Safety Lighting

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Safe also without electricity

Since it is practically impossible to find a way out of the unknown building in the dark, it is compulsory to provide adequate security lighting in the event of power failure. Safety lighting allows us to:

- safely finish the work,
- quickly and safely leave the building and
- avoid panic.

Standards

SIST EN 1838: 2011
Lighting applications – emergency lighting

ISO 30061 (2007)
Emergency lighting

CIE S 020 (2007)
Emergency lighting

Emergency lighting

Lighting in the building can be divided into:

- general lighting,
- emergency lighting.

Emergency lighting

Emergency (and safety) lighting ensures that a minimum level of brightness is guaranteed after a failure of general lighting. That mean it needs its own independent source of electrical energy (batteries, rechargeable batteries (individual, group or central), power generator and/or special fire proof electric installation.

Emergency lighting

Emergency lighting is used as the umbrella term for mains-independent lighting and can be divided into:

- standby lighting,
- safety lighting.

Standby lighting

Standby lighting is mains-independent light that is installed where no hazard for employees is anticipated. Usually it is used for „normal“ continuation of work in the event of a power failure.

Standby lighting

For example in large stores, we do not want to stop the work in the event of a power failure. Standby lighting usually uses general lighting luminaires and diesel generator as a power source.

Safety lighting

Safety lighting has only safety tasks and is intended to:

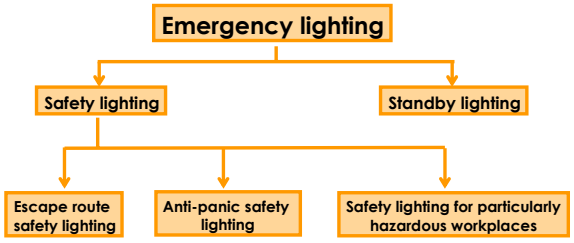
- allow potentially hazardous work to be safely stopped or finished,
- allow persons to safely and quickly leave the affected premises or building and
- to prevent the outbreak of panic in areas where there is a greater number of people present.

Safety lighting

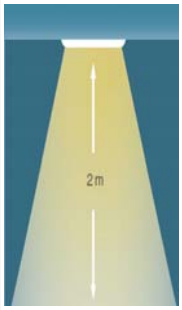
Safety lighting can be divided into:

- safety lighting of escape routes,
- anti-panic safety lighting
- safety lighting for particularly hazardous working areas (places).

Overview of emergency lighting



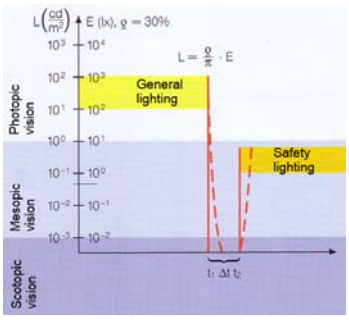
Safety lighting



Main features of safety lighting:

- luminaires need to be mounted at least 2 m above floor level;
- escape signs need to be illuminated;
- if emergency exit is not directly visible, escape signs need to be positioned along escape route;
- safety luminaires need to be installed in proper places.

Isues with safety lighting



Visual conditions with safety lighting are not the same as with general lighting:

- visual acuity
- vision of colours
- adaptation time

Escape route safety lighting

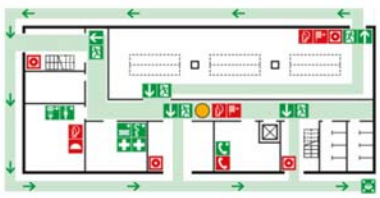
The purpose of the escape route safety lighting is:

- to allow safe escape from the area and/or building;
- to allow the identification of safety signs;
- to enable rough orientation in space and
- to enable the identification of obstacles on the route.

Escape route safety lighting

To properly mark the escape route following is used:

- escape sign luminaires or illuminated escape signs for marking the escape route,
- luminaires for illuminating the escape route and
- escape route plans.

