













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lichtwerk  
inspired by light

# Symbol key



## Colour code/Colour

	traffic white (similar RAL 9016)
	white-aluminium (similar RAL 9006)
	aluminium natural anodized
	stainless steel
	chrome
	silver
	silver grey
	aluminium
	translucent
	clear
	grit grey
	black (similar RAL 9017)

## Control gear

ED	Electronic Driver, non dimmable
DALI	Electronic Driver, DALI, dimmable
DALI DT8	Electronic Driver, DALI, dimmable Change of light colour
Tast dim	dimmable via push button
NL-B	Emergency light single battery

## Ceiling systems

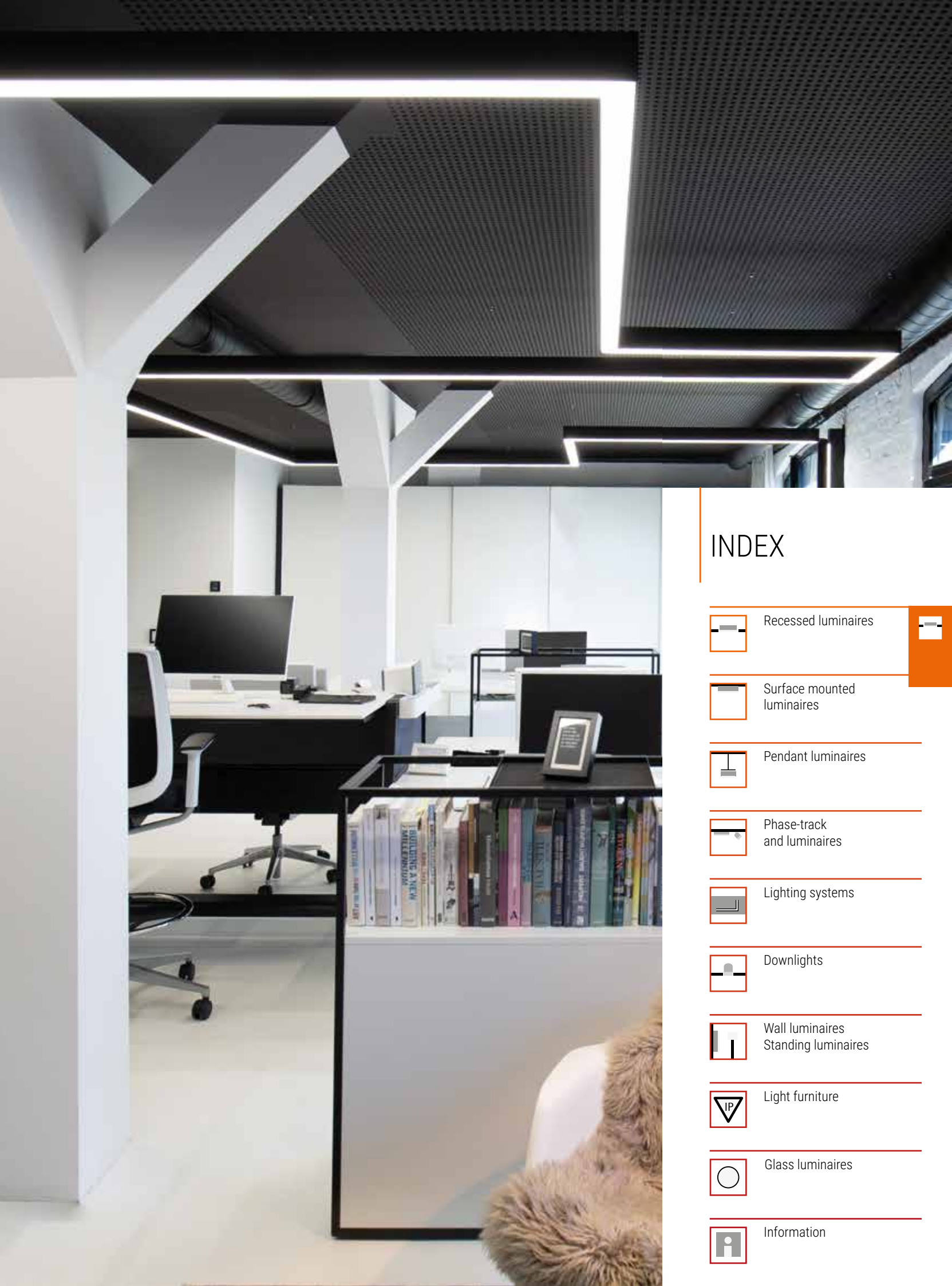
	for ceilings with visible T-rails
	for cut-out ceilings

## Definition of measurement table variables

L	Length
□L	Length/Width for square luminaires
L2	Additional length
B	Width
H	Height
∅D	Diameter
FL	Length of luminaire base
FB	Width of luminaire base
FD	Diameter of luminaire base
T	Depth
KE	Cable infeed
KL	Length of luminaire head or ballast box
KB	Width of luminaire head or ballast box
KH	Height of luminaire head or ballast box
KD	Diameter of luminaire head or ballast box
A1	Fixing distance in case of single mounting
A2	Fixing distance between the luminaires in case of light run mounting
X	Distance from centre of the luminaire to the electrical feed in (x direction = length)
Y	Distance from centre of the luminaire to the electrical feed in (y direction = width)
SL	Length of cut for recessed luminaires
SB	Width of cut for recessed luminaires
SD	Diameter of cut for recessed luminaires
e	Minimum necessary depth for luminaire mounting
Psys	Lighting system performance
ML	Modul (axis) Length
MB	Modul (axis) Width
P	Wire suspension
P min/max	Min./Max. length wire suspension
DS min/max	Min./Max. ceiling thickness in case of suspended ceiling







## INDEX



Recessed luminaires



Surface mounted luminaires



Pendant luminaires



Phase-track and luminaires



Lighting systems



Downlights



Wall luminaires  
Standing luminaires



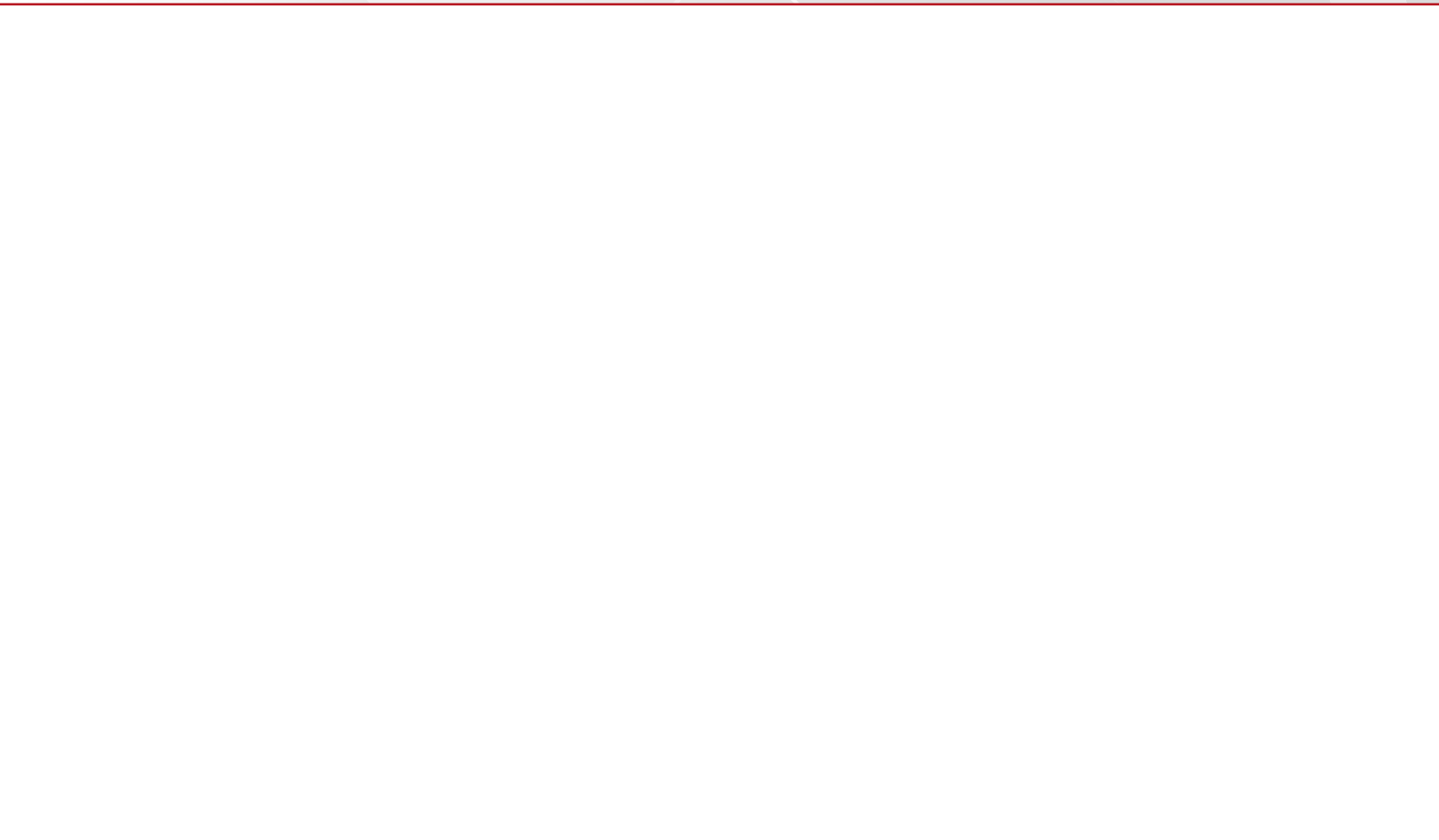
Light furniture




Glass luminaires



Information



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  - P. 403 ... Test symbols and protection classes
  - P. 404 ... Quality criteria for good light
  - P. 406 ... LED - light emitting diode
  - P. 408 ... LED Service life
  - P. 409 ... Resistance table chemical substances
  - P. 410 ... HCL - Human Centric Lighting
  - P. 412 ... HCL - Actual project
  - P. 414 ... Photo index
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
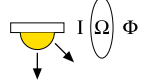

