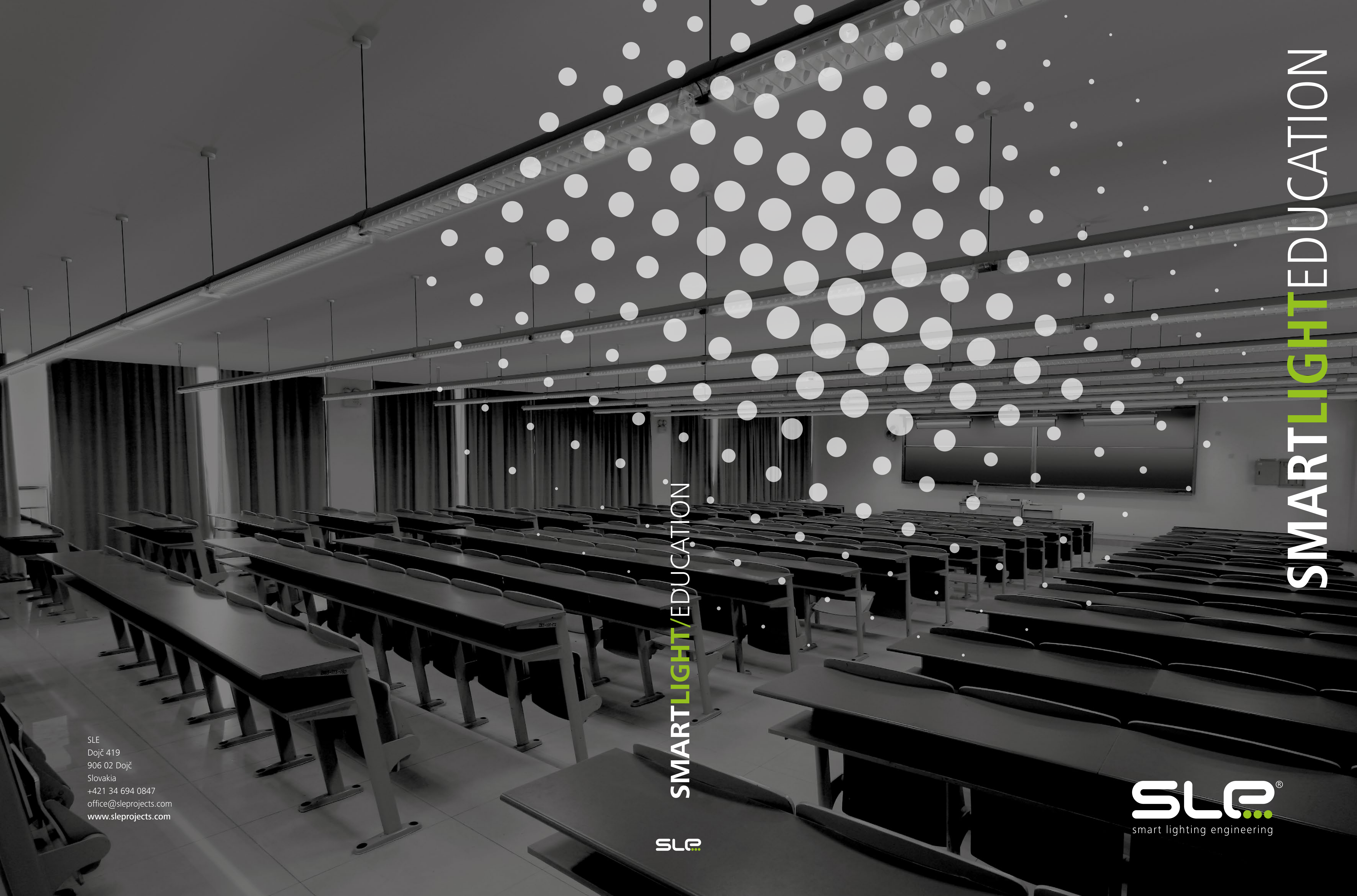

SMARTLIGHTEDUCATION

SLE®
smart lighting engineering

SMARTLIGHT/EDUCATION

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It is often simple to learn because people's brains work as incredible sponges which are able to absorb knowledge without limits. But only when we succeed in keeping its cerebral cells open by appropriate education and motivation.

Stephen Jay Gould

The visual perception plays a decisive role when we acquire information about the world and how its regularities work. Before we are able to give the things their names and to understand the comprehensiveness of the relations the things are entering, we perceive them through our eyes. Appropriate lighting of the space the educational process is realised in is therefore one of the key factors which play a decisive task during the schooling. The light creates a positive communication atmosphere between the teacher and pupil; it is able to positively affect the concentration ability and performance efficiency of the students, to create such conditions in which both the students and the teachers will feel comfortably and especially is able to ensure the correct perception of the displayed objects and information. Correct lighting at school has a substantial influence on what relation the pupils and students will create to school and if they will like the educational process. The time when children learnt under the light of the paraffin lamps or incandescent bulbs belongs fortunately to the past today.

The scientific knowledge about the influence of the light on people and their visual and psychological well-being and the importance of correct space illumination the teaching process is realised in has been implemented to the educational premises at all levels during recent years. Appropriate lighting plays the same important role also for the games in the kindergartens, during teaching the alphabet in the first grades of the basic schools as well as during scientific experiments at higher educational levels. The modern school places increased demands on the lighting solutions today. The strict organisation of the space has made way for the requirement of flexibility. The pupils today do not spend the whole day solving individual tasks at their desks, they work in groups and the desks alter to working islands. The conventional wooden blackboards are replaced by the interactive ones; the paper and pen are replaced by the PC monitors. That is why the lighting solutions have to adjust to these changes. The objective of this publication is to provide comprehensive information about correct space lighting in the educational premises as well as the tools for assessing the quality of the individual lighting systems.

smart lighting engineering

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CONTENT

$$\frac{1}{x+2}+\frac{2}{x-2}=0$$

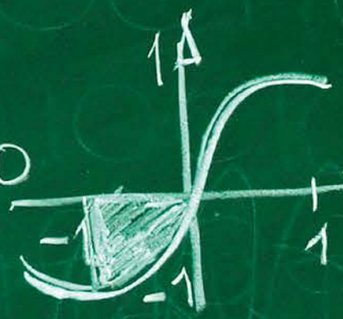
$$\frac{1}{x+2}+\frac{2}{x-2}=0$$

$$\frac{-6x+16+x^2-2x+2x^2}{(x^3+x^2-1)-x^2(3x^2+2x)}$$

$$(x^3+x^2-1)^2$$

$$(\sin x^2)$$

$$\begin{cases} x\neq 0 \\ x-2\neq 0 \\ x+2\neq 0 \end{cases} \Rightarrow \begin{cases} x\neq 0 \\ x\neq 2 \\ x\neq -2 \end{cases}$$



$$\frac{(x+2)(-3x+8)+x(x-2)+2x(x-2)}{x(x-2)(x+2)}$$

$$\frac{x+1}{x+1}-\frac{2}{x-3}+\frac{x+1}{(x+1)(x-3)}=0$$

$$\begin{cases} x+1\neq 0 \\ x-3\neq 0 \end{cases} \Rightarrow \begin{cases} x\neq -1 \\ x\neq 3 \end{cases}$$

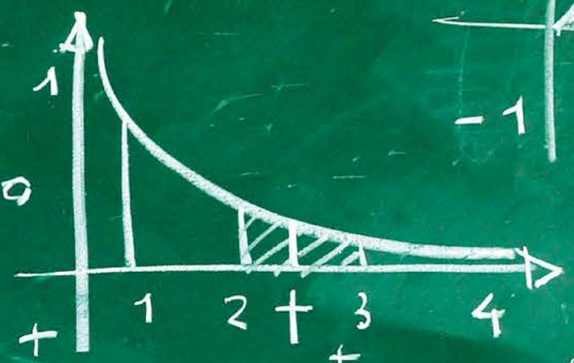
$$\frac{x-1}{(x-3)(x+1)}+\frac{2}{(x+1)}-\frac{1}{x-3}=0$$

$$x^2-1+2x-6-x^2-2x-1=0$$

$$=\frac{2x+3}{x+2}$$

$$\frac{x+1}{x-2}=\frac{2x+3}{x+2}$$

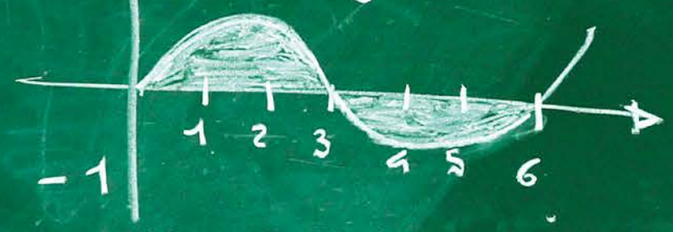
$$\Rightarrow \begin{cases} x\neq +2 \\ x\neq -2 \end{cases}$$



$$\int_1^+ \frac{1}{x^2}dx=\int_1^+ x^{-2}dx=\left[\frac{x^{-1}}{-1}\right]_1^+=\frac{-1}{+}+1$$

$$5x=-10$$

$$\int_a^b f(x)\,dx$$



$$\operatorname{ch}x\ \sqrt{1+\text{sh}}$$

$$\operatorname{sh}(-x)=-\operatorname{sh}x;$$

$$\operatorname{Th}(-x)=-\operatorname{Th}x$$

$$\operatorname{cosech}(-x)\ \text{cosec}$$

$$\operatorname{cth}(-x)=-\text{cth}$$

$$\int\frac{1}{\text{sen}x}dx=\log\left|\text{tg}\frac{x}{2}\right|+c$$

$$\int\frac{1}{x}dx=\log|x|+c$$

$$\int\cos x\,dx=\text{sen}x+c$$

$$\int\left(1+\text{tg}^2\right)dx=\int\frac{1}{\cos^2 x}$$

$$\frac{1}{\sqrt{1-\text{Th}^2x}}\qquad \pm\sqrt{1+\text{cosech}}$$

$$\text{cosec}$$

LIGHTING AND HUMAN

NEW ORDER IN LIGHTING WORLD

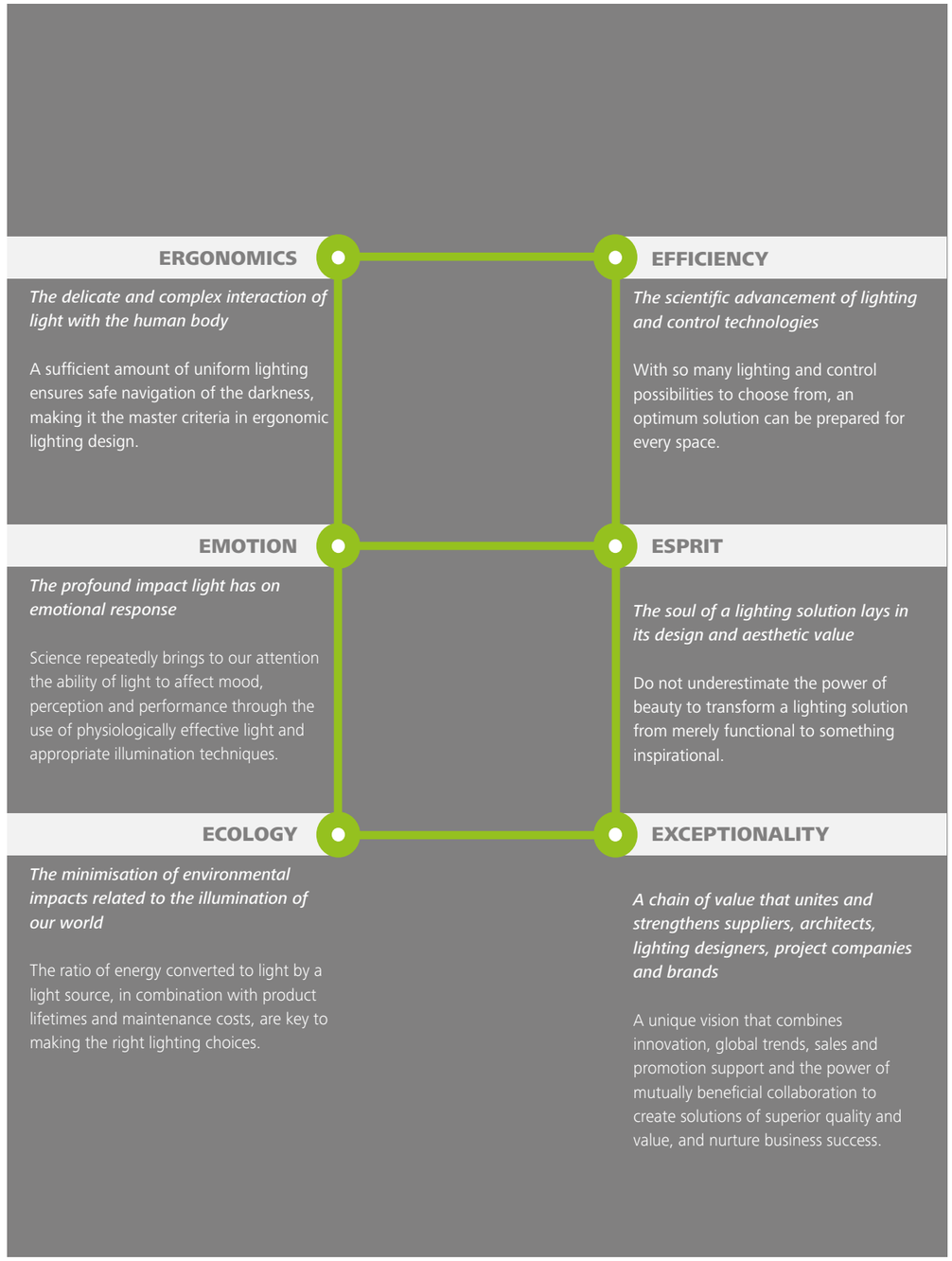
When designing the lighting system for the educational premises of all levels the lighting designer has to respect the legal standards as well as many other important parameters which affect the quality of the overall lighting solution. The summary of these criteria has been presented by a non-standardised system until recently and it did not provide a sufficient overview. The six-point system of assessing the lighting quality – Lighting Quality Standard – developed by the company SLE is bringing a new order into the chaotic lighting world.

Living by rules is important.
Respecting laws is relevant as well. The ancient conflict of our world is driven by patterns and order; otherwise we become adrift by chaos that is present in our civilisation to these days. Whether the former or the latter concept is the right one, is an eternal question. One thing is certain: we in SLE love the order much more than chaos. That is why we have created a brand new lighting quality standard to help the customers, buyers and competitors better understand and evaluate lighting devices and solutions.

Until now there was no unifying system used in the world of lighting for evaluation of eiher light fixtures or lighting solutions, and every producer has got its own way for that. Consumers get lost in the vast array of criteria used, and comparing neither products nor solution was an option. SLE brings order to this chaos. We are prepared to help the LQS become a unified standard used by the whole lighting sector. No overstatement, the LQS is an important step to the new level. Not just for our company, but for the branch and the giant world of lighting.

We have chosen more than twenty objectively quantifiable criteria and we are using them to evaluate both individual light fixtures and complete lighting solutions for different types of spaces. Each criterion has got its value and the result is the LQS Index. The higher the index is, the better the lighting device or solution is for use in a given space. Simple and intuitive approach to the agenda is exemplified by the LQS Composer, a unique tool to evaluate each and every lighting product.

There is a six-part program behind the acronym LQS.
The chapters are named ERGONOMICS, EMOTION, ECOLOGY, EFFICIENCY, ESPRIT AND EXCEPTIONALITY, **or just 6 E's.**
If you imagine a house, the first four chapters are strong pillars representing criteria that are well-known in the world of lighting. The remaining two are the roof, a powerful superstructure on the top of these pillars. Together, they create an inseparable complex, because the parts of the whole cannot be perceived independently, but only in their context. That is the basic philosophy of the LQS. Immerse in the 6 E's and conceive the idea of living in a place where rules are crystal clear.



ERGONOMICS

Up to 80 % of all information is perceived through our vision therefore the visual perception plays a decisive role during the educational process. Correct lighting enables the student to perceive the objects and shapes correctly, to acquire information about the space and makes the orientation inside the space easier.

Correct lighting in the classroom improves the capability of the pupils to concentrate and makes the educational process more cheerful.

When designing modern educational premises the ergonomic solution of lighting represents one of the most important items.

The lighting system which complies with the principles of ergonomics improves the performance efficiency and capability of the pupils, protects the eyes, reduces the risk of injuries and first of all – it makes the process of education more entertainment. The variedness of the educational activities places increased demands on the lighting variability. This fact results in the task of the lighting designer to design the lighting system in such a way that it will comply with every type of activity which will be carried out in the individual spaces.

The basic quantities the ergonomics pays attention, to when creating optimal lighting conditions – the colour rendering index, glare prevention, the illumination level, the illumination of the task area and the surrounding of the task area, the lighting uniformity and harmonious distribution of brightness.

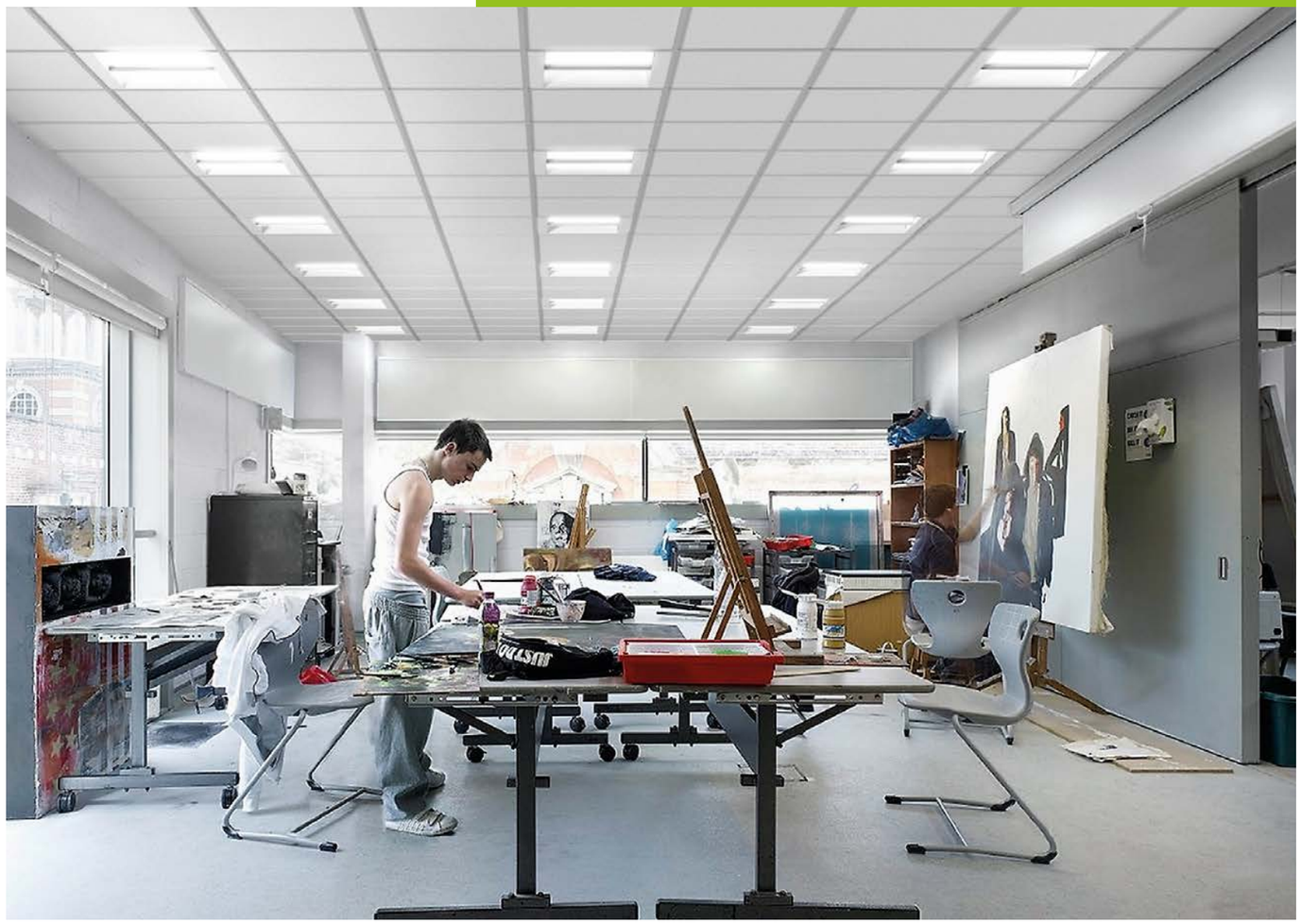
The correct recognition of colours plays a decisive role in the process of learning on all educational levels. Ensuring their correct perception is therefore one of the lighting designer's key roles.

COLOUR RENDERING INDEX

The correct recognition of colours plays a decisive role in the process of learning and identifying things on all educational levels. At the kindergartens it enables the children to call and allocate the colours; at higher educational levels it is important in the framework of the artistic subjects but the subjects of natural sciences as well. Therefore one of the key tasks of a designer when solving the illumination is to ensure the correct perception of colours.

The influence of the light source on the appearance of the colour objects is expressed by the Colour rendering index (CRI) which indicates how truthfully the individual light sources are able to copy the colouring of the object compared to the natural daylight. The CRI value of a light source is expressed by the average of the values of the first eight indices R1 – R8 out of fifteen colour samples illuminated at first under the reference light source with the ideal value (CRI = 100) and then under the light source being tested. The bigger the difference of the truthfulness of reproducing the colour is, the lower the value of the colour rendering index of the light source tested and its ability to depict truthfully the objects´ colouring is. From the practical point of view the colour rendering index is one of the most important aspects when selecting a light source. The European standard EN 12 464-1 determines the light sources with the colour rendering index minimally 80 for the common classrooms, for classrooms where special subjects are taught and where the emphasis on the correct recognition of colours (e.g. art lessons, chemistry, etc.) is laid, the luminaires with CRI 90 and more are required.

From the point of view of LQS the highest score is assigned to the light sources with CRI 90 and more.

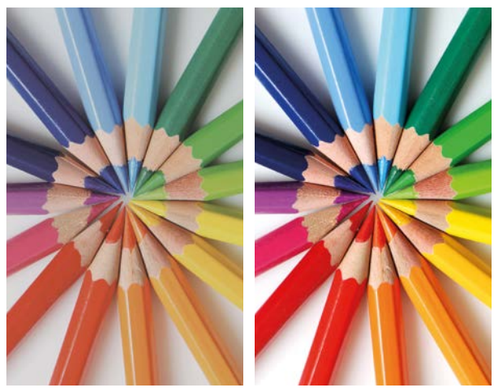


The emphasis on correct colour recognition in the educational process is laid especially in the classrooms where teaching of art lessons takes place. The standard determines to use the light sources with CRI 90 for here.

LQS VALUE

Colour rendering index (CRI)

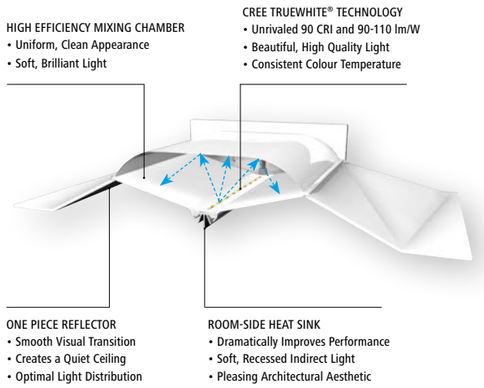
CRI	LQS Value
>90	5
80-90	4
70-80	3
60-70	2
40-60	1
20-40	0



Comparison of colour rendering indices – CRI.
Left: CRI 70. Right: CRI 93.

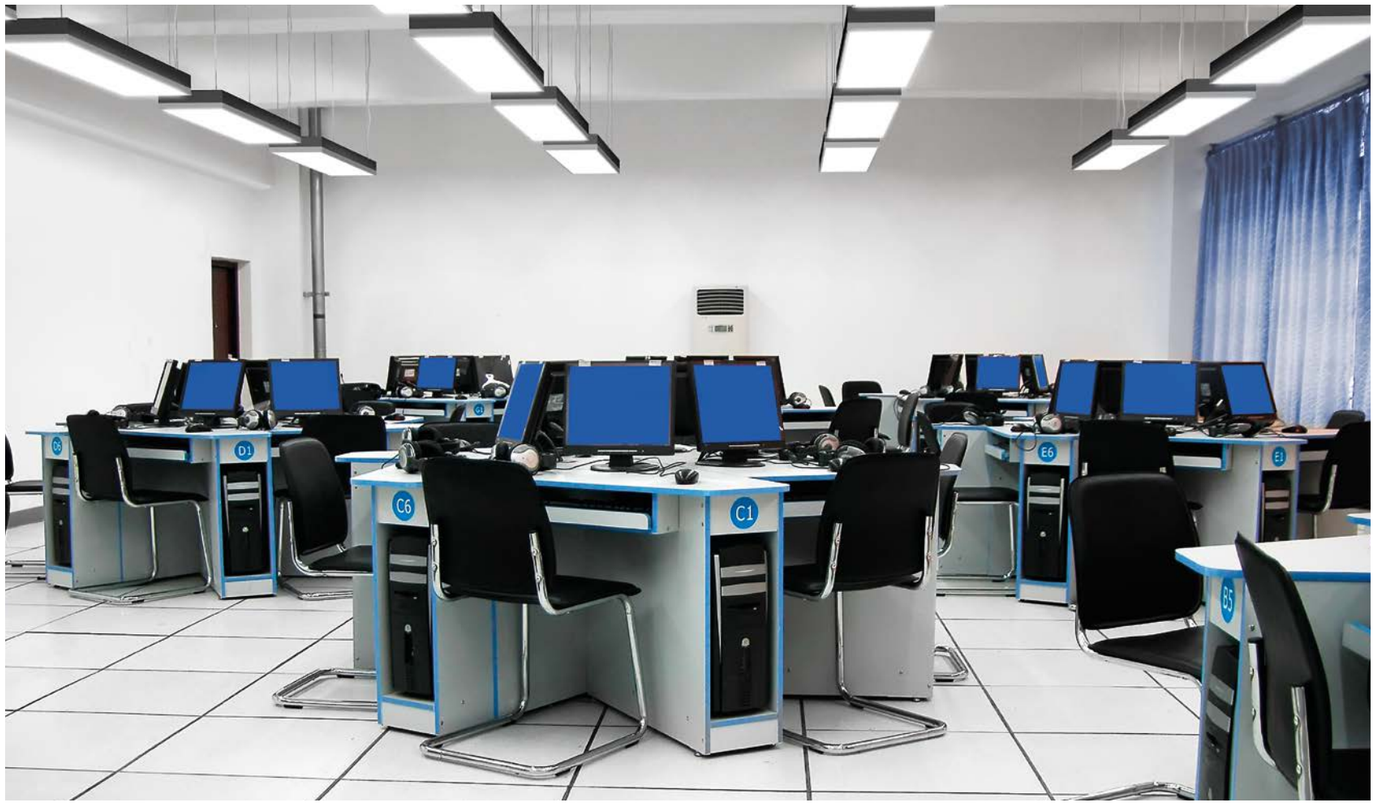
Truewhite technology

Cree TrueWhite® Technology represents a patented method of generating a white light of high quality developed by the company CREE. It is a relatively simple and very effective method where a white light of high quality develops through combining the yellow and red LED module. By implementing this technology to the luminaires with diffuse optics we can acquire pleasant soft light with high colour rendering index – CRI 93, warm colour and excellent efficacy up to 111 lm/W. The Cree TrueWhite® Technology is proof that the LED sources are highly energy-effective and are able to generate light with the quality at the level of the conventional light sources. The company SLE utilises the Cree TrueWhite Technology e.g. for the luminaires GRUMIUM, CYGNUS, CASTOR and in the last product novelty SAIPH.



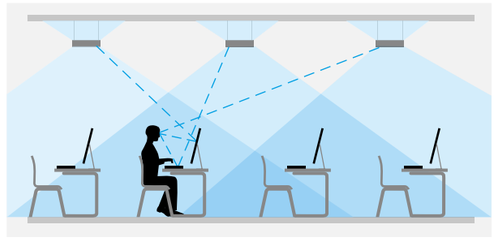
GLARE PREVENTION

Glare is a negative visual perception caused by light surfaces in the field of vision. To prevent it or to minimise its occurrence is extraordinarily important not only from the point of view of the visual comfort but also safety. The excessive direct or indirect glare in the school spaces can cause fatigue, damage of sight and can reduce concentration. At the same time, the glare reduces the visibility of the text on the PC monitor and makes reading on glossy paper more difficult. The prevention of disturbing glare therefore belongs among the basic tasks of the designer when planning the lighting solution.



At schools the glare is especially undesirable in the rooms with VDUs (Visual Display Units). The excessive glare can reduce the display contrast on VDUs by veiling reflections caused by illuminating the monitor surface, the luminaire luminance and bright surfaces which mirror on the display. The requirements on the visual quality of the screens concerning the undesirable reflections are stated by the European standard EN ISO 9241-307.

Reducing the risk of exposing the pupils to glare begins with correct organisation of the working plane. Placing the desks rectangular to the windows for the pupil not to be exposed to the sunshine and fitting the windows with an effective system of blinds belong among the basic measures how to limit the glare. The indirect glare represents the same psychological and physiological burden as the direct glare. Moreover, it reduces the ability to perceive the contrasts. It is aroused by the disruptive reflection of light falling from the luminaires or unblinded windows from glossy surfaces (e.g. glossy paper or monitor). The direct glare is caused by excessive luminance, e.g. by incorrectly placed luminaires or non shield luminaires. It arouses psychological and visual feeling of being unwell; therefore it is inevitable to reduce it to a minimum. E.g. the luminaires with microprism represent a suitable solution.



