Abstract

Emergency lighting luminaires and modules can help to save lives. They should be constructed in accordance with appropriate standards, assembled in a factory employing recognized and suitable quality assurance procedures, and correctly installed in accordance with correct performance data. Minimum standards of illumination are required so that people may move safely within the works, including if they have to escape. In addition, escape routes are required to provide secure and adequate lighting, capable of operating despite failure of the electrical supply.

Keywords

Emergency lighting, escape route, escape luminaries, illumination, anti-panic lighting, safety lighting for workplaces, high risk task area lighting, safety signs.

1. Introduction

Some directives controls the way that the building will be used and the equipment and systems needed to safeguard the occupants. The legal requirement is that - “Emergency routes and exits requiring illumination must be provided with emergency lighting of adequate intensity in case the lighting fails”.

The main reason for installing an emergency lighting system is to enable the building to meet fire safety legislation in a way that is visually acceptable and meets the user’s needs for ease of operation and maintenance. Consequently it is important to establish all the relevant legal requirements for emergency lighting and fire alarm systems before commencing the design these should ideally be agreed between the system designer, user, fire authority, building control officer and system installer.

2. Emergency lighting

Emergency lighting is an essential part of the building services installation Fig.1.

For the purposes of the European standard EN 1838, emergency lighting is regarded as a generic term of which there are a number of specific forms, as shown in the figure below:

Fig. 1

**Emergency escape lighting** - that part of emergency lighting provided to enable safe exit in the event of failure of the normal supply.

**Standby lighting** - that part of emergency lighting provided to enable normal activities to continue in the event of failure of the normal mains supply. Stand-by lighting represents a part of the emergency lighting required to enable necessary tasks to be continued without any essential change. If the stand-by lighting generates an illumination level that is below the minimum level of the general lighting system, it may only be used in order to close or complete a work process.

There are three types of safety lighting: safety lighting for escape routes, anti-panic lighting and safety lighting for workplaces exposed to special hazards.

**Escape route lighting** - that part of emergency lighting provided to enable safe exit for building occupants by providing appropriate visual conditions and direction finding on escape routes and in special areas/locations, and to ensure that fire fighting and safety equipment can be readily located and used. Safety lighting for escape routes is at least twice as bright as the moon on a clear night, namely 1 lux. It thus provides adequate visibility and good orientation, enabling evacuees to find their way so that they can leave the building safely. This is
guaranteed by ensuring a minimum illuminance of > 1 lux horizontal on the ground with an evenness of 1:40. In order to guide people leaving the building, the escape routes are marked with escape sign luminaires or illuminated signs.

**Open area (or anti-panic area) lighting**-that part of emergency escape lighting provided to reduce the likelihood of panic and to enable safe movement of occupants towards escape routes by providing appropriate visual conditions and direction finding. Anti-panic lighting is the minimum basic lighting needed to enable evacuees to reach emergency exits safely.

**High risk task area lighting**-that part of emergency lighting provided to ensure the safety of people involved in a potentially dangerous process or situation and to enable proper shut down procedures to be carried out for the safety of other occupants of the premises.

Safety lighting for workplaces exposed to special hazards must be installed where direct risks of accident, or special risks for other employees, occur when the general lighting system fails. Workplaces exposed to special hazards that might be near moving machinery, for example.

**3. Emergency lighting system design**

There are a number of points that are of major importance to emergency lighting system design.

- The evaluation of areas with a fire risk assists when deciding which areas need protection, e.g. a school chemical laboratory may be smaller than 60m² but still need emergency lighting, as combustible materials and sources of ignition would be present
- The assessment of the location of employees and any visitors to the site assist in determining the most appropriate escape routes
- The guidance to the directive gives detailed requirements for the suitability of escape routes and calls for the installation of emergency lighting to be in accordance with British Standard BS 5266-1
- It recommends that advice on the installation should be given by a competent person who specializes in emergency lighting systems
- Continued maintenance and testing must be correctly carried out, to comply with the directive
- The equipment used must be capable of being demonstrated as of adequate quality. Compliance with the appropriate British Standard, or other approved third party scheme, gives evidence of this. The standard for luminaries is BS EN 60598-2-22. The standard for central battery systems is BS EN 50171

Note: When the premises are being assessed for risk, shortcomings in other areas of fire protection can be compensated for by improved levels of emergency lighting and fire alarms.