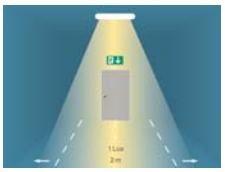


Escape route safety lighting

Standard SIST EN 1838 gives different requirements for escape route lighting:

- needed minimum illuminance;
- minimum uniformity of illuminance;
- proper glare limitation;
- minimum colour rendering index;
- minimum operating time in
- minimum power-up delay.

Escape route safety lighting: requirements



Illuminance

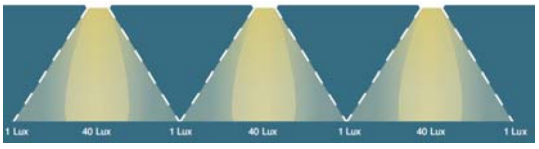
$$E_{min} = 1\,\text{lx}$$

Minimum horizontal illuminance on floor level (preferably no more than 2 cm high) for escape routes up to 2 m wide. Can decrease to 50 % at a distance of 50 cm.

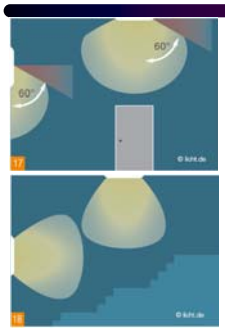
Escape route safety lighting: requirements

Uniformity of illuminance

$$E_{max} : E_{min} \leq 40 : 1$$



Escape route safety lighting: requirements



Glare limitation

In the case of horizontal escape routes, luminous intensity must not exceed certain limits at any azimuth angles between 60° and 90°. For other escape routes the limits must not be exceeded at any angle.

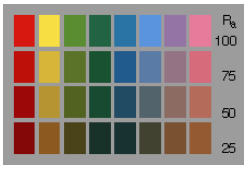
Escape route safety lighting: requirements

Glare limitation

The limiting luminous intensity depends on the height of the luminaire:

height (m)	up to 2,5	2,5 - 3,0	3,0 - 3,5	3,5 - 4,0	4,0 - 4,5	over 4,5
lum. intensity (cd)	500	900	1.600	2.500	3.500	5.000

Escape route safety lighting: requirements



Colour rendering index

$$R_a \geq 40$$

The colour rendering index of the light sources in luminaires bust be at least 40 so that the colours of safety signs can be recognized.

Escape route safety lighting: requirements

Power-on delay

50% of illuminance within 5 seconds, 100% of illuminance within 60 seconds.

The power on-delay of luminaires with instantaneous 100% luminous flux should not be more than 15 second. If the full luminous flux is not achieved right after the power-on, upper limits need to be taken into account.

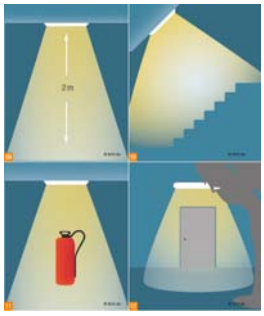
Escape route safety lighting: requirements

Rated operating time

$$t_{\min} \geq 1\ \text{h}$$

The needed illuminance must be maintained at least for 1 hour or in some cases at least for 3 hours (depending on data in safety assessment documents)

Escape route safety lighting



Where escape route luminaires should be placed:

- along the escape route (to achieve needed E);
- at exit doors;
- near stair, single steps or any other change of level;
- at emergency exits and safety signs;
- at any point of change of direction;
- at any point where corridors or aisles cross;
- near any first aid post, fire-fighting facility or alarm device;
- outside the building up to safe distance from each exit.

Anti-panic lighting

The purpose of anti-panic safety lighting:

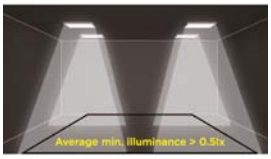
- To prevent a possible outbreak of panic in areas with a lot of people;
- To enable people to find escape routes.

Anti-panic lighting

Main features:

- luminaires should be directed directly downwards;
- lighting should shed light on the potential obstacles to a height of 2 m above the ground.

Anti-panic lighting: requirements



Minimum illuminance

$$E_{min} = 0{,}5 \text{ lx}$$

Horizontal illuminance at the floor level need to be at least 0,5 lx. The total area of the room is taken into account except the 0,5 m wide stripe around the walls.