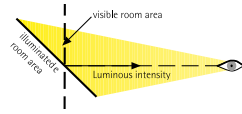
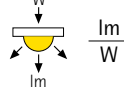
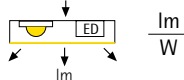


## Information





## Lighting technology basic concepts

Basic terms	Unit	Symbol	Definition	
1. Luminous flux	Lumen (lm)	$\Phi$	The total quantity of light emitted from the light source.	
2. Luminous intensity	Candela (cd)	$I = \frac{\Phi}{\Omega}$	The luminous intensity I evaluates the light radiated in a definite direction. It depends on the luminous flux $\Phi$ in this direction and on the radiated solid angle $\Omega$ .	
3. Illuminance	Lux (lx)	$E = \frac{\Phi}{A}$	The illuminance E is the luminous flux $\Phi$ , on a defined surface A.	
4. Luminance	Candela pro m <sup>2</sup> (cd/m <sup>2</sup> )	$L = \frac{\Phi}{A \cdot \cos \epsilon}$	The luminance is the luminous intensity per m <sup>2</sup> of visible surface. The luminance L of an illuminated surface is the measure for the luminosity perceived.	
5. Bulb light output	Lumen pro Watt (lm/W)	$\eta = \frac{\Phi}{P}$	The bulb light output is the luminous flux of a light source related to its electrical power consumption	
6. Luminaire light output	Lumen pro Watt (lm/W)	$\eta = \frac{\Phi}{P}$	The luminaire light output is the net light flux of a luminaire relative to its power consumption, including the operating equipment.	

## Degrees of protection

IP degrees of protection according to the first reference number

Ref-No.	Short description	Short details which foreign bodies cannot ingress the housing
0	Unprotected	No special protection
1	Protected against the ingress of foreign solid bodies with a diameter greater than 50 mm	Great body surface, e.g. a hand (however no protection against intentional contact), foreign solid bodies
2	Protected against the ingress of foreign solid bodies with a diameter greater than 12 mm	Finger or similar up to 80 mm length; foreign solid bodies greater than 12 mm diameter
3	Protected against the ingress of foreign solid bodies with a diameter greater than 2.5 mm	Tools, wires etc. with a diameter or a thickness greater than 2.5 mm; foreign solid bodies greater than 2.5 mm diameter
4	Protected against the ingress of foreign solid bodies with a diameter greater than 1 mm	Wires or strips thicker than 1 mm; foreign solid bodies greater than 1 mm diameter
5	Dustproof	Ingress of dust is not completely prevented, however, dust must not penetrate in such quantities that a proper operation of the device is impaired
6	Dust tight	No penetration of dust

IP degrees of protection according to the second reference number

Ref-No.	Short description	Details of protective measures through the housing
0	Unprotected	No special protection
1	Protected against dripping water	Dripping water (vertically falling drops) shall have no harmful effects
2	Protected against dripping water up to 15°	Vertically falling drops shall have no detrimental effect, if the housing is inclined up to 15° from its original operation position
3	Protected against spraying water	Water falling as a spray at an angle of up to 60° from the vertical shall have no detrimental effect against the vertical position
4	Protected against splashing water	Water splashed against the housing from any direction shall have no detrimental effect
5	Protected against water jets	Water projected by a nozzle against the housing from any direction shall have no detrimental effect
6	Protected against heavy seas	Water from heavy seas or water jet under high pressure shall not penetrate the housing in harmful quantities
7	Protected against the effects of immersion	Ingress of water in harmful quantities shall not be possible when the housing is immersed in water under defined conditions with regard to pressure and time
8	Protected against immersion	The device is suitable for permanent immersion in water; the conditions are to be indicated by the manufacturer Note: In general, this signifies that the device is completely sealed. However, this may signify with specific devices that water penetrates but has no detrimental effects.

## Test symbols

### Test symbols and protection classes

All lichtwerk luminaires are manufactured according to approved technical standards and 100% electrically tested. The luminaires are designed as standard for 230 V, 50 Hz and an ambient temperature

of 25° C, and satisfy European norms and directives, including ENEC provisions in relation to safety, electromagnetic compatibility and energy efficiency.

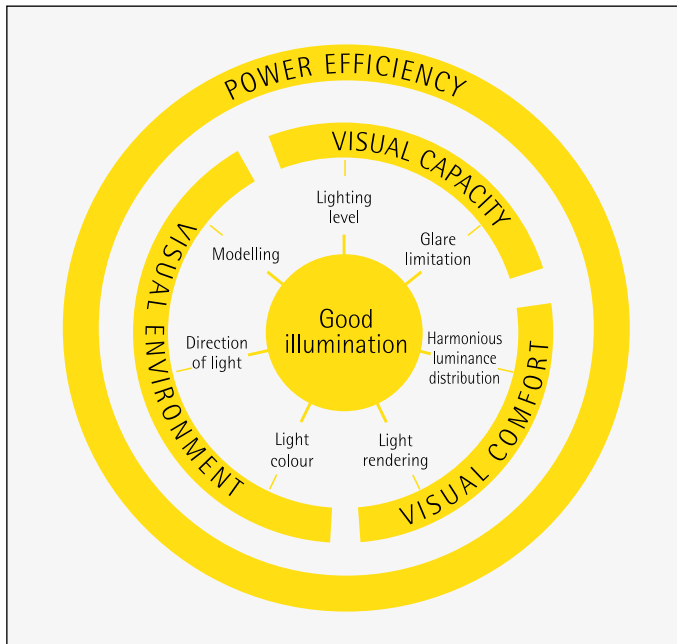
Test symbols	Description
	The -symbol is the European safety symbol for luminaires. The test regulations are determined by the European standard DIN EN 6598. The -symbol is issued in combination with the identification number of a European test center (VDE = 10). This documents that the luminaires have been built and tested „in conformity with the standards“ as per the Low-voltage Directive 2006/95/ EG.
	All luminaires meet the -conditions. In the event of faulty luminaire the fastening surfaces will not be hotter than 180° C. They may be mounted on inflammable building materials as described in DIN 4102 with an ignition point of at least 200°C (e.g. wood). Observe the installation instructions in order to avoid incorrect installation.
	Identification for thermally insulated ceilings. Luminaires may be directly covered with insulating material.
	EN 60598-2-24 requires that luminaires with the -symbol and at least with degree of protection IP 50 must be installed in areas where dust and/or fibers pose a fire hazard. Observe the installation instructions when installing.
	Luminaires with the -symbol are intended for surface-mounted and recessed installation in furniture. They have been designed so that inflammable materials as defined in VDE 0710 section 14 cannot be ignited in the event of a faulty luminaire. Observe the installation instructions in order to avoid incorrect installation.
	Luminaires with the -symbol are intended for surface-mounted and recessed installation in furniture. They are constructed so that in the case of luminaire failure, materials with inflammability characteristics not recognised by VDE 0710 section 14 cannot be ignited. Observe the installation instructions in order to avoid incorrect installation.
	Luminaires with this symbol correspond to EN 60598-1 standard conditions for the temperature specified by this symbol. Testing is carried out according to IEC 60695-11-5 (needle-flame test) or IEC 60695-2-10 (glow-wire flammability index).
	The IK-Impact resistance degree describes the resistance of the housings of electric operating equipment to mechanical loads, particularly impact. The IK-classes correspond to a respective minimum impact energy in Joules, that the housing must be able to withstand. The given value in Nm/J corresponds to the mechanical resistance.
	The -marking is performed by the manufacturer at his own responsibility. The manufacturer declares conformity with the respective EC or EU directives. Conformity in accordance with the „Low-voltage Directive“ and the „EMC directive“ (interference immunity, emitted interference) is the precondition for the -marking of the products.
	With this symbol, the suitability of luminaires for computer workstations according to DIN EN 12464-1 is specified. The degree number means that the luminance in all luminaires planes beyond that angle does not exceed certain limitation values. Depending on screen quality and screen visualisation, the norm specifies different limitation values.
	Generally, the luminaires are suitable to be used in companies of the food and beverage industry certified according to IFS version 6 and /or BRC Global Standard Food version 6.
	The luminaires meet the limit value $\leq 19$ in accordance with the unified glare rating method UGR. This rating is based on conditions in the so-called standard room with lines of vision crosswise and lengthwise to the luminaire.