Compliance with BS5266-1:1999 is deemed to comply with these requirements.

When referring to the provision of Escape Lighting in section 4.2 (BS 5266), requires that when the supply to all or part of the normal lighting in occupied premises fails, escape lighting is required to fulfill the following function:

(a) To indicate clearly and unambiguously the escape routes.
(b) To provide illumination along such routes to allow safe movement towards and through the exits provided.
(c) To ensure that fire alarm call points and fire fighting equipment provided along escape routes can be readily located.
(d) To permit operations concerned with safety measures.

BS 5266-1 recommends that discussions should be held prior to commencing the design, to establish the areas to be covered, the method of operation, the testing regime and the most suitable type of system. These discussions should include the owner or occupier of the premises, the system designer, the installer, the supplier of the equipment and the fire authority.

**4. Pre-Design**

Before designing an emergency lighting scheme the following information needs to be determined from the site drawings or from the specifies:

1. The duration of the emergency lighting:
   a) Three hour duration is required in places of entertainment and for sleeping risk;
   b) Three hour duration is required if evacuation is not immediate, or early re-occupation is likely to occur;
   c) One hour duration may be acceptable, in some premises, if evacuation is immediate and re-occupation is delayed until the system has recharged.

2. Emergency lighting should be of the maintained type in areas in which the normal lighting can be dimmed. In addition, the draft standard prEN 50172 stipulates that emergency lighting is of the maintained type in common areas within shopping malls where a build-up of smoke could reduce the effectiveness of normal lighting.

3. The draft standard prEN 50172 Emergency escape lighting systems requires that exit signs are of the maintained type where the premises are used by people who are unfamiliar with its layout.

4. Building plans need to be assembled showing the location of the fire alarm call point positions, the positions of fire fighting equipment, and fire and safety signs.

5. Emergency escape routes should be established, and potential hazards investigated.

6. Open areas larger than 60m² floor area should be identified.
7. High risk task areas should be identified and normal lighting levels established.
8. The need for external illumination outside final exit doors and on a route to a place of safety should be determined.
9. Other areas that need illumination, although not part of the escape route, should be located, e.g. lifts, moving stairways and walkways, plant rooms and toilet accommodation over 8m² gross area.
10. If a central system is being used, the locations of central battery units and cable runs should be established in areas of low fire risk.
11. For non-maintained applications the area covered by the final circuit of the normal lighting has to be determined as it must be monitored by the central system. Non-maintained self-contained luminaries must be fed from that final circuit.
12. Standby lighting requirements should be established if activities need to continue during a failure of the normal lighting supply.
13. The customer’s preference and operating considerations should be ascertained, e.g. ceiling heights, mounting heights or wall mounting.

5. Design Objective

When the supply to any part of the normal lighting fails, the requirements of BS 5266 and EN 1838 apply and escape lighting is required to fulfill the following functions:
1. Show clearly and unambiguously the escape routes.
2. Provide illumination along such routes to allow safe movement towards and through the exits provided.
3. Ensure that fire alarm call points and fire fighting equipment provided along escape routes can be readily located.
4. Allow operations concerned with safety measures to continue. Locate luminaries at points of emphasis. These are mandatory locations to cover specific hazards and to highlight safety equipment and signs. This should be performed regardless of whether the area is an emergency escape route or defined as an open area. Only when this is accomplished should the type of luminary or its light output be considered.
(a) Near stairs (Fig.2)
On long flights of stairs more than one luminary will be required so that each tread receives direct light.
(b) Near changes of level (Fig.2)
(c) Near each change of direction (Fig.2)
(d) To illuminate Exit doors and safety signs (Fig.2)

(e) Near each piece of fire fighting equipment or call point
This luminary also illuminates change of direction.