Anti-panic lighting: requirements

Uniformity of the illuminance

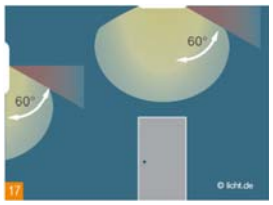
$$E_{max} : E_{min} \leq 40 : 1$$

Because of persistence of vision, the ratio of highest to lowest illuminance should be no greater than 40:1; this avoids excessive differences in brightness that interfere with the visual task.

Anti-panic lighting: requirements

Glare limitation

Glare limitation requirements are the same as for escape route safety lighting. Luminous intensity must not exceed certain limits at any azimuth angles between 60° and 90°.



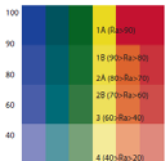
Anti-panic lighting: requirements

Glare limitation

Allowed luminous intensity is the same as at the escape route safety lighting.

height (m)	up to 2,5	2,5 - 3,0	3,0 - 3,5	3,5 - 4,0	4,0 - 4,5	over 4,5
lum. intensity (cd)	500	900	1.600	2.500	3.500	5.000

Anti-panic lighting: requirements



Colour rendering index

$$R_a \geq 40$$

Colour rendering index of light sources should be at least 40 so that safety signs and their colours can be clearly identified.

Anti-panic lighting: requirements

Power-on delay

within 5 seconds: 50% of illuminance,
within 60 seconds: 100% of illuminance

Anti-panic safety lighting should provide 50% of the required illuminance within the first 5 seconds and 100% in 60 seconds.

Anti-panic lighting: requirements

Rated operating time

$$t_{\min} \geq 1\ \text{h}$$

Anti-panic safety lighting must provide appropriate conditions (at least on escape route areas) for a minimum of one hour (three hours).

Safety lighting for hazardous work areas


The purpose of this type of safety lighting is:

- to enable safety for workers, which are located in potentially hazardous areas (acting machines, containers of hazardous liquids ....

Safety lighting for hazardous work areas

The main feature:

- workers who operate machines and processes or control them, must be able to stop these machines and/or processes safely and without putting in danger themselves or other employees.

Safety lighting for hazardous work areas: requirements

Minimum illuminance

$$E_{\min} = 10\%\ E_n > 15\ \text{lx}$$

Minimum illuminance on the working area must be at least 10% of the maintained illuminance required for the task or at least 15 lx.

Safety lighting for hazardous work areas: requirements

Stroboscopic effect

Stroboscopic effect is not allowed

As rotating machines might be present, safety lighting may not have the stroboscopic effect (recommended use of incandescent lamps or fluorescent lamps with electronic ballasts).

Safety lighting for hazardous work areas: requirements

Uniformity of illuminance

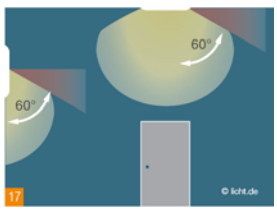
$$E_{max} : E_{min} \leq 10 : 1$$

Required uniformity of illuminance (ratio between the maximum and minimum luminance) on the illuminated area should not exceed the ratio of 10: 1.

Safety lighting for hazardous work areas: requirements

Limitation of glare

Also in this case the glare is limited with the help of maximum luminous intensity of the luminaires. Luminous intensity must so not exceed certain limits at any azimuth angles between 60° and 90°.



Safety lighting for hazardous work areas: requirements

Glare limitation

The maximum permissible luminous intensity values are in this case two times higher than in case of escape routes and anti-panic safety lighting:

height (m)	up to 2,5	2,5 - 3,0	3,0 - 3,5	3,5 - 4,0	4,0 - 4,5	over 4,5
lum. intensity (cd)	1.000	1.800	3.200	5.000	7.000	10.000

Safety lighting for hazardous work areas: requirements

Colour rendering index

$$R_a \geq 40$$

Also in this case it is necessary to provide a colour rendering index of at least 40, or more. It is important to ensure the proper distinguishing of safety colours at the machines and devices.