The correct illumination of the task area creates optimal conditions for employees to work. You will prevent their feeling of fatigue, reduction of concentration and you will also prevent situations in which they could make unnecessary failures

Screen high state luminance	High luminance screen $L > 200$ cd/m²	Medium luminance screen $L \leq 200$ cd/m²
Case A *The values for the spaces with common demands on correct colour rendering and the details of the information depicted.*	≤ 3000 cd/m²	≤ 1500 cd/m²
Case B *The values for the spaces with increased demands on correct colour rendering, precision work and the details of the information depicted, e.g. determined for teaching art lessons or chemistry.*	≤ 1500 cd/m²	≤ 1000 cd/m²

The boundary dimensions of the average luminance of the luminaires that can reflect from the flat screens.

The excessive direct or indirect glare at school can cause fatigue, eye damage and reduction of concentration.

LQS VALUE

Glare prevention

Glare prevention	LQS Value
URG<16	5
URG<19	4
URG<22	3
URG<25	2
URG<28	1
URG>28	0

Unified glare rating

The Unified Glare Rating (UGR) is used for a unified qualification of the psychological glare rate defined by the Commission Internationale de l´Eclairage. The European standard EN 12464-1 determines UGR maximally 16 for the educational spaces with high demand on precision and with a high rate of eye strain (e.g. geometry), for common classrooms, lecture rooms, teacher rooms and offices UGR 19, for the reception rooms UGR 22 and for archives or warehouse UGR 25.

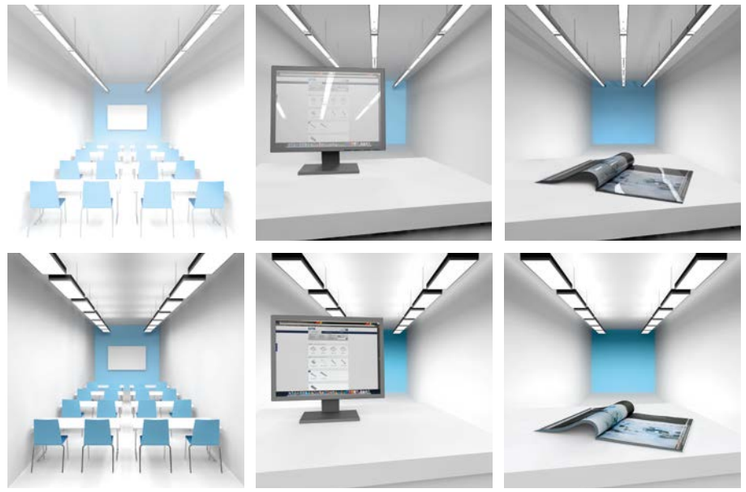
LQS assigns the higher rating of 5 points to the light solutions less than UGR 16.

$$UGR = 8\log\left[\frac{0.25}{L_b}\sum\frac{L^2\Omega}{p^2}\right]$$

Where
- L stands for luminance of lighting parts of every luminaire in the direction of the eye (in candelas per square meter).
- Ω is a cut-off angle of a luminaire relative to the eye of an observer (in sr).
- P is a Guth factor of spatial position of every single luminaire relative to the field of view. Finally,
- L_b expresses background illuminance (in candelas per square meter).

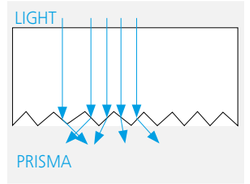
Microprism

The recessed luminaire MODUL BOX MAX with the direct characteristic of the luminous flux distribution is fitted with special microprismatic optics. The microprism represents the most effective method of distributing the diffuse light as the light breaks at the very end of the material, on the so called optical prisms and this causes the uniformly dispersed distribution. The soft diffuse light is pleasant for the human eye, it strains it less and in this way the unified glare rate (UGR) is reduced. The luminaire MODUL BOX MAX with the LED light source generates the light with correlated colour temperature of 3,000 K or 4,000 K and achieves the colour rendering index CRI 80, the efficacy up to 81 lm/W and UGR<19.



Direct glare is caused by excessive luminance, e.g. by incorrectly placed luminaires or non shield luminaires. It arouses a psychological and visual feeling of being unwell; therefore it is inevitable to reduce it to a minimum. E.g. the luminaires with microprism represent a suitable solution.

Indirect glare represents the same psychological and physiological burden as the direct glare. Moreover, it reduces the ability to perceive the contrasts. It is aroused by the disruptive reflection of light falling from the luminaires or unblinded windows from glossy surfaces (e.g. glossy paper or monitor).



ILLUMINATION LEVEL

The light substantially affects the feeling of well-being of the pupils and teachers; it influences their psyche, performance efficiency, the ability to concentrate and regeneration. The correct illumination of the space enables correct perception of the visual information, recognising the object shapes and faces.

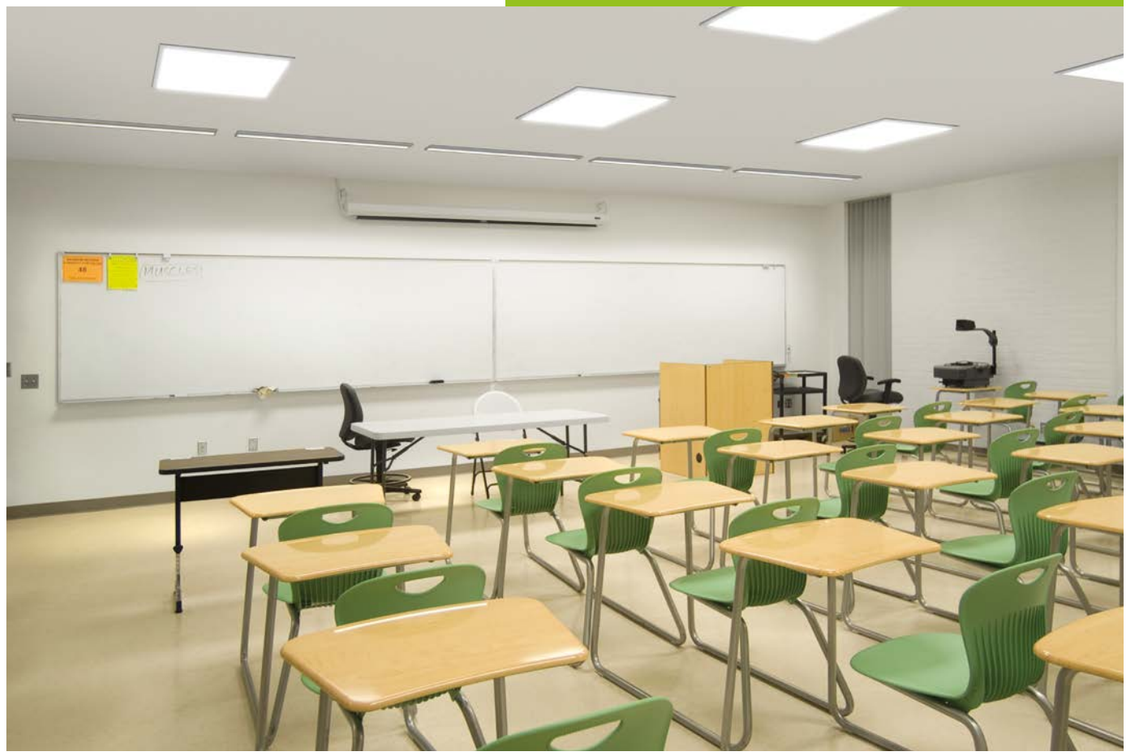
In general the optimal solution is considered when we place the luminaire in such a way that the luminous flux will be directed to the working surface moderately from the left hand side in the direction of the pupil's or teacher's view. Using this solution they do not cast a shadow and good visibility of the pen point is ensured. This direction of the luminous flux is determined for right-handers; the left-handers are often disadvantaged in this case. However, today there are lighting solutions which enable adjusting the luminous flux to create the same conditions for the left-handers also. The insufficient or erroneous illumination of the classroom or another educational space can have a negative impact not only on the quality of the teaching process and the ability to learn but also on the state of mind of the students and teachers. The modern lighting solutions are based on the research results which have shown that the light is the decisive factor for the psychological and visual well-being of people. That is why the designers attempt to be as close as possible to its properties when planning the illumination.

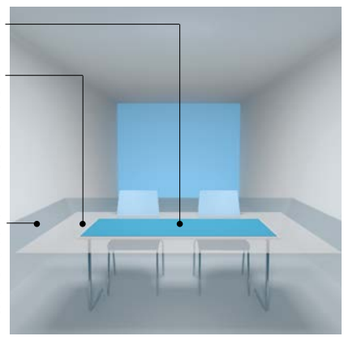
Task area

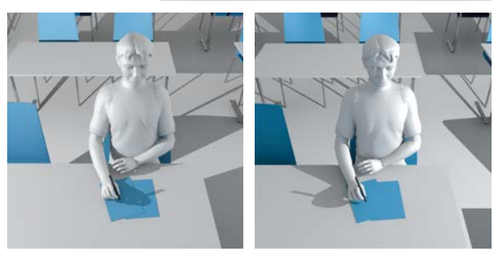
The task area places the greatest demands on the lighting in every type of the educational space. The European standard EN 12464-1 determines the illuminance level 300 lux for the task area in the classrooms. Our experience from practice and the research results have shown that from the point of view of the teaching process quality this normative value is insufficient and we recommend maintaining the minimal illuminance 500 lux.

Appropriate lighting of the space enables correct perception of the visual information, recognising the objects and faces.

In the educational premises there are besides the desks also presentation surfaces or boards as parts of the task area. For the board the normatively determined illuminance level is 500 lux and the lighting uniformity 0.7.



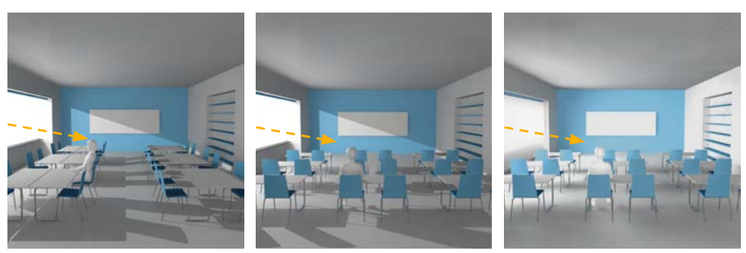




To ensure optimal conditions for writing it is suitable to place the luminaire for its luminous flux to be directed from above and moderately from the left hand side in the direction of the pupil's view. Using this solution the pupils do not cast a shadow when writing and good visibility of the pen point is ensured.

Illuminance on the task area E_{task} lux	Illuminance on immediate surrounding areas $E_{surrounding}$ lux
≥ 750	500
500	300
300	200
200	150
150	E_{task}
100	E_{task}
≤ 50	E_{task}

Relationship of illuminances on immediate surrounding to the illuminance on the task area.



Direct glare can be prevented by correct organisation of the working plane. Placing the desks rectangular to the windows will prevent pupils to be directly exposed to the sunshine and thus to the undesirable glare.

Fitting the windows with an effective system of blinds belongs among the basic measures how to avoid the direct glare from sunshine.

Surrounding area

The correct illumination of the surrounding area (from 0.5 m from the task area) and the background (up to 3 m adjacent to the surrounding area in the framework of the limited space) is also an important factor. Their correct lighting can prevent problems with perceiving objects, minimise the risk of eye fatigue, the rise of stress and strain. The illuminance of the surrounding area and the background is connected with the task area illuminance and is to ensure the balanced luminance distribution in the field of vision. The illuminance values of the surrounding of the task area corresponding with the individual illuminance level of the task area are defined by the European standard EN 12464-1. For the background illuminance the standard states a minimum of one third of the surrounding area value.

LQS assigns the spaces fulfilling the standard requirements 5 points; the non-conforming values of the illumination level 0 points.

In the educational premises there are, besides the desks, also presentation surfaces or boards as parts of the task area. The European standard EN 12464-1 determines the minimal illuminance level 500 lux at the uniformity of 0.7 for the board. When solving the illumination of the board it is necessary for the surface to be illuminated uniformly and sufficiently along its whole height. To achieve the required values of the level and uniformity of illuminance by general lighting is almost impossible; therefore it is inevitable to use an additional luminaire. The recessed luminaire RELAX ASYMMETRIC LED with an asymmetric luminous intensity curve by which we achieve sufficient vertical illuminance of the whole presentation surface. It is recommended to install the luminaire 0.85 to 1.3 metres from the presentation surface.

LQS VALUE

Illumination level (task area)

Illumination level (task area)	LQS Value
Yes	5
No	0

LQS VALUE

Illumination level (surrounding area)

Illumination level (surrounding area)	LQS Value
Yes	5
No	0

The lighting uniformity can be expressed as the ratio of the minimal and average illumination. The closer their values are, the more uniform the space illuminance is.

LIGHTING UNIFORMITY

The uniform illumination affects our ability to perceive the environment and to orient ourselves in the space. The uniformly illuminated space is perceived as a consistent one, however, great differences in the rate of lighting create an impression of a broken space and increase demands on the human eye adaptation ability. The lighting uniformity is expressed as a ratio of the minimal and maximal illumination of the space assessed. The closer their values are, the more uniform the space illuminance is.

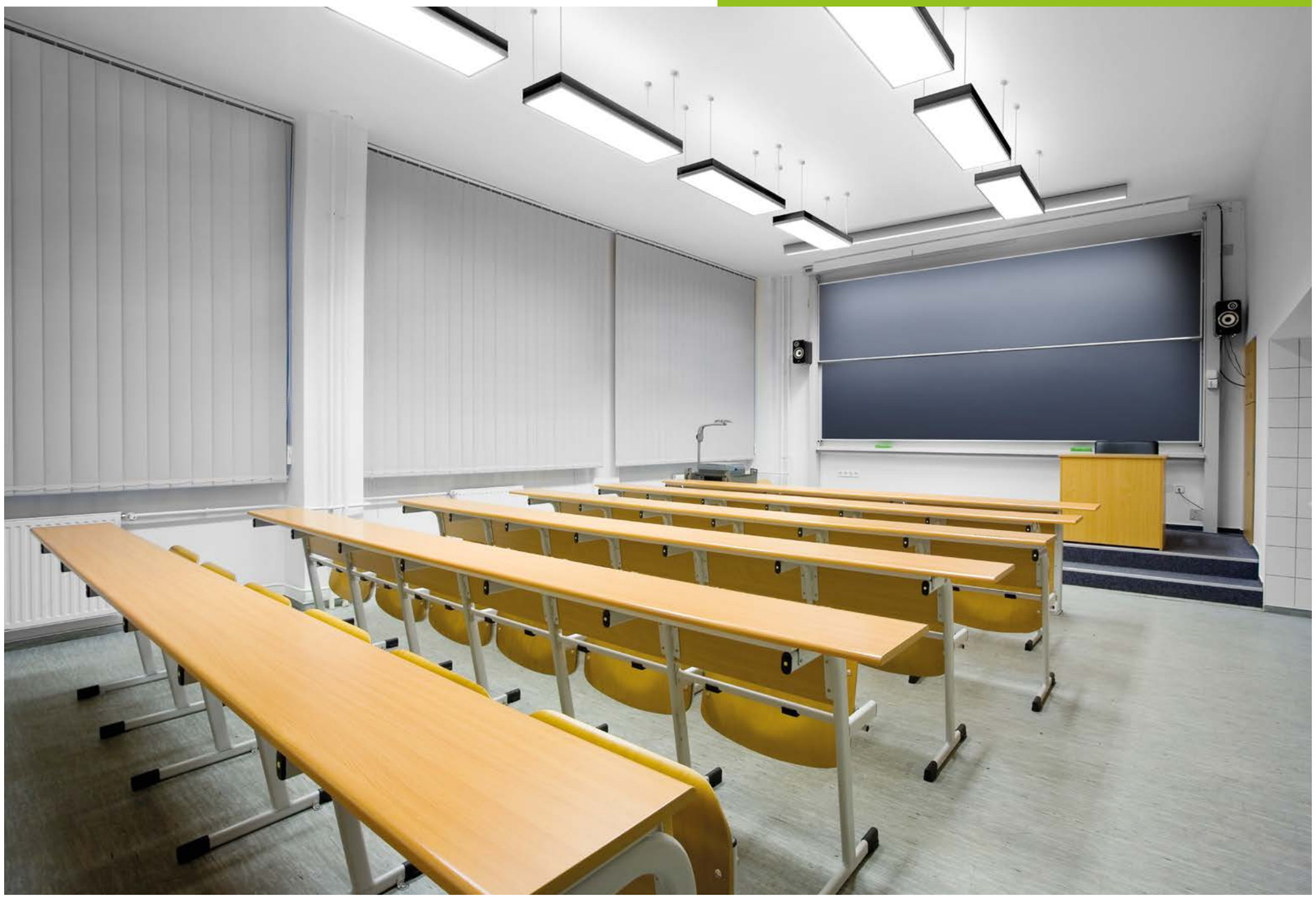
The optimal state can be achieved by selecting the right type and number of luminaires and their correct placement. From the point of view of the luminaire type the direct/indirect lighting fixtures with a wide luminous intensity curve seem to be the most effective. The index of the lighting uniformity is adjusted by the European standard EN 12464-1 which similarly as in the case of the illumination level places higher demands on the classrooms where subjects with higher requirements on eyes are taught, e.g. the art lessons. For these classrooms the index with the minimal value 0.7 is determined.

From the point of view of LQS the optimal illumination meeting the requirements of the standard is assessed by 5 points, the non-conforming one by 0 point.

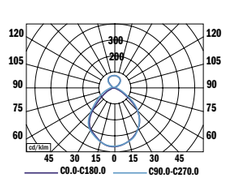
LQS VALUE

Lighting uniformity

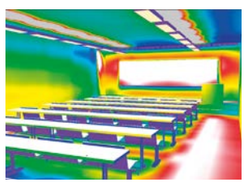
Lighting uniformity	LQS Value
Yes	5
No	0



The suspended luminaire MODUL BOX MAX with the direct and indirect characteristic of the luminous flux represents an optimal solution for the illumination of the classrooms. The direct component directed straight to the task area ensure a sufficient illuminance level, the indirect component of the light directed to the ceiling illuminates the ceiling and vertical surfaces sufficiently.



The luminous intensity curve of MODUL BOX MAX.



The specialised software dialux will enable the simulation of lighting uniformity of the space already during the process of designing the lighting system.

Already the luminous intensity curve itself will give the designer a hint about the final effect.

The customer obtains the visualisation of the room space including defining the material surfaces and parts of the interior.

An excellent lighting uniformity in the school premises on which the standard places the highest demands from the point of view of the lighting uniformity can be achieved by luminaires with a wide luminous intensity curve. Through the correct layout of the luminaires we can achieve high levels of the lighting uniformity.

To achieve optimal light conditions with a uniform distribution of brightness it is necessary to increase the illuminance of the vertical surfaces and ceiling dramatically.

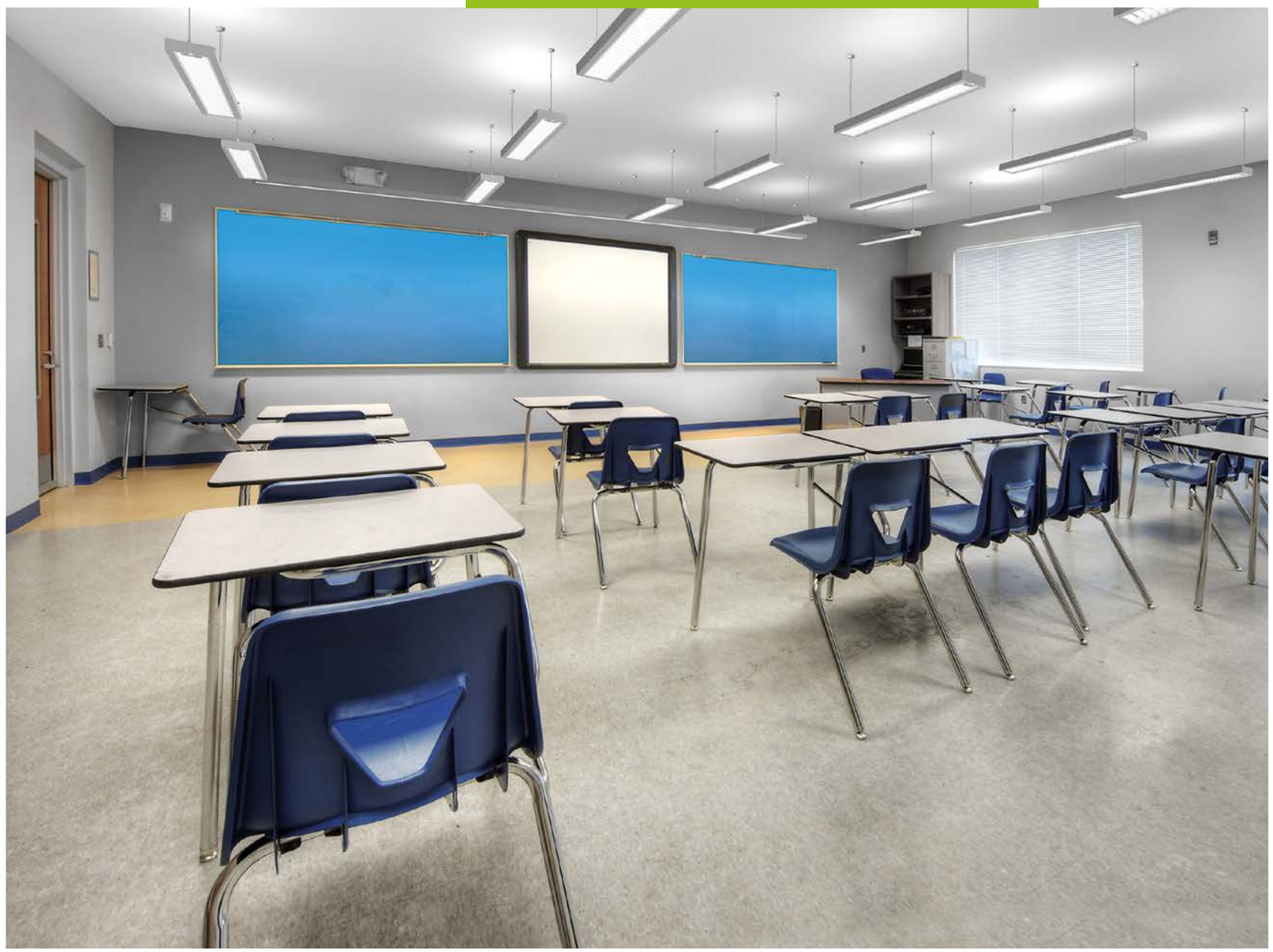
HARMONIOUS DISTRIBUTION OF BRIGHTNESS

People acquire 80 % information through their eyes and therefore the illumination is the key factor for their correct visual perception. The unbalanced distribution of brightness in the educational spaces places increased demands on the adaptation ability of the human eye. This fact especially in the case of young pupils can, besides the visual discomfort, cause even damage of vision.

The uniform brightness distribution in the room where teaching is under way is closely connected with the level of maintained illuminance. The current normative requirements resulting from the standard EN 12464-1 require the minimal illuminance level 300 lux for the classrooms, for the vertical surfaces 50 lux (with the recommended value 75 lux) and for the ceiling 30 lux (with recommended value 50 lux). The extensive investigations of lighting influence on the human eyes proved unambiguously that the stated normative values are insufficient and require extensive examination with special emphasis on the uniform distribution of brightness.

These investigations show that for achieving the optimal light conditions with a uniform distribution of brightness we need to increase the illuminance of the vertical surfaces and the ceiling substantially. For the classroom space it is recommended to achieve the vertical illuminance of the wall surfaces 300 lux and the horizontal ceiling illuminance 300 lux. These illuminance levels can be achieved by using the suspended luminaires with the direct and indirect characteristic of the luminous flux distribution. The practical experiments carried out by scientists with a group of pupils show that the optimal ratio of the divided direct and indirect component of the luminous flux is 50:50. During these experiments the pupils were to carry out several visual tasks with various demands in the simulated light conditions, e.g. to read a book, to identify the numbers on the board, to copy an image, etc. and they themselves could control the ratio of the direct and indirect component of the luminous flux from the luminaire. The results showed that the most suitable light conditions for realising the visual tasks are when the utilised luminaires with the direct and indirect character of the luminous flux distribution direct 50 % of the light directly downwards to the working plane and 50 % of the diffuse light towards the ceiling.

The luminaire MODUL LAMBDA from the SLE portfolio meets these requirements. Thanks to its excellent luminous parameters it fulfils the requirements on the usage in the classrooms. The direct component of the luminous flux emitted by this lighting fixture is able even at an approximately 2 metre distance from the working plane (desk) to ensure a sufficient illuminance level at the level of 500 lux. The indirect diffuse component directly illuminates the ceiling and when the luminaires are placed correctly it ensures also sufficient vertical illuminance of the walls. Such light conditions help orienting in the space and modulating the objects better which is important in the classroom especially from the point of view of safety. The pupils are able to identify the edges of the desks or other obstacles which represent potential danger of injury better and without problems. At the same time thanks to the diffuse light the cylindrical illuminance is improved and it is important for correct recognising of faces. At the minimal level of the cylindrical illuminance 150 lux the faces of the pupils and teachers can be recognised without any disturbing shadows and this fact contributes to creating a pleasant communication atmosphere. The results of the investigation and our experience show that this light solution represents the most ideal and comprehensive method for solving the illumination in the classrooms at all educational levels.



LQS VALUE

Harmonious distribution of brightness

Harmonious distribution of brightnees (contrast)	LQS Value
Em(wall)>150 lux with U_0>0,3 Em(ceiling>75 lux with U_0>0,3	5
Em(wall)>75 lux with U_0>0,3 Em(ceiling>50 lux with U_0>0,3	4
Em(wall)>75 lux with U_0>0,1 Em(ceiling>50 lux with U_0>0,1	3
Em(wall)>50 lux with U_0>0,1 Em(ceiling>30 lux with U_0>0,1	2
Em(wall)>30 lux with U_0>0,1 Em(ceiling>10 lux with U_0>0,1	1
Em(wall)<30 lux with U_0>0,1 Em(ceiling<10 lux with U_0>0,1	0

For the correct modelling of the faces it is important to ensure in the classrooms sufficient cylindrical illuminance amounting 150 lux. The suspended luminaires with the direct and indirect characteristic of the luminous flux distribution which eliminate forming undesirable shadows and at the same time do not cause glare are the optimal solution.

The classical solution of the classroom lighting with recessed luminaires with a parabolic louvre ensures sufficient illumination of the workplace but the upper parts of the walls and the ceiling remain dark. Such illumination causes a feeling of a cave effect and makes the classroom optically smaller.

The sufficient illumination of the ceiling can be achieved by using the luminaire MIRZAM with the direct and indirect characteristic of the luminous flux distribution which is reached thanks to the specially shaped diffuser. The classroom then gives an impression of a lighter and larges space.

The suspended luminaires with the direct and indirect character of the luminous flux distribution which direct 50 % of radiation directly to the task area and 50 % towards the ceiling represent an ideal lighting solution for the classrooms. The required distribution ratio of the direct and indirect component of illumination is achieved by placing the luminaire in the distance of 0.3 to 0.6 metre from the ceiling.

Also the selection of the materials used affects the harmonious distribution of brightness in the space. In general we recommend lighter colours. Dark walls, ceiling and furniture have lower brightness compared to the lighter materials and therefore they give a depressing impression.

ACCORDING TO EN 12464-1

Ceiling illumination

Dark ceiling, only 100 lux causes cave effect which can even result in depressive claustrophobic feelings of the children.

Illumination on the working surface

Direct illumination from the luminaires always gives only 300 lux on the table.

Illumination level on the board

Good illuminance of the board must fulfil 500 lux and 0.7 uniformity.

Vertical illumination

Vertical illumination on the wall, 100 lux, provides bad orientation in the room and high value of adaptation luminance.

OUR RECOMMENDATION

Cylindrical illuminance

Cylindrical illumination especially affects visual communication and the ability to interpret faces, events and objects. The standard requires a minimum illuminance of 150 lux in rooms with demands of good visual communication.

Illumination on the working surface

Direct illumination from the luminaires always gives 500 lux on the table, to make the visual task easier.

Ceiling illumination

Indirect illumiantion on the ceiling, 300 lux, provides good ambient light and pupils who are more alert and perform better.

Vertical illumination

Vertical illumination on the wall, 300 lux, provides good ambient light and helps pupils feel more alert and better orientation in the room.

The extensive investigations of lighting influence on the human eyes proved that the stated normative values require extensive examination with special emphasis on the uniform distribution of brightness.

LIGHTING REQUIREMENTS FOR INTERIOR AREAS, TASKS AND ACTIVITIES EN 12464-1

Type of area, task or activity	Em [lux]	UGR	U_o	CRI	Specific requirements
Nursery school, play school					
Play room	300	22	0.40	80	High luminances should be avoided in viewing directions from below by use of diffuse covers.
Nursery	300	22	0.40	80	High luminances should be avoided in viewing directions from below by use of diffuse covers.
Handicraft room	300	19	0.60	80	
Educational buildings					
Classrooms, tutorial rooms	300	19	0.60	80	Lighting should be controllable.
Classroom for evening classes and adults education	500	19	0.60	80	Lighting should be controllable.
Auditorium, lecture halls	500	19	0.60	80	Lighting should be controllable to accommodate various A/V needs.
Black, green and white boards	500	19	0.70	80	Specular reflections shall be prevented. Presenter/teacher shall be illuminated with suitable vertical illuminance.
Demonstration table	500	19	0.70	80	In lecture halls 750 lux.
Art rooms	500	19	0.60	80	
Art rooms in art schools	750	19	0.70	90	5,000 K < TCP 6,500 K.
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 workshop	500	19	0.60	80	
Music practice rooms	300	19	0.60	80	
Computer practice rooms (menu driven)	300	19	0.60	80	VDU-work – See the chapter GLARE PREVENTION (page 14)
Language laboratory	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	300	22	0.60	80	See the chapter SPORT FACILITY (page 76)
School canteens	200	22	0.40	80	
Kitchen	500	22	0.60	80	

Em = average illuminance in lux (maintained value)

UGR = UGR limit (direct glare limitation)

U_o = lighting uniformity

CRI = colour rendering index of light sources

LIGHTING REQUIREMENTS FOR INTERIOR AREAS, TASKS AND ACTIVITIES EN 12464-1

EMOTION

The correct perception of the depicted information has a decisive influence on creating the pupils´ relation to school and learning. The correct and biologically effective light makes their learning simpler and more amusing.