## Protection classes

Protection classes	Description
	Luminaires with the indoor symbol are only suitable and approved for the use in buildings.
	Luminaires of protection class I must be connected to a protective conductor.

Protection classes	Description
	Luminaires of protection class II are double insulated and therefore a PE terminal is not authorized.
	Luminaires of protection class III are intended for operation at safety extra low voltage < 50V (effective)

## Lighting Requirements

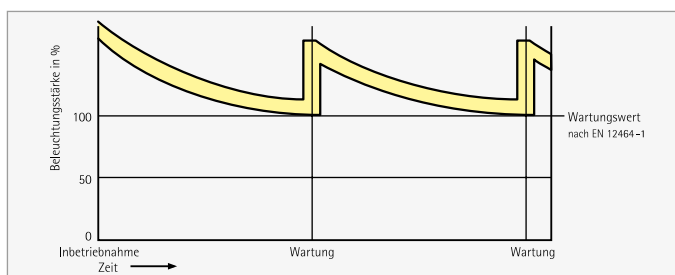


The function of the interior illumination is to provide human beings with an environment which contributes to their mental and physical well-being and prevents accidents. Moreover, it should influence the mental state of the human being with the aim of achieving a higher degree of performance, combating premature fatigue and reducing errors.

To fulfill these conditions ideally, several quality criteria have to be taken into account at the design stage:

- Lighting level
- Luminance distribution
- Glare limitation
- Directionality of light and modelling
- Light colour and light rendering

## Lighting level/Lighting illuminance



The lighting level is primarily defined by the level of illuminance. This in turn is dependent upon the visual task, and is oriented to the difficulty of recognising specific contrast and detail as well as the speed at which these must be perceived. The EN 12464 standard defines the required illuminance levels for various types of rooms and activities. Maintenance values specified for the illuminance levels are mean values for the workzones of the rooms in the specific working planes. Independent of the age and condition of the lighting system, the mean illuminance level must not fall below the specified value. For all lighting systems, illuminance levels decrease with increasing age of the lamps and because of the collection of dust. In addition, the reflecting peripheral surfaces of the room also usually darken with age or become dusty. The lighting system must therefore be planned according to a light loss factor that considers all influences and that was calculated for the intended lighting equipment, the spacial environment and the maintenance plan to be defined.



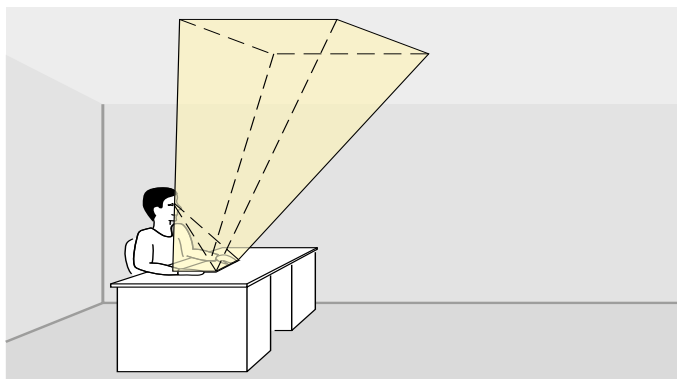
# Glare suppression

## Glare limitation

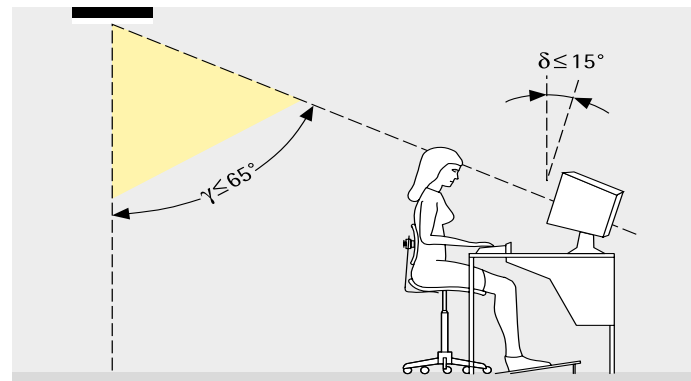
Direct glare is caused by excessive luminance in the field of view. It diminishes visual acuity (physiological glare) and may seriously lessen the sense of well-being (psychological glare). Methods of glare evaluation for indoor luminaires evaluate the limitation of luminance within the critical beam angle. As a standard evaluation system the UGR (Unified Glare Rating) method was introduced in Europe as the DIN EN 12464-1 standard. Standard spreadsheets could be used for a rough evaluation. The given values correspond to the conditions in the so called standard room.

Reflected glare is caused by disturbing reflections upon blank surfaces. According to the physical law 'angle of incidence = angle of reflection', reflections occurring would lie precisely in the field of view of the person working there. Matt work surfaces help significantly in solving the problem of reflected glare. Reflected glare leads to similar disturbances as direct glare, and impairs mainly contrasts, which are required for disturbance-free seeing. The lighting of computer screen workspaces requires especially careful planning, because strong reflections on the screens often make work impossible.

The reflective properties of the screen surfaces, the screen polarity and its curvature in combination with shining surfaces in the room are the decisive factors of influence for the assimilation of information via screens. Disturbing reflections can be lessened with anti-reflection measures for the screen surface. The suitability of luminaires is specified in DIN EN 12464-1. Depending on screen quality and screen polarity, the luminance values of luminaires and shiny surfaces reflected on the screens must not exceed the specified limitation values for mean luminance. Depending on these screen classes and the screen polarity, the luminance values of luminaires and shiny surfaces reflected on the screens must not exceed the specified limitation values for mean luminance. These limitation values are considered for luminaires above an emission angle of 65° all round.



Reflected glare is caused by disturbing reflections on bright surfaces.



„High state“-luminance of the screen	Screens with high luminance $L > 200 \text{ cd/m}^2$	Screens with mean luminance $L \leq 200 \text{ cd/m}^2$
<b>Case A</b> Positive polarity and usual requirements with regard to colour and details of the presented information e.g. as available in offices, etc.	$\leq 3000 \text{ cd/m}^2$	$\leq 1500 \text{ cd/m}^2$
<b>Fall B</b> Negative polarity and/or higher requirements with regard to colour and details of the presented information e.g. as available in case of CAD, colour verification etc.	$\leq 1500 \text{ cd/m}^2$	$\leq 1000 \text{ cd/m}^2$
<b>Note</b> „High state“-luminance of the screen (see EN ISO 9241-302) describes the maximum luminance of the white area of the screen. Manufacturers of screens indicate that value.		

## Light source LED

The LED technology offered by lichtwerk is a sure winner thanks to its high levels of efficiency and low energy consumption. Efficiency here includes low maintenance expense, ruggedness, and a long service life.

Effective temperature management in luminaire construction with LED is important when it comes to meeting all expectations. It ensures the performance characteristics are met and the luminaire has the promised service life.

An effective and passive cooling is the consequence in technical terms. An optimal light control system affects lighting wellbeing, as well as energy efficiency. You are sure to expect high-quality light technology in all our LED luminaires.

As an energy-efficiency option for traditional lighting systems, our LED luminaires also always need to meet basic quality demands on light wellbeing. We also performed solid work here too. We have selected specific lumen packages, optimal colour rendition and various colour temperatures for our lichtwerk luminaires. Another quality characteristic is our uniformly stable colour locus.

Energy efficiency and service life are not always the crucial factors in LED lighting. LED technology gets further plus points when the lighting system also needs quick and frequent switching the dimmability e.g. in plants with control systems, long maintenance intervals or special toughness requirements. lichtwerk LED luminaires ensure you can realise sophisticated lighting concepts and provide perfect illumination for your projects. Our photometric data are created by us with great care. Due to the high dynamics in the LED and LED-driver field, however, the electrical and photometric data indicated by our suppliers come with a tolerance of typically  $\pm 10\%$ .

Therefore, this tolerance also applies to our figures and is indicated by our suppliers on their data sheets. These data sheets can be provided upon request.