Safety lighting for hazardous work areas: requirements

Power-on delay

0,5 s

Needed illuminance must be continuously present (continuously powered-on safety lighting) or has to be achieved in 0.5 seconds (in any case).

Safety lighting for hazardous work areas: requirements

Rated operating time

As long as a hazard exists

Safety lighting for hazardous work areas should be powered-on at least until all potential hazards are removed (all the machines stopped, ...).

Safety lighting for guidance

The features of this type of safety lighting is:

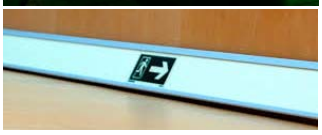
- if there is a danger that people would lost orientation because of the smoke in the room the safety lighting for guidance can be very helpful.
- safety lighting for guidance is mounted on the floor level or near the floor and runs along the escape routes (irrespective of whether it is straight or curved).
- electric or phosphorescent systems can be used.

Safety lighting for guidance

In smoke filled corridors only the floor mounted dynamic escape routing luminaires are visible.

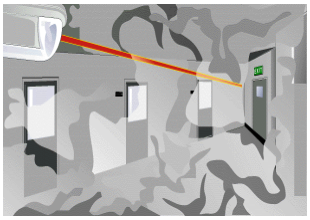
Safety lighting for guidance

Examples of use



Safety lighting for guidance

Other solution: pointing to the escape exit with laser light.



Safety signs

Standards:
- ISO 3864-1 (photometry)
- ISO 7010 (design)

Safety signs: colours

- Safety sign is made with two colours:
  - safety colour – tell us the purpose of the sign,
  - contrast colour – is used to draw a clearly visible symbol.

Safety signs: colours

Signs for prohibitions:

- safety colour: white with red stripe
- contrast colour: black

Safety signs: colours

Signs for warnings:

- safety colour: yellow (with black stripe)
- contrast colour: black

Safety signs: colours

Signs for commands:

- safety colour: blue (with white stripe)
- contrast colour: white

Safety signs: colours

Signs for safety:

- safety colour: green (with white stripe)
- contrast colour: white

Safety signs: colours

Signs for fire fighting equipment:

- safety colour: red (with white stripe)
- contrast colour: white

Safety signs: colours

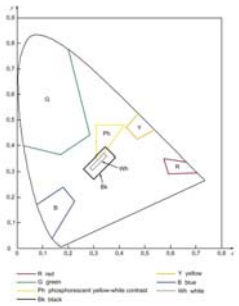
Markings for dangerous zones:

- safety colour: yellow or red
- contrast colour: black or white

Safety signs: illuminantion

- Based on the used principle for providing adequate brightness (luminance) of the safety signs, these can be:
  - illuminated or
  - back-lit.

Safety signs: requirements



Colours need to be according to ISO 3864-4:

Green: x=0,026, y=0,399

White: x=0,305, y=0,315

Safety signs: requirements

Luminance:

average luminance of green safety colour:

≥ 2 cd/m²

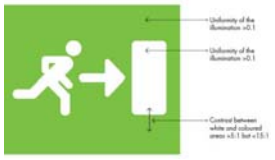
average luminance of the sign as a whole:

≥ 5 cd/m².

Safety signs: requirements

Uniformity of luminance (of green white surfaces):

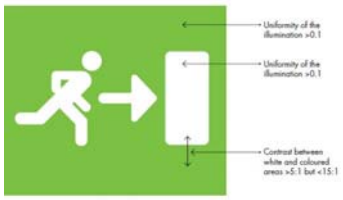
$$L_{max} : L_{min} \leq 10 : 1$$



Luminance and its uniformity are key criteria for judging a good safety sign and thus the safety it affords.