The human eye responds to large continuously illuminated surfaces and the white diffuse light reflected from the ceiling and walls in the best way.

BIOLOGICAL FACTOR OF ILLUMINATION AVAILABILITY OF DAYLIGHT

As we have already mentioned in several areas, the scientific research has unambiguously confirmed the positive impact of the natural light on the feeling of the pupils´ visual and psychological well-being, their performance efficiency and the ability to concentrate. The requirement on the availability of the daylight in the spaces determined for education is therefore a rule. The task of the artificial light is to fulfil an additional function to the daylight.
The most important moment when planning the lighting for any space is its correct solution, the type of the luminaires is of secondary importance if the required result can be ensured. However, in general it is valid that the human eye responds to large continuously illuminated surfaces and the white diffuse light reflected from the ceiling and walls in the best way. As a matter of fact, this type of lighting simulates the properties of the daylight most truthfully.

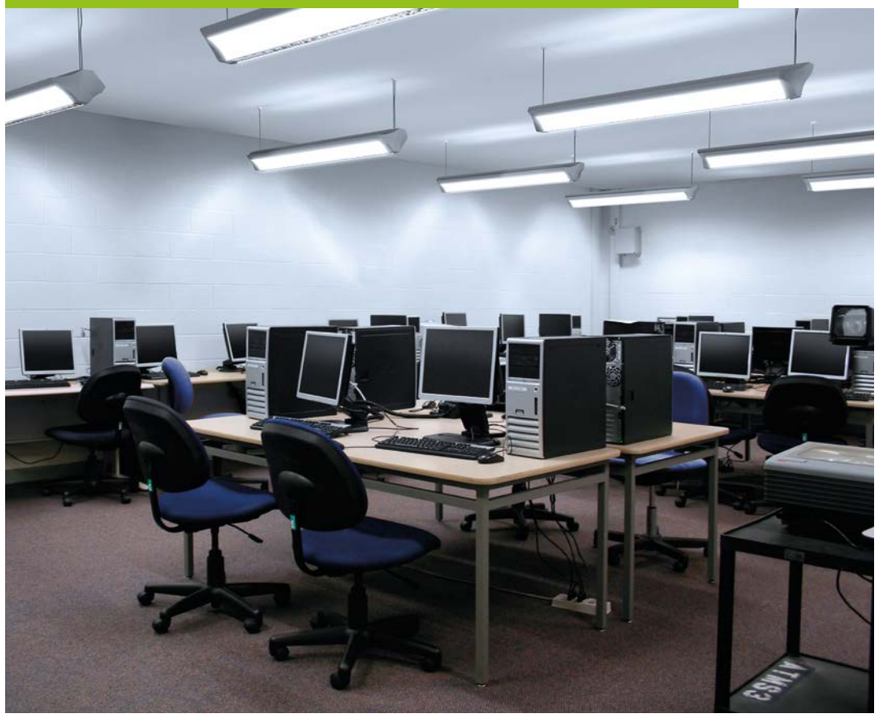
The scientific research during last decades has deeply changed the view at the task of lighting and its effect on people. The light is able to substantially affect not only the ability to perceive but also to change the mood, to arouse the feeling of comfort or vice versa discomfort and to control the human circadian rhythm. All this knowledge has extended the perception of the task of the artificial illumination due to the simple need to illuminate the space by a new dimension – to be biologically effective. When designing the lighting solution at schools it is inevitable to take both requirements equally into account.

LQS approaches the lighting of space in a holistic way. It perceives the solution as a whole with the goal to copy the properties of the natural light as trustfully as possible.

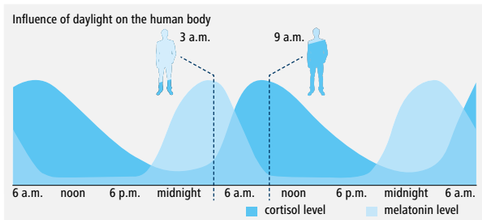
Revealing the third type of photoreceptors in the human eye sensitive to the blue part of the light spectrum enabled the developing of biologically effective luminaires.

BLUELIGHT CONTENT

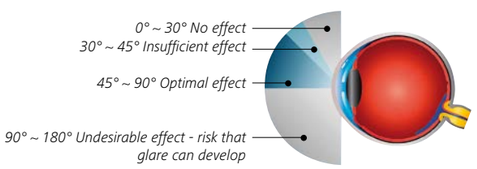
Revealing the function of the third type of photoreceptors in the human eye being able to affect the production of melatonin, a hormone managing the circadian human cycle belongs among the discoveries of modern science. These receptors are sensitive to that part of the light spectrum with the wavelength of approximately 464 nanometres, i.e. the blue light. This knowledge has become the basis for the manufacturers of the luminaires which through appropriate proportioning the spectrum's blue part of the artificial illumination and its leading directly to the human eye are able to affect the activities of the individuals effectively. As a matter of fact, from the point of view of evolution, the blue light signals to the human organism if it is day or night.



In the spaces with a limited access of daylight, the presence of the blue light is a key factor which significantly contributes to the psychological and visual well-being of the pupils. Its shortage stimulates production of melatonin which signals to the human organism that there is time for rest and induces an increased need of sleep. The absence of the blue light in the spectrum can lead to reduced performance efficiency and disrupting the circadian rhythm of the human organism. On the contrary, its appropriate proportion in the light spectrum of the artificial light source can stimulate the performance efficiency and affect positively the psychological well-being of the pupils. When implementing the biologically effective luminaires with the blue light component, it is necessary to take into account the age of the students as the melatonin production fluctuates according to their hormonal maturity. At an early age, especially in children in the pre-school age melatonin is created also during the morning hours. The proportion of the blue light in the light spectrum is subject to changes during the day – an appropriately planned light solution is able to respond to this situation by simulating the daylight.



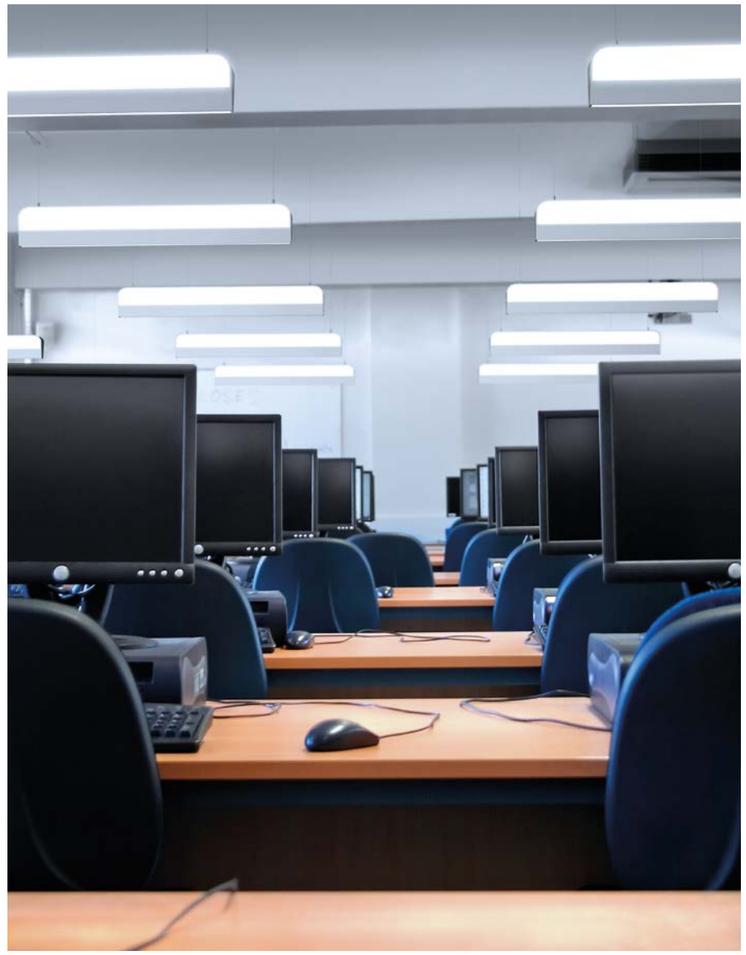
The human organism produces the hormone cortisol during the morning hours which increases the concentration and performance efficiency of the organism. Its concentration in the blood reaches its maximum at about 9 a.m., then it gradually decreases during the rest of the day. Melatonin, also called a sleep hormone, is produced by the human body during the night and its concentration in the human organism culminates at about 3 a.m.



The third type of the photoreceptors in the human eye is sensitive to that part of the light spectrum with the wavelength of approximately 464 nanometres, i.e. the blue light. These photoreceptors affect the creation of melatonin, a hormone managing the circadian rhythm of people.

LQS VALUE

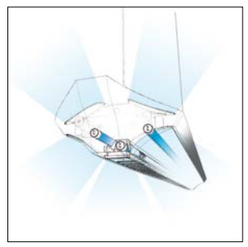
Biological factor of illumination	LQS Value
Biological factor of illumination	
availability of daylight	0/1 (No/Yes)
blue light concent	0/1 (No/Yes)
daylight simulation	0/1 (No/Yes)
dynamic lighting	0/1 (No/Yes)
tunable white	0/1 (No/Yes)



The correct proportion of the blue light in the light spectrum from an artificial source is able to stimulate the performance efficiency and to positively affect the feeling of the students´ as well as teachers´ psychological well-being.

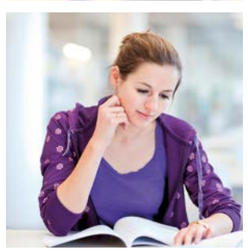
MODUL SPIKER

It is a LED luminaire with two modules. The bottom module directs the luminous flux directly downwards and ensures optimal illuminance of the workplace. The backlit side diffuser is a source with specially adapted spectrum to support the bluelight content. Its vertical displacement ensures optimal luminance levels in the field of vision and at the same time a higher level of the vertical illuminance. The luminous flux flowing out of the luminaire in a specific direction helps, together with vertical surfaces of the room, direct a certain part of the luminous flux to the human eye in the required angle. It is able to directly affect the receptor in the eye sensitive to light (the so called third photoreceptor) that controls the internal biorhythm of people and in this way it is able to optimise their performance efficiency during working hours. The luminaire design itself, suitably selected light sources and appropriate directing the luminous flux create a concept of the so called biologically effective lighting.



Modul RAY
The basic attributes of the unique luminaire Modul RAY are an innovative and compact design as well as the mechanical structure. The luminaire can be dimmed, if necessary, and can be fitted by various types of sensors and tools of intelligent management.

Modul SPIKER
From the point of view of the design the Modul SPIKER represents an interesting and biologically effective luminaire. The direct light from the LED sources placed in the bottom part of the structure is completed by a microprismatic refractor which changes the direct light to soft and diffuse one. The side optics is designed to direct the blue spectrum of the light to the human eye under an optimal angle and to affect the third photoreceptor responsible for the operation of the human circadian rhythm. The positive biological effect of this luminaire arrives especially at very cold light with the correlated colour temperature from 6,500 to 8,000 K.



Melatonin
Melatonin makes us feel drowsy, slows down bodily functions and lowers activity levels to facilitate a good night's sleep. It also ensures that a large number of metabolic processes are wound down. Body temperature falls; the organism, as it were, is put on the back burner. In this phase, the body secretes growth hormones that repair cells at night.

Cortisol
Cortisol is a stress hormone, produced from around 3 a.m. onwards in the adrenal cortex. It stimulates metabolism again and programmes the body for day-time operation. The first light of the day then stimulates the third receptor in the eye and suppresses the production of melatonin in the pineal gland. At the same time, the pituitary gland makes sure the body secretes more serotonin.

Serotonin
Serotonin acts as a mood-enhancing, motivating messenger. While the level of cortisol in the blood falls during the day in a counter-cycle to melatonin, serotonin helps us achieve a number of performance peaks. When daylight fades, the internal clock switches to night.

However, if our body does not get enough light during the day, it produces only a low level of melatonin. As a result, we sleep badly, we wake feeling unrested, we are tired during the day and lack energy and motivation. Insufficient exposure to stimulating light during autumn and winter can turn the process into a downward spiral. At that time of year, some people develop seasonal affective disorder (SAD). Their internal clock misses its cues because the hormonal balance in the brain is upset.

The daylight is not naturally monotonous. It changes its properties not only in dependence on the season of the year, but also in dependence on the cloudiness during the day. Its intensity and correlated colour temperature change during the day.

DAYLIGHT SIMULATION

As we have already mentioned in several areas the scientific research has proved that the daylight is the most natural type of light for people. This knowledge results in our attempt to adapt the artificial light to its properties as much as possible. Through changing the lighting intensity and the correlated colour temperature of the light as well, we can achieve improving the visual well-being of the pupils and in this way to create conditions where they enjoy learning.

The daylight simulation function is one of the tools through which we can achieve this effect. It is based on the fact that the daylight is not naturally monotonous. It changes its properties not only in dependence on the season of the year, but also in dependence on the cloudiness during the day. Its intensity and correlated colour temperature change during the day. All these factors affect our perception of the space and objects inside of it. The goal of the daylight simulation in the schools is to achieve such an intensity of the correlated colour temperature which copies the properties of the daylight as truthfully as possible. The daylight simulation is often implemented together with the daylight sensor which assesses the lighting intensity in the room during the day and according to this it increases or decreases the performance of the luminaires in the lighting system so that the constant illuminance of the space in compliance with the standard during the whole working hours can be ensured.

Concept "Brilliant Mix"

The system Brilliant mix implemented to the SLE product CAPH was developed by the company SLE in collaboration with Osram Opto semiconductor (Regensburg, Germany) and Mazet (Jena, Germany). The Brilliant mix is a demonstration of what white light of high quality SLE is able to produce.

The principle of Brilliant mix is based on mixing three LED colours ("blue" white, "green" EQ-WHITE and "red" amber) in one luminaire and the result is a white colour with a high colour rendering index. By adding/taking away individual channels it is simultaneously possible to change the correlated colour temperature of the white light in a wide range (2,700 - 6,500 K). It is important that every adjusted colour temperature has a durably high CRI of more than 90 and a relatively high efficacy (lm/W). The whole concept is completed with electronics which are able to control each channel independently and a colour sensor which permanently evaluates the CRI and CCT data. If the values differ from those being selected, the sensor gives the electronic a command for correction. In this way permanent monitoring of the light quality during the whole LED life cycle is ensured. Using the concept Brilliant mix we can achieve that all luminaires installed in one room have the exact same CCT value permanently.

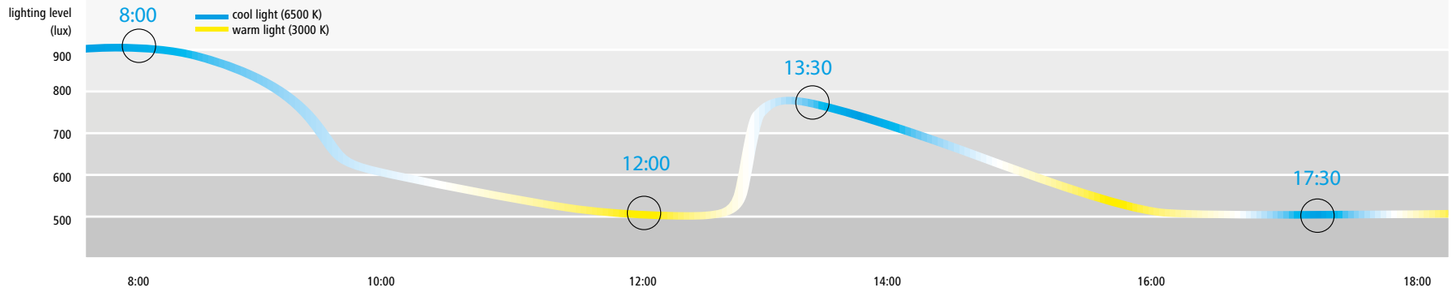
The goal of the daylight simulation is to achieve such a light intensity and colour that copies the properties of the daylight as truthfully as possible.

Good morning
Cool, fresh light raises the energy level of students coming into the school and provides a good start to the day.

Lunch time
A short rest helps the students to recharge out batteries. The light level decreases and the warm light facilitates relaxation.

Post-lunch dip
After lunch students usually feel sleepy. The light level rises again and changes to cool white to counter the „post lunch dip".

Happy hour
Just before the end of the school day a change to cooler white light provides an alertness boost ahead of the journey home.



If there is too big of a difference between the luminance levels in the individual parts of the space, it takes the human eye a few minutes until it adapts to this new luminance.

ILLUMINATION OF ROOM SURFACES

When designing the lighting system of the educational premises it is necessary to take into account the importance of the sufficient illuminance of the vertical as well as horizontal surfaces. The vertical illuminance supports better orientation in the space and creates better conditions for problem-free perception of objects or faces. The problem of the majority of the school premises consists in the fact that in the existing lighting systems solutions created by ceiling surfaced luminaires with the direct characteristic of radiation still dominate.

Although this solution is sufficient for lighting the working plane, however, it has not sufficient potential for adequate lighting the walls and ceiling. In the framework of this lighting solution the walls and ceiling remain dark which causes the so called cave effect which can even result in depressive claustrophobic feelings of the children. The pupils need a sufficiently and uniformly illuminated space for the feeling of the psychological and visual comfort. The requirement on uniform illuminance of the space without any distinctive light transfers results from the nature of the teaching process itself.

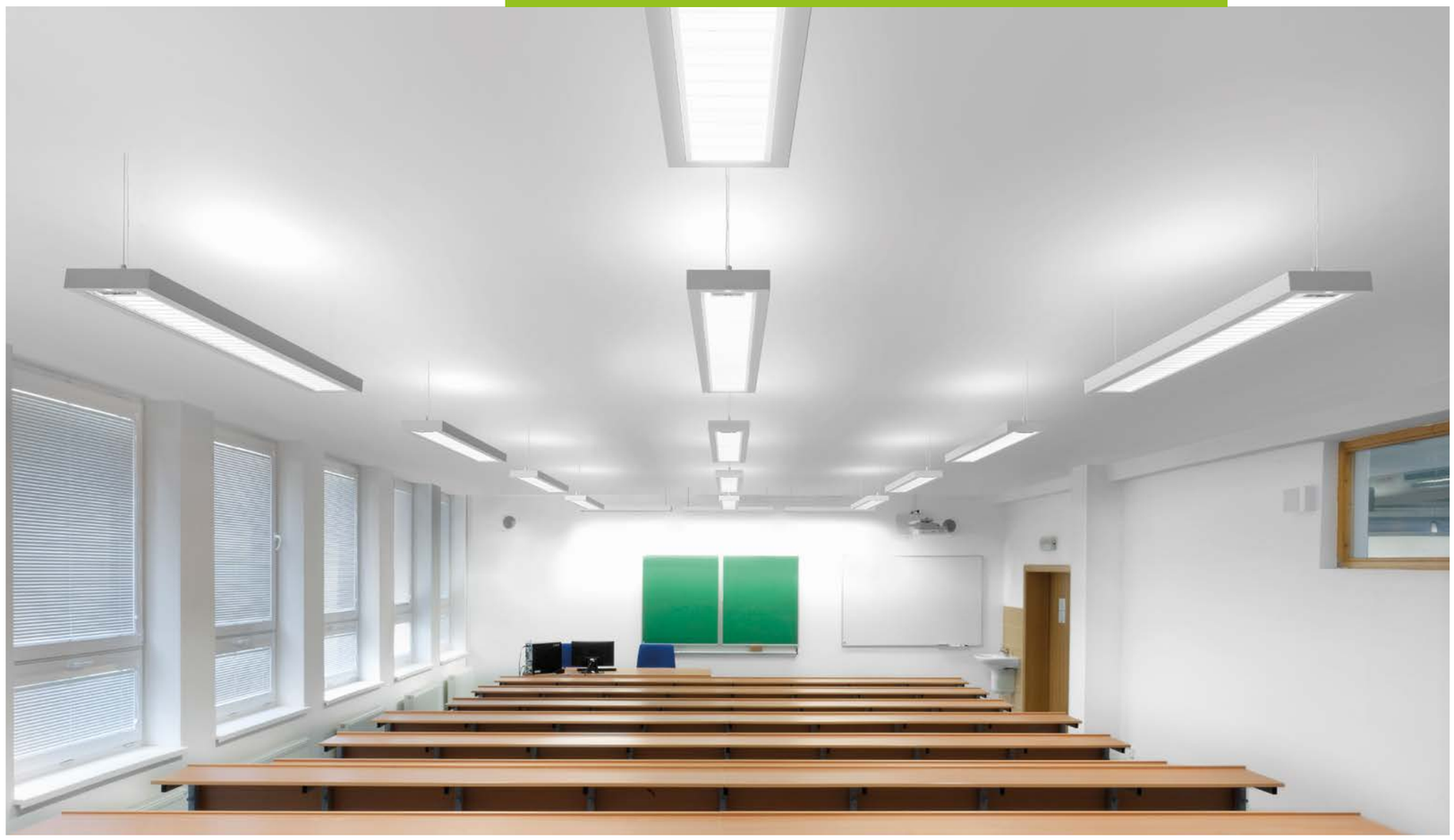
During the lessons the pupils permanently move their view from the desk to presentation surfaces or the teacher. During this process the vision adapts through an automatic change of the pupil diameter and it regulates the luminous flux falling to the retina. This reflex is called the adaptation state of vision. If there is too big of a difference between the luminance levels in the individual parts of the space, it takes the human eye a few minutes until it adapts and due to this fact the eye-pupil is increasingly overstrained and the eye fatigue develops.

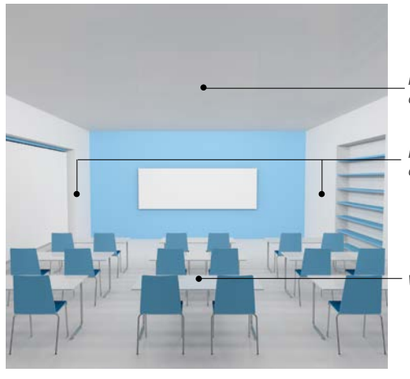
To prevent it, it is necessary to design the lighting system in such a way that we create a homogeneous light environment without any distinctive differences of the luminance intensity in the whole panoramic field of vision of the students and the teachers as well. In this way we will create conditions where the eye is not forced to carry out any adaptation to new luminance after each change of the view. Here the need of adequate and uniform illuminance of all vertical surfaces in the students´ or teachers´ fields of vision comes to the foreground.

For the teacher's visual well-being it is necessary to illuminate the back wall of the room which is his/her field of vision sufficiently. To prevent any big differences of luminance, it is necessary to achieve the illuminance of the back wall minimally 300 lux. The board or other presentation surfaces that are placed in the field of vision of the students and together with the desks represent a task area from the point of view of the standard have to comply with the requirement on the uniform luminance distribution in the educational spaces. The angle of vision is changed from the desk to the board during the active utilisation of the presentation surfaces in the educational process. For the eye not to be strained by a forced adaptation to a changed luminance level, it is necessary to ensure the corresponding vertical illuminance of the presentation surface and adequate luminance uniformity on the presentation surface and in its immediate surrounding.

The standard EN 12464-1 determines the illuminance level 500 lux with the uniformity of 0.7 for the board. This requirement can be met by using the asymmetric additional luminaire placed in the distance of 0.85 – 1.3 metres from the presentation surface.

The luminaire MODUL LAMBDA II ASYMMETRIC from the SLE portfolio represents a suitable solution. It is a luminaire with the asymmetric radiation curve whose optical system was designed to fulfil the strict normative requirements for the educational premises. The optimal light conditions with the required illumination levels of vertical and horizontal surfaces can be achieved in two ways. The first option are recessed luminaires with the direct and indirect characteristic of the luminous flux distribution which thanks to the specially formed diffuser are able to direct part of the emitted light directly to the ceiling. The other option is represented by the suspended luminaires with the direct and indirect characteristic of the luminous flux distribution which direct part of the light directly to the working plane and the second indirect diffusion part directly to the ceiling. For this lighting solution it is recommended to place the luminaires in such a way that the proportion of the direct and indirect part of the luminous flux is 50:50.





By a correct ratio of the illuminance of all surfaces in the room we can prevent both the psychological and eye fatigue and damaging the human sight as well.

LQS VALUE

Vertical illumination

Vertical illumination	LQS Value
$Ev_{avg} > 0,5\ Eh_{avg}$ (Wall LG7) $Ev_{avg} > 150$ lx	5
$Ev_{avg} > 0,5\ Eh_{avg}$ (Wall LG7)	4
$Ev_{avg} > 0,4\ Eh_{avg}$	3
$Ev_{avg} > 0,3\ Eh_{avg}$	2
$Ev_{avg} > 0,1\ Eh_{avg}$	1
$Ev_{avg} < 0,1\ Eh_{avg}$	0

LQS VALUE

Ceiling illumination

Ceiling illumination	LQS Value
$Eh_{avg} > 0,3\ Eh_{avg}$ (Ceiling LG7) $Eh_{avg} > 75$lx	5
$Eh_{avg} > 0,3\ Eh_{avg}$ (Ceiling LG7)	4
$Eh_{avg} > 0,2\ Eh_{avg}$	3
$Eh_{avg} > 0,15\ Eh_{avg}$	2
$Eh_{avg} > 0,1\ Eh_{avg}$	1
$Eh_{avg} < 0,1\ Eh_{avg}$	0

With emotional lighting the light solution is strengthened by a potential to create various light scenes that are able to induce a relaxation, working or motivation atmosphere.

EMOTIONAL LIGHTING

The emotional lighting provides large opportunities in various types of interior from the point of view of its utilisation.

The emotional lighting finds its place in the schools e.g. where we solve the illumination of the relaxation zones (clubrooms, lounges, etc.) or in the lecture halls or rooms determined for the multimedia presentations. From the technological point of view it provides a large space for utilising the RGB LED technology enabling the mixing of colours from red to blue. Using the RGBW by adding the white colour it is possible to achieve more intensive colour saturation along the whole colour spectrum. The light solution is thus strengthened by a potential to create various light scenes that are able to induce a relaxation, working or motivation atmosphere. This category includes two different types of lighting: the accent and ambient ones.

LQS assesses the space according to the fact if the emotional lighting is or is not part of the lighting solution. The spaces with the emotional lighting are assessed by the full score of 5 points; the spaces without this type of lighting obtain 0 points.

Accent lighting
finds its place in cases where we want to emphasise the extraordinariness of the object or to draw attention to an important detail. At schools it is used e.g. in the corridors, for illuminating the information boards and boards or awards and diplomas which the pupils of the school acquired. Its effectiveness is based on the ability of the human eye to perceive the contrast of phenomena; therefore the extraordinariness of an object is highlighted by increased luminance which is in the ratio 3:1 to the average luminance in the space.

Ambient lighting
completes the atmosphere of the space where it is used and gives it the necessary mood and character. The RGB and RGBW technologies are often part of this lighting and enable colour solutions of the lighting scenes. It often finds its place in the lounges and lecture rooms of the schools and educational premises.

LQS VALUE

Ambient lighting

Ambient lighting	LQS Value
Yes	5
No	0

LQS VALUE

RGB colour mixing

RGB colour mixing	LQS Value
Yes	5
No	0

LQS VALUE

Accent lighting

Accent lighting	LQS Value
Yes	5
No	0

ECOLOGY

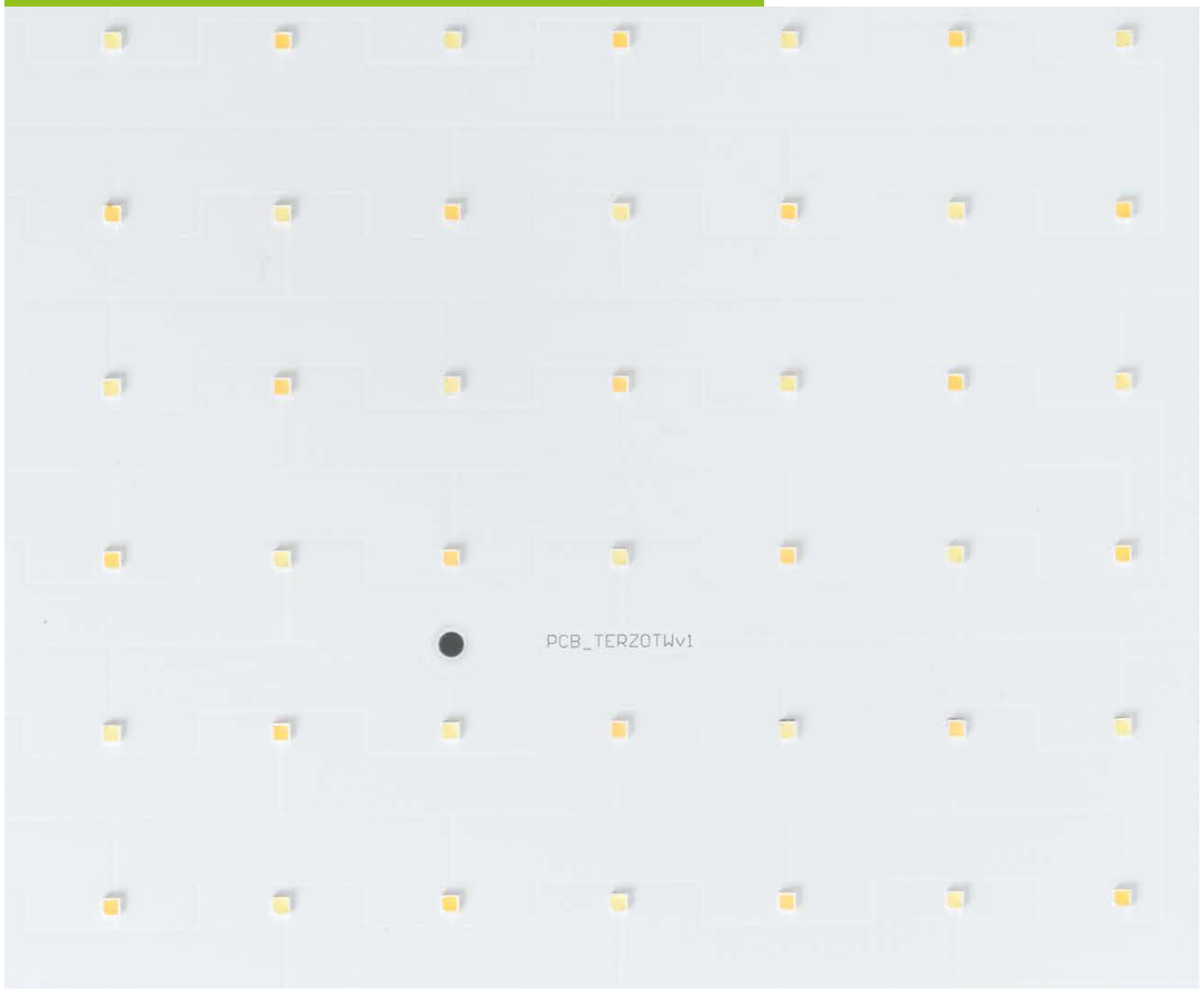
The ecology and ecological solutions respecting the fragile equilibrium of the environment are important topics which have become key values across the whole industrial spectrum during the last decades. The manufacturers of the luminaires and light sources are no exception in this area.