## LED benefits

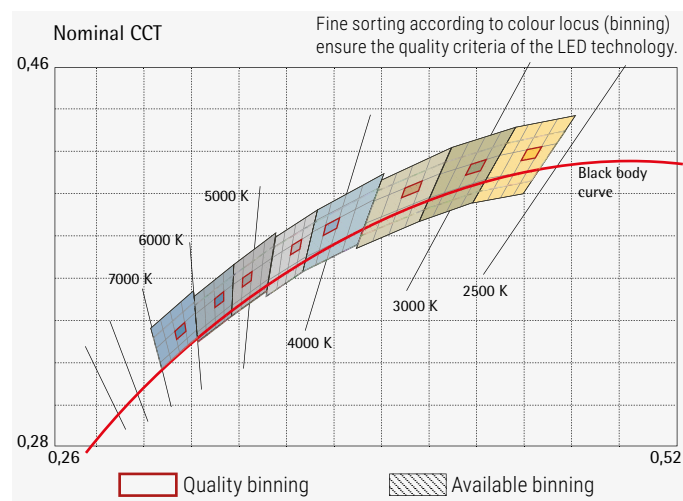
- Lower power consumption
- Long service life
- Unlimited switching capability
- Full light right away
- Continuously dimmable
- No IR and UV radiation
- High impact- and vibration strength
- Small dimensions
- Mercury free

## Binning

Depending on production tolerances of LED, these may vary in their light quantity and colour temperature. However, to achieve a constant light quality with the same level of brightness and light colour, LED are sorted by their values. LED with identical or similar parameters end up in the same bin. The narrower the tolerances, the higher the quality of the 'binning'.

The following terms are often used in connection with binning:

Colour consistency – same light colour from lamp to lamp  
 Colour locus constancy – the light colour does not drift due to ageing or when the luminaires are dimmed



## Luminous flux and light yield

Thanks to the rapid development of LED in recent years, they are also able to provide the relatively high quantities of light for general lighting in the technical light area. The amount of light - or Luminous flux (unit: Lumens) - denotes the total amount of light power emitted by a bulb or luminaire. When the Luminous flux in an LED only relates to the LED module (or an LED spot), this is called the gross luminous flux. This information is dependent on the different operating parameters and is defined by the LED manufacturer. If the module is built into a luminaire, the luminous flux will change due to a change in the operating conditions (such as temperature). Losses also come about as a result of technical light measures carried out on the luminaire (e.g. glare reduction), which means that a reduced luminous flux actually exits the luminaire. This is called the net luminous flux.

According to the definition, the light yield denotes the ratio of the emitted luminous flux to the electrical supply and is given in Lumens per Watt. A distinction must be made between gross and net here. For the gross light yield, the yield luminous flux of the module is used, whereby the electrical connecting line can be calculated with or without the operating device. In planning programs such as e.g. Relux however, the net light yield is calculated - this is called the luminaire light yield. This is based on the net luminous flux and the system performance of LED and driver. An identifying characteristic in terms of the net figure is data about the operating efficiency of the LED luminaire at precisely 100%. In light technology, this is called absolute photometry.

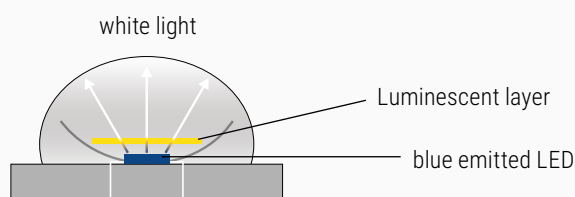
In the meantime the market has come to prefer net values, in particular, when comparing different types of LED luminaires. Knowledge of gross and net is essential to avoid comparing apples with oranges.

## Luminous flux and light colour

In contrast to the colour mix comprising red/green/blue, the efficiency of most white-emitting LED is based on the LED chip initially producing blue radiation. This blue light is deflected by a luminescent layer which is e.g. constructed from yellow phosphorus. According to the principle of luminescence conversion, white light is then produced from blue and yellow.

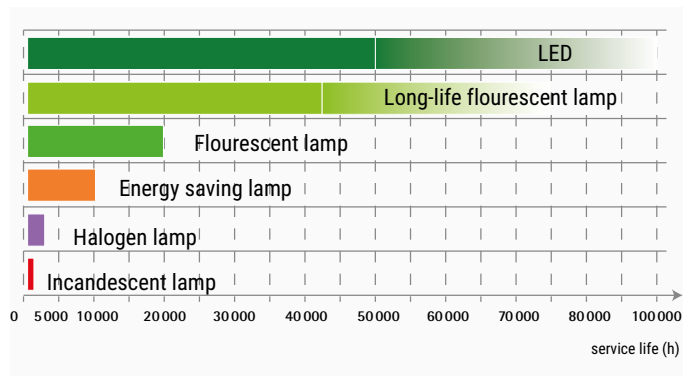
If wanting to produce a warmer light colour, the admixture of light needs additional red components in the luminescent layer. However, these components work less effectively. This is the reason why the LED luminaires of the same type and rating have a lower luminous flux for a warm white light colour compared to variants with a higher colour temperature.

Origin of the light colour in an LED



## Service life

LED used in the technical light area usually have a service life of 50,000 hours and above. This makes the LED one of the longest-lasting lighting mediums available today - without question. In practice, this means a considerable reduction in maintenance costs. Service life information is supplemented by values about degradation and mortality. An important factor influencing both the Luminous flux and the service life is temperature. If there is too much heat, this has a negative effect on the luminous flux and service life. This means effective thermal management with efficient heat dissipation is especially important for LED luminaires.



For detailed explanations referring to service life of LED please see Page 408.

## Light management

Light management components further increase the energy efficiency of lighting systems. Even basic presence indicator switches improve the efficiency of such systems at relatively little expense. Since frequent switching of the LED does not result in a reduction of the service life, this lighting medium is ideal for such applications.

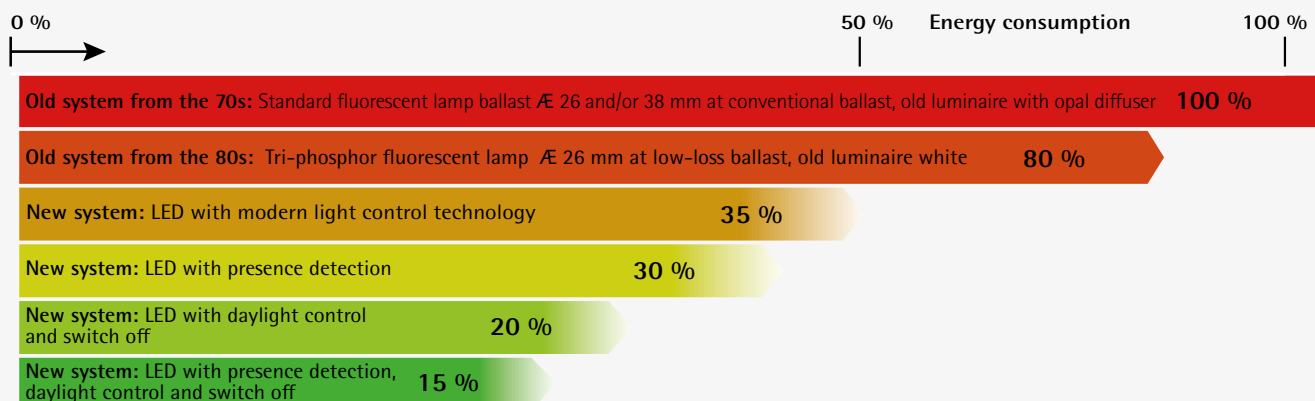
In addition, the LED immediately starts at 100 % light and no follow-up times need be configured.

Daylight-dependent rules with or without a presence function can be realised. Compared to legacy systems with conventional luminaires and magnetic pre-switching, the savings potential of energy costs can reach up to 85%.

## Thermal management

The LED light is free of infrared radiation. This makes the LED ideal for illuminating sensitive objects, such as in museums or shops. A high proportion of heat arises directly in the LED chip during light generation. This is due to high power density on a small surface. This heat will need to be dissipated since the luminous flux falls at high temperatures and the service life decreases. Construction of the luminaire with appropriate heat dissipation measures is thus very important in ensuring that the operating temperature of the LED is optimal.

### Saving potential indoor lighting





## Service life analysis for LED

### L-value

LED lose their luminosity over time. This decline can occur in different ways. The light itself may simply become darker, individual LED or even entire LED modules or sections may fail.

The L-value describes this decline as an average value calculated for all LED in use. It states the percentage of luminous flux that can still be expected after expiration of the stated service life.

### B-value

The B-value serves as additional information to the L-value. It describes the percentage of LED that are lower than the L-value stated as an average after expiration of the specified service life.

If no B-value is stated, a value of B50 is assumed. This predicts that 50% of used LED will exhibit a higher and 50% will exhibit a lower decline in luminous flux than the stated L-value after expiration of the stated service life.