Safety signs: requirements

$$5 : 1 \leq L_{white} : L_{green} \leq 15 : 1$$



Luminance contrast between green and white surface:

Safety signs: requirements

Power-on delay (back-lit signs):

within 5 seconds: 50% of luminance, within 60 seconds: 100% of luminance

Safety signs: requirements

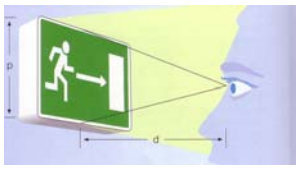
Height of the sign:

$$h = \frac{\text{viewing distance}}{\text{distance factor}}$$

Safety signs: requirements

Height of the sign (back-lit sign):

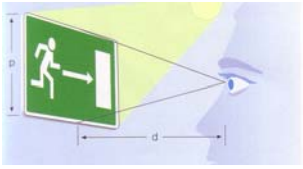
$$h = \frac{30}{200} = 0{,}15\,\text{m} = 15\,\text{cm}$$



Safety signs: requirements

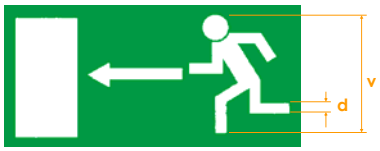
Height of the sign (illuminated sign):

$$h = \frac{30}{100} = 0{,}30\,\text{m} = 30\,\text{cm}$$



Safety signs: requirements

Good visibility and readability:



$$\frac{d}{v} = \frac{1}{7}$$

Safety signs:
back lit, illuminated or retro-reflective?

Back-lit and illuminated signs have some advantages compared with the retro-reflective ones:

- colour,
- operating reliability,
- luminance,
- height or viewing distance.

Safety signs: back lit, illuminated or retro-reflective?

at general lighting

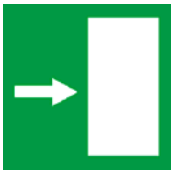
after failure of general lighting

Safety signs: back lit, illuminated or retro-reflective?

after 10 minutes

after 30 minutes

Safety signs: meaning



Escape route

Escape route

Safety signs : pomen

Meeting point

Safety exit

Luminaires for safety lighting

- Special safety lighting luminaires

Luminaires for safety lighting

- General lighting luminaires with double lighting source: usual one for main voltage and safety lighting ones for DC voltage

Luminaires for safety lighting

- Luminaires for general lighting with integrated safety lighting module. The same lighting source is used in both cases.

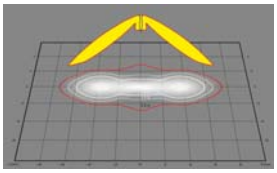
Luminaires for safety lighting

Safety lighting luminaires differ depending on operation locations:

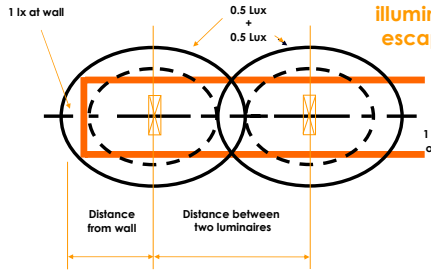
- ceiling mounted luminaires for escape routes;
- wall mounted luminaires for escape routes;
- ceiling mounted luminaires for anti-panic safety lighting;
- ceiling mounted luminaires for safety lighting for dangerous working areas;
- … .

Luminaires for safety lighting

Example of ceiling mounted luminaire for escape routes.



Luminaires for safety lighting



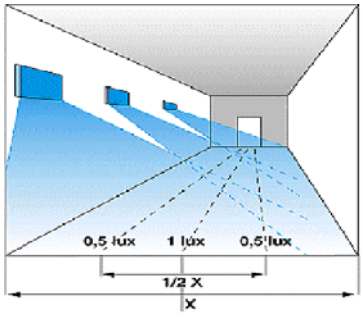
Providing needed illuminance on the escape route with the ceiling mounted luminaires.

Luminaires for safety lighting

Example of wall mounted luminaire for escape route safety lighting.

Special reflector for proper distribution of luminous flux (luminous intensity)

Luminaires for safety lighting

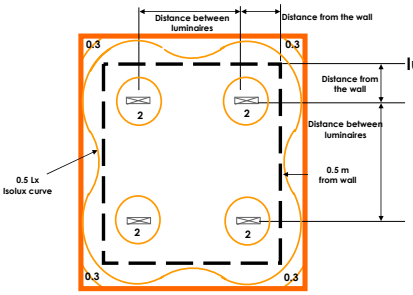


Safety lighting of escape route with wall mounted luminaires.