(f) Outside and near to each final exit
(g) Near each First Aid point new category not previously covered in BS5266
This luminary also illuminates change of direction.

6. Emergency Signs

Viewing distances are given in the draft standard EN 1838 as 200 x H for internally illuminated signs, and 100 x H for externally illuminated signs where H is the height of the pictogram. Signs which are provided at all exits intended to be used in an emergency and along escape routes shall be illuminated to indicate unambiguously the route of escape to a point of safety. Where direct sight of an emergency exit is not possible, an illuminated directional sign (or series of signs) shall be provided to assist progression towards the emergency exit.

- Sign formats should not be mixed
- BS2560: 1975 Old-style signs now obsolete. Should have been replaced by December 1998

"Near" is defined as being within 2m of horizontal height.
- BS 5499 Pt 1 Signs are still acceptable, if they are already in the building

- European Signs Directive Format. This came into force on 1st April 1996, under The Signs Directive

If there is any doubt as to the most appropriate format of sign, guidance should be obtained from the local Fire Authority.

• Maximum viewing distances
For all format of safety signs the maximum viewing distances and luminance conditions are given in BS 5266 pt7/EN 1838 Signs can be either internally illuminated, such as exit boxes or edge lit emergency luminaries with a screened sign that have a controlled illuminance, or painted signs with an external emergency light illuminating them.

Maximum viewing distances are: internally illuminated signs - 200 x the panel height, externally illuminated signs - 100 x the panel height

Fig. 4 Maximum viewing distances

• Illumination requirements
The sign must conform to the colors, which defines that exit and first aid signs must be white with green as the contrast color. The ratio of luminance of the white color to the green color must be between 5:1 and 15:1. The minimum luminance of any 10mm patch area on the sign must be greater than 2cd/m² and the ratio of maximum to minimum luminance shall be less than 10:1 for either color (Fig.7)

Fig. 5 Illumination requirements

Internally illuminated exit signs are pre-tested to ensure they meet these requirements, provided that they comply with EN 60598-2-22.

If the sign is designed to be externally illuminated, considerable care must be taken by the system designer to see that these conditions are met. Even though an emergency luminary must be sited within 2 meters from the sign calculations should still be made to check that the sign is adequately illuminated.

6.1 Additional emergency lighting
Additional emergency lighting should be provided at these locations:

(a) Lift cars. Although they may be part of the escape route in exceptional circumstances, they may present a problem if the public are trapped in them in the event of a supply failure.

(b) Toilet facilities and other open tiled areas exceeding 8m² floor area and all toilets for the disabled.

(c) Escalators, to enable users to get off them safely.

(d) Motor generator, control or plant rooms require battery supplied emergency lighting to help any maintenance or operating personnel.

(e) Covered car parks along the normal pedestrian routes.

These locations are not part of the escape route but because of their risk they require protection by emergency lighting.

7. Escape route lighting
In addition to luminaries at the points of emphasis, it may be necessary to provide extra luminaries to ensure that minimum light (illuminance) levels are met along the whole escape route. For 2m wide escape routes, the illuminance is specified along the centre line with 50% of that illuminance over the 1 meter wide central band. Wider routes should be treated as open areas or as multiple routes.

The European standard EN 1838 requires 1 lux along the centre line of escape routes including those with minor obstructions such as hotel trolleys. The UK has a National Exception which recommends 1 lux but accepts 0.2 lux along the centre line for permanently unobstructed escape routes, with the points of emphasis illuminated to 1 lux.

BS 5266: Pt 1: 1988 will be amended to reflect this requirement.