Also in this line of business the demands on efficient utilisation of energy, the recyclability and long life of the products constantly rise. In the area of manufacturing the luminaires and the light sources, the effectiveness of the light sources, the effectiveness of the luminaires and their impact on the environment are more and more emphasised. These are categories which, besides the ecological approach, contain a substantial potential for energy savings and in this way also reducing the operating costs. For the developers and architects of the school buildings just this factor is the source of the strongest motivation when designing the light systems.

Together with awareness of the limited character of the energy sources that causes the permanent increase of their prices, taking into account the ratio of the luminaire or light source effectiveness and the energy consumed the trend is coming to the foreground.

ECO
FRIENDLY

The main indicator for selecting an optimal lighting solution in a school is the efficacy of the light source.



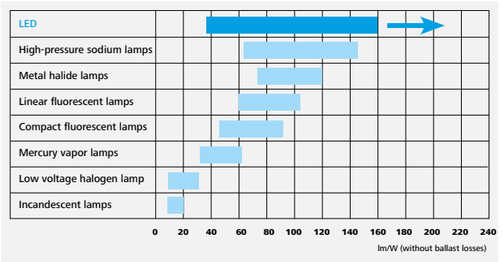
LATEST LAMP TECHNOLOGY

The times when the whole world applauded Thomas Alva Edison for the discovery of the light bulb are irrecoverably over. Although he made his mark on history forever as the inventor of artificial light, other scientists and inventors came after him and they shifted and are still shifting the development by leaps and bounds ahead.

With the knowledge about the limitedness of the energy sources which causes permanent increase of their prices, the trend taking into account the ratio of effectiveness of the luminaire or the light source and the consumed energy is coming to the foreground. As late as three years ago, the metalhalide lamps especially met these requirements but even they are retreating in favour of the light emitting diodes – LED. Compared to the conventional sources the LEDs achieve better parameters in each respect: they are more effective, they emit a negligible amount of heat, they place lower demands on the consumption of electrical energy, they do not contain mercury and so they are more ecological. In the area of manufacturing the light sources just LEDs represent a category which currently progresses most quickly. Up to 90 % of all innovations today take place in the category of the LED light sources. Of course, the development and production of the conventional light sources has not been stopped but they progress more slowly. However, also here it is valid that the trend leads especially to manufacturing more effective and economical types of the existing light sources. The original types are replaced by the eco and long-life fluorescent lamps or metal-halide lamps with ceramic burner of the second generation, etc.

The main indicator for selecting an optimal light source which a designer of the light system in a school has to follow is the efficacy of the light source. Its value shows with what effectiveness electric power is changed into light, i.e. how much of luminous flux (lm) is produced from input power (W) delivered to a light source. The unit is lumen per watt (lm/W). The LED light sources achieve the best parameters also in this category. Currently the LED chips with efficiency of 160 lm/W at cool white CCT, are commercially available; however, in the lab conditions the value of 254 lm/W has already been achieved. The higher price of LED luminaires is the reason why they have not replaced lighting fixtures with conventional light sources in spite of the fact they are obviously of higher quality. But also this factor is to be viewed in a wider context. Although the initial costs for purchasing of LED luminaires will always be higher, the return on investment in the form of energy savings during the whole luminaire life time and practically no maintenance costs make the LED luminaires extraordinary commercially interesting. From this point of view the retrofits where we only change the conventional light source for a more modern type prove to be only temporary and from a long-term point of view it is also a loss-making solution.

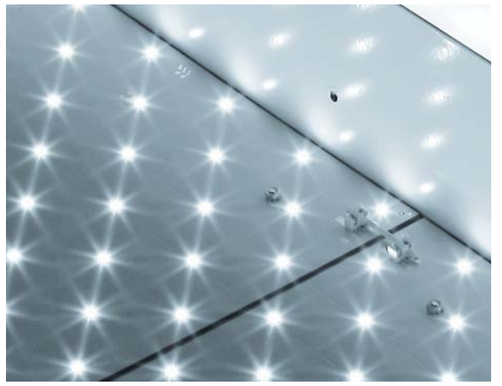
EFFICACY OF LIGHT SOURCE



LQS VALUE

Latest lamp technology

Latest lamp technology	LQS Value
η > 100 lm/W	5
η > 90 lm/W	4
η > 80 lm/W	3
η > 70 lm/W	2
η > 60 lm/W	1
η > 50 lm/W	0



The materials used for the production of a luminaire have the biggest impact on its efficiency.

SYSTEM EFFICACY OF LUMINAIRE

The luminaire efficacy factor determines how effectively the lighting fixture itself is able to direct the light from the light sources with the smallest possible losses on the surfaces of the optical system. The light output ratio (LOR) expresses the ratio of the luminous flux flowing from the luminaire and the sum of the luminous fluxes of all light sources in the system.

$$LOR = \frac{\text{Lumen output of luminaire}}{\text{Lumen output of lamp}} \%$$

This value can be divided into the upward and downward ratio that expresses how many percent of the luminous flux from the luminaires leads to the upward and downward space (i.e. over and under the luminaire). This is of special importance for those spaces which place high demands on the illumination of the ceiling.

The materials used for luminaire production have the biggest influence on its efficiency. The optical materials enable changing the distribution of the luminous flux of sources, diffusing the light or changing the spectral composition. They are divided into reflective and transparent ones. Aluminium, using various surface finishes, creates the predominant part of the reflective materials. The most often used transparent materials are glass and plastics. Aluminium, glass, plastics, steel have different reflectance and capability to absorb light. However, in general it is valid that the more effective the materials used in the optical system are, the lower the losses on these surfaces will be as well as the luminaire efficiency being higher.

$$\text{System efficacy of luminaire} = \frac{\text{Lumen output of luminaire}}{\text{Installed power of luminaire}} \left[\frac{\text{lm}}{\text{W}}\right]$$

Besides the used material themselves the luminaire efficacy is also affected by the design or the shape of the optical system. A correctly designed luminaire reflects the largest amount of light to the surroundings at minimal losses. The optimal mathematical and physical geometrical shapes of the lighting fixture can be calculated by modern computer systems.

LQS assigns the highest score the luminaires with efficacy of more 80 lm/W.

LQS VALUE

System efficacy of luminaire

System efficacy of luminaire	LQS Value
η > 80 lm/W	5
η > 70 lm/W	4
η > 65 lm/W	3
η > 55 lm/W	2
η > 40 lm/W	1
η > 30 lm/W	0

It is approximately valide that for 2.5 W of the luminaire energy 1 W of the air-conditioning energy is used, i.e. if the energy consumption of the lighting system increases, the energy consumption for the air-conditioning operation grows in direct proportion, too.

THERMAL OUTPUT OF LAMP

The light spectrum visible for the human eyes is between the ultraviolet (UV) and infrared (IR) spectrum. In spite of the fact that the human eye is not able to catch the infrared light, it perceives it as radiant heat.
Every object that is exposed to such radiation is constantly strained. However, the majority of the light sources used radiate this part of the spectrum in various extents. The lower the value of the radiated IR is, the more effective the light source is. From this point of view, on the bottom of the scale as the least efficient, there are the usual incandescent lamps which change up to 95 % of energy into heat and only remaining 5 % into visible light.

In the schools with air-conditioning the light sources with a high IR radiation percentage are a sufficiently big load for the electric power consumption. The heat from the non-effective sources heats the air continually in the closed space cooled by the air-conditioning – this fact is connected with the need for a higher performance of the air conditioning. It is approximately valid that for 2.5 W of the luminaire energy 1 W of the air-conditioning energy is used, i.e. if the energy consumption of the lighting system increases, the energy consumption for the air-conditioning operation grows in direct proportion, too. The owners of schools illuminated by outdated light sources is burdened by increased costs not only for the energy needed for the operation of the light system but also for the air-conditioning.

From this point of view the installation of luminaires with light sources creating the minimal percentage of the IR radiation is considered the most economical. These requirements are currently reliably fulfilled by the latest LED light sources that radiate only a negligible amount of the IR radiation.

LQS assesses with the highest number of points those light systems which on average do not exceed 15 % proportion of the IR radiation in the overall radiated spectrum. This assessment is fulfilled especially by the LED light sources.

LQS VALUE

Thermal output of lamp

Thermal output of lamp	LQS Value
< 15 % proportion of IR radiation	5
< 26 % proportion of IR radiation	4
< 28 % proportion of IR radiation	3
< 31 % proportion of IR radiation	2
< 60 % proportion of IR radiation	1
> 60 % proportion of IR radiation	0

ECO FRIENDLY

The designers of the lighting system for schools should also take in account the ecological potential of the light sources when they select them.

DANGEROUS MATERIAL CONTENT

The vision of danger in connection with luminaires and light sources for common people is connected with the risk of cutting by a broken bulb. As a matter of fact, the risks connected with using some types of the light sources are much more serious and can have an impact on the people's health as well as on the quality of the environment. The reason is the mercury content, a heavy metal with high toxicity, which is an inevitable part of the fluorescent lamps and metal-halide lamps. In spite of extensive scientific research, until now we have not revealed a material which would replace the task of mercury in the light sources. The solutions which would not represent any risk from the point of view of safety are extremely costly and therefore unsuitable for the mass market.

The task of mercury in some types of the light sources remains thus irreplaceable. When the luminaire is switched on, a discharge arises during which ionisation of the mercury atoms develops and they subsequently emit ultraviolet radiation. This radiation excites the phosphorus molecules spread on the internal side of the fluorescent lamp and during their return to the original state they emit photons of visible light.

The risk connected with the light sources containing mercury does not consist in their common usage. It arises when they are broken during handling or they are not disposed in compliance with legislation which defines the method how the used and damaged light sources containing toxic substances are to be removed. In the first case there is a threat that the mercury vapours can leak to the air which in dependence of the number of disrupted sources, the size of the room and method of airing can cause the students short-term health problems (nausea, anxiety). In the second case, when disposing the toxic waste inadequately, it represents a long-term risk of soil contamination, as the heavy metals do not decompose and become a permanent art of the environment.

The designers of the lighting system for schools should also take into account the ecological potential of the light sources when they select them. The new types of the fluorescent lamps marked "eco" contain a smaller proportion of mercury than the older types. However, from the point of view of safety the LED light sources are undoubtedly considered the least dangerous option.

LQS assesses the light sources according to the mercury content and the highest score – 5 points are assigned to the light sources with zero content of mercury.

LQS VALUE

Dangerous material content

Dangerous material content	LQS Value
mercury content 0 mg	5
mercury content < 0,5 mg	4
mercury content < 1,5 mg	3
mercury content < 2,4 mg	2
mercury content < 5 mg	1
mercury content > 5 mg	0

PRODUCT LIFETIME AND MAINTENANCE COSTS

When designing a lighting system of a school building one of the key factors the architect and developer should take into account is the lifetime of the light source and the costs for its maintenance.

These light sources wear off rapidly when they are frequently switched on and off. Therefore their placement e.g. in a corridor with an installed movement detector (most frequently due to saving of electric power) is not the best solution, just because of the shortened life span. The user of the space is then burdened by the costs not only for the purchase of the replacement light sources but also for activities connected with maintenance and service of the lighting system. Further indirect costs aroused by the need to make the space of the school building accessible during maintenance operations and not to restrict the everyday operation of the individual workplaces are connected with a more frequent replacement of the light sources.

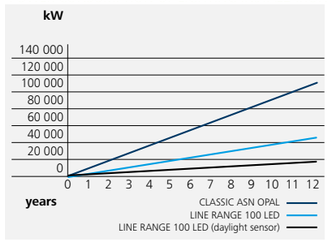
Compared to the incandescent lamps the LED light sources represent at the first sight a more costly solution. Their price compared with the conventional light sources is really higher; however, their utilisation in the lighting system is profitable for several reasons. Their first and the biggest advantage is the extremely long lifetime reaching more than 50,000 hours and it represents at 11 hours operation time 250 days during the year approximately 18 years. In the case of LED the end of the lifetime is given by the decrease of the light output on to 70 % (in some cases 50 %). At the same time they are light sources which show an extremely low failure rate, only two LED sources pre million pieces produced. The regular costs for their replacement and maintenance are thus removed. By adding the functionality lighting management system into the lighting system we can reduce the need of the manual control which is also considered a certain type of maintenance. The long lifetime and minimal demandingness in the area of maintenance in combination with energy economy make the LED light sources an ideal solution when designing the lighting system in the school building.

When taking into account all relevant criteria, LQS assigns the highest score for the parameter "product lifetime" and the "costs for maintenance" just to those light sources with the lifetime of or higher than 50,000 hours.

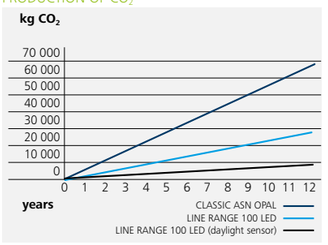
COMPARING TOTAL COSTS FOR ILLUMINATION (TCO) TOTAL COSTS OF OWNERSHIP

		CLASSIC ASN OPAL	LINE RANGE 100 LED	LINE RANGE 100 LED (daylight sensor)	
type of light source		FD (T8)	LED CRI 80	LED CRI 80	
power consumption		58	59	59	W
number of light sources in luminaire		2	1	1	pc
control gear		CCG	ECG	ECG	
type of lighting control		none	none	light sensor	
lifetime of light source		15 000	50 000	50 000	hour
power consumption of luminaire		140	59	59	W
luminuos flux		10 000	4 700	4 700	lm
LOR		50	100	100	%
luminaire light output		5 000	4 700	4 700	lm
number of luminaires		20	20	20	pc
average time when luminaire switch on between 6.00 – 18.00		10	10	10	hour
average time when luminaire switch on between 18.00 – 6.00		0	0	0	hour
number of days in week when luminaire switch on		5	5	5	day
price for electrical energy		0.18	0.18	0.18	€/kW/hour
purchase price of luminaire		50	200	220	€
purchase price of light source		2	0	0	€
purchse price of service hour		30	30	30	€
time needed for the exchange of one source		0.25	0.25	0.25	hour
COOLING ENERGY					
cooling system usage factor		50 %	50 %	50 %	
cooling efficiency		2.5	2.5	2.5	Wh/Wc
purchace for initial instalation		1 080.00	4 000.00	4 400.00	€
Number of maintenance required per 12 years		2	0	0	
Maintenance fee		230.00	0.00	0.00	€
power consumption of luminaire		140.00	59.00	28.00	W
power consumption of cooling system		28.00	11.80	5.60	W
completly power consumption of room		3 360.00	1 416.00	672.00	W
consumption of el. energy for	**day**	33.60	14.16	4.84	kWh
	month	730.00	307.64	105.12	kWh
	year	8 760.00	3 691.71	1 261.44	kWh
production of emission CO_2 per year		5 606.40	2 362.70	807.32	kg
price for el. energy per	**day**	6.05	2.55	0.87	€
	month	131.40	55.38	18.92	€
	year	1 576.80	664.51	227.06	€
difference between input costs			2 920.00	3 320.00	€
saving difference per year			-912.29	-1 349.74	€
saving CO_2 per year			-3 243.70	-4 799.08	kg
payback excluding maintenance			**3.2**	**2.5**	**Years**
payback including maintenance			**3.3**	**2.5**	**Years**

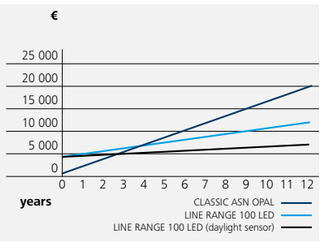
POWER CONSUMPTION OF LIGHTING INSTALLATION



PRODUCTION OF CO_2



OPERATING COSTS AND PAYBACK TIME



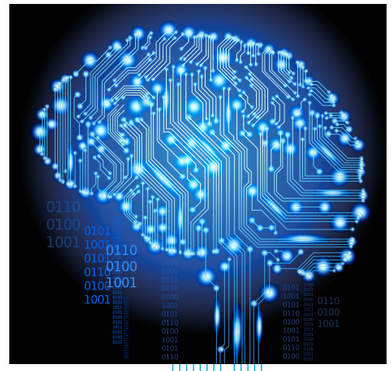
LQS VALUE

Product life-time & maintenance costs

TProduct life-time & maintenance costs	LQS Value
≥ 50000	5
> 24000	4
> 19000	3
> 12000	2
> 10000	1
≥ 2000	0

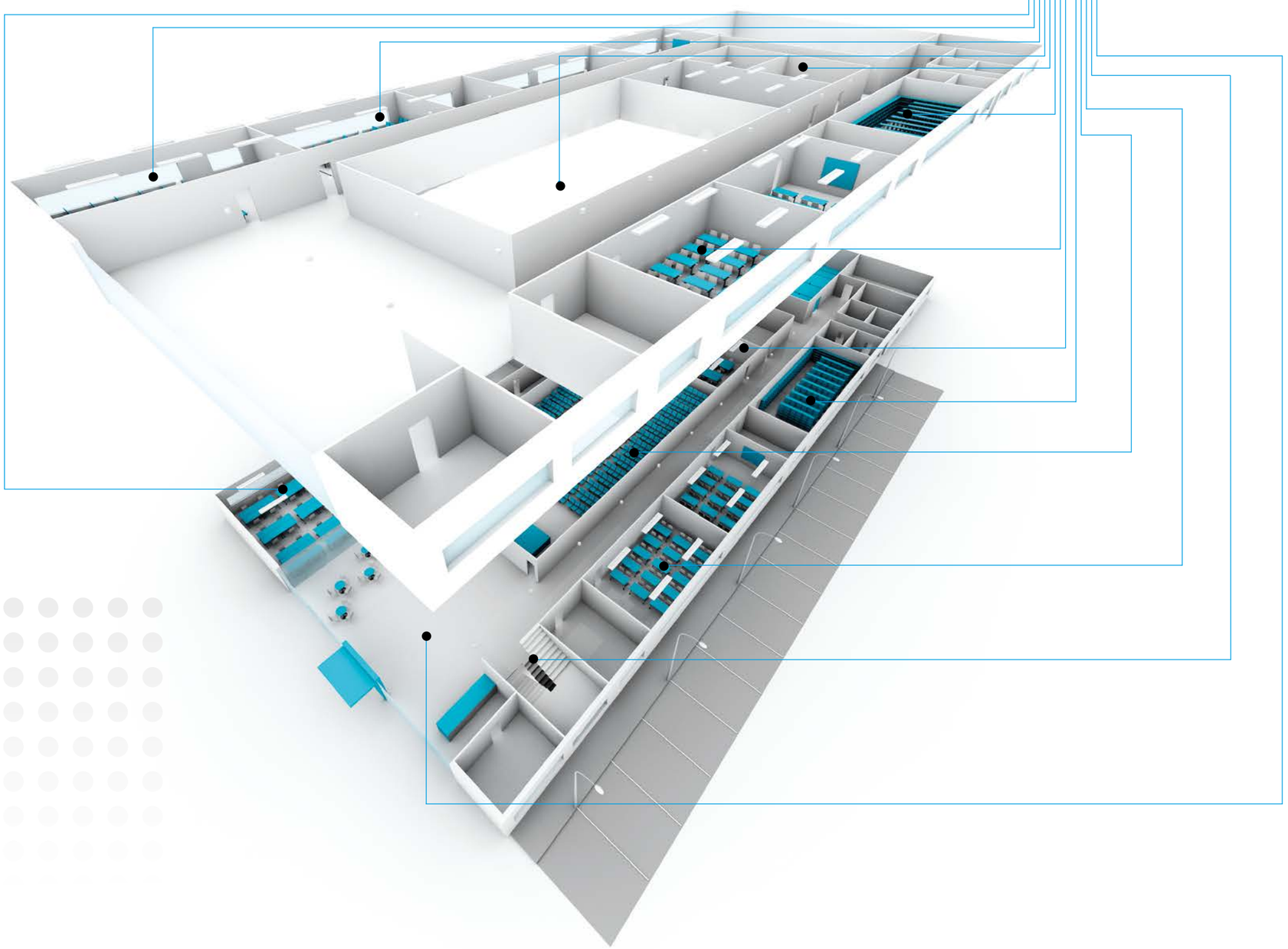
EFFICIENCY

The task of the modern technologies in the lighting systems is to provide the user with maximal comfort for their control. However, in the schools they simultaneously create a potential for substantial savings.



LIGHTING
MANAGEMENT
SYSTEM

The technological progress today enables taking benefits of a high-quality illumination of the space and at the same time to saving time, energy and maintenance costs. Through the intelligent forms of the lighting management system the operation of a school can be more effective than any time before. At the same time the modern technologies enable changing the lighting intensity and the colour of the light in the individual spaces and so to offer varied atmospheres or emotions and currently all of that can be controlled only by one touch on the display of the smartphone.



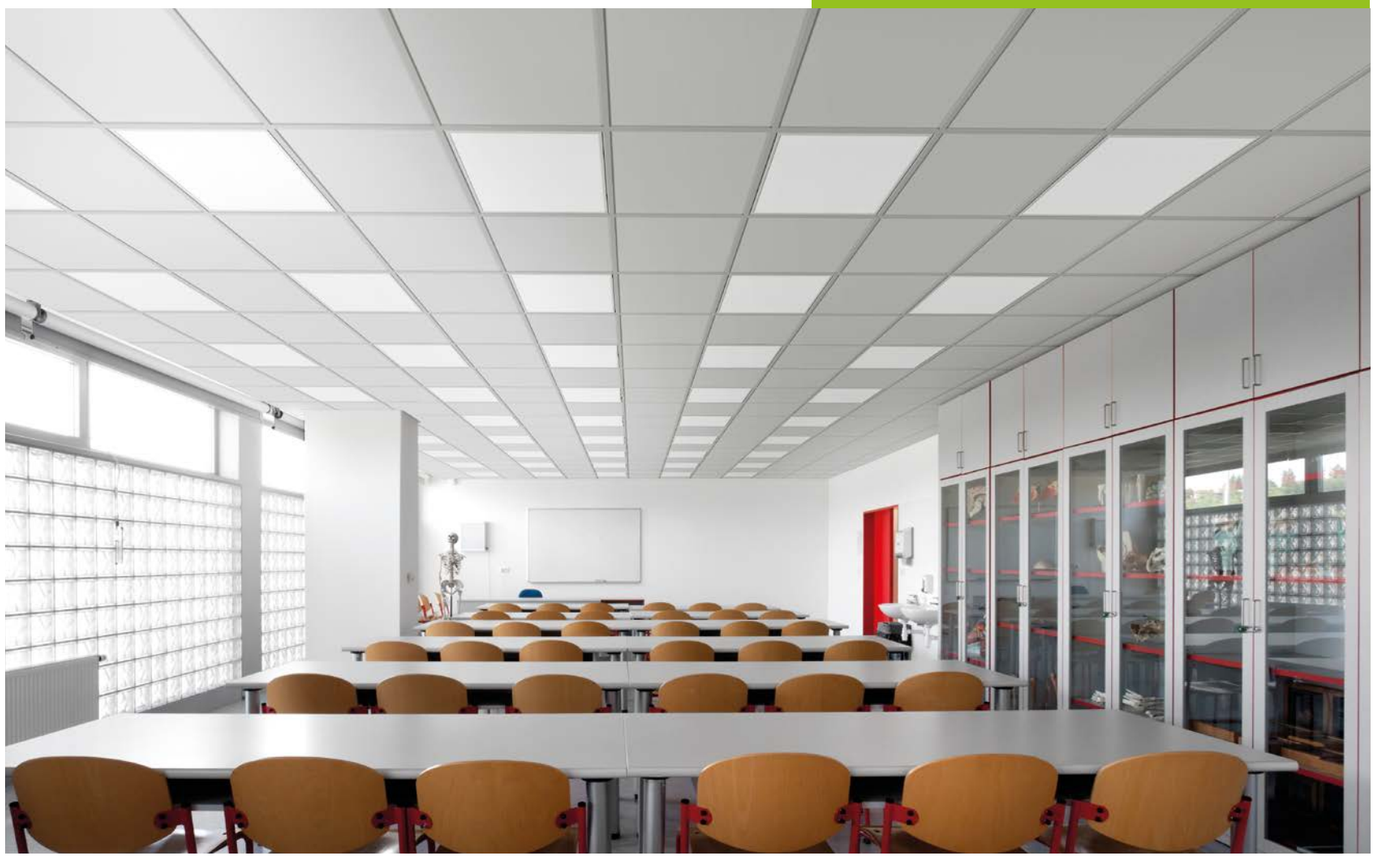
DAYLIGHT SENSOR

Daylight has decisive importance for the health and well-being of people. Its shortage has not only influence on the quality of vision but also the performance efficiency and concentration and can even cause disruption of the circadian rhythm. Therefore it is important to create such an environment at school which is able to copy the daylight properties as truthfully as possible. Although the majority of the rooms in the school has minimally one wall with windows, the availability of the daylight is never so optimal that it can do without a lighting system of high quality. The light conditions change in dependence on the hour of the day, weather and the season of the year. The task of the artificial light is to balance these differences and to complete or fully replace the natural light when its availability is limited. The requirements on the adequate intensity of the workplace lighting can be achieved by installing the daylight sensor.

The core of the system itself is the luminance sensor which reads the light conditions at the scanning plane. The advantage is that the daylight and the artificial light complete each other, i.e. when the day illumination decreases, the artificial one increases and vice versa. This property ensures that in the given space there is always as much light as necessary. This regulation method can be carried out continuously or by jumps, here the luminaires dim down to the value of 10%. In larger spaces we use several sensors which asses the mutual resulting value by averaging. The management of the luminaires based on the lighting intensity is realised fully automatically and besides saving energy it also increases the user's comfort. Its effectiveness is higher the more daylight falls to the given space. When installing the daylight sensors the scanned zones must not overlap. It is also unsuitable to place the sensor in the reflection zone of mirrors and radiation sources which negatively affect the scanning process. It is ideal to place the scanner over the task area which places the largest demands on the constant illumination.

LQS considers the daylight sensor the most effective technology from the point of view of saving energy and assesses the spaces with the daylight sensors by 2 points.

The requirements on the adequate lighting intensity of the workplace can be achieved by installing the daylight sensor.



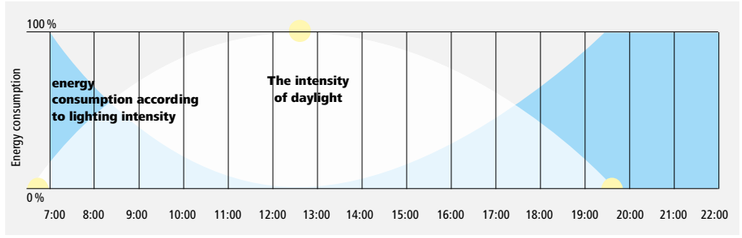
The light conditions change in dependence on the hour of the day, weather and the season of the year. The task of the artificial light is to balance these differences and to complete or fully replace the natural light when its availability is limited.

10 % of power consumption

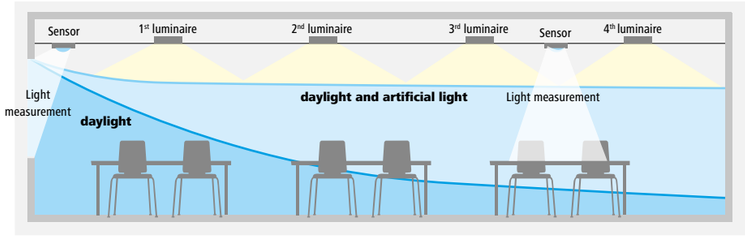
30 % of power consumption

70 % of power consumption

100 % of power consumption



The energy consumption of the lighting system in dependence of the daylight availability achieves the maximum values early in the morning and during evening hours.



When installing the sensors it is important to pay attention for the zones scanned not to overlap and to be placed in sufficient distance from radiation sources which negatively affect their detection ability.

