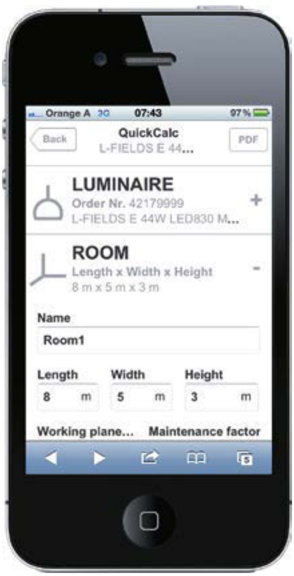
This tried-and-tested program by Zumtobel has been optimised for mobile terminal devices, ensuring that users can now make rough calculations not only at the office, but also directly at the construction site.

Based on product data available in the mobile e-catalogue, QuickCalc mobile needs just a few steps to calculate how many luminaires are required to achieve the necessary illuminance level at a given room size.

For any number of luminaires specified, the program will calculate the illuminance level that can be achieved.



The calculation program opens as soon as you click the QuickCalc icon in the online product catalogue.



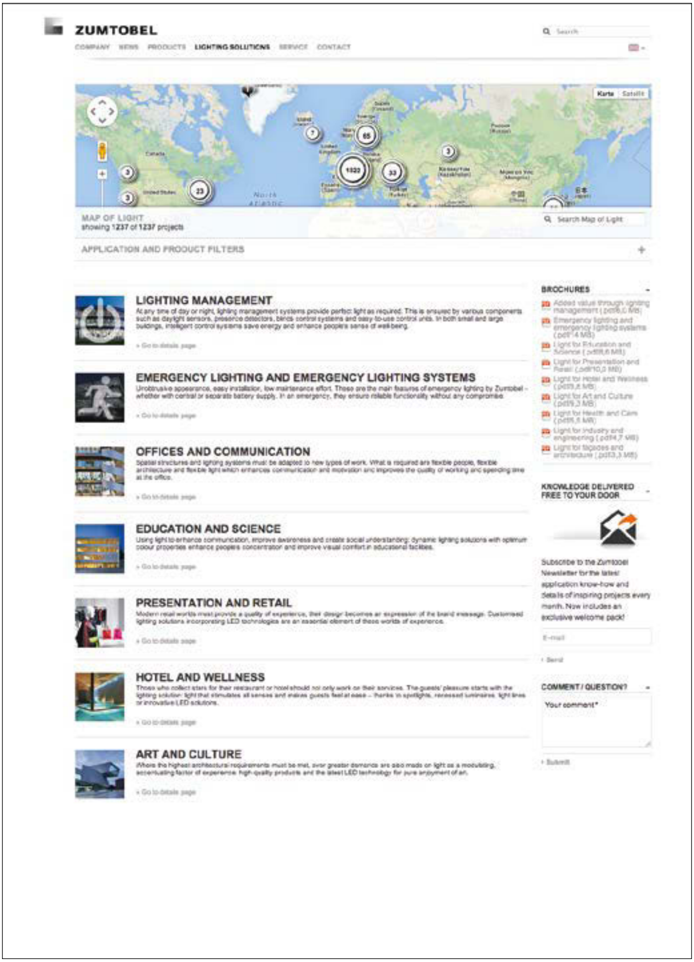
Now enter the length, width and height of the room.

The number of luminaires required will now be calculated, and a PDF file can be created from the calculation.

Map Of Light

The Map Of Light shows you state-of-the-art lighting solutions and impressive pictures of more than 1000 projects implemented all over the world, providing you with inspiring ideas and new stimuli for forthcoming projects.

For the Map Of Light, please refer to:
zumtobel.com/com-en/lighting_solutions.asp



Zumtobel Lighting DVD

Zumtobel data plug-in for DIALux and Relux with all available product data (Product Explorer – with QuickCalc and maintenance factor calculation), 3D BIM REVIT files, the latest program versions of DIALux and Relux, and other tools: LUXMATE Energy Light, ZX2 Configurator, SLOTLIGHT II Configurator, ELI/LENI Calculator, ecoCALC and VIVALDI demo version.

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Personal notes

Personal notes

Personal notes

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