## L + B-value Combination makes the difference

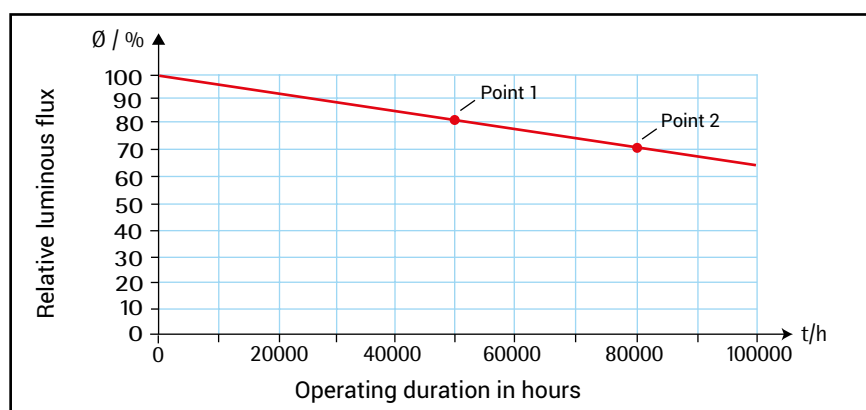
The L-value with its stated service life and the B-value must always be considered in combination with one another.

The following diagram shows a typical graph for the decline of an LED over time:

This LED can be described with different statements using the characteristics values cited above:

Point 1 of this graph would be indicated with L80 50,000h:  
This means that the luminous flux would decrease by 20% on average after 50.000h.

The statement L70 80,000h would, however, also be correct (see table point 2):  
This means that the luminous flux would decrease by 30% on average after 80.000h.



## LED luminaires by lichtwerk

It is important to know that these are calculated forecast models due to the rapid innovation cycles in the LED sector and that these values are based on data provided by LED manufacturers. As a manufacturer of luminaires, we provide these prognostic values for the service lives of our products based on this data and our own measurements, for example of the temperature (TP) of the luminaire when installed.

Using this measurement and design measures undertaken by us, for example in regard to proper heat dissipation of the installed LED, we are able to claim a very good service life prognosis of L80 50,000h B10 for the majority of our products.

Thanks to our own laboratory measurements, we are also able to cite service life values for increased ambient temperatures, for example. Please ask us if your application is subject to such requirements.

A typical table of values for an LED module that is representative of the modules used in our luminaires is presented here as an example. The influence of temperature on the service life analysis is clearly apparent:

	Statements L+B-value						
	L	70		80		90	
	B	10	50	10	50	10	50
Temperature	[mA]	Service life [h]					
Tp = 50°C	225	50.000	50.000	41.000	50.000	22.000	28.000
Tp = 65°C	225	50.000	50.000	35.000	50.000	18.000	24.000
Tp = 75°C	225	49.000	50.000	32.000	43.000	16.000	21.000





# Chemical substance

Resistance-Table

Chemical substance	Polyester	Acrylic glass (PMMA)	Polycarbonate (Housing PC)
Acetone	not resistant	not resistant	not resistant
Aliphat. hydrocarbons	partially resistant	partially resistant	resistant
Alcohol up to 30%	resistant	resistant	resistant
Alcohol concentrated	partially resistant	not resistant	not resistant
Amoniac 25 %	not resistant	resistant	not resistant
Accumulatore acid	resistant	resistant	resistant
Aniline	not resistant	not resistant	not resistant
Aromat. hydrocarbons	partially resistant	not resistant	not resistant
Ether	partially resistant	not resistant	not resistant
Ethyl acetate	not resistant	not resistant	not resistant
Benzine	resistant	resistant	resistant
Benzole	not resistant	not resistant	not resistant
Beer	resistant	resistant	resistant
Blood	resistant	resistant	resistant
Bromine acid	not resistant	not resistant	not resistant
Chloroform	not resistant	not resistant	not resistant
Chlorophenol	not resistant	not resistant	not resistant
Diesel oil, crude oil	resistant	resistant	partially resistant
Dioxane	resistant	not resistant	not resistant
Acetic acid up to 5 %	resistant	partially resistant	resistant
Acetic acid up to 30 %	resistant	not resistant	partially resistant
Glycerine	resistant	resistant	partially resistant
Glycol	resistant	resistant	resistant
Glystantine	resistant	resistant	resistant
Carbon dioxide	resistant	resistant	resistant
Carbon monoxide	resistant	resistant	resistant
Lime water	resistant	resistant	partially resistant
Saline	resistant	resistant	resistant
Ketone	not resistant	not resistant	not resistant
Lysol	not resistant	not resistant	not resistant
Sea water	resistant	resistant	resistant
Methylene chloride	not resistant	not resistant	not resistant
Methyl alcohol	not resistant	not resistant	not resistant
Metal salts and their watery solutions	resistant	resistant	resistant
Sodium hydroxide 2 %	partially resistant	resistant	not resistant
Sodium hydroxide 10 %	not resistant	resistant	not resistant
Petroleum ether	resistant	resistant	partially resistant
Pyridine	not resistant	not resistant	not resistant
Phenol	not resistant	not resistant	not resistant
Nitric acid up to 10 %	resistant	resistant	resistant
Nitric acid 10 - 20 %	partially resistant	partially resistant	partially resistant
Nitric acid over 20 %	not resistant	not resistant	not resistant
Hydrochloric acid up to 20 %	resistant	resistant	resistant
Hydrochloric acid over 20 %	resistant	resistant	partially resistant
Sulfuric acid up to 50 %	resistant	resistant	resistant
Sulfuric acid up to 70 %	resistant	partially resistant	partially resistant
Sulfuric acid over 70 %	not resistant	not resistant	not resistant
Solfurous acid up to 5 %	partially resistant	partially resistant	not resistant
Hydrogen sulphide	resistant	resistant	resistant
Soapsuds	resistant	resistant	resistant
Soda	resistant	resistant	resistant
Synth. suds	resistant	resistant	partially resistant
Oil of turpentine	resistant	partially resistant	partially resistant
Carbon tetrachloride	resistant	not resistant	not resistant
Water up to 60° C	resistant	resistant	resistant
Hydrogene peroxide up to 40 %	not resistant	not resistant	partially resistant
Hydrogene peroxide over 40 %	not resistant	partially resistant	partially resistant
Xylene	not resistant	not resistant	not resistant



## Light for Living

### Importance of Daylight for people

The life of most living beings on the planet Earth has been determined by the day-night cycle for millions of years. The biological clock is deeply rooted in our subconscious. Even if humans were already able to create artificial light with fire 300,000 years ago, it did not become possible turning night into day with the distribution of electricity at the end of the 19th century. This period of time is far too short to be reflected in human genes.

Witnessing these facts, it becomes apparent how straining our way of living must be for us - mainly in enclosed rooms - with only little or even no daylight. It is assumed that at least 20% to 30% of the people working in industrial countries suffer from recurring sleep disorders. The body's inner clock gets out of step.

With today's technologies and knowledge it is possible to compensate for this handicap of static light in our surroundings. The lack of natural daylight can be compensated for by convergence of the artificial light to the course of daylight. Thus, the human biological clock will be synchronised again.

### Biological Clock

Life on Earth is also determined by the alternation of day and night. Many types of cells from species have developed some type of inner clock in the course of evolution. The brain synchronises this clock with the environment. Light is the pulse generator for this process.



## Artificial Light

### Consequences of the use of artificial light

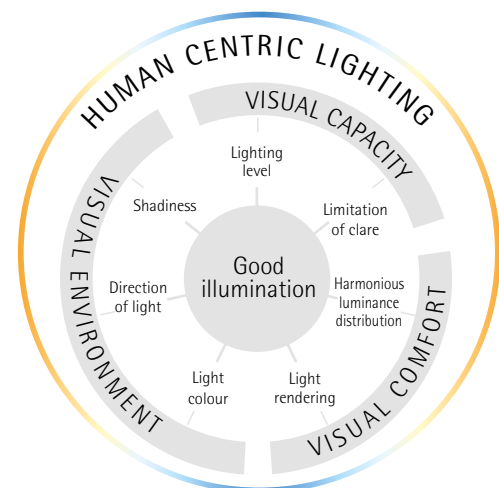
The year 1879 is the start of the era of electric lighting. Thomas Alva Edison files a patent for his light bulb. This modern invention has radically changed our lives. Now men were able to extend their day, change their rhythm of time or turn the night into day. Artificial light was introduced in manufacturing plants and it became possible to also work without daylight. Initial approaches for light planning developed, when it became obvious that good light does not only depend on the illumination level.

As well as the illumination level, other criteria are in the focus of today's state-of-the-art light planning, such as harmonic distribution of brightness, limitation of glare effects, light colour, colour rendering, light direction and shade. If all these points, known as quality characteristics of lighting, are met a „good“ lighting system will certainly be achieved. So far so good. But why not make something good better?

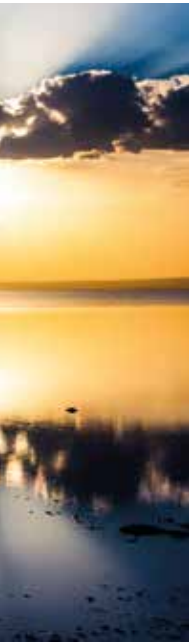
## New Approach

The classic quality characteristics are lacking one approach: dynamics. The level of illumination is designed for a specific minimum value according to standard; this so-called target value is kept constant for light control. The light colour is specified in the planning phase and is not subject to any change during operation.