LQS VALUE

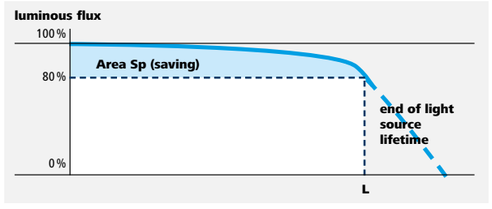
Daylight sensor

Daylight sensor	LQS Value
Yes	2
No	0

CONSTANT ILLUMINANCE SENSOR

The task of this sensor type is to ensure the constant illuminance independently of the conditions of luminaires in the lighting system. The essence of this type of management results from the fact that the light properties of the luminaires deteriorate during the installed life, the optical parts are polluted or some of the luminaires in the lighting system are damaged.

The constant illuminance sensor behaves in the space as a sensor of the lighting intensity and in this way it artificially adjusts (increase or decreases) the luminous flux of the luminaires. For the sensor to be able to fulfil its function it is necessary to count on its installation already when designing the lighting system which has to be over-dimensioned already at the beginning of the design. The economy of this solution can look controversial at first sight. However, the reality is that savings are really achieved as during the first years of the over-dimensioned lighting system operation the individual light sources do not run at full power. The system is adjusted to 100 % output after the signs of wear began to be evident. In this way the constant lighting intensity of the whole scanned space is guaranteed. From the point of view of improved economy this solution can be realised by combining the constant illuminance sensor with the daylight sensor. Both sensors in this combination are able to utilise the potential of the natural light falling to the space through the windows in full extent and to adjust the intensity of the artificial light. The combination of several types of the lighting management systems enables to make use of the natural light potential in full extent and to adjust the output of the lighting systems to it – this will prolong its life span and maximise the savings of energy.



When designing a lighting system, it is always over-dimensioned by minimally 20 %. In this way at the end of the life span the required illuminance intensity is still achieved. Using the constant illuminance sensor we can achieve 20 % energy savings during the first years of the lighting system lifespan.

LQS VALUE

Constant illuminance sensor

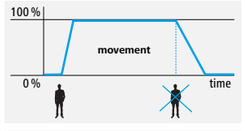
Constance illuminance sensor	LQS Value
Yes	1
No	0

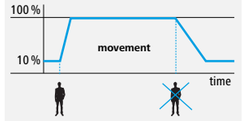
The presence detector can be used for both the indoor and outdoor applications with different sensitivity and assembly height.

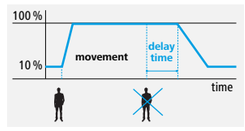
PRESENCE DETECTOR

In a school building there are spaces which do not require permanent lighting. They are rooms or communication zones without permanent occurrence of persons. These spaces represent a distinctive potential from the point of view of energy savings. A suitable type of management for this type of spaces is the presence detector which manages the luminaires to light only when somebody occurs in the given space and thus when the lighting is really necessary. It is automatic management fitted with a sensor responding to the heat of the moving persons in the detection area. The passive infrared technology with built-in scanners in the sensor which respond to the heat radiation emitted by the human body and transfer it to an electric signal ensure the scanning of the space. The sensor subsequently assesses the information and switches on the illumination. The scanner itself does not emit any radiation and therefore we can speak about the passive infrared sensors (PIR).

The presence detector switches on the luminaires in the selected spaces when somebody occurs there and thus when the illumination is really necessary.





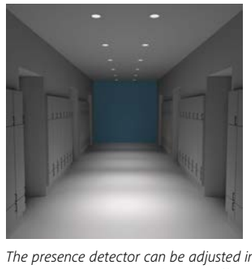


The presence detector can be used for both the indoor and outdoor applications with different sensitivity and assembly height. For an ideal coverage of the space it is ideal for the sensors to overlap their scanning areas (partially). It is important not to install the sensors close to the luminaires with strong IR radiation, the air-conditioning or heating units and other sources of the IR radiation – it could affect their functionality. When they are installed appropriately, the sensor will respond immediately after somebody enters the scanned zone. When the system is managed by movement the function of delay for dimming can be used and it means that the luminous flux does not change immediately after the movement fades but after passing the adjusted time when there is no movement. This time is determined according to the type of the space and the frequency of the assumed movement. Dimming can be transferred either to a certain level (e.g. 10 %) of the luminaires´ luminous flux or dimming up to the value of 0 %. The luminous flux level 10 % is used due to the safety reasons. The space, though without any movement, should not be fully dark due to the safety reasons but also because of the security cameras, prolonging the life span of the light sources. The presence sensor can be installed as an independent action element (which controls the lighting system) or it serves only as an input element which gives information for the assessment of the supervising control unit or system.

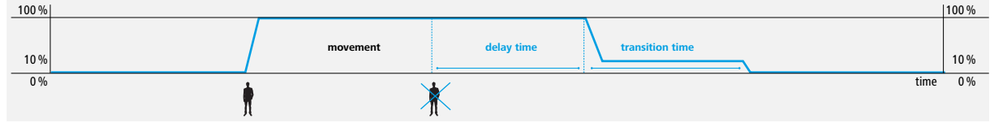
From the LQS point of view the presence detector is an extraordinarily effective method how to improve the effectiveness of the lighting system and to optimise the energy consumption therefore the spaces with this element of the lighting management are assigned the score 1.

When there is nobody in the space being detected. The presence detector switches off the lighting.

When a person enters the room the presence detector responds to the infrared radiation the human body emits and switches on the lighting.



The presence detector can be adjusted in such a way that the lighting in an abandoned space will not switch off immediately after departure of the last person but gradually.



LQS VALUE

Presence detector

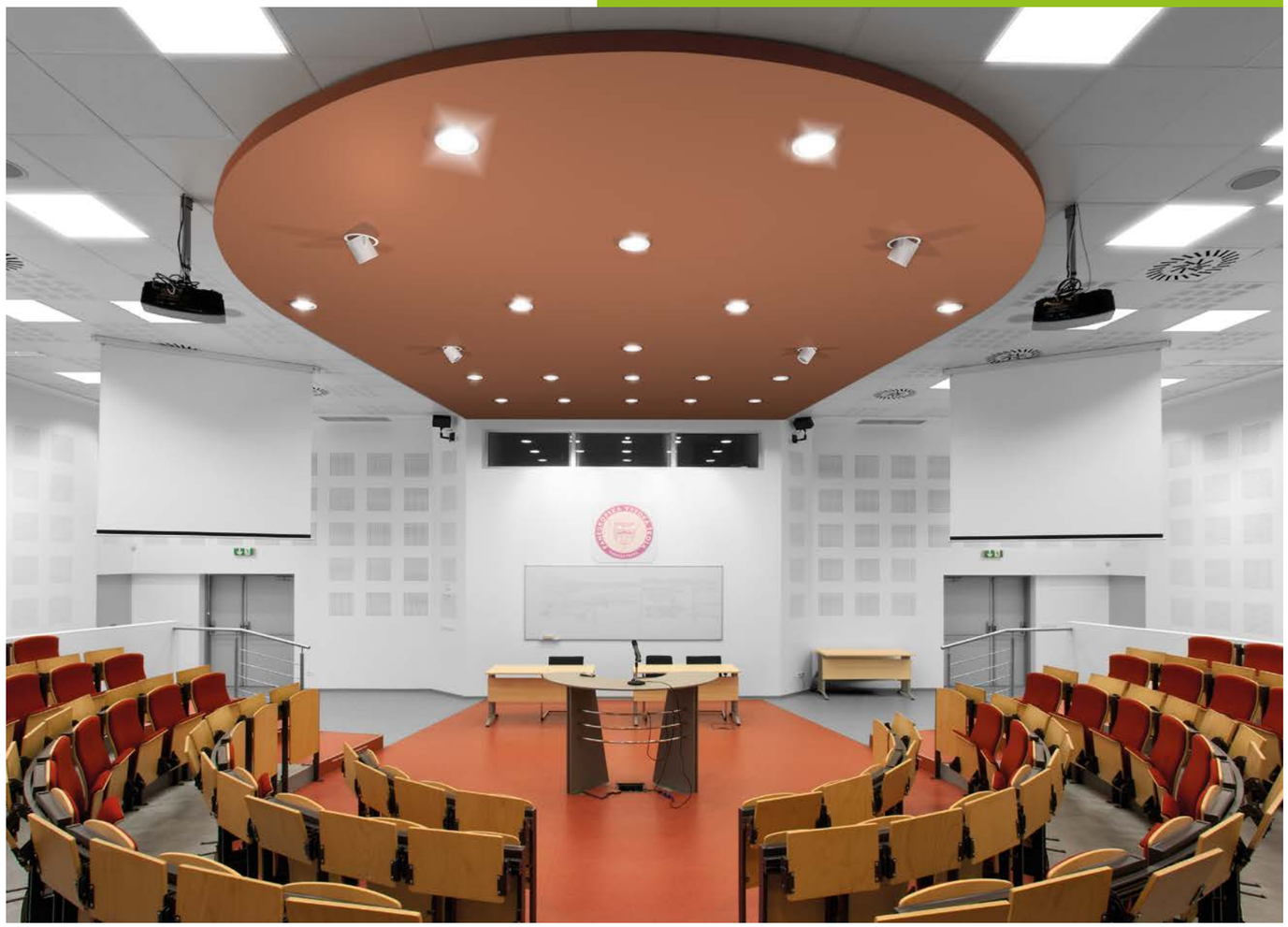
Presence detector	LQS Value
Yes	1
No	0

The modern technologies enable to control the lighting through a tablet or smart phone.

CALLING OF LIGHTING SCENES

The lighting system management based on the change of the firmly adjusted lighting scenes has a wide implementation in the educational premises. Under a lighting scene we can understand a summary of several adjusted factors which can be controlled by pushing a button. Here belong e.g. – the lighting intensity (e.g. 100 %, 75 %, 50 %, 25 %, 0 %), colour of the light, RGB scenes, calendar or the simulation of the daylight. By arousing a change of the lighting scene we can adjust the illumination to the needs of the education.

In the school buildings this type of the lighting management finds its place especially in the spaces where various educational activities take place, e.g. in the classrooms or in the lecture theatres. By implementing this function it is possible, with the simple control of a button, to switch on, dim or switch off part of the illumination according to the individual need. During the tests it is possible to switch on only the main lighting through the adjusted scene. During lectures and lessons where the presentation surfaces are utilised, the selection of the corresponding lighting scene enables switching on the asymmetric additional lighting, dimming it during projection or switching off the main lighting in the room. The control is carried out by a built-in panel or by remote controls – we recommend using the controls on the wave basis especially in the structured spaces. The electromagnetic waves which are emitted are able to pass though materials which create an obstacle between the sender and receiver and this fact enables being built in a receiver. The modern technologies currently enable managing the lighting through smart phones or tablets. By creating a specific application we can control the lighting system in the whole premises of the school with only one touch. Through the wireless communication the sender emits a signal to the controller, it assesses it and through the control unit is sends the information directly to the luminaire or a group of luminaires which can be remotely switched off, switched on. The user can also increase or decrease their radiation intensity or the colour temperature.



LIGHTING SCENE 1:
During presentation the general lighting and the lighting of the presentation surface lights at 100 %.

LIGHTING SCENE 2:
During tests the general lighting lights at 100 %.

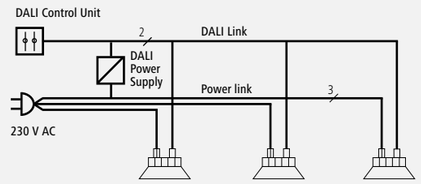
LIGHTING SCENE 3:
During presentation with an overhead projector the general lighting is dimmed and lights at 10 %.

LIGHTING SCENE 4:
During lectures the general lighting and the lighting of the presentation desk used by the lecturer light at 100 %.

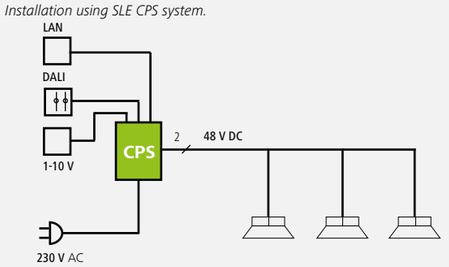
SLE CPS

The Central Power Source (CPS) developed by the company SLE belongs to the latest types of control. It is an innovative system with a centralised source of feeding for the LED luminaires. The CPS system is equipped with an intelligent communication interface between the central system (MASTER) and connected luminaires (SLAVE) which communicate with each other directly in the safe power supply 48 V DC system. Centralising the power supply source brings advantages in the form of a lower price for the LED luminaires which can be used without an electronic control gear, their smaller dimensions and also lower number of conductors is necessary. Thanks to the web interface implemented directly in the SLE CPS it is possible to control, follow and adjust the luminaires to various scenes practically from any "web place". The DALI interface for ensuring the compatibility with older systems is also available. A big advantage of this control system with maximum load 2.4 kW is that during its installation the conductors and wires of the existing installation can be used.

Standard DALI installation.



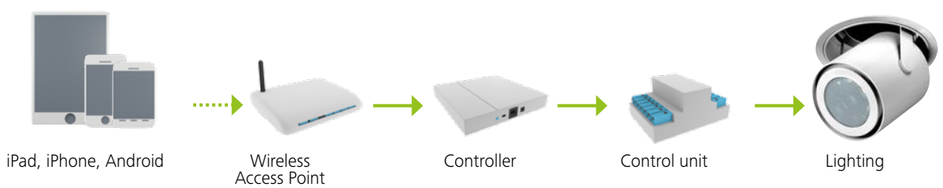
Installation using SLE CPS system.



LQS VALUE

Calling of lighting scenes

Calling of lighting scenes	LQS Value
Yes	1
No	0



ESPRIT

People love flawlessness. Therefore the lighting producers do not take only their light and technical properties into consideration but also their overall design. Where an attractive look is combined with modern technology also inanimate objects acquire a new dimension. Let us call it esprit.

To breathe spirit into the inanimate objects is the basic ambition of the current industrial design. In the area of luminaire manufacturing it means the effort of the luminaire designers for an innovative connection of shapes and functionality. Today the modern materials and technologies enable countless numbers of variations which can be modified according to the client's vision.

The new, design dimension of the luminaire production has also been revealed by the designers and users of the school buildings. They do not only emphasise the functionality when selecting the lighting fixtures but alsow the ability to add interest to individual parts of the interior, to contribute to their specific atmosphere or to represent.

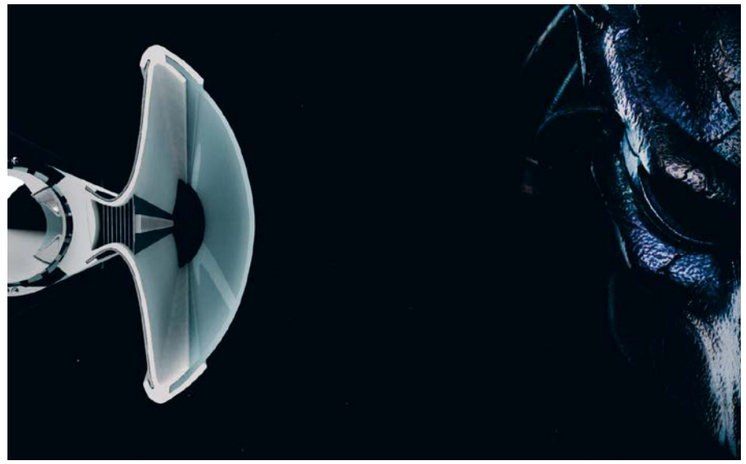
Although there are no quantifiable criteria for assessing the quality, it is important to respect a few rules in the creative process. They are as follows: overall impression of the luminaire, luminaire appearance in the room, detailed solution, surface finish, material of construct parts, functional elements.

The company SLE has responded to the design demands for the space illumination by creating an in-house department of research and development in the framework of which the "court" designers in collaboration with technical departments and the students of the Academy of Fine Arts and Design in Bratislava, specialisation industrial design, are working on the development of new design luminaires using the latest technologies. The result of this collaboration is series of the design and highly functional luminaires falling into the category of futuristic visions.

REAL SKY

by Ján Štofko

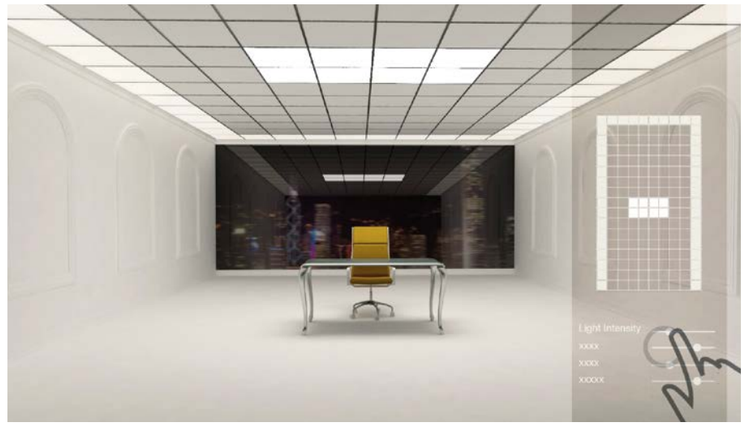
REAL SKY ceiling is unique futuristic concept, that moves the daylight inspiration step ahead. These organic flowing light waves will create spectacular sky experience above your heads. LED light sources,together with the moving grid behind the elastic ceiling, are programmed to create various sceneries and moods. This high-end solution is suitable for the most ambitious clients with the passion for unique interiors.



PARASIT

by Eliška Dudová

The designer´s assumption is the need of individualisation in lighting for the future – interactivity and for enabling consumers to enjoy more exciting experiences with lighting scenes. The concept of luminaire is designed to offer functional, a wide range of lighting scenes.



OLED

by Ján Štofko

The OLED technology indicates a great potential to change completely our view at the lighting system. Who would not like to sketch a shape of a optical part on a tablet?

EXCEPTIONALITY

It is our ambition to create smart lighting solutions that bring added value and wellbeing to our lives in addition to showing respect for the environment. To this end, we act as a lighting solutions project platform focused on connecting everyone involved in lighting in mutually beneficial collaboration under the umbrella of SLE's knowledge, tools and services. In this way, each participant can contribute their unique skill set towards a cooperative final solution of higher value and quality than could be achieved alone.

We tailor our services and support to current and future market needs, thereby increasing the effectiveness of every link in the value chain, from supply to end use

METHODOLOGY

We have created a framework of clear and accessible knowledge, practical and theory-based support, and insights into the development of lighting through research. To achieve this, we eagerly follow the trends that are driving technological and ecological development in the global market and apply them to lighting and its influence on both humans and the environment. This knowledge is implemented both through our own lighting services and in the development of a number of specialised proprietary supportive tools for all involved in sales, project planning and implementation.

Lighting Quality Standard & LQS Composer PRO

The Lighting Quality Standard (LQS) and supplementary LQS Composer PRO software tool enable the objective and quantifiable evaluation and comparison of lighting solutions. Using a framework categorised into six key areas, they support the assessment of the quality of lighting solutions.

Smart Light

The Smart Light methodology is presented as a series of guides for various types of application that show how to put the entire depth of our knowledge into practical use.

Lighting trends

The global trends of health, wellbeing, sustainability and technology affect our everyday activity and behaviour. Interpreted by the lighting world, these global trends become light and psychology, human centric lighting, light and safety, and energy saving.

EXCLUSIVE PRODUCTS

Our distinctive product portfolio offers cutting-edge luminaire and lighting control technologies that are guaranteed to perfectly integrate with each other and in every solution we provide.

Each product it designed for a specific application, so partners can rely on finding the best fit for every project. The possibility of product customisation further assures both partners and customers that every solution is specialised and therefore unique and worry-free.

www.sleprojects.com

SERVICES

We provide partners with access to almost 80 R&D, lighting, sales and marketing services, allowing them to focus on their markets and customers while we take care of the rest.

Research & development

All our luminaires and control technologies are developed in our own R&D department by a team of experienced and inventive specialists who consistently implement the latest scientific findings and global, technological and lighting trends. The result is a portfolio of truly innovative, stylish and technologically advanced products that will bring added value to every solution they are used in.

Lighting planning & realisation

Exceptional lighting solutions can only be conceptualised and realised by the best minds and trustworthy specialists with the help of an in-depth understanding of light, lighting and its application.

Sales

Our partners' realisation is at the heart of our interests, which is why almost everything in SLE is useful for those on the front line. From technical support tools through product information to marketing materials and project promotion, we provide everything needed to achieve sales success. And once a sale has been made, we will also help with financing, giving customers a name they can trust. With such a complete business package, our partners will never be short of help in attracting and building a firm and long-term relationship with customers and brands.

Marketing

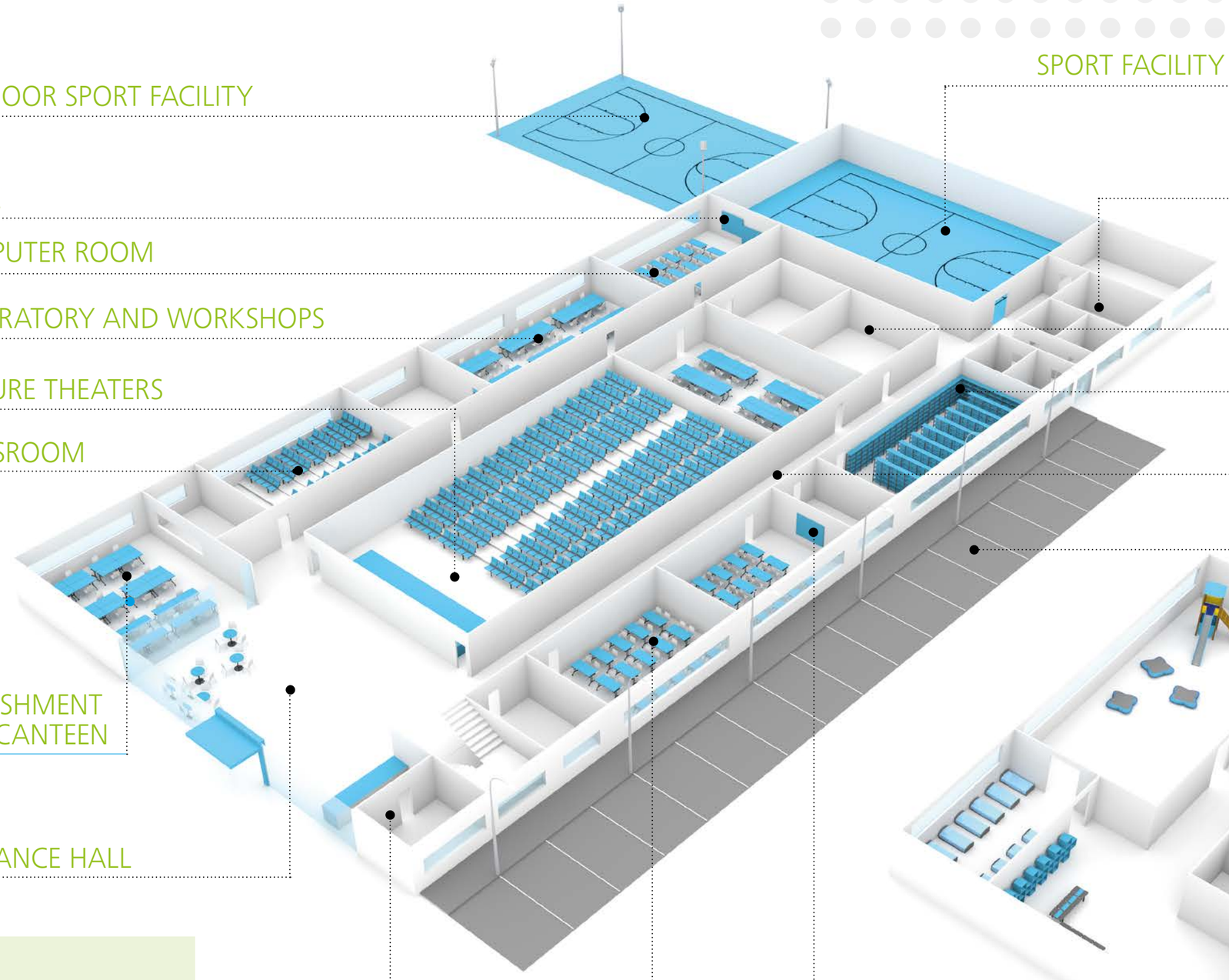
It is no fun doing the work and never getting any credit, which is often the case for the individuals and small companies involved in the provision of lighting solutions. We believe that everyone involved in a project should be given due recognition. All partners involved in our projects are included in related promotion. This strengthens both the presence of truly skilled professionals on the global lighting scene and the network of support and collaboration that will drive the success of all.

BEST-FIT SOLUTIONS

Lighting can be complicated, especially considering the constant influx of new technologies, terminology and possibilities. With this in mind, we offer a range of complete 'ready-made' solutions to keep things simple for everyone, but never at the expense of quality or suitability.

Each solution includes everything needed for its implementation. Moreover, as each solution is provided as a whole, full compatibility of all components is guaranteed, and the entire system falls under one straightforward warranty. In this way, lighting suddenly becomes very simple.

LIGHT IN THE SCHOOL



OUTDOOR SPORT FACILITY

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RECEPTION

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STOCK ROOMS

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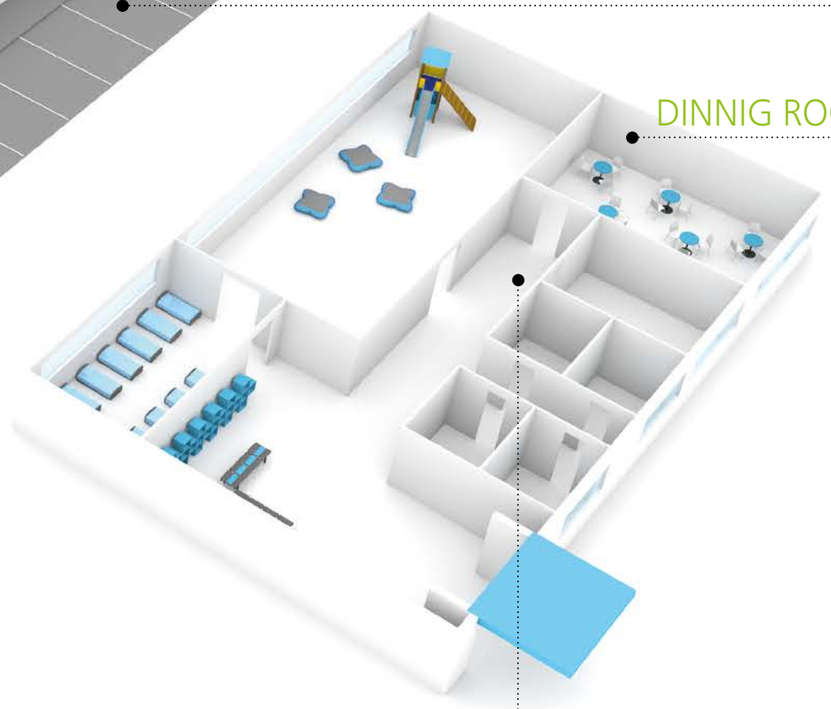


DINNIG ROOM

KINDERGARTEN

For ensuring the performance efficiency and visual well-being of the pupils we recommend to maintain in the classes the minimal illuminance level 500 lux.

CLASSROOM

The modern teaching process places high demands especially on the visual perceptions. The correct lighting of the space where the teaching process takes place has a decisive influence on the pupils´ performance efficiency and their capability to concentrate.

A strict organisation of the working space in the classrooms belongs to the past. The layout of the desks changes in dependence on the needs of the teaching process and enables the pupils to carry out both the individual and group tasks. Therefore the basic requirement which is currently laid on the lighting system in the classroom is the uniform lighting ensuring the users the same good light conditions for every activity. The layout of the desks plays an important role from the point of view of ergonomics. It is recommended to place them rectangular to the window for the daylight to fall on the working plane laterally. This solution prevents the undesirable glare and lower sharpness of vision. The European standard EN 12464-1 determines the minimal illuminance level 300 lux for the task area (i.e. the desk), for the classrooms for evening classes and spaces determined for education of adults the minimal illuminance value 500 lux. However, our experience from practice has shown that the normative requirements are insufficient and therefore for ensuring the optimal performance efficiency and the visual well-being of the pupils we recommend to maintain the minimal illuminance level of the working plane 500 lux also in common classrooms. Our experience and research shows that the required illuminance of all surfaces in the classroom can be achieved with luminaires with the direct and indirect characteristic of the luminous flux distribution that lead 50 % of the direct light to the working surface and 50 % of the diffuse light upwards to the ceiling. Through this solution we achieve the optimal illuminance of the working plane 500 lux, the vertical illuminance of the walls 300 lux and the illuminance of the ceiling 300 lux. The indirect diffuse component of the light simultaneously enables modelling the objects better; it ensures the cylindrical illuminance of the faces and in this way their recognition and reduces the rise of sharp shadows deteriorating the visibility. This lighting solution also fulfils the requirement for harmonious distribution of brightness in the classroom space. The variedness of the working tasks and the need of an interaction between the pupils and teachers or the board force the students to pass their vision from one to another object. The unequal distribution of brightness places higher demands on the eye's adaptation ability which adapts to the average, the so called adaptation luminance. It causes rapid fatigue, loss of concentration and reduction of performance efficiency. When planning the lighting system it is important to create homogeneous light environment without any distinctive differences of the brightness intensity. Almost all classrooms have a wall with windows. The availability of the daylight is also in this type of space desirable. Therefore the artificial light in the classrooms should be controllable to complete the daylight when necessary. That is why the usage of the daylight sensor should be considered. At the same time it is necessary to prevent the undesirable glare and to fit the windows with a system of blinds or curtains. From the point of view of savings these classes currently represents an unused potential. The expenses for lighting represent up to 40% of the costs necessary for the performance of the school building. Through replacing the old luminaires with new ones and installing the elements of the lighting management system (e.g. the daylight sensor completed with the presence sensor) the saving of energy up to 75 % can be achieved.

The recessed luminaires with louver with the direct characteristic of the luminous flux distribution are not suitable for the classrooms. We will not achieve the sufficient illuminance of the ceiling.