Luminaires for safety lighting

Example of ceiling mounted luminaire for anti-panic safety lighting: it has lighting source with larger luminous flux and larger battery.

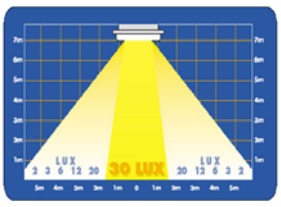
Luminaires for safety lighting



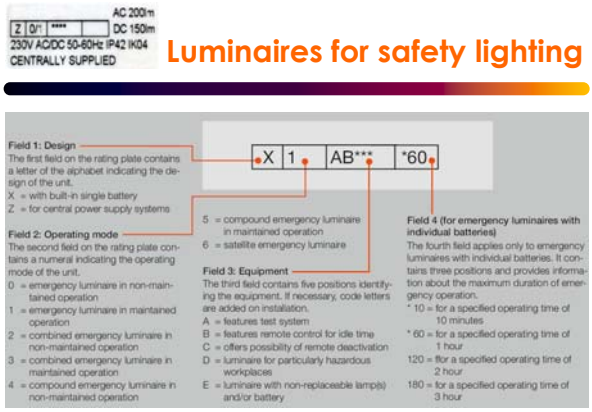
Use of ceiling mounted safety luminaires for anti-panic safety lighting.

Luminaires for safety lighting

Example of ceiling mounted luminaire for safety lighting of hazardous working areas.



Luminaires for safety lighting



Light sources

Electric energy sources

Single local battery:

- **1,2 to 3,6 V/cell**
- **life: 4 years**

Electric energy sources

Central power supply system (battery) with limited output (LPS):

- 24 to 48 V
- Lead battery (2V/cell)
- Life: min. 5 years, recommended 10 years
- max. 1500 W (1 hour)

Electric energy sources

Central power supply system (battery) with non-limited output (CPS):

- any voltage (pref. 216 V)
- Lead battery (2V/cell)
- Life: min. 10 years

Electric energy sources

Generator unit with rapid start.

Modes of operation

Luminaires for safety lighting can be operated in three modes:

- non-maintained operation,
- maintained operation and
- switched maintained operation.

Additional features

Power failure simulation:

A power failure simulation test button or a connection to a remote test system needs to be located on every single-battery luminaire or on the central power source for safety services. Manually operated test buttons must automatically return to their original position or be equipped with lock switch.

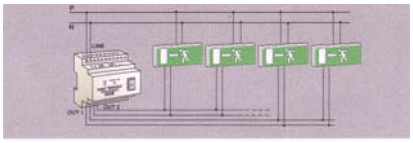
Additional features

Signaling the status of the luminaire:

Additional features

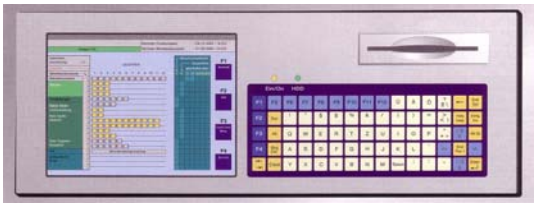
Switch off possibility:

in case safety lighting is not needed (e.g. empty building) it can be switched off to safe battery content.

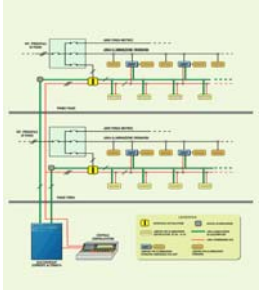


Safety lighting systems

Safety lighting systems and central monitoring systems



Safety lighting systems

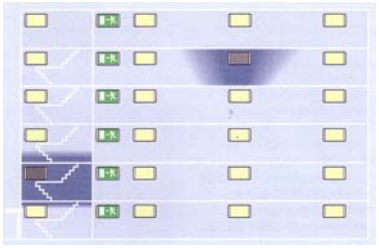


Functions of central monitoring system:

- control of individual luminaires (light source, battery, ...);
- function tests (simulation of a power failure);
- switching-off part of luminaires when part of the building is not in use or during the day;
- logging and storing data on condition and faults in the system.