However, people are conditioned differently, people live with and by changes, also in matters of light. During evolution, homo sapiens started around 300,000 years ago to adapt to the cycle of natural sunlight. Daylight is characterised by different levels of light and different light colours. No wonder that people also orient themselves to such parameters of the light and are clocked by them in their rhythm of life.



## Chemical Messengers



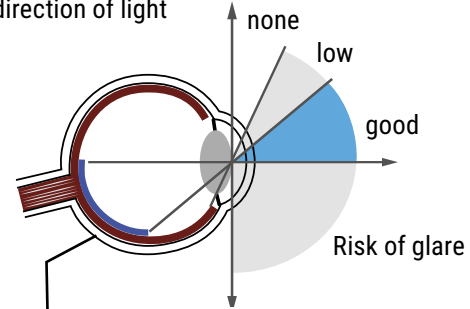
It was not clear for a long time how these light stimuli are exactly processed. It was known that the so-called cones in the eye are responsible for colour vision and the rods for mesopic vision. A third receptor, the ganglion cells, was discovered in the year 2002. However, these light-sensitive cells are not used for vision but regulate biological processes in the body when in contact with light. The retinal ganglion cells are directly connected to a specific area of the brain for this purpose. The body's rhythms are clocked from this central control point - the „Master Clock“. It controls the production of hormones and the activation of enzymes. Increasing exposure to light thus ensures, that the production of the sleep hormone melatonin is suppressed. Instead, serotonin is released, which has a mood-enhancing and motivating effect.

The task expands for light planning which is geared to the biological rhythm of men. The objective must be to create a lighting solution beyond the standard quality characteristics for illumination. It is not only a matter of meeting applicable standards. Light, and therefore also good illumination, can do more. Good light does not only illuminate, but has a biological effect.

### Retinal Ganglion Cells

Photoreceptors in the retina of the eye. These cells are sensitive to light, however, they are not used for vision. Instead, they assume a role for the synchronisation of the internal clock of the person.

**Ganglion cells and direction of light**



Area of the retina, where the ganglion cells respond particularly sensitively

## Biologically effective Light

Light which is characterised by dynamics with regard to luminance, light colour and direction of arrival. This light is able to initiate biological processes for living creatures.

For the artificial illumination, a simulation of daylight means starting in the morning with warm-white light. Derived from sunrise, this light has more red content in the spectrum and thus has a relatively low colour temperature of e.g. 2700 Kelvin. A gradual transition to daylight-white light colour (e.g. 6500 Kelvin) is performed in the course of the day. The now increased blue portion in the spectrum results in an activating effect which stimulates the concentration. This change of the light colour at noontime should also involve an increase in the level of illumination to exceed a specific threshold value for the biological effectiveness of the light.

As the eye is adapted to the natural environment and thus at noon-time to the light of the sky, this should also be taken into consideration for the selection of luminaires and light distribution. The most sensitive ganglion cells are mainly distributed in the rear and lower part of the eye. Large-surface luminaires or luminous ceilings are better suited than point light sources to reach as many of these receptors in the eye as possible.

In the later afternoon and evening, the dynamic process of the morning hours will be reversed, e.g. the level of illumination will be gradually reduced and the colour temperature changes to warm-white light.

Using simulation of daylight, artificial light can assume a biologically effective function. This makes sense as people are spending more and more time in enclosed rooms. Modern dynamic light concepts will replace the static light solutions. The focus is on the person and the increase of his/her well-being.

## Circadian Rhythm

The term is derived from Latin (circa = around, dies = day) for a cyclic biological process with a period of approx. 24 hours.

## HCL Human Centric Lighting

The characteristics of the HCL illumination consider more than just vision. The focus is on the person. Human Centric Lighting stimulates the well-being and supports stable health of the person.

# HCL

## Actual project - Maria Ward school

### Human Centric Lighting - Simulation of Daylight

The focus is on the person, also regarding to illumination. A contemporary lighting system must be able to enhance the well-being of the person more than ever before. Knowing that the human organism has been and will be characterised by daylight, the objective must be integrating the positive aspects of daylight into modern light planning. It was not without reason, that the issue of daylight was included in the revision of the European standard EN 12464-1 „Illumination for workplaces in interior rooms“. But what should be done, if sufficient daylight is not available? In this case, artificial light can assume specific daylight functions and provides „the right light at the right time“. Based on the natural light, the artificial light is given a dynamic structure in the course of the day. Thereby, the changes in the level of illumination and in the light colour are of particular importance. Such lighting is able to support the circadian rhythm of the person. Our cells and organs and thus the body's functions are linked to this rhythm, with the human body clock being the pulse generator. It controls sleep and waking phases, but also heart beat, blood pressure and mood. This cyclic process is also characterised by the fact that all biochemical functions have individual high and low points in the course of the day. The circadian rhythm is regularly synchronised with the outside world whereby humans are primarily influenced by the brightness of the day and the darkness of the night.

The Maria-Ward-School, located in the middle of Bamberg old town, was extended. The new Construction is convincing with its modern, energy efficient an environment friendly design.



3000K





To fit always the right illumination the hall is equipped with recessed LED luminaires "lopia Q". The fixtures obtain with their tunable-white-technology always the right mood. They are capable of a color temperature bandwidth from 3000K to 6500K. Starting at warm white through neutral white to cool white. This gives the responsible the opportunity to choose the right light colour needed for each individual event.

The smaller type of the luminaire "lopia Q 330-EG" was also used in the hallways, staircases and locker rooms. The luminaire family connects the different areas with its unified visual appearance. Through its homogeneous appearance it significantly contributes to a harmonic room atmosphere.

**Products:**

lopia Q LED

**Building owner:**

 Erzbischöfliches Ordinariat,  
Bamberg

**Architect:**

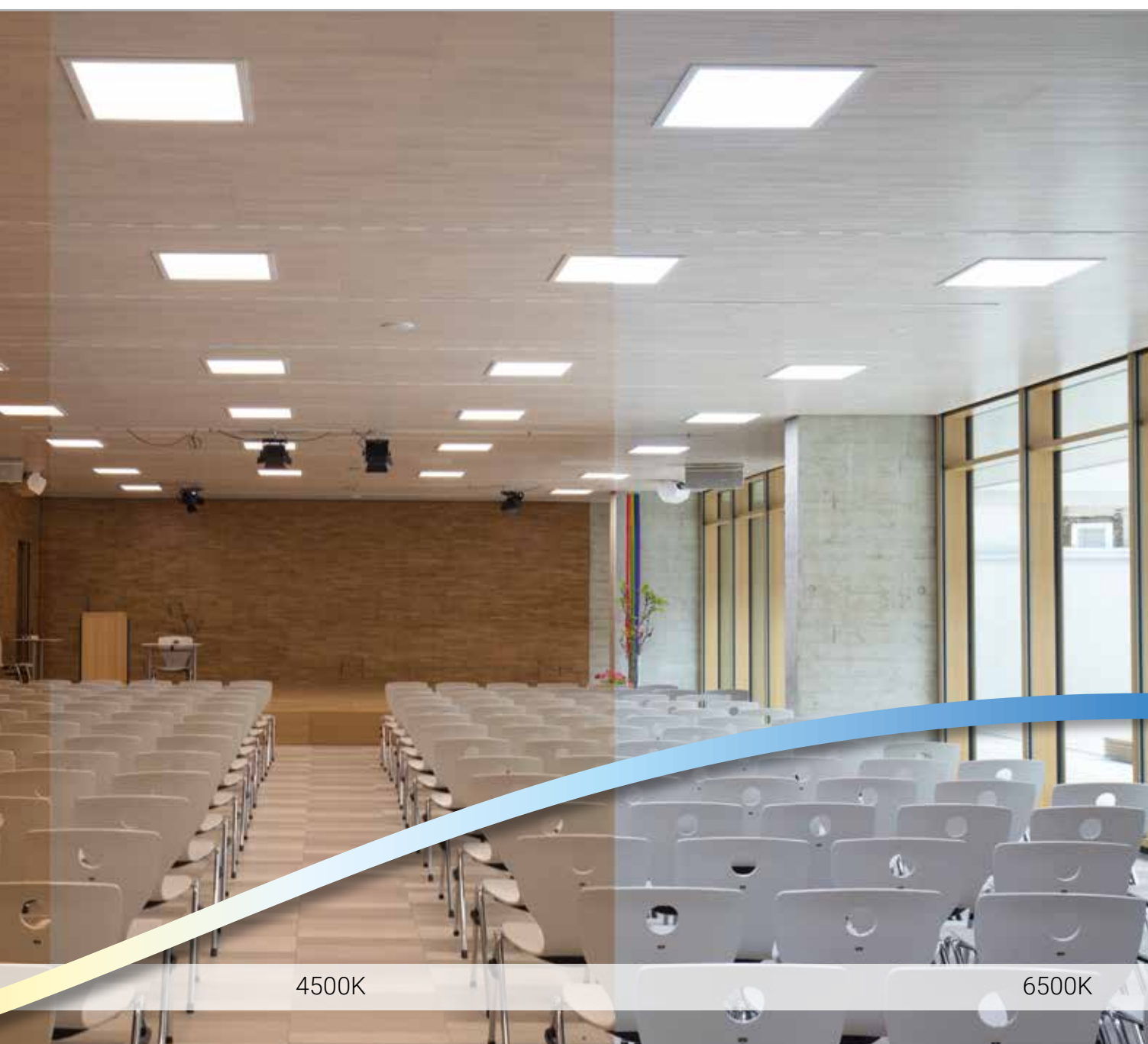
 PECK.DAAM Architekten GmbH,  
München  
Architekturbüro Dietz, Bamberg