The suitable light conditions with sufficient illumination of the vertical surfaces and ceiling can be achieved by recessed luminaires with a specially shaped ejected diffuser.

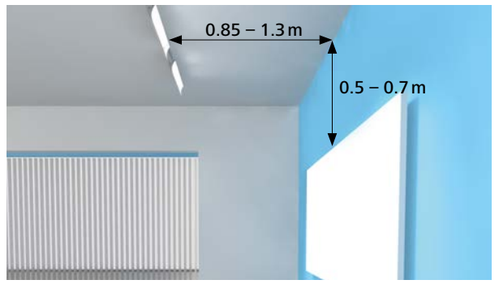
The linear suspended luminaires with the direct and indirect characteristic of radiation will ensure the required illuminance of the working plane and sufficient vertical illuminance of the surfaces. The most ideal solutions are those luminaires which lead 50 % of the luminous flux directly to the working plane and 50 % of the indirect components are led to the ceiling.

The correct luminance level on the presentation surfaces will create contrast conditions which will enable the pupils to perceive the depicted information from every angle of vision.

TABLE AND PRESENTATION AREA

Correct and sufficient vertical lighting of the board and presentation surfaces is a guarantee of correct perception of information and at the same time it protects the pupils against inadequate fatigue.

The boards, white-boards, flipcharts and projection screens currently belong among the standard outfit of the classrooms. Their utilisation in the educational process does not principally differ; however, the method of their illumination is different. The standard EN 12464-1 recommends the average vertical illuminance 500 lux and it states a minimal value of 0.7 for the lighting uniformity. If the board is movable or has wings, the stated values have to be fulfilled on the whole presentation surface. For illuminating the presentation surfaces we most frequently use the asymmetric luminaires placed 0.85 to 1.3 metres from the presentation surface. When we solve the illumination of the board the colour and type of material of the presentation surface play an important role. Our experience from practice shows that pupils perceive information depicted on a blackboard written with white chalk better. The black surface has low reflectance and the contrast between the white and black colour creates better conditions for the visual comfort. However, the reality is that the modern schools more and more frequently use the white glossy board. They place higher demand on the illumination as they are surfaces with higher reflectance and therefore they represent a higher risk for the rise of undesirable reflections which cause deteriorated visibility of the information depicted. A correct layout of the luminaires can prevent this problem. The different properties of the black and white presentation surfaces require for the designer to create a lighting system always for a particular space and type of board which located there. When using the presentation surfaces actively the pupils and teachers change their angle of vision when they transfer their look from the desk to the presentation surface and this can cause vision fatigue when the luminance is distributed in the room incorrectly. For the eye not to be strained permanently by the forced adaptation to the changed luminance level, it is necessary to ensure correct vertical lighting of the presentation surfaces and uniform distribution of brightness on the presentation surface and its surrounding (maps, flipcharts). The correct luminance level will create optimal contrast conditions which will enable the pupils to perceive the information of the presentation surface from every angle and ensure sufficient visibility of the depicted information also for the students sitting in the last desks. Due to the fact that the board is an aid which is not utilised permanently in the teaching process, it is desirable for the illumination of the presentation surface to be controllable and could be switched off independently.



For illuminating the presentation surfaces we use most frequently the asymmetric luminaires placed 0.85 to 1.3 metres from the presentation surface.

COMPUTER ROOM

The computer competence is assigned such a great importance today as the knowledge of foreign languages or natural sciences. Therefore today computers are an inseparable part of the educational process.

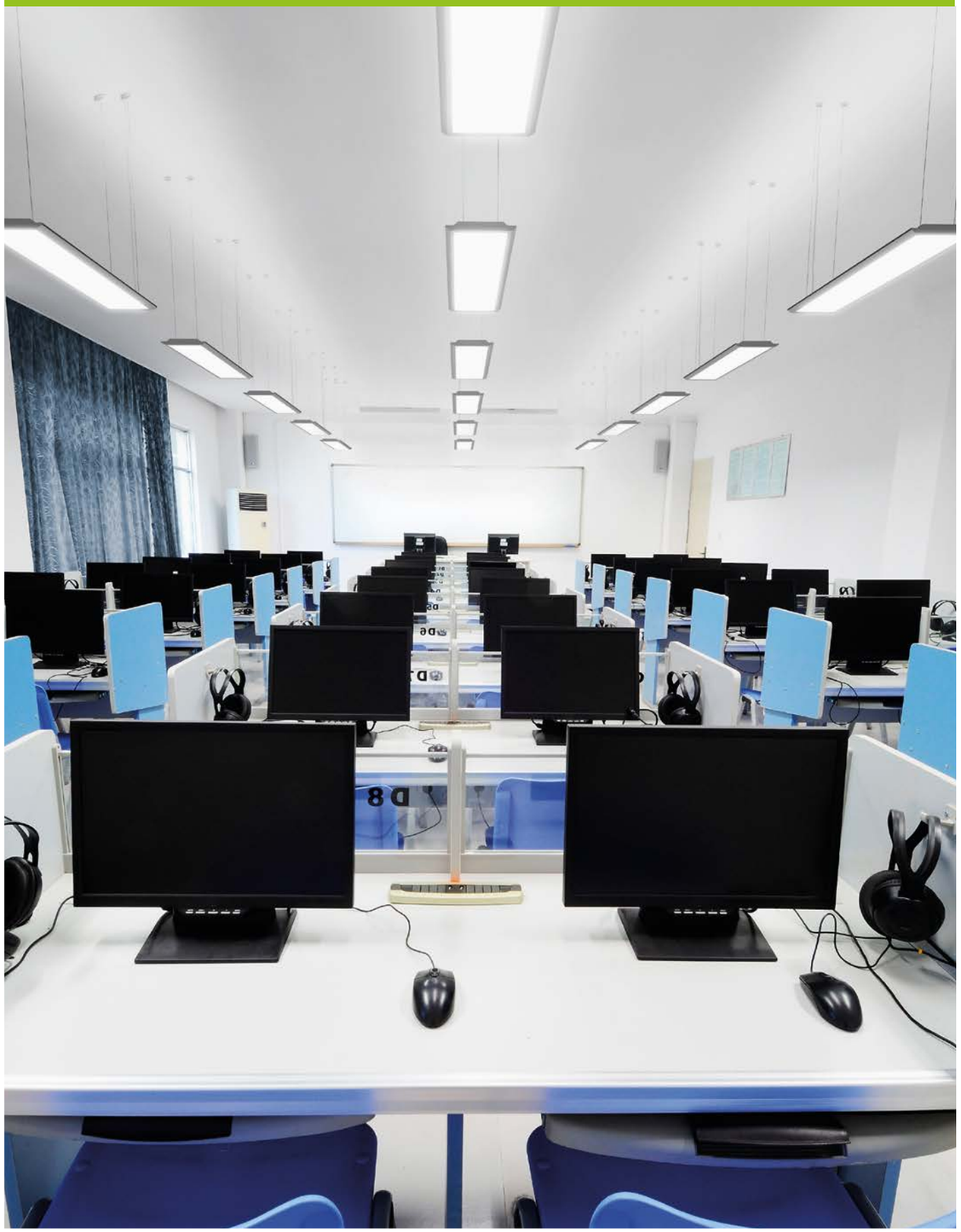
The rooms where the lessons on the PC screens take place have increased demands on the illumination of the space. Besides the main lighting it is important to think about the correct vertical illumination of the walls and ceiling of the computer room. The package with recommendations of the British designers – Lighting Guide 7 (LG 7) – states the ratio 50 % for the illumination value of the vertical surfaces compared with the working plane, for illuminating the ceilings 30 % of the working plane illuminance. The suspended linear luminaires with the direct and indirect radiation of the luminous flux are an ideal solution for this type of space.

Compared with other classrooms in the computer room it is very important to prevent undesirable glare and reflection on the screens. The optimal conditions can be achieved by the sufficient shielding of the light sources and correct layout of the luminaires. In the rooms with availability of daylight it is due to the same reason to fit the windows with systems of curtains or blinds. The minimal shielding angles of the light sources and the value of the psychological glare admissible for the computer rooms are adapted by the European standard EN ISO 9241-307.

The interactive teaching process in the computer rooms where the vision is permanently transferred from the PC monitor to the teacher and vice versa requires a uniform distribution of brightness in the room. Too much of a contrast luminance in the individual levels of the space could represent a burden for the eyes and could cause fast fatigue of the pupils. If the computer room is equipped with a projection screen and an overhead projector and the teaching process is realised through multimedia presentations, it is important to dim the lighting to the required intensity or to switch off completely part of the lighting system.

As the computer rooms are spaces without a permanent occurrence of persons, it is suitable to consider some tools of the lighting management system due to energy savings.

In the computer room it is very important to prevent undesirable glare and reflection on the screens.



The recessed luminaires with louvers – see the figure 1 – do not provide sufficient illuminance of the vertical surfaces and ceiling. At the same time they represent a risk of arising undesirable reflections on the screens due to the indirect glare. The recessed or suspended luminaires with the direct and indirect characteristic of radiation with diffuse surface or microprism represent an optimal solution.

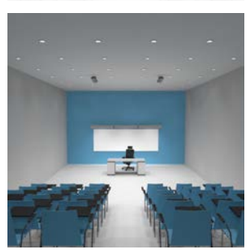
For the basic illumination of the lecture theatre it is suitable to use the light sources emitting the light of neutral white colour with the correlated colour temperature 4,000 K.

LECTURE THEATERS

In the modern higher (e.g. university) educational premises the lecture theatres fulfil a multifunctional task. They are used for lectures, social events as well as multimedia performances. From this point of view we place higher demands on the lighting solution especially concerning their comprehensiveness and flexibility.

The lighting system in a structure space of the lecture theatre has to be adapted to its structure. The individual groups of luminaires have to offer adequate lighting value in the zones they are determined for and at the same time induce an atmosphere in compliance with type of the event. For the basic lighting of a lecture theatre it is suitable to use sources emitting homogeneous, non-glare light of neutral white colour with the correlated colour temperature 4,000 K. It supports the impression of the space openness, creates condition for concentrated work and enables the students to work out their notes. For the illuminance of the task area we have a stated value of minimally 500 lux, the lighting of the surrounding task area and the background is to reach the value minimally 300 lux. For this purpose it is suitable to use the suspended luminaires with the direct and indirect luminous flux distribution or the built-in ceiling luminaires with a wide luminous intensity curve. When designing the lighting system in the case of a tiered auditorium, it is inevitable to ensure the same lighting intensity at any point of the space. This demand can be met by placing an increased number of luminaires over the lowest desks. The harmonious distribution of brightness in the space of the lecture theatre can prevent excessive fatigue. The demonstration area plays an important role in the lecture theatre. The standard EN 12464-1 determines a value 1.5 times higher than the main lighting of the auditorium has for its illuminance. The board or projection screen in the demonstration area requires an independent solution. The normative requirement for their illuminance – 500 lux – can be fulfilled by placing an asymmetric luminaire 0.85 to 1.3 m from the presentation surface. For the purposes of the multimedia presentations or events when documents or films are projected, it is inevitable for the individual groups of the luminaires to be dimmed or fully switched off independently. At the same time, during these events it is important to ensure the basic visibility in the space due to the orientation and safety. It can be achieved by placing the additional controllable luminaires on the walls. The adequate vertical illuminance contributes to a better orientation feeling. If there is a staircase in the lecture theatre, it is inevitable to illuminate the individual steps by the recessed floor luminaires. Placing the safety and emergency lighting and adequate marking the escape routes is adjusted by the standard EN 1838. The variedness of the roles fulfilled by the lecture theatre in dependence on the type of the event requires an effective utilisation of the lighting management system tools. Through implementing the tool - calling of lighting scenes - it is possible to choose the pre-selected scene for any type of event by using a simple control -pushing a button. In the halls where the daylight is available it is effective to consider the installation of the daylight sensor. The windows are to be fitted by a system of curtains and blinds.

The variedness of tasks and activities which are performed in the lecture theatres require the implementation of the lighting management intelligent tools. By using the tool – calling of the lighting scenes – and pushing a button of the simple control we can choose the pre-selected scene for any type of event.



In the workshops it is suitable to use luminaires fitted with electronic control gears to avoid the rise of the stroboscopic effect during operations with rotational tools.

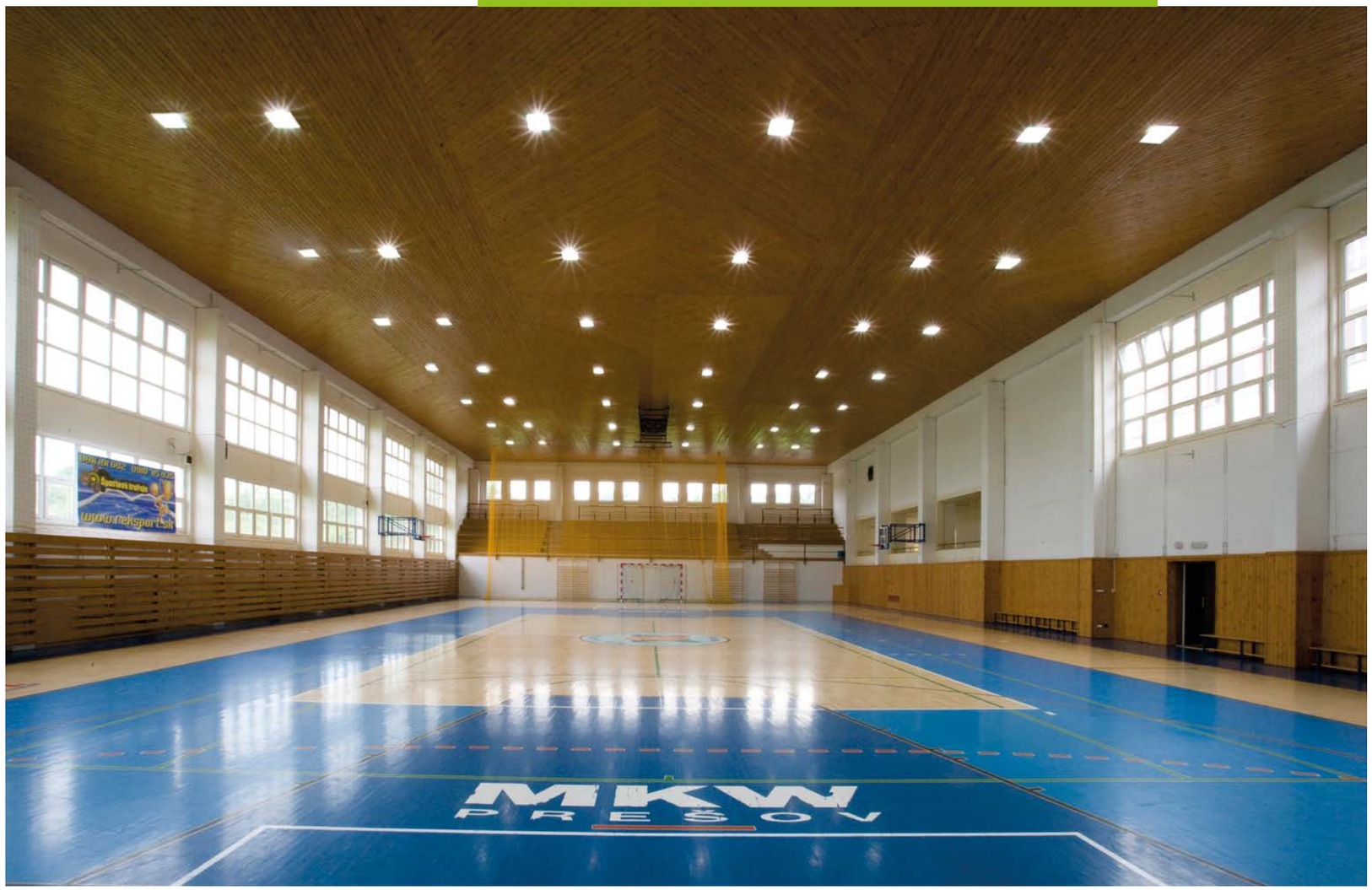
LABORATORY AND WORKSHOP ROOMS

The education of the natural sciences and development of practical skills are part of the teaching process at many schools. The learning process of this type of subjects is based on observing and practical experiments. The correct lighting of the space creates optimal conditions for teaching and at the same time the level of safety is increased.

The education in the area of physics, biology or chemistry as well as development of the practical skills in the workshops cannot be realised without practical experiments and handling of tools. The experimental labs and workshops place extraordinary high demands on the solution of the lighting system. The correctly designed lighting system has to comply with the illuminance parameters stated by the standard and simultaneously has to create such light conditions which contribute to the safety of these spaces. The European standard EN 12464-1 determines the minimal illuminance 500 lux for the labs and workshops and the more demanding the visual tasks to be realised in the specialised room are, the higher its value has to be. It is important to prevent the rise of undesirable glare and reflections from the glossy surfaces and to avoid sharp shadows. The optimal light conditions can be achieved by using the suspended luminaires with a larger part of the indirect radiation which are the source of soft diffuse light and will ensure sufficient vertical illuminance. For better concentration of the pupils it is suitable to use the light sources emitting cold white light. The experiments in the labs of natural science place increased demands on the correct identification of colours of chemicals, wires or connectors therefore from the point of view of safety it is inevitable to use the luminaires with a high colour rendering index – CRI >90. It is suitable to use luminaires with a housing made of unbreakable material which does not change its photometric properties. When solving the lighting system in the workshops it is important to avoid the stroboscopic effect when the artificial lighting is on. The stroboscopic effect represents extreme danger especially when we work with rotational tools because at the same frequency and rotational speed, an impression that the tool is off can develop and it can cause serious injuries to the user. The stroboscopic effect can be prevented by installing the LED luminaires or high-frequency control gears emitting the light with such a frequency that the human eye is not able to notice and therefore he/she perceives it as permanently continuous. If overhead projectors or computers are used in the lab or workshop during the educational process, it is suitable to design the lighting system in such a way that one part of the luminaires can be independently switched off or dimmed. Through implementing the tool - calling of lighting scenes - it is possible to choose the pre-selected lighting scene by using a simple control -pushing a button, necessary for carrying out the corresponding type of activity.

When selecting the luminaires for the labs and workshops it is necessary to take into account several factors at the same time. It is suitable to use luminaires with the protection level IP 54 or IP 65 in these spaces. In the workshops where there is a higher risk of injuring by moving rotating or reciprocating machines the luminaires should be fitted by electronic control gears to prevent the rise of the stroboscopic effect.

The luminaires in the gym have to be resistant against the impact of a ball or to be protected by a cover.



SPORT FACILITIES

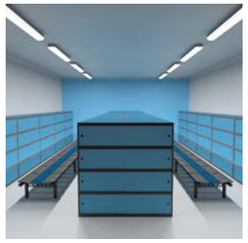
The gym and playing field provide space for relax and physical activities in every school facility. Their utilisation for various types of sport activities requires variable solutions of the lighting system.

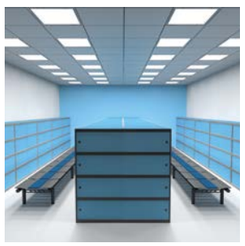
The most important criteria, when planning the illumination of the sports grounds, are the intensity and uniformity of the lighting, low glare and good rendering of colours. The heterogeneity of the sports places an additional demand on the lighting management – it has to correspond with the sport activity or event carried out that takes place in the spaces of the sports ground. The individual types of sport and events require various levels of lighting. Their values are stated by the European standard EN 12193 which states the value of 200 lux for the majority of sports at the level of a lesson or training. The standard adjusts the minimal illuminance according to the speed of the individual type of sport and divides them to three groups. The group C has the highest demands on the illuminance level (300 to 500 lux) – this includes e.g. tennis, squash, hockey, floorball. At the same time it adjusts the minimal illuminance for competitions. If we organise a higher or international competition in the gym or at the sports ground, the minimal illuminance is increased up to 500 – 700 lux. In the case of ball games, the requirement on the minimal illuminance is in direct proportion to the size of the ball. The smaller the ball and the faster the sport is, the higher illuminance rate we require. When planning the lighting system the basis is the sport activity placing the highest demand on the lighting quality. The required illuminance levels, lighting uniformity and low glare can be achieved by correct selection and deployment of the luminaires. The recessed ceiling or ceiling surfaced luminaires with sufficient protection against impacts and with shielding (e.g. with a louvre) which avoids undesirable glare are suitable. In the gyms with high ceilings it is possible to use linear suspended luminaires. The white neutral light with the correlated colour temperature CCT 4,000 K is ideal lighting for the sports grounds. An additional criterion when selecting the luminaires for playgrounds is the resistance against impacts. They are especially the luminaires with the certificate DIN VDE 0710-13 which confirms they fulfil the requirements on the resistance for the indoor playgrounds. These luminaires have to be resistant against the impact of a ball and to have a cover which will prevent the fall of the fragments to the ground if the luminaire is damaged. The luminaire tested has to resist 36 impacts of the ball from three directions at the maximum speed 60 km/h and the ball has the size of a handball. The utilisation of the gym for various types of sports and school events requires involving into the lighting solution an intelligent management system which enables e.g. dimming the individual groups of lighting fixtures or using the adjusted lighting scenes. In the gyms with availability of daylight it is recommended to use the daylight sensor due to the economy. Because this is a space without permanent presence of persons, we recommend using the presence detector which will switch the lighting off if the gym is not being used. The selection of the light source plays here an important role. From the point of view of economy, life span and demands placed on the maintenance the LED source is an ideal solution.

When planning the illumination of the sports facilities, intensity and uniformity of the lighting are the most important criteria.

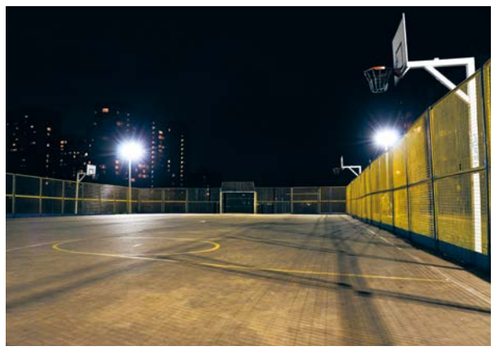
The changing rooms in the sports premises require a special solution. The emphasis is especially laid on the correct vertical illumination which helps recognising the clothing in the lockers. To ensure that the clothing and sports dresses will be recognised well, it is suitable to use the light sources with a sufficient colour rendering index CRI 80. Similarly as the gym the changing room is a space without permanent occurrence of persons. By installing the presence detectors we ensure the illumination of changing rooms when it is really necessary and in this way we achieve the optimal energy consumption.

The swimming pool places extremely high demands on the illumination. Due to safety it is inevitable to use only special water-proof luminaires determined for lighting the swimming pools. When designing the lighting system, it is necessary to solve not only the lighting in the surrounding of the swimming pool but also lighting of its interior. Without lighting the internal surfaces of the swimming pool the water surface reflecting the light from the external lighting would perform as a mirror and would cause undesirable glare. For the illumination of the swimming pool's internal surfaces it is good to use the recessed luminaires located on the walls of the pool.





From the normative point of view there are not high demands on the illuminance level in the changing rooms. However, it is important to ensure sufficient vertical illuminance of the lockers and to create conditions for appropriate recognising the colours.



For reaching an optimal intensity and uniformity for lighting the outdoor sports grounds we recommend to use high-performance column lighting by luminaires with a narrow luminous intensity curve. To avoid creating sharp and long shadows they are placed in the corners of the playground or at its edges. The luminaires are to be placed in such a way that every point on the playground is illuminated minimally from two places. The undesirable glare can be prevented by installing the luminaires in sufficient height.

LIGHTING REQUIREMENTS FOR SPORT AREAS, TASKS AND ACTIVITIES EN 12193

INDOOR

sports	Horizontal illuminance		CRI	Note
	Em (lux)	U_o		
Basketball	200	0.5	20	No luminaires should be positioned in that part of the ceiling, which is above a 4m diameter circle around the basket.
Floorball	200	0.5	20	
Football	200	0.5	20	
Handball	200	0.5	20	
Volleyball	200	0.5	20	No luminaires should be positioned in that part of the ceiling, which is directly above at least the net area.
Wrestling	200	0.5	20	
Dancing	200	0.5	20	
Gymnastics	200	0.5	20	
Tennis	300	0.5	20	No luminaire should be positioned in that part of the ceiling which is directly above the area limited by the rectangle of the marked area extended to 3m behind the base lines.
Swimming	200	0.5	20	1. Diving-Additional reqirement Eh_{avg} / Ev_{avg} = 0.5 2. The above are general requirements only. Special requirements can be needed for individual pools
Badminton	300	0.7	20	No luminaires should be positioned in that part of the ceiling witch is above the principal area.
Table tennis	300	0.7	20	

OUTDOOR

sports	Horizontal illuminance		CRI	GR	Note
	Em (lux)	U_o			
Athletics (all activities)	100	0.5	55	20	1. Horizontal illuminance can be reduced to 50 lux for running events 2. For discus, javelin and hammer special precautions shold be taken to ensure the safety of persons within the stadium since the object being thrown maytravel above the line of light and hence be invisible during part of their flight. 3. The vertical illuminance at the finishing line should be 1,000 lux for photo-finish equipment and officials.
Tennis	200	0.6	55	20	
Running Street / Cross Country	3	0.1	-	-	
Cycle racing	100	0.5	55	20	The vertical illuminance at the finishing line should be 1,000 lux for photo-finish equipment and officials
Ice hokey	200	0.5	-	20	
American football	75	0.5	55	20	
Basketball	75	0.5	55	20	
Floorball	75	0.5	55	20	
Football	75	0.5	55	20	
Handball	75	0.5	55	20	
Volleyball	75	0.5	55	20	
Golf driving range	100	0.8	-	20	Vertical illuminance on Distance Marker (at 1 m height)
Swimming	200	0.5	-	20	1. The above are general requirements only. Special requirements can be needed for individual pools. 2. No underwater lighting should be used.

Em = average illuminance in lux (maintained value)

U_o = lighting uniformity

UGR = UGR limit (direct glare limitation)

GR = glare rating limit (upper limit of glare)

CRI = colour rendering index of lamps

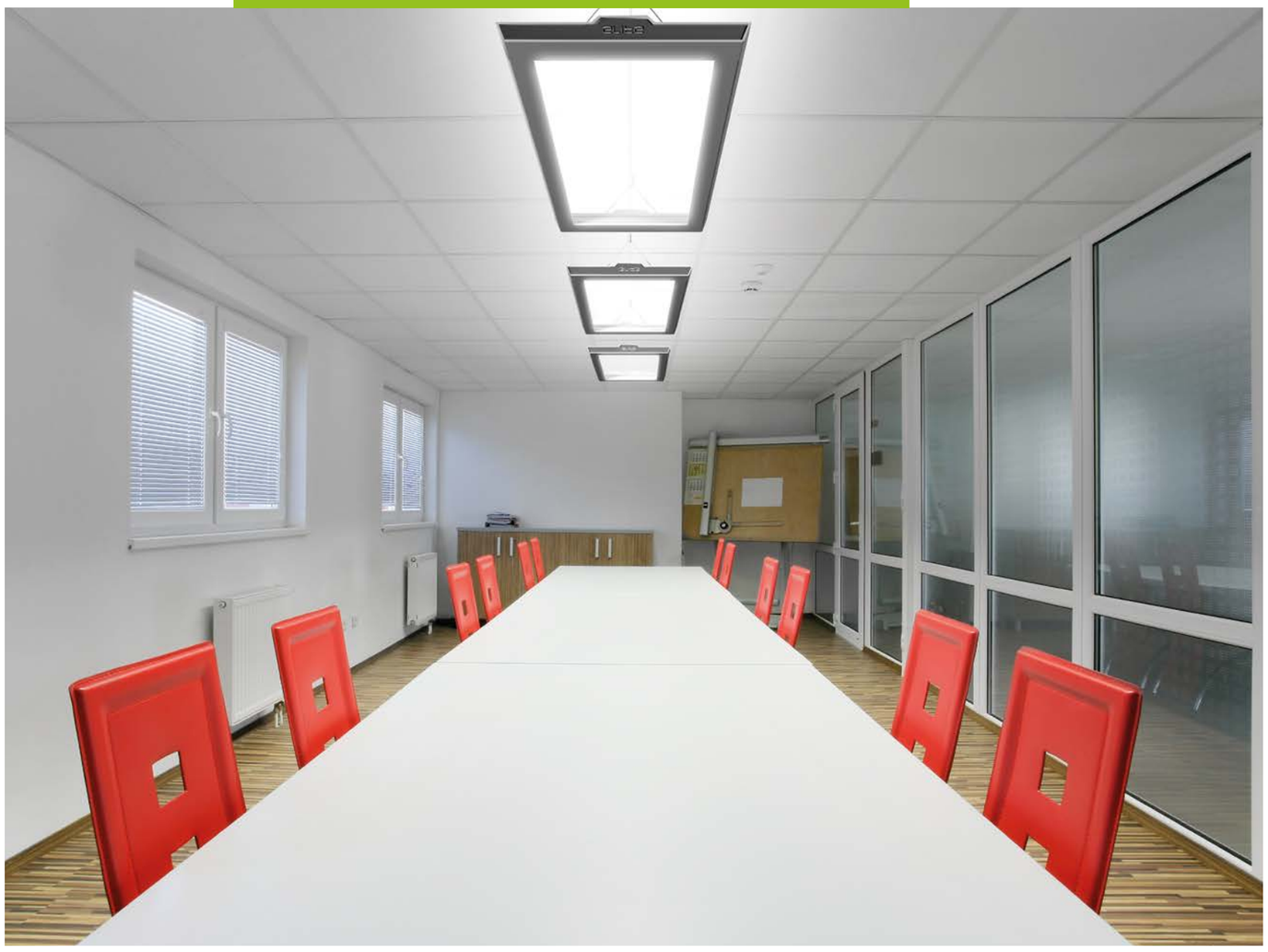
LIGHTING REQUIREMENTS FOR SPORT AREAS, TASKS AND ACTIVITIES EN 12193

Suitable conditions for concentrated work in the teacher's room can be achieved by the light sources emitting the light of neutral white colour.