BS 5266 and prEN 50172 recommend using a larger number of low power luminaries rather than a few high power units. In this way, no part of the escape route is lit by just one luminary. Thus, if a luminary fails, the route will not be plunged into darkness.

Spacing tables Tab.1 provide the information to help decide whether or not additional fittings are needed besides those required for the points of emphasis.
The use of spacing tables or a suitable computer program provides the information to determine whether luminaries are needed in addition to those for the points of emphasis to provide the minimum required level of illumination on the escape routes. To ensure that the design will meet the required levels at all times the data is de-rated, as required by the standard, to cover the following factors:

1. Reduction in light as the battery voltage reduces during discharge.
2. Aging of lamps in maintained circuits
3. The effects of dirt (Spacing tables use a figure of 80%).

Locate luminaries at mandatory “Points of emphasis”

Add additional luminary to achieve 1 lux minimum

**8. Open (anti-panic) core areas**

Emergency lighting is required for areas larger than 60m² or open areas with an escape route passing through.

BS 5266 requires 1 lux average over the floor area. The European standard EN 1838 requires 0.5 lux minimum anywhere on the floor level excluding the shadowing effects of contents. The core area excludes the 0.5m to the perimeter of the area.

Spacing tables (Tab.2) provide simple and accurate data that can easily be used.

These assume a regular array of emergency luminaries.

Specific data is available for self-contained dedicated emergency luminaries. This can be found on each of the individual product entries in catalogue. The data details the polar distribution for common types of luminaries, from which a suitable match should be selected.

The factors considered should be the shape of the polar curve and the scale, which is shown by the nadir intensity. Alternatively, a computer program can be used and the light outputs of the appropriate kit can be used with the actual distribution data of the luminary chosen.

High risk task area lighting requires that higher levels of emergency lighting are provided in areas of particular risk, although no values are defined.

The European standard EN 1838 says that the average horizontal illuminance on the reference plane (note that this is not necessarily the floor) should be as high as the task demands in areas of high risk. It should not be less than 10% of the normal illuminance, or 15 lux, whichever is the greater. It should be provided within 0.5 seconds and continue for as long as the hazard exists. This can normally only be achieved by a tungsten or a permanently illuminated maintained fluorescent lamp source.

The required illuminance can often be achieved by careful location of emergency luminaries at the hazard and may not require additional fittings.
9. Control

In the field of emergency lighting there are two switching modes: maintained or non-maintained. If a non-maintained system is on standby, the lamps are not switched on under normal operating conditions. The safety lighting is activated by a failure or drop in the mains voltage of the general lighting system. When the mains supply returns, the safety lighting is automatically switched off and the general lighting system resumes its function. If the safety system is in constant service, it runs whenever it is required, i.e. whenever there are people in the building or the normal illumination system is not in operation, it is a maintained system. In rooms that are illuminated sufficiently by daylight, cannot be darkened for operating reasons or are not permanently occupied, it is permissible for the safety lighting to be switched via the normal lighting. If the mains voltage fails or drops, the safety lighting is switched to standby mode and starts up, irrespective of the setting of the light switch.

In emergency operation, it is assumed that the mains supply for the lighting system is not guaranteed in one section of the building. DIN VDE 0108 thus specifies requirements and constructional regulations for the safety power supply. The following are permitted as substitute electricity sources:

<table>
<thead>
<tr>
<th>Units:</th>
<th>Substitute generating units</th>
<th>(switch-over time &lt;15 Sek.)</th>
<th>(switch-over time &lt;0.5 Sek.)</th>
<th>(without switch-over time)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Quick-start standby units</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>No-break standby generating units</td>
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<tr>
<td>Battery-supported substitute electricity sources:</td>
<td>Central battery systems</td>
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<td></td>
<td>Group battery systems</td>
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<td></td>
<td>Single battery systems</td>
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<tr>
<td>Second mains supply:</td>
<td>Electricity from a second, specially protected mains supply</td>
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Visual tasks of Safety Lighting:

- Escape routes
  - roughly identify details
  - identify obstacles (e.g. stairs, landings, etc.)
  - identify escape signs

- Workplaces exposed to special hazards
  - identify details (finish the job and read measuring equipment safely)
  - identify safety sign colors

Two different network structures can be used for safety lighting systems. In 2-wire networks, the directly earthed conductor and the phase of the mains voltage supply are used. A central switch-over unit separates the conductor from the network and connects it to the standby voltage. No additional installation work is necessary. In 4-wire networks, the standby voltage is fed to the safety luminary via two separate lines. The switch-over from mains to standby voltage takes place in the luminary itself.

Central batteries provide a substitute electricity source for the entire building or parts thereof and include a main monitoring facility, recharge, battery space and an electric circuit distributor.

The standby voltage is fed to the emergency luminary or the escape sign luminary via a two or four-wire network. As maximum deviations of ±10% are permissible with the nominal voltage, the ballasts used offer a power constancy function that maintains the light flux at 100% within a voltage range of 176V-254V (DC).

Group Battery function in more or less the same way as central batteries. A group battery system may supply a maximum of 20 safety lights. The two or four-wire network is used.

Single batteries supply one single luminary with electricity. The recharge, control gear and battery pack are incorporated into the luminary. Single-battery luminaries are also often used for general lighting systems and are thus switched with this. An unswitched phase must be fed into the luminary so that the batteries can be charged and the system can switch over to battery operation in the event of a failure in the power supply.

Operating Luminaries using Dimmable Electronic Ballasts (EB) 1-10V control voltage provides the control current during operation with standby voltage; the control current is taken from the current sink (e.g. potentiometer). It is irrelevant whether the emergency voltage is AC or DC. A separation of the control current circuit is necessary during emergency operation since the light flux specified by the current sink remains set.

Digital control signal Digital Addressable Lighting interface (DALI): when the power supply failure is of duration < 0.5 seconds, the electronic ballast maintains the most recent value. As faster switch-over times are required with emergency lighting, at this point, the central control logic has to set the desired light flux. Separation of the control line - as with 1-10V control - has no effect on the light flux set.

In order to limit the power consumption of the ballast, and thus to increase the capacity of the substitute electricity source, a reduced light flux during emergency operation can also be intentionally set.
10. Conclusion

If your premises are never occupied during the hours of darkness and have adequate natural lighting through windows, etc., then you may not need to provide emergency lighting. Even if your premises are used at night, there may be sufficient 'borrowed' light from street lighting to illuminate the escape routes. You may wish to provide torches or other forms of temporary (emergency) lighting in very small premises. However, you would have to decide within your risk assessment whether these are realistically going to be adequate, and if so, you should put procedures in place to make sure that they will be available and serviceable when required. These methods are unlikely to be adequate if your premises have complicated escape routes, staircases, or if members of the public are present (as they will be unfamiliar with the building).

In a fire situation it takes less than thirty seconds for conventional lighting and escape route signage to be rendered totally ineffective. Inevitably building occupants, in often unfamiliar surroundings, are faced with reduced visibility and poor directional guidance, frequently leading to panic and disorientation. As a result, people have been known to die tragically only a few meters from exits which could have led them to safety. Mounted emergency lighting systems clearly identify the escape path and illuminate the escape route, thus improving evacuation times, reducing panic and ultimately saving lives.

References

5. EN 1838 Lighting applications – Emergency lighting.
7. EN 60598-1 Luminaries Part 1: General requirements and tests
8. EN 60598-2-1 Luminaries Part 2: Particular requirements, Section 1: Fixed general purpose Luminaries
9. EN 55015 Limits and methods of measurement of radio interference characteristics of fluorescent lighting
10. EVS-EN 50172:2005 Evakuatsiooni häda-valgustussüsteemid
11. prEN 50172 Emergency escape lighting systems
12. ISO 3864:1984 Safety colours and safety signs