**Planing:**

 Ingenieurbüro Förner,  
Memmelsdorf

**Installation:**

Elektro Kramer, Burgebrach



4500K

6500K



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002 - 003	s.h.schroeder; Köln DE	Word Conference Center; Bonn DE
008 - 009	lichtwerk GmbH; Königsberg DE	Gustav-Heinemann-Schule; Rastatt DE
012 - 013	lichtwerk GmbH; Königsberg DE	Harter Gebäudetechnik GmbH; Gerolzhofen DE
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020 - 021	BSD Agentur; Mainz DE	Rendering
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076 - 077	lichtwerk GmbH; Königsberg DE	Rendering
078 - 079	lichtwerk GmbH; Königsberg DE	Rendering
088 - 089	Jan-Eric Winkelmann; Rostock DE	Ernst-Moritz-Arndt Universität; Greifswald DE
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110 - 111	Ursula Karoline Göhring; Lichtenfels DE	Bodycare; Forchheim DE
116 - 117	Inga Paas; Köln DE	Goldener Ring; Düsseldorf DE
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124 - 125	Jörg Wenderoth; Baunatal DE	Bürgerhaus; Altstadt-Waldsiedlung
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	lichtwerk GmbH; Königsberg DE	Zahnarztpraxis Dr. Ambros; Knetzgau DE
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160 - 161	lichtwerk GmbH; Königsberg DE	Harter Gebäudetechnik GmbH; Gerolzhofen DE
164 - 165	lichtwerk GmbH; Königsberg DE	Harter Gebäudetechnik GmbH; Gerolzhofen DE
168 - 169	Katrin Heyer; Dettelbach DE	ZDI Cube; Würzburg DE
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222 - 223	lichtwerk GmbH; Königsberg DE	Singer Ingenieur Consult GmbH; Bamberg DE
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232 - 233	lichtwerk GmbH; Königsberg DE	Göhring Innenarchitektur; Lichtenfels DE
238 - 239	lichtwerk GmbH; Königsberg DE	Singer Ingenieur Consult GmbH; Bamberg DE
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260 - 261	lichtwerk GmbH; Königsberg DE	Realschule; Feucht DE
274 - 275	lichtwerk GmbH; Königsberg DE	Firma Heidrich; Nürnberg DE
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302 - 303	lichtwerk GmbH; Königsberg DE	SRAM; Schweinfurt DE
304 - 305	Inga Paas; Köln DE	Gemeindezentrum DIE ARCHE; Wüstenrot DE
312 - 313	Boris Golz; Arnsberg DE	IGS - Integrierte Gesamtschule; Nienburg DE
316 - 317	Jana Wenderoth; Kassel DE	Hürner Funken GmbH; Mücke DE
320 - 321	lichtwerk GmbH; Königsberg DE	Optik Demmler; Bamberg DE
324 - 325	Jörg Wenderoth; Baunatal DE	Vom Fass; Kassel DE
328 - 329	Jana Wenderoth; Kassel DE	Firmenzentrale medDV; Fernwald DE
332 - 333	lichtwerk GmbH; Königsberg DE	Familienzentrum; Rastatt DE
338 - 339	lichtwerk GmbH; Königsberg DE	Familienzentrum; Rastatt DE
342 - 343	lichtwerk GmbH; Königsberg DE	Regiolux GmbH; Königsberg DE
346 - 347	lichtwerk GmbH; Königsberg DE	Rendering
348 - 349	Tom Reindel; Düsseldorf DE	Medienhafen; Düsseldorf DE
354 - 355	Tom Reindel; Düsseldorf DE	Medienhafen; Düsseldorf DE
358 - 359	Inga Paas; Köln DE	Wiehler Wasserwelt; Wiehl DE
362 - 363	Inga Paas; Köln DE	Wiehler Wasserwelt; Wiehl DE
364 - 365	Danny Gohlke; Rostock DE	DJH Prora; Rügen DE
370 - 371	Frank Freihofer; Kitzingen DE	Pfarrzentrum; Limbach DE
374 - 375	Frank Freihofer; Kitzingen DE	Pfarrzentrum; Limbach DE
378 - 379	S. Meyer Architekturfotografie; Berlin DE	Gemeindezentrum; Stammheim DE
382 - 383	lichtwerk GmbH; Königsberg DE	Straßenmeisterei; Forchheim DE
386 - 387	lichtwerk GmbH; Königsberg DE	Straßenmeisterei; Forchheim DE
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398 - 399	S. Meyer Architekturfotografie; Berlin DE	Gemeindezentrum; Stammheim DE
412 - 413	lichtwerk GmbH; Königsberg DE	Maria Ward Schule; Bamberg DE



## 1. General

1.1 These conditions of sale apply exclusively to companies, legal persons under public law or public-law special assets in the sense of § 310 paragraph 1 BGB (German Civil Code). The following conditions of sale apply exclusively for all offers and contracts regarding the delivery of goods by lichtwerk GmbH. They also apply for all future transactions with the Orderer when dealing with legal transactions of the related kind. The Orderer recognises the conditions as binding for him for all of the business relations. Modifications and amendments must be in written form. Conflicting or deviating terms and conditions of the Orderer are not terms of the contract, even if we do not expressly object to them. This will only be content of the respective contract in cases where we expressly approve the conflicting or deviating terms and conditions in writing.

1.2 We reserve our own rights of ownership, copyright and other intellectual property rights for all cost estimates, drawings and documents that are handed over to the Orderer during the contract negotiations. They may only be disclosed to third parties with our prior written permission. If an order is not issued, all transferred documents shall be returned immediately at our request. The Orderer does not have the right to use, retain or disseminate these documents.

## 2. Conclusion of the contract and scope of services

2.1 Our offers are not-binding and without obligation. In terms of the nature and scope of delivery, they will first be binding upon our written order confirmation. If an order is to be regarded as an offer according to § 145 BGB, we can accept this within two weeks by sending an order confirmation.

2.2 Verbal agreements, in particular supplementary agreements and commitments made by our employees, require our written confirmation to be effective.

2.3 For the delivery, we reserve the right to deviations of goods compared to the documents belonging to the offers, such as catalogues, illustrations, descriptions, drawings as well as weight and dimension information, provided they are commercial and reasonable for the Orderer and in particular do not impair quality and function.

## 3. Prices, deliveries and terms of payment

### 3.1 Prices and delivery

3.1.1 The prices are calculated in Euro exclusive of the legal VAT, which is invoiced separately according to the valid rate. The prices are calculated according to the prices valid at date of contract conclusion; if the delivery is made more than 4 months after contract conclusion, the prices valid at date of delivery can be invoiced.

3.1.2 Principally, prices shall be ex works excluding VAT, packaging, freight costs and insurance.

3.1.3 For a net order value of €1,500.00 or more, we deliver to the delivery location free of charge within Germany, whereby we provide the goods at the delivery location ready for unloading. Starting at € 750.00, we charge half of the transportation charges for a delivery location within Germany. For a net order value below € 250.00, we charge an additional small-volume surcharge of €25.00.

### 3.2 Terms of payment

3.2.1 Our invoices are to be paid within 30 days from the date of the invoice. For payment within eight days from the invoice date, we grant a 2 % discount. A payment is considered effected if we are able to access the funds. In the case of payment by cheque, payment is only considered effected when the cheque is redeemed by us.

3.2.2 The acceptance of cheques shall only be accepted on account of performance.

3.2.3 The Orderer's right of retention, as far as it is not based on the same contractual relationship, and the offsetting with contested or not legally determined claims is excluded.

3.2.4 If the Orderer is in default of payment as a whole or a part, he is bound - notwithstanding all other rights of the supplier - to pay from that point of time on default interests to the amount of 8 % annually above the base lending rate.

3.2.5 If the Orderer ceases payments or if bankruptcy is filed or mature checks or bills of exchange are not redeemed, all claims made by the supplier are immediately due.

## 4. Delivery times and acceptance obligations

4.1 The delivery period begins with the date of written agreement about the order between Orderer and supplier.

4.2 Hindrances beyond our responsibility, in particular acts of God, war, insurrection, strikes, transport disruptions, business disruptions, lack of material, official orders and other inevitable events that delay the delivery in whole or in part automatically lengthen the delivery period by the duration of such conditions. In such cases the parties have the right to withdraw from the contract in whole or in part.