TEACHER'S ROOM

The teacher's room and the teacher officials represent in the school premises a background determined for group meetings and individual preparation of the teachers. Their correct illumination creates suitable conditions for concentrated work.

At school premises the teacher's room is a space determined for meetings and information exchange between teachers. The tasks are assigned here; they plan, realise and assess the school projects as well as the performance of the pupils. The standard EN 12464-1 determines the minimal illuminance level 300 lux for the teacher's room. The required normative level can be achieved by using the luminaires with the direct and indirect characteristic of the luminous flux distribution which also gives sufficient illuminance of the walls and ceiling. For creating optimal conditions for concentrated work we recommend using the light sources producing the light of neutral white colour with the correlated colour temperature CCT 4,000 K. If there is a presentation surface in the teacher's room, it is necessary to use the additional luminaire with an asymmetric luminous intensity curve. Its placement 0.85 to 1.3 metres from the presentation surface we ensure its sufficient vertical illuminance. The heterogeneity of the activities carried out in the teacher's room creates a potential for utilising the programmable lighting scenes. Implementing the lighting management system tool – calling of lighting scenes – we can simply choose and release the selected scene by simple pushing a button on the control panel. As the teacher's room is a space with availability of the daylight, it is suitable to consider installing the daylight sensor due to optimisation of the energy consumption.



The classical solution of the lighting with recessed luminaires with a parabolic louvre ensures sufficient illumination of the workplace but the upper parts of the walls and the ceiling remain dark. Such illumination causes a feeling of a cave effect and makes the room optically smaller.

Optimal lighting solution in this space is represented by suspension luminaires with direct and indirect characteristics of the luminous flux distribution. The indirect diffuse light helps to model objects, it reduces indirect glare when the light reflects from the PC screen or the shiny surfaces in the room.

A similar result as with the suspension luminaires with direct and indirect characteristics of the luminous flux distribution can be achieved with recessed luminaires with a specially shaped diffuser.

TEACHER'S OFFICE

The teacher's offices in the school facilities create the teachers backgrounds for preparation of teaching or self-study.

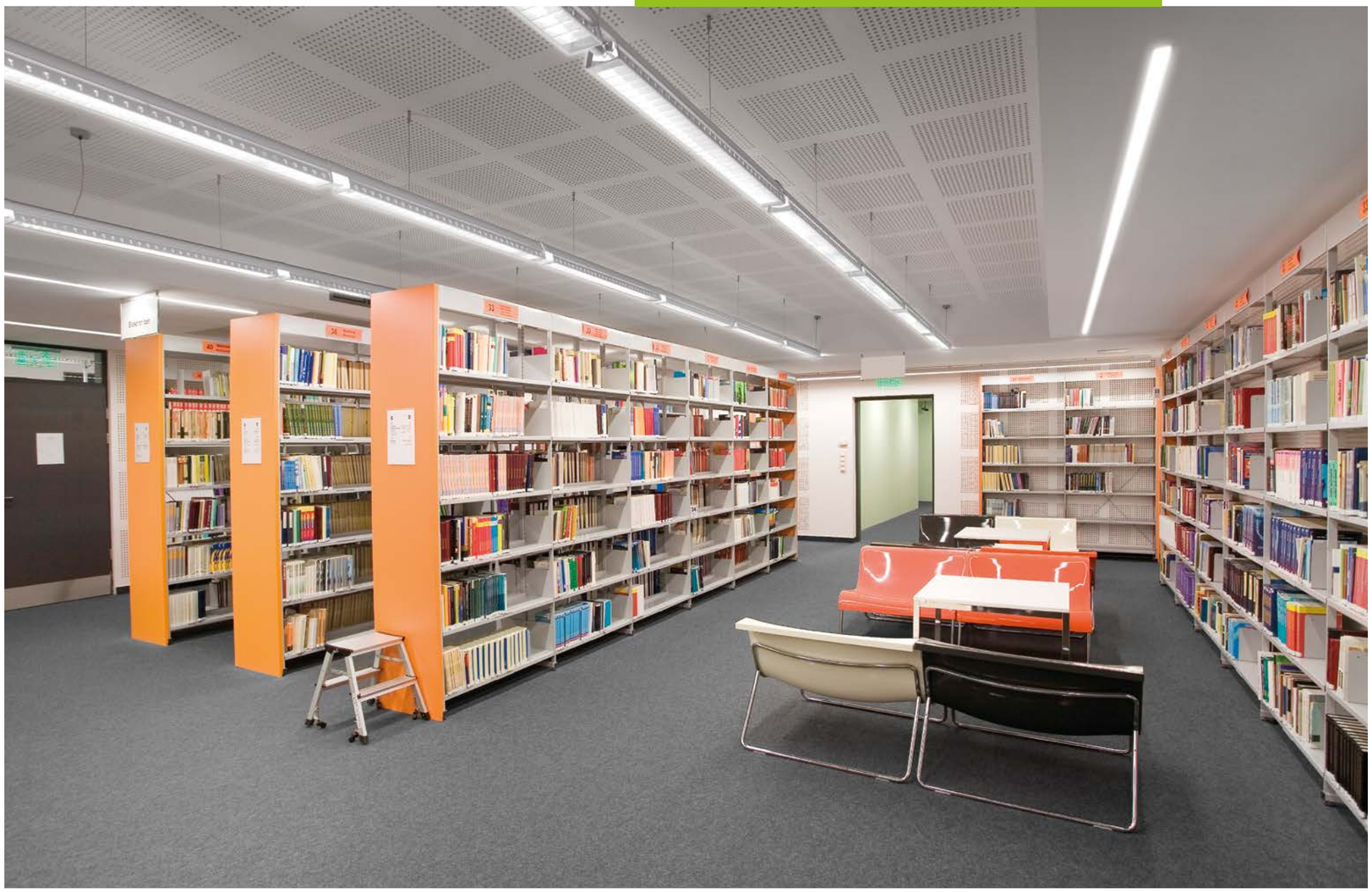
From the normative point of view it is necessary to maintain the minimal illuminance level 300 lux in these spaces. Currently the most frequently used lighting solutions are the recessed luminaires with louvers which are, however, unsuitable from the ergonomic point of view. This type of luminaires cannot achieve the sufficient illuminance of the walls and ceiling. The dark walls and ceiling cause the rise of the so called cave effect which can affect the teachers in a depressive way. The ceiling surfaced or suspended luminaires with the direct and indirect characteristic of the luminous flux distribution which reach sufficient vertical as well as horizontal illuminance represent a suitable solution. Thanks to this solution even the space of a small teacher's office is larger and lighter. For achieving constant visual conditions we also recommend completing the lighting system by standard lamps or table lamps which serve for illuminating the task area. In this way we also reach the required illuminance 500 lux. Similarly, as in the case of the teacher's room, it is suitable to use the light sources producing neutral light of white colour with the correlated colour temperature CCT 4,000 K. In the teacher's offices equipped with the VDU workstations it is necessary to avoid undesirable veiling reflections on the monitor during work with PC which reduce the contrast of depicted information and make reading difficult. The rise of undesirable reflections can be prevented by choosing appropriate types of the luminaires (the luminaires with low luminance are suitable) and their suitable layout. By placing the desks rectangular to the windows for the sunshine to fall onto the desks from side and fitting the windows by a system of blinds or curtains we simultaneously reduce the risk of the glare from the sunshine. From the point of view of the energy consumption the teacher's offices have a big potential for savings. Due to the fact that it is a space with a good availability of daylight, it is suitable to use the function of the daylight sensor. The teacher's offices are also spaces without permanent occurrence of persons. Thanks to this fact it is possible to make use of the presence detector which ensures switching on and off in dependence on the fact if the room is just being used.

To prevent excessive noise it is recommended to use the luminaires with passive thermal management.

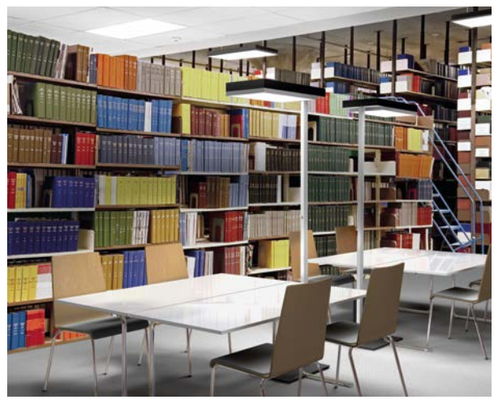
LIBRARY

Libraries are an inseparable part of the educational process. When designing their lighting system it is inevitable to take into account aspects which characterise this type of space. For the lighting system designers it means not only designing the adequate main lighting but also the illumination of the reading area, shelves and VDU workstations.

The European standard EN 12464-1 determines the value 500 lux for the workplaces and spaces of the library for reading. The suitable solutions are the recessed or suspended luminaires with the direct and indirect luminous flux distribution, ensuring uniform lighting and harmonious distribution of brightness in the room. It is suitable to use additional table or free-standing luminaires for illuminating the surfaces determined for reading and work. The neutral white light with the correlated colour temperature 4,000 K induces a pleasant atmosphere in the space, for a better recognition of colours we recommend to use the luminaires with the colour rendering index CRI 80. The library spaces are also sensitive to noise; therefore it is suitable to prefer luminaires with passive thermal management which in difference to the fluorescent lamp luminaires with the magnetic control gear do not emit any sounds. Digitalising of information has digitising changes in the form of the VDU workstations to the libraries. Also for these zones the standard EN 12464-1 determines the illuminance rate 500 lux. Similarly as in the whole library space here it is desirable to avoid any undesirable glare as well. It can be prevented by correct selection of luminaires emitting non-glare light or correct shielding and locating the light source. In the spaces with availability of daylight we should not forget to fit the windows with a system of blinds and curtains which prevent direct glare caused by sunshine. The availability of daylight in the majority of the library spaces contributes to the overall visual and psychical well-being of people and at the same time it gives an opportunity (when we utilise the lighting management system, e.g. daylight sensor) to achieve substantial energy savings. When solving the library lighting the question of a correct selection of the light source comes to foreground. The paper documents, magazines and books are sensitive to the ultraviolet radiation therefore the LED light sources which are the only not to emit it are considered the best choice in this type of space.



From the point of view of safety we must not forget about marking and lighting the escape routes and exits in the library. Marking has to be visible from every place in the room. The parameters of the emergency and safety lighting are adjusted by the standard EN 1838.



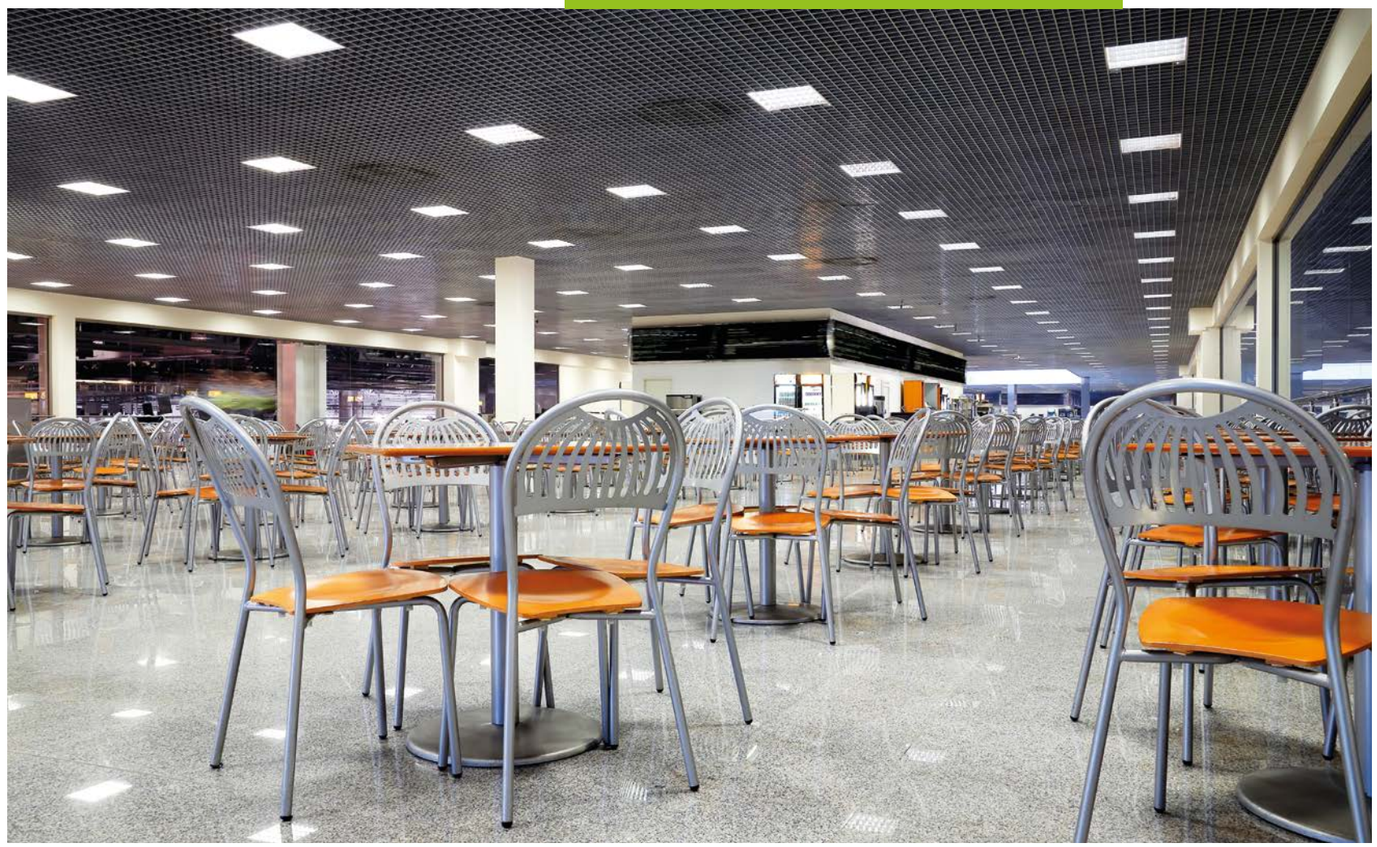
When designing the library lighting system the emphasis is laid also on the vertical illumination of the racks and shelves. The correctly illuminated racks ensure sufficient visibility of the books from the highest shelf to bottom one. The linear suspended luminaires with the direct and indirect radiation component, located along the aisles between individual book shelves are considered a suitable solution. The standard EN 12464-1 determines the minimal illuminance 200 lux for the racks.

The multifunctional utilisation of the canteen requires a flexible solution of the lighting system.

REFRESHMENTS AND CANTEEN

The catering establishment in the school facilities plays a specific role. As a matter of fact, besides refreshments this space also provides possibility for recovery and socialising. The illumination has to meet this mission.

The illumination in the catering establishments should be designed to create a positive communication atmosphere (besides meeting the normative requirements). The time people spend in these spaces is mostly limited therefore the recovery effect of the illumination on the human well-being should come in the shortest possible time. Through the combination of the natural light, daylight and artificial light in the buffet and canteen areas we can create an impression as if they were literally filled by light and in this way contribute to the welcoming atmosphere. The standard EN 12464-1 determines the value 200 lux for the main lighting of the catering establishments. It is suitable to use the suspended linear luminaires with the direct and indirect component of radiation or the ceiling luminaires with the direct and indirect component of radiation which will sufficiently illuminate also the vertical surfaces and ceiling. When there is a stable layout of the tables, it is suitable to deploy the luminaires in such a way that they will copy the communication paths in the canteen (café) and will make the orientation in the space easier. The main lighting can be completed by suspended luminaires placed over individual tables. If they were to affect the space in a disruptive way, a suitable alternative can be the luminaires with a narrow luminous intensity curve directed straight over the table. For improving the vertical space illuminance it is possible to place the wall-washers directly on the walls which will take care of pleasant colour accents on the coloured walls. In the canteen and café spaces it is recommended to use luminaires with sources emitting warm white light which creates a pleasant relaxing atmosphere and gives the human skin a more natural tone. For the colour of the meal and the food to remain as truthful as possible, it is necessary to use the luminaires with a high colour rendering index CRI >90. Due to the fact that the canteens and cafés are located at the periphery of the building and have sufficient availability of daylight, it is recommended due to the energy economy and efficiency to use the tool management system daylight sensor. The multifunctional utilisation of the canteen space for social events requires a flexible solution of the lighting system. When designing it, it is reasonable to count on the function "calling of lighting scenes" which will complete the atmosphere of a social event by a mere push of the button.



The suspended luminaire over the table is to be placed for the distance between the table surface and the bottom edge of the luminaire to be approximately 60 centimetres. If there are persons sitting at the table, the luminaire will be over their eye level and will not cover part of the face of people sitting opposite. It is good to use luminaires made of opaque or coloured glass. If the suspended luminaires were to give a disruptive impression, they can be replaced by a downlight with a narrow luminous intensity curve directed straight to the table.

For lighting the kitchens of the mass catering establishments the standard EN 12464-1 determines the minimal illuminance level 500 lux. The luminaires have to possess sufficiently high colour rendering index CRI, to be resistant against high temperatures, vapour and chemicals. It is recommended to use unbreakable luminaires over the area for preparing meals or luminaires protected by a special cover which will prevent the fragments from falling onto the meals if the luminaire is damaged.

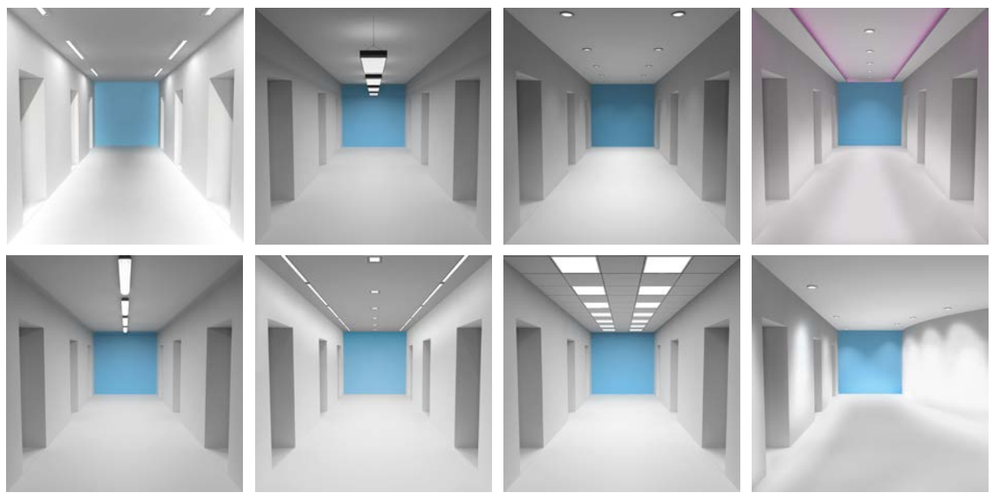
The correct illumination of the corridors will make the orientation in space easier and will increase the safety during the transfer of pupils.

CORRIDORS AND COMMUNICATION

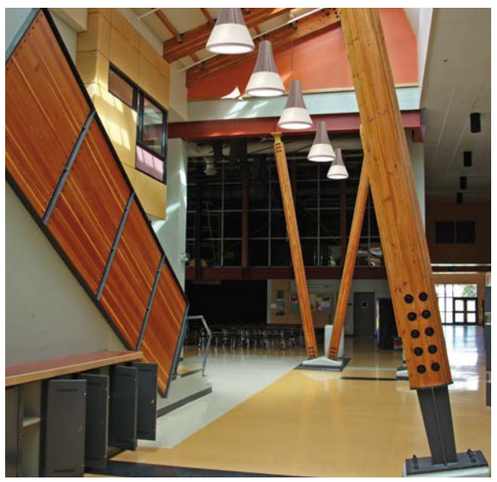
In the schools the communication zones connect the entrance with foyer, individual floors and classrooms. Through their correct illumination we can achieve quick orientation in the space, contribute to the feeling of overall well-being and last but not least increase safety.

The entrance, reception, and foyer represent the place of the first contact at schools. When planning the illumination it is necessary not only to think about fulfilling the standard but we have to think of creating a positive welcoming atmosphere and if necessary this space is to fulfil the representation role. The recessed luminaires with a wide luminous intensity curve and light sources radiating warm white light could be a suitable solution. If the reception is part of the foyer or a reception desk with permanent service, it is necessary to also take into account appropriate lighting of the task area and surrounding area when designing the lighting system. The suspended luminaires with the direct and indirect component of radiation over the working desk of the permanent service, possibly completed by a table or free-standing luminaire will ensure the receptionist optimal working conditions. The corridors at schools not only represent connecting lines between individual levels of the building and rooms but also the space where the pupils gather during breaks. The correct lighting of the corridors will simplify the orientation in the space and will contribute to the overall feeling of comfort of persons who are moving in the school spaces. The sufficient vertical illuminance of surfaces is considered one of the most important criteria for lighting corridors. The insufficiently illuminated walls and ceilings create the cave effects and cause depressive impressions. It is suitable to use luminaires with a wide luminous intensity curve or suspended luminaires with the direct and indirect luminous flux distribution which will sufficiently illuminate all corridor surfaces. The corridors belong among the spaces utilised during the breaks where the students transfer between classrooms and lecture rooms. In this situation considerable reduction of the adaptation luminance represents the greatest risk – it develops when transferring from the space illuminated by 500 lux (classroom) to a space with significantly lower illuminance 100 lux (corridor). To prevent injuries during a sudden transfer to worse light conditions, it is recommended to make this transfer softer.

The school utilises the corridors often as a communication tool and places there information boards, message boards, pieces of work of its students or awards from various competitions. For highlighting these objects it is appropriate to use the accent lighting in the form of luminaires with a narrow luminous intensity curve or the wall-washers.



In practice we achieve this by using additional luminaires or placing these luminaires directly over the classroom door. The communication zones in the school premises are spaces without permanent occurrence of persons and have a considerable saving potential. A correctly selected lighting management system tool enables the school to achieve significant energy savings. The presence detectors are suitable tools in the school communication zones (e.g. corridors and lockers) and possibly the daylight sensors (for the communication zones with availability of the daylight). High demands in the school spaces are laid on the lighting of the staircases. It is important to ensure sufficient visibility of the individual steps and to prevent the rise of undesirable reflections and glare during the movement upwards and downwards as well. The recessed floor and wall luminaires are an ideal solution. From the point of view of safety it is inevitable to install the emergency lighting which in the case of a power cut will ensure the minimal illuminance level necessary for safe movement of persons around the building on the staircase and the corridors as well.



Correctly planned and carefully maintained emergency lighting can prevent an outbreak of panic, injuries and even save lives.

SAFETY AND EMERGENCY LIGHTING

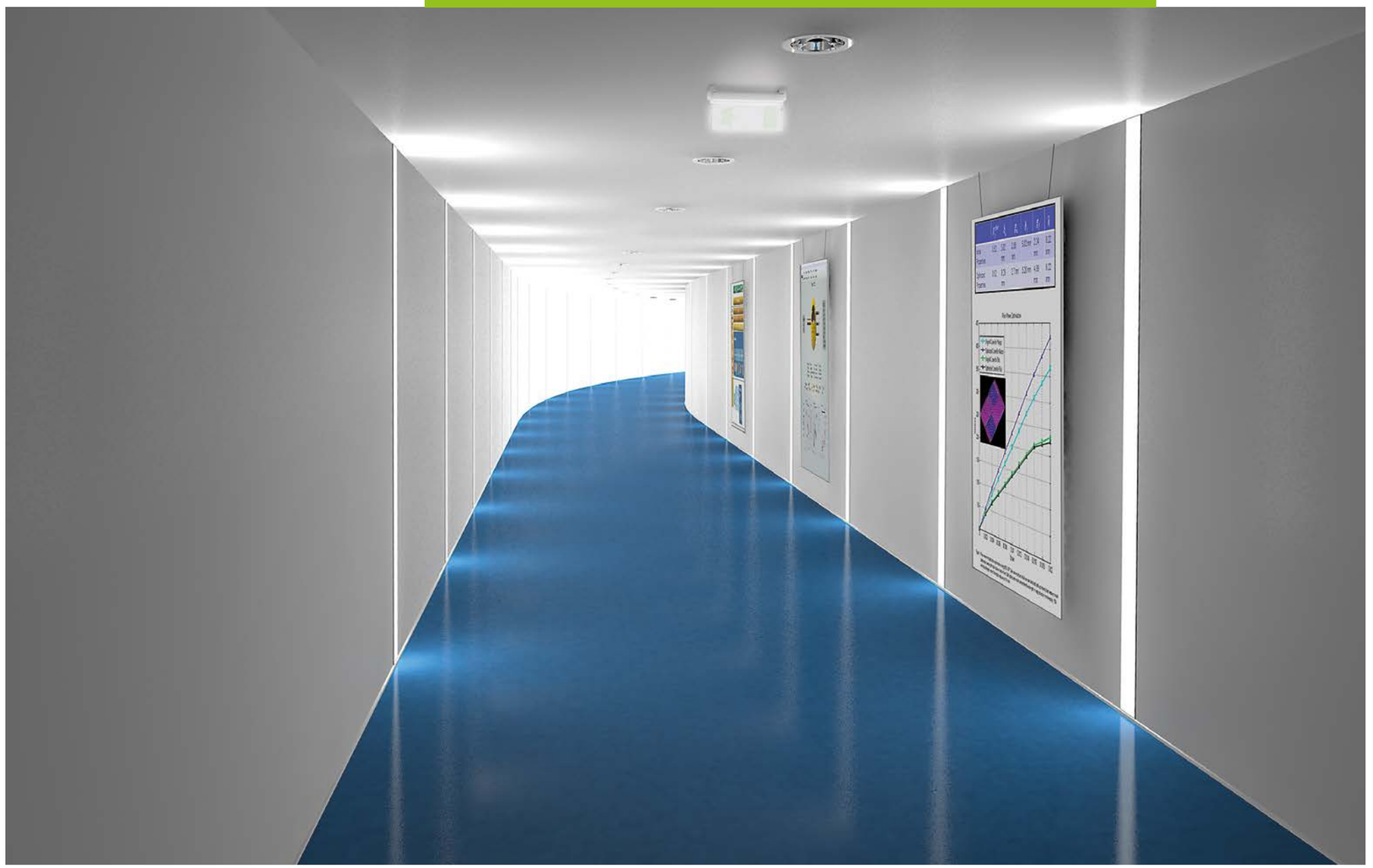
In the spaces with an increased concentration of persons, rooms without any access of the daylight and in the communication zones determined for escape paths the safety and emergency lighting helps to solve collision situations and reduces the risk of injury.

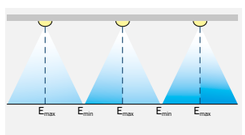
Regardless to the fact if it is a power cut, danger of fire or another crisis situation, the task of the safety and emergency lighting is to ensure the pupils basic visibility and orientation during leaving the space or to make their access to the fire extinguishers easier. Correctly planned and carefully maintained emergency lighting can prevent an outbreak of panic, injuries and even save lives. When selecting the type of the emergency lighting the requirement on its long-term lifetime and the ability to fulfil its tasks at good visibility also during the power cut plays the most important role.

The battery pack LED luminaires represent the optimal solution – the producers guarantee here the minimal lifetime of 50,000 hours. In this way the maintenance costs are reduced and compared to other light sources the user can save up to 70 % of the power consumption.

The effectiveness of the LED emergency lighting can be increased by installing the additional optics and reflectors which will reduce the number of the LED luminaires when the legal standard is fulfilled.

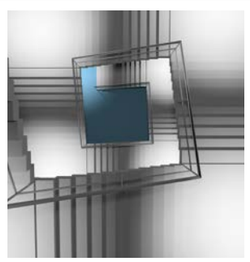
The requirement on the safety and emergency lighting is adapted by the European standard EN 1838. The EN 1838 standard specifies the minimum horizontal lighting needed to be 1 lux along the central axis of escape path that has to be at least 2 m wide.





REQUIREMENTS ON EMERGENCY LIGHTING
Illuminace E_{min} = 1 lux
Uniformity E_{max}:
E_{min} ≤ 40: 1 lux
Colour rendering index CRI ≥ 40
Operating time 1 h
Activation of lighting 50 %, or for required illuminance within
5 seconds, 100 % within 60 seconds

During normal operation the illumination level of communications zones reaches prescribed levels. During the blackout or in case of fire emergency lighting ensures the pupils basic visibility and orientation during leaving the space or to make their access to the fire extinguishers easier.