Checking of safety lighting systems

Safety lighting must be maintained and controlled regularly!



Checking of safety lighting systems

Routine checking of safety lighting system:

- all luminaires must have installed functioning light sources and source of electric energy;
- LPS and CPS battery systems must be regularly (daily) tested;
- single local batteries should be tested at least once a week;
- the entire operation of safety lighting system should be tested at least once a month;
- it is required to keep appropriate log records on all performed tests and interventions on safety lighting system.

Measurement of safety lighting

Measurements on safety lighting system:

- verification of the correctness of the project;
- assessment of the current state of luminaires and safety lighting system;
- assessment of a new state of the system after alterations and repairs;
- identifying characteristics of luminaires and parts of the system when selecting appropriate components for safety lighting.

Measurement of safety lighting

What needs to be measured:

- power-on delay times and/or times in which illuminance reaches 50% and 100% of needed illuminance;
- rated operating times of individual luminaires;
- illuminance on escape routes in places with anti-panic safety lighting or on hazardous working areas;
- luminous intensity distribution (connected with glare) - this measurement is usually carried out by the manufacturer;
- voltage of sources and the ambient temperature due to their impact on the outputted light flux of light sources.

Measurement of safety lighting

Needed equipment:

- calibrated temperature measuring device;
- calibrated volt-meter
- calibrated stopwatch;
- calibrated illuminance-meter (lux-meter).

Lux-meter must have at least accuracy of class B (total error <10%, error of V(λ) <6%), it must have a probe with diameter of at least 30 mm embedded in the cardan joint or equipped with level control. It must be calibrated every 2 years.

Measurement of safety lighting

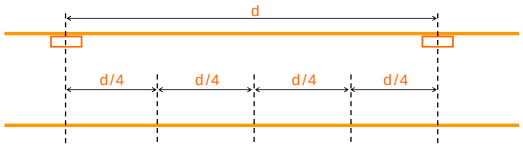
Preparations for measurements:

- determination of characteristics of space and of safety lighting (escape routes safety lighting, anti-panic safety lighting, ...);
- determination of activities that take place in a space and determination of the hazardous working areas;
- determination of the overall state of safety lighting (in operation, cleanliness, ...)
- selection of measurement points.

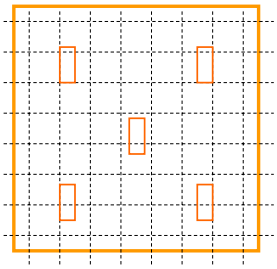
Measurement of safety lighting

Selection of measuring points along the escape route:

Illuminance on escape route is measured in symmetrically placed points along the axis of the escape route (escape route wider as 2 m). If there is only one luminaire on the route, illuminance is measured under the lamp and where required to obtain E_{min}.



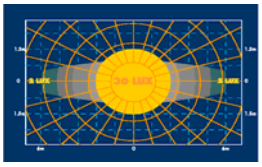
Measurement of safety lighting



Measuring points for anti-panic safety lighting:

Measuring points in a room are selected by means of an appropriate network. Care should be taken that the network raster does not coincident with the luminaire raster. Illuminance is measured on the floor (max. 20 cm high, preferred not more than 2 cm high).

Measurement of safety lighting



Measuring points for safety lighting of hazardous working areas:

Illumination of hazardous working areas should be measured on concrete working areas as specified in SIST EN 12464-1. For larger working areas a similar network raster can be used as in the case of anti-panic safety lighting.

Measurement of safety lighting

Procedure for measurement of safety lighting:

- measurement of the temperature in the room (particularly important when fluorescent lamps are used);
- safety lighting is switched on and the power-on delay time is measured (or time for luminous flux increase);
- measurement of the illuminance at selected points. The measurement is made with only safety lighting on. It is also necessary to exclude the contribution of natural light (measurements at night);
- measurement of the battery voltage;
- production of the appropriate report.

You should remember …

- Security lighting is a very important part of the building with views of the safety of its users.
- Planning for security lighting should take into account all the specificities of the building.
- Security lighting should be regularly checked and maintained.

… end:

Questions?