4.3 In the event of a delayed delivery for which we are responsible, the Orderer can only assert his rights arising from the delay if the grace period he granted us has passed without result. If the Orderer proves in this case that he has incurred damages caused by the delay, he can claim a delay compensation for each completed week of the delay in the amount of 0.5% for the entire duration of the delay, but not to exceed 5% of the value of the goods not delivered on time. The right of the Orderer for exercising the right of withdrawal shall remain unaffected. Further-reaching claims shall only apply in cases of intent or gross negligence where liability is mandatory.

4.4 We are entitled to make reasonable installment deliveries.

4.5 If the Orderer causes a delay of dispatch or delivery of the goods or if the Orderer is otherwise in default in accepting the delivery of goods or should the Orderer intentionally violate other obligations to co-operate, we then have the right to claim compensation for any incurred damages in this respect, including any possible additional expenditure. Rights remain reserved for more extensive claims. Insofar as such aforesaid conditions apply, the risk of accidental loss or accidental deterioration of the purchased goods passes over to the Orderer at the precise point of time in which he is in default of acceptance or payment.

## 5. Dispatch, transfer of risk, returns

5.1 The risk is passed on to the Orderer when the goods leave the factory or a warehouse. Shipping takes place uninsured at the Orderer's risk. This also applies even if free delivery is agreed and also for deliveries by our transport staff. If the shipment is delayed as a result of circumstances for which the Orderer is responsible, the risk is transferred with our notification of readiness for shipment. If the shipment is delayed at the Orderer's request or at the fault of the Orderer, then we will store the goods at the Orderer's expense. The Orderer is required to check without delay whether the goods have been damaged during transportation and to immediately inform the carrier and deliverer of any damage or loss. Shipping takes place on behalf of the Orderer.

5.2 If the supplier has no statutory obligation to accept returned goods, the Orderer may only return goods with our express written consent and provided that they are undamaged and returned in the original packaging. 30% of the invoiced amount will be deducted from the credit note to cover processing costs. All reprocessing, freight, insurance and packaging costs are charged to the Orderer. Principally, it is not possible to return custom-made products.

## 6. Retention of Title

6.1 The goods remain our property until the fulfilment of all our entitled claims against the Orderer (goods subject to retention of title), even if the individual goods have been paid for. A pledge or chattel mortgage of the reserved goods is not permissible.

6.2 In the case of the permissible resale of the reserved goods within the ordinary course of business, the Orderer assigns us already now, until payment of all our claims, as collateral for its future claims towards his customers resulting of such resale without requiring any specific further explanations. This assignment also covers balance claims resulting from existing current account relationships or at their termination of the Orderer with his customers. If the reserved goods are sold together with other goods without agreeing upon an individual price for the reserved goods, the Orderer assigns us the priority over the other claims for such part of the total price claimed which corresponds to the value invoiced by us. Until revoked, the Orderer is authorized to collect the assigned demands from the resale, he is not entitled to dispose of them otherwise, e.g. by assignment. Upon our request, the Orderer must inform his customer about the assignment and to furnish us the necessary documents for the assertion of his rights towards the customer, e.g. to deliver invoices and to provide the required details.

6.3 If the purchaser does not meet all or a part of his payment obligations within 10 days after due date, if he does not cash due checks or if an application for insolvency is filed, we have the right to withdraw from the contract and to require the return of the goods. The purchaser is obliged to procure us with the possession of the goods. The Orderer grants us or any of our authorized representatives the access to all business premises during business hours. We are entitled to use the reserved goods with the diligence of a prudent businessman and to satisfy ourselves with the offsetting of open claims with their proceeds.

6.4 As long as the ownership has not been transferred, the Orderer is to inform us in writing immediately if the supplied item is seized or is exposed to other interventions by third parties. If the third party is unable to indemnify us for the costs of legal or out-of-court costs of a claim according to par. 771 ZPO (German Code of Civil Procedure), the Orderer is liable for our amount outstanding.

## 7. Warranty

7.1 We are liable for the defects of the goods (in the first instance under the exclusion of the Orderer's rights to back out of the contract or to reduce the purchase price) through rectification of the defect or replacement delivery at our choice. The Orderer shall grant us a reasonable time period to provide the rectification. If the supplementary performance does not work, the Orderer may basically according to his choice demand a cut of the compensation (decrease) or a cancellation of the contract. The improvement is considered failed after the second unsuccessful attempt, provided further improvement attempts are not appropriate due to the subject matter of the contract and are not reasonable to the Orderer. In case of a minor breach of contract, especially minor defects, the Orderer, however, does not have a right of cancellation.

7.2 Warranty rights of the Orderer require that the Orderer's obligations to make inspection and give notice of defects according to par. 377 HGB (German Commercial Code) have been properly fulfilled.

7.3 The Orderer must notify us concerning obvious defects within a period of 10 days after receipt of goods, otherwise the assertion of the warranty claim is excluded. Non-obvious defects must be claimed immediately when they are discovered or determined, otherwise they are deemed to be approved. For all presuppositions for claims he full burden of proof for lies with the Orderer, especially for the deficit itself, for the time period of the determination of the defect, and for the timeliness of the notice of defect.

7.4 If the Orderer, due to a deficiency in title or a material defect after failed subsequent performance, chooses to cancel the contract, he shall not be entitled to additional claims for damages due to the defect.

7.5 The warranty period amounts to one year from date of delivery of our goods to the Orderer.

7.6 The warranty obligation is void if the goods have suffered from improper handling or storage or if improper changes were made to them without the supplier's approval. We are not liable for subsequent changes to the lights, their internal circuitry, equipment or the lamps.

7.7 The condition of the goods only the product description of the manufacturer applies as agreed upon. Additional public statements or advertisements of the manufacturer do not represent a contractual statement on the nature of the goods.

7.8 In the event that the article of sale cannot be used by the Orderer as stipulated in the contract of sale as a result of negligent violation of collateral contractual duties, especially with regard to operating and maintenance instructions, we shall also be liable in accordance with paragraph 7.6.

In case of consulting we can only be held responsible if special payment was agreed in writing.

7.9 Claims made by the Customer against the Supplier for installation and disassembly costs, unless they serve to detect errors, costs of disposal and costs for hoisting devices and scaffolding shall be excluded. The Customer shall bear the costs of the necessary recommissioning, software reinstallations or software updates. Where the Supplier meets its cost absorption obligation pursuant to Article 478 of the German Civil Code with respect to other expenses necessary for supplementary performance, the Supplier shall be entitled to pay such expenses by means of a credit note for goods. A right to compensation for damages to the goods themselves shall be excluded. This does not apply, as far as compelling liability is given in cases of intent, gross negligence, lack of guaranteed product properties or the Product Liability Act.

## 8. Limitation on Liability

8.1 As far as it is not expressly stipulated otherwise in these conditions, the claims against us, our legal representatives and any person employed by us in the performance of our obligation and any vicarious agent resulting from damages, including consequential damages, which occur to the Orderer or a third party, in particular such damages resulting from fault at contract conclusion, culpable breach of an obligation and negligent and impermissible actions are excluded.

8.2 The aforesaid limitations of liability shall not affect the Orderer's product liability claims. In addition, we are liable for loss of life, physical injury and damage to health (regardless of existing limitation of liability according to the statutory provisions) that are caused by a negligent or wilful breach of duty on our part, our legal representatives or our assistants. We are liable under statutory provisions for damages that are not covered by clause 1 and that are based on fraudulent intent by us, our legal representatives or our assistants.

8.3 The Orderer's claim for damages for defect becomes time-barred after one year from date of delivery of the goods to the Orderer. This shall not apply if we can be accused of malice. In these cases, the statutory provisions apply.

## 9. Applicable law, place of jurisdiction

For these business relationships and all legal relationships between us and the Orderer, - including export contracts - the governing law of the Federal Republic of Germany applies exclusively. The application of the UN jurisdiction, concerning sales and purchase procedure, is excluded. If legally permissible, the place of jurisdiction for all disputes directly or indirectly resulting from a contractual relationship is, by our choosing, either Halßfurt or the court responsible for the Orderer's registered office. The place of fulfillment for deliveries and payments is also Hassfurt. If individual conditions of the contract including these GTC are partially ineffective or will be, the validity of the other conditions are not affected by it. The whole or partial ineffective condition should be replaced by conditions, whose economic purpose comes as close as possible to the ineffective one.







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## Exclusion of Liability

Illustrations, dimensions and weights in our catalogues, price lists and quotations are non-binding. Subject to technical changes, errors and color deviations. All luminaires have been designed for 230V 50Hz mains connection and ambient conditions according to DIN EN 60598 unless otherwise stated, and are supplied without lamps unless otherwise stated. Most of the indications with regard to certifications are presented in our catalogue in a general form. Verification with regard to products can be easily carried out on our website.

Because of the dynamics in the technical development especially in the field of LED modules and their drivers, the information in this paper can only be a snapshot of the current state and are therefore legally not binding. Please refer to our web site for current product specifications.

We point out that the orderer recognises our delivery and payment conditions unless he/she objects in writing when sending his/her order.



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