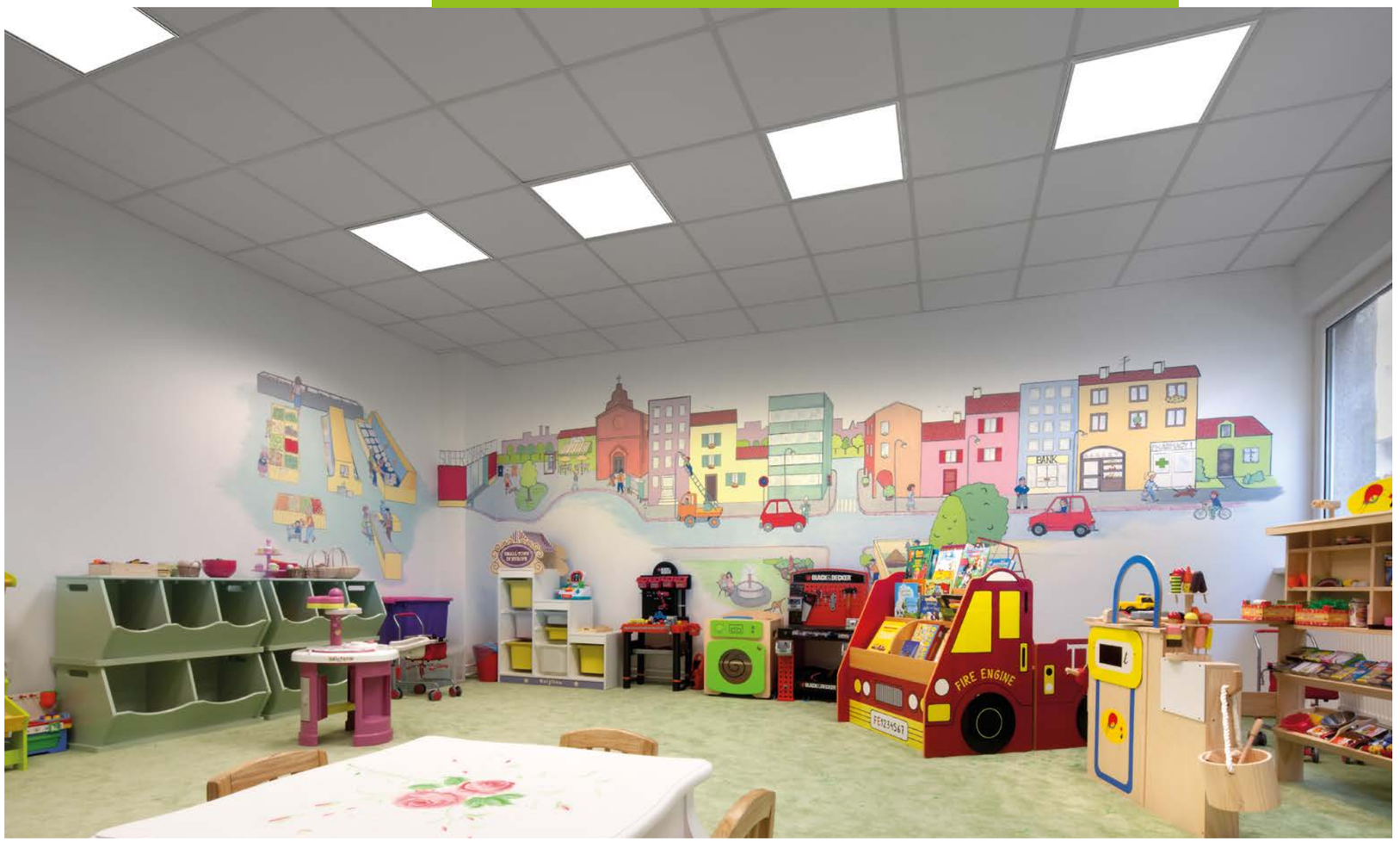


The games determined for recognising colours require using light sources with the CRI value of more than 90.

KINDERGARTEN

In the system of education kindergarten fulfils one of the most important missions. The children here learn to recognise the world. The way in which they can see it plays a key role in this process. The correct illumination of the space will enable them to understand it to the smallest detail.

The children are driven by their own curiousness. The kindergarten is to give them the space to learn as much as possible about the world that surrounds them though they are in continual movement, during playing and larking around. The visual perception and imitation are the strongest tools through which the children are able to grasp the world around. The designed lighting system has to show it to them in the real shapes and colours. The decisive factor when selecting the luminaires for the kindergarten is therefore the type of the luminaire and the optimal value of the colour rendering index of the light source. For the overall lighting of the space we recommend using lighting fixtures with the direct and indirect radiation of the luminous flux. It is also important to take into account how the children play and move. As they often fall down and roll about intentionally on the carpet it is necessary to use such luminaires that do not glare and emit soft diffuse light. The creative games aimed at correct recognising and assigning the colours place specific demands on the capability of the luminaire to show the coloured objects truthfully. Therefore it is appropriate to use the light sources with the colour rendering index CRI>90. During the day the majority of activities in the kindergarten take place in the day room. That is why the illumination here requires increased demands on the lighting flexibility. It is suitable to complete the main illumination by additional luminaires determined for various types of activities. The issue of safety is an important factor when we choose the lighting fixtures. Regarding the type of the facility for the children it is recommended to use unbreakable, covered luminaires which are resistant against impacts (e.g. by a ball). The freestanding or any other portable luminaires are considered unsuitable for the kindergarten premises. The majority of the kindergarten spaces have availability of the daylight and therefore it makes sense to consider the installation of the daylight sensors. In the day rooms determined for carrying out various activities from drawing through games up to the rest and relaxation it is good to implement the lighting management system – calling of lighting scenes – which enables starting a pre-adjusted lighting scene by pushing a button.



In the rooms determined for relaxation it is good to implement the lighting management system – calling of lighting scenes, which enables to create a relaxing atmosphere by a simple pushing of a button.

It is important to take into account how children play and move. As they often fall down and roll about intentionally on the carpet it is necessary to use such luminaires that do not glare and emit soft diffuse light.

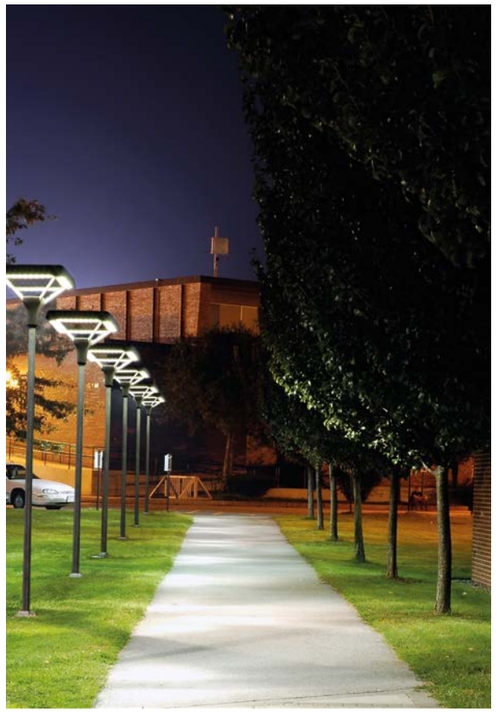
The balanced ratio between the light and the shadow improves the capability to orient in the space.

EXTERNAL AREAS AND PARKING AREAS

The external areas of the school represent a combination of the relaxation and communication zones and a space where the pupils can release their accumulated energy during the breaks. The correct illumination increases the safety especially during the winter months when the students move in the external areas and creates a positive mood.

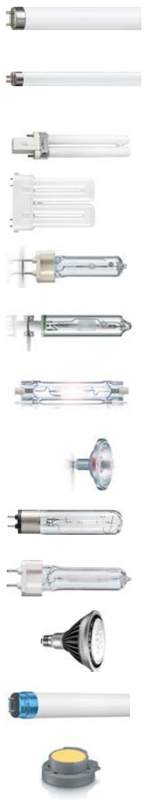
The task of the lighting designer when solving the external lighting is to achieve sufficient illumination of the horizontal and vertical surfaces without any dark places and differences of the luminance levels. This prevents the rise of sharp shadows which decrease the ability of the human eye to respond to the possible obstacles. The balanced ratio between the light and the shadow improves the capability to orient in the space. Sufficient cylindrical illuminance (minimally 1 lux) and enough diffuse light will make the recognition of faces easier. The illumination of the staircase should be paid special attention. The non-glare illumination that enables recognising the steps safely can be reached e.g. by using the recessed floor luminaires. The adequate general lighting of the external areas can be made by placing the pole luminaires with a wide luminous intensity curve. There are increased demands on their resistance against the temperature fluctuations, dust and water, ideally in an anti-vandal environment. It is recommended to use the luminaires with IP 66 for this type of space. The accent lighting in the form of the recessed floor lighting fixtures with a narrow luminous intensity curve can emphasise interesting architectonic details of the school building. The lighting solutions also require porches above the entrance of the school which can be illuminated by luminaires with the direct characteristic of the luminous flux distribution. The more sophisticated solutions can also involve the ambient lighting and specific solutions of the green areas. The coniferous trees and broad-leaved trees of light green colour become apparent in the light of the luminaires with sodium discharge lamps, the dark green trees in the light of the metal-halide lamps. Their suitable placement helps achieve a multicolour effect. From the point of view of the moving persons it is extremely important to pay increased attention to the illumination of the entrances, entryways, parking areas and zones where the routes of the pedestrians, bikers and motor bikers or car drivers overlap each other. The higher the traffic density is, the higher the risk of collision is. Sufficient visibility ensured by a higher lighting intensity reduces the risk of accidents. The rules for lighting the parking areas and communication zones in the external areas are adjusted by the standard EN 12464-1. When choosing the type of the light sources for the external lighting, the issue of ecological character and economy is coming to the foreground.

From the ecological point of view, new types of luminaires that do not emit the light towards the upper half-space and thus do not produce the light smog are a suitable solution. These requirements are met especially by the LED light sources. They are typical by high efficacy and effectiveness. Due to their low failure rate and long life span they do not represent any increased burden from the point of view of the maintenance costs. In difference to the traditional light sources, e.g. fluorescent lamps or discharge lamps, the LEDs reach the full luminance immediately, moreover, after a short power cut the full luminance is reached without any delay. For the illumination of the external areas and the parking area of the school it is possible to achieve full luminance immediately and this fact significantly improves the safety of pupils´ and teachers´ movement in the school premises. In the external environment, the fact that in difference to the conventional sources there is no decline of efficiency at low temperatures and vice versa its effectiveness is even increased in such conditions, says in favour of the LED. From the point of view of safety it is a very resistant light source that can be hardly damaged, moreover also in the case of damage they do not constitute any threat for the health of the pupils and teachers. Compared to the conventional sources they contain a negligible amount of heavy metals which are, moreover, only in the solid state in the LED and this reduces the danger of contaminating the air.



SELECTING THE RIGHT SOURCE

The individual areas in the school building place different demand on the illumination. When designing a lighting system the task of the lighting designer is to choose the light sources with the most suitable parameters where besides the procurement price the categories of effectiveness, lifespan and safety are also included.



Lamp type	Power rating from - to (W)	Luminous flux from - to (lm)	Efficacy from - to (lm/W)	Light colour	Colour rendering index (CRI) from-to	Socket
Tube-shaped fluorescent FD (T8) Ø 26 mm	18 - 70	860 - 6,200	61 - 93	ww/nw/dw	80 - 96	G13
Tube-shaped fluorescent FDH (T5) Ø 16 mm	14 - 80	1,100 - 6,150	67 - 104	ww/nw/dw	80 - 93	G5
Compact fluorescent lamp 2 or 4 tube, elongated construction	5 - 57	250 - 4,300	46 - 90	ww/nw/dw	80 - 90	2G11 2G7
Compact fluorescent lamp 3 or 4 tube, compact construction	60 - 120	4,000 - 9,000	67 - 75	ww/nw	80 - 85	2G8-1
Metal halide - single-end mounting with ceramic technology	20 - 400	1,600 - 46,000	80 - 100	ww/nw	80-95	G12
Metal halide - double-end mounting with ceramic technology	70 - 250	5,100 - 25,000	73 - 100	ww/nw	80-85	PGJ5
Metal halide lamps - double-end mountings	70 - 150	6,800 - 14,500	86 - 115	nw/dw	88-95	RX7s
Tubular shape with ceramic technology and with reflector	45 - 315	2,200 - 128,000	96 - 120	nw/dw	82-90	GX8,5
High-pressure sodium - ellipsoidal shape	35 - 1000	2,200-128,000	63 - 139	ww	25, 65	PG12-1
High-pressure sodium - tubular shape	50 - 1000	4,400 - 130,000	70 - 150	ww	25, 65	GX12-1
LED retrofit	3 -7	90 - 806	37 - 46	ww/nw/dw	80 - 90	GU10 E27
LED tubes Ø 26 mm	24-30	700 - 1,900	51 - 66	ww/nw/dw	70 - 90	G13
LED module	0.2 - 50	100 - 5,000	90 - 160	ww/nw/dw	70 - 98	-

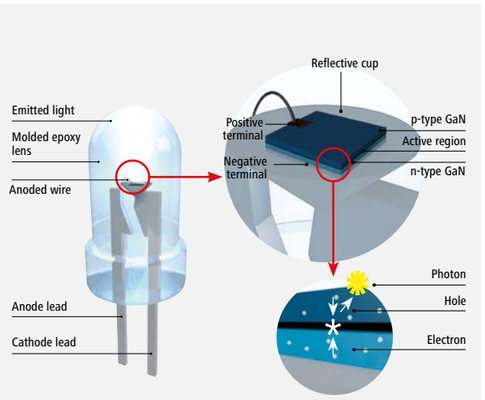
ww = warm white correlated colour temperature (CCT) below 3,300 K
nw = neutral white correlated colour temperature (CCT) 3,300 K to 5,300 K
dw = daylight white correlated colour temperature (CCT) over 5,300 K

LED FOR SCHOOL

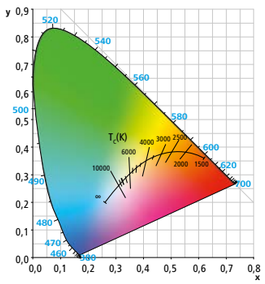
When in 1962 the American professor Nick Holonyak created the prototype of the first "light emitting diode" – LED, his invention remained almost unnoticed. The only one who anticipated its revolutionary future on the pages of the magazine Rider´s Digest was the inventor himself. It lasted almost forty years until the industry revealed all the exceptional properties of the LED and learned how to utilise them. In the lighting industry the LED sources currently represent an area that is developing in the most dynamic way.

In what respect are the LED sources so exceptional and exceed the properties and parameters of the conventional sources? Why do the architects, developers and users of school buildings concentrate more and more frequently on the LED sources when designing the lighting systems? It would be possible to answer in a very simple way: The LED sources are highly effective, they have a long lifespan and an excellent colour rendering, they are cost-effective and environment-friendly. But let us have a look at the individual categories more thoroughly and we will explain why the LED sources represent also for your school the best solution.

The LED sources are based on the semi-conductor basis. A very small amount of energy is necessary for emitting the light. The diodes emitting light consist of two types of semi-conductors – the N-type with surplus of electrons and the P-type which has lack of electrons (the so called holes). After connecting the power the excessive electrodes and holes begin to migrate to the PN junction. When they meet the recombination develops and the diode starts emitting a photon. By its size that is not larger than a dot made by a pencil the LED ranks among the smallest light sources. The package which is at the same time a lens serves as protection. It enables distributing the luminous flux directly under the angle 15 to 180°. While a common light bulb is able to change into visible light only 5 % and the fluorescent lamp 30 % of the electric power, the LED with its ability to change up to 40 % of the total energy reaches incomparably better parameters in this category. The efficiency of the light source or its efficacy says with what efficiency the electric energy is changed into the light, i.e. how much of luminous flux it produces fem. the electric input power (W) delivered to the light source. The unit is lumen per watt (lm/W). While the first LEDs in 1996 had an efficacy of 0.1 lm/W, today there are commercially available LED chips with an efficacy of 160 lm/W for cool white CCT LED and in the labs there has been achieved an efficacy of up to 254 lm/W.

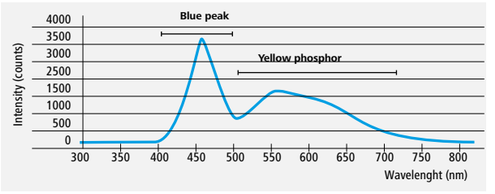


If the LED sources after binning are on the Planck curve, they emit "pure white", i.e. pure white light.



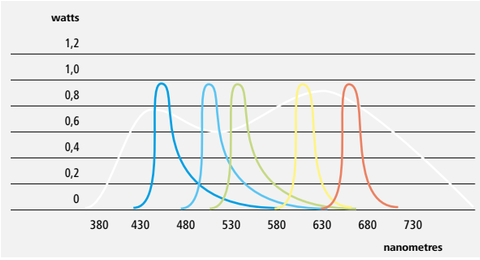
The LED luminaires used in the schools have to fulfil high ergonomic and economic requirements. In the school they are required to deliver high-quality, glareless lighting for the optimal visual comfort also for the Visual Display Units (VDU) and at the same time they have to fulfil the requirements of the European standards. The LED diodes are primarily the source of the white colour radiation. The white LED light can be acquired by various methods; however, the principle of luminescence is most frequently used for its production. In this method a thin phosphorus layer is applied to the blue LED which, after the switching on of the source, changes part of the blue light which passes it into the white one. This technology of the LED production enables achieving the emission of the white light with various correlated colour temperature from 2,700 K to 10,000 K.

Another method making it possible to acquire the white LED light consists of mixing the coloured light of various wavelengths. Through additive mixing the red, green and blue colours (RGB) the white light can arise. The advantage of this method is that besides the white light by targeted mixing we can also acquire coloured light. The disadvantage when acquiring the white light by the RGB technology consists in its demandingness. It requires a lot of know-how because the management of the coloured LED with various values of luminance is demanding and the white light produced often achieves lower values of the colour rendering index CRI 70 – 80. If we consider changes of the correlated colour temperature of the white light when solving the illumination in the schools, it is suitable to combine the coloured chips with white LEDs. In this way optimal CRI values are obtained.



White light can be produced by combining blue and yellow light only. Sir Isaac Newton discovered this effect when performing colour-matching experiments in early 1700 s.

SPECTRUM OF WHITE AND COLOURED LEDS



LEDs do not require colour filters. The colour tone of the light is determined by the semiconductor material used and the dominant wavelength.

COLOURS STRAIGHT FROM THE SEMICONDUCTOR

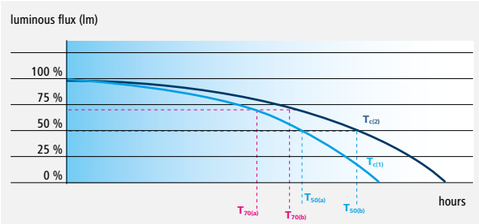
LEDs do not require colour filters: their light comes in different colours produced directly by different semiconductor materials. Secondary colours are also possible. The major semiconductors are:

Semiconductor material	Abbreviation	Colour(s)
Indium gallium nitride	InGaN	green, blue, (white)
Aluminium indium gallium phosphide	AlInGaP	red, orange, yellow
Aluminium gallium arsenide	AlGaAs	red
Gallium arsenide phosphide	GaAsP	red, orange, yellow
Silicon carbide	SiC	blue
Silicon	Si	blue

The lifespan of the LED sources moves in the values of up to 50,000 hours which represents 18 years for 11-hour-operation daily, 250 days a year.

From the point of view of the lifespan the LED light sources achieve above-average parameters. Their lifespan moves in the values of up to 50,000 hours which represents 18 years for 11-hour-operation daily, 250 days a year. The drop of the light source performance to 70 %, in some cases to 50 % is introduced as the LED lifespan end. It means that the LED failure rate is substantially lower compared to the conventional sources. However, appropriate cooling of the light source is a necessary condition for maintaining the lifespan parameters.

DEFINITION OF LIFESPAN



LEDs do not fail but the intensity of the light they produce diminishes over time. The lifespan (L) of an LED thus needs to be defined for different applications. For emergency lighting, for example, rating up to L80 or more are required, this means that the LED reaches the end of its service life when the luminous flux falls to 80 percent of the original flux measured. For general lighting, values of L50 or L70 are defined. The lifespan of an LED depends on a large extent on ambient and operating temperature. Where an LED is operated at a high temperature ($T_{c(1)}$) or with poor thermal management, its life is shortened.

The experts estimate that if we replaced all existing light sources for the LED ones today, the energy savings worldwide could reach the amount of 30 %. If we realise that the artificial lighting consumes up to one fifth of the energy produced, this amount is not negligible at all.

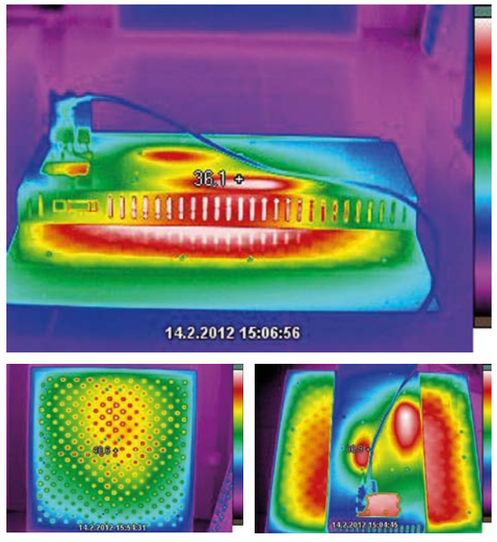
In spite of higher purchase costs the LED sources represent in a longer-term horizon the most effective and economical light solution. The experts estimate that if we replaced all existing light sources for the LED ones today, the energy savings worldwide could reach the amount of 30 %. If we realise that the artificial lighting consumes up to one fifth of the energy produced, this amount is not negligible at all. When we take into account a smaller area, e.g. the classroom illuminated by obsolete conventional sources, we would be able to save up to 75 % of lighting system input power by the controlled LED illumination. All light sources also produce the IR radiation during the change of the electric power into the light which the human organism perceives as heat. However, the LED light sources produce it in a negligible amount compared to the conventional sources and thus they do not increase the inadequate costs for the air-conditioning power consumption. The lifespan and failure rate of the LED sources reduces the lighting system maintenance costs as it does not require any regular interventions of service staff and purchasing new light sources.

The LED source saving potential can be maximised by installing the intelligent lighting management which enables adjusting the radiation intensity of every luminaire in the lighting system automatically in dependence on the availability or intensity of the daylight.

The environment-friendly approach is a topic also for the producer of the light sources today. The reality is that the majority of the conventional light sources cannot be produced without using the toxic heavy metals – lead and mercury. The users of the premises equipped with this type of light sources have an additional burden when they replace them as they are compulsory to remove the used or damaged sources in compliance with the law about disposal of the toxic waste and on the other hand they are exposed to the risk of breathing the toxic vapours when the light source is damaged. In this respect the LED sources represent an incomparably lower risk. Though they contain a small amount of heavy metals, they are in solid state and so there is no danger of breathing in the toxic vapours when the LED source is damaged.

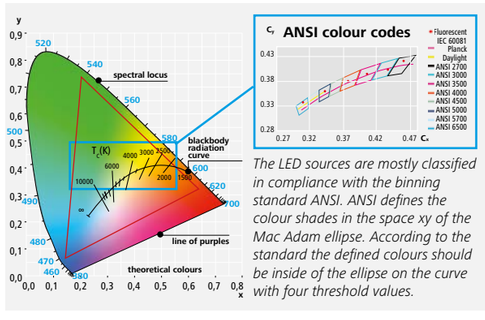
Thermal management

Similarly as in the case of other light sources, the temperature significantly affects the performance of the LED light source. Without any adequate thermal management overheating of the LED source can develop and it reduces its lifespan and the risk of its damage is also increased. Implementing a suitable cooling system we achieve maintaining the declared lifespan of the LED light source and its high efficacy. From this point of view the thermal management represents the most critical factor for the luminaires with the LED source.



Binning

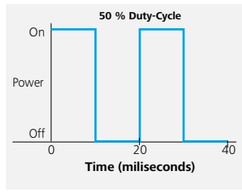
During the industrial production of LEDs deviations of the key parameters arise in the individual batches. In the framework of one batch the parameters are generally the same, but when we compare two various batches, the LEDs difference e.g. in colour or the luminous flux. To ensure the constant quality of light with the same level of luminance and colour of the light, it is inevitable to sort out every batch according to the value of individual parameters. This sorting is called binning. The main criteria taken into account when binning are as follows: the luminous flux measured in lumens (lm), the correlated colour temperature measured in Kelvins (K); the forward voltage measured in volts (V). The LED sources are nowadays classified according to the binning standard ANSI. This standard defines the colour shades of LED by the MacAdam ellipses which depicts the colour deviation on the axis X and Y. The MacAdam ellipses shows how the colour of the individual LED modules can differ. The binning standard ANSI recommends for the resulting colours to be inside of the ellipse on the curve with four threshold values. The binning groups of the LED sources which show minimal differences of the values measured will produce the light of the same colour.

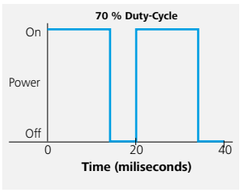


The LED sources are mostly classified in compliance with the binning standard ANSI. ANSI defines the colour shades in the space xy of the Mac Adam ellipse. According to the standard the defined colours should be inside of the ellipse on the curve with four threshold values.

PWM control

The Pulse Width Modulation (PWM) represents the most effective method how to check the intensity of the LED light source. The PWM principle is based on periodical switching on and off of the constant current directed to the LED. The resulting intensity of the LED light source is characterised by the ratio between the state of switching on and off. The frequency of switching on and off is adjusted for the human eye to perceive the emitted light as a continuous luminous flux. Its intensity depends on the adjustment of the PWM cycle (0 % to 100 %). The advantage of the impulse width modulation is the maintaining of the constant correlated colour temperature in the whole range of dimming.





Compared with the conventional light sources the LED light sources reach the full luminance immediately. The immediate start of the LED source is a benefit from the point of view of safety and comfort. At the same time compared to the conventional sources, frequent switching on and off does not make any damage to the LED source and does not reduce its lifespan as well.

BASIC TERMS

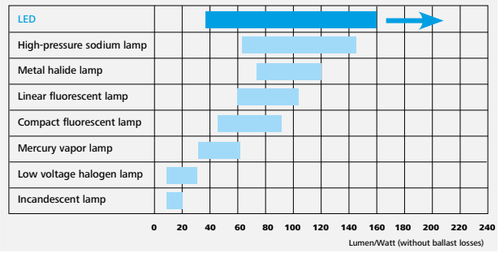
LUMINOUS FLUX Φ

The luminous flux is a physical quantity which states how much light in total a light source emits to all directions. It is the radiant power of the light source assessed from the point of view of the human eye sensitivity. The luminous flux expresses the ability of the radiant flux to cause a visual perception. The unit of the luminous flux is lumen (lm).

EFFICACY H

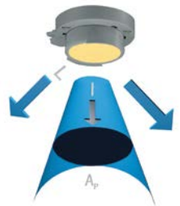
The luminous efficacy states with what efficiency the electric power is changed into the light, i.e. what proportion of the luminous flux is produced from the input power (W) delivered to the light source. The unit is lumen per watt (lm/W).

LUMINOUS EFFICACY OF THE SOURCE



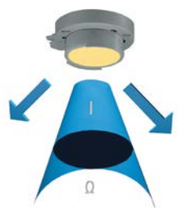
LUMINANCE L

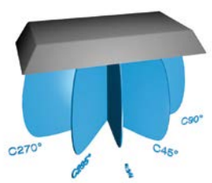
The luminance is the gloss of the shining or illuminated surface as the human eye perceives it. The unit is candela per square metre (cd/m²). This quantity gives the level of the luminous intensity over the specified surface area. The luminance of the illuminated surface depends in a great extent on its reflectance.



LUMINOUS INTENSITY I

The luminous intensity is a physical quantity which states what volume of the luminous flux the light source (or luminaire) emits to the elementary space angle in the direction evaluated. The unit of the luminous intensity is candela (cd).

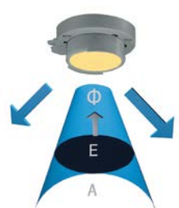




intensity distribution curve

ILLUMINANCE E

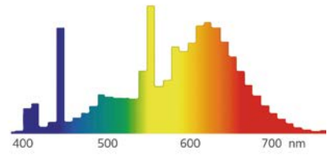
This vector quantity states what amount of the luminous flux falls to the illuminated surface. The unit of the illuminance is lux (lx).



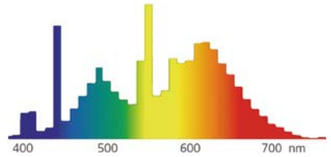
GLARE

If too great luminance occurs in the field of vision of the eye, its differences or the spatial or time contrasts which exceed the vision adaptability, the glare arises. During the glare the activity of the visual system is deteriorated.

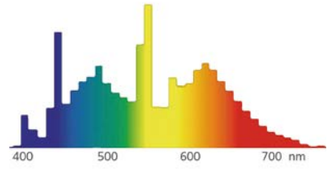
CORRELATED COLOUR TEMPERATURE (CCT)



2,700 K



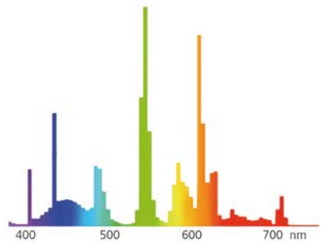
4,200 K



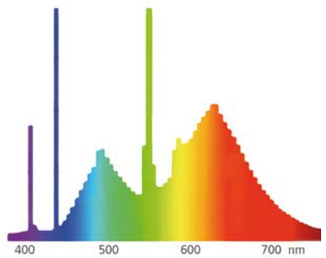
6,500 K

The correlated colour temperature of the light source determines the atmosphere in the room. It is defined by the correlated colour temperature of the light source expressed in kelvins (K). Low temperatures create a warm light, the high ones the cooler ones. The most used light colours are the warm white (over 3,300 K), the neutral white (3,300 to 5,300 K) and the day white colour (over 5,300 K). The warm white colour is predominantly used for emphasising the red and yellow colour. The blue and green colours become apparent at higher temperatures.

COLOUR RENDERING INDEX (CRI)



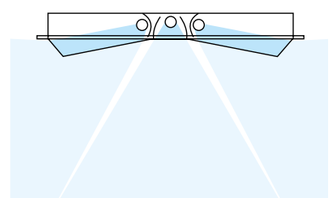
CRI 70



CRI 95

The properties of light source colour rendering are given in the levels of the general index of colour rendering – Ra. The CRI gives the rate of the congruence of the object surface's real colour illuminated by the considered light source under stated conditions of comparison. The smaller this difference is, the better the property of the colour rendering of the given source is. The light source with Ra=100 renders all colours completely equally as a standard light source. The lower the index Ra, is the worse the colour rendering is.

LIGHT OUTPUT RATIO (LOR)



The Light Output Ratio is the share of the luminous flux coming out of the luminaire and the sum of the luminous fluxes from all light sources.