Study Paper on Emergency lighting

Produced for:

Discussion and Determination

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Analysis debating the suitability of emergency lighting systems

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ISSUED FOR REVIEW

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1. Section 1 Preliminary

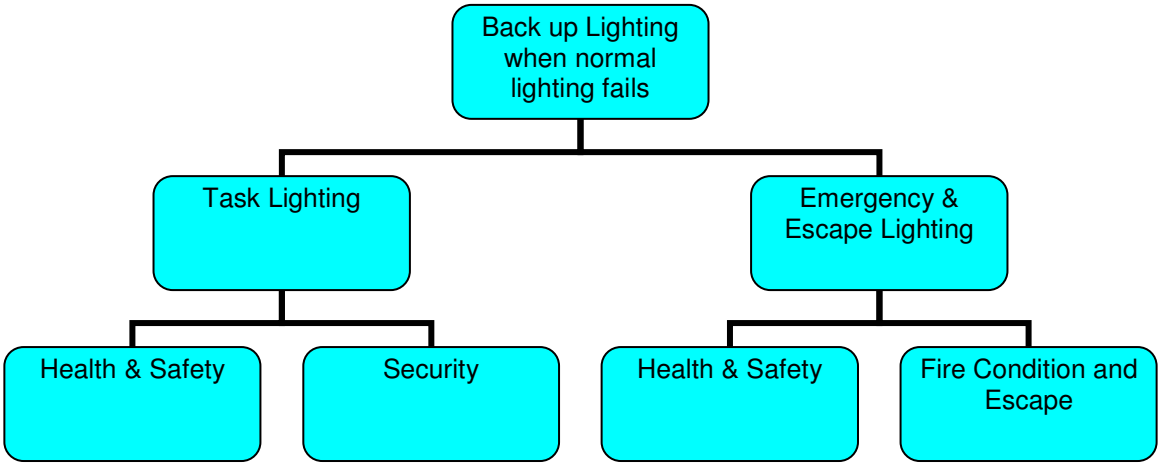
1.1 INTRODUCTION

The recommendations given in BS5266 have been drawn up to encourage uniformity of application, based on providing adequate safety to people in the event of interruption of the normal lighting (by power failure or otherwise), and having due regard to the hazard level and degree of familiarity of occupants within any particular premises. The standard recognises that, in addition to ensuring safe unobstructed means of escape from the premises at all times, an important function of emergency lighting is to make possible the immediate location and operation of fire alarm call points and fire-fighting equipment, and another is to minimize the chance of panic arising in enclosed spaces, such as lifts. Although the standard makes recommendations for the provision of emergency lighting in a wide variety of premises, the fact that particular types of premises are mentioned in BS5266-1:2011 Clause 9 does not necessarily mean that all such premises will be required by law to have emergency lighting installed. For certain types of premises, the provisions of this standard might be supplemented or replaced by alternative requirements at the discretion of the enforcing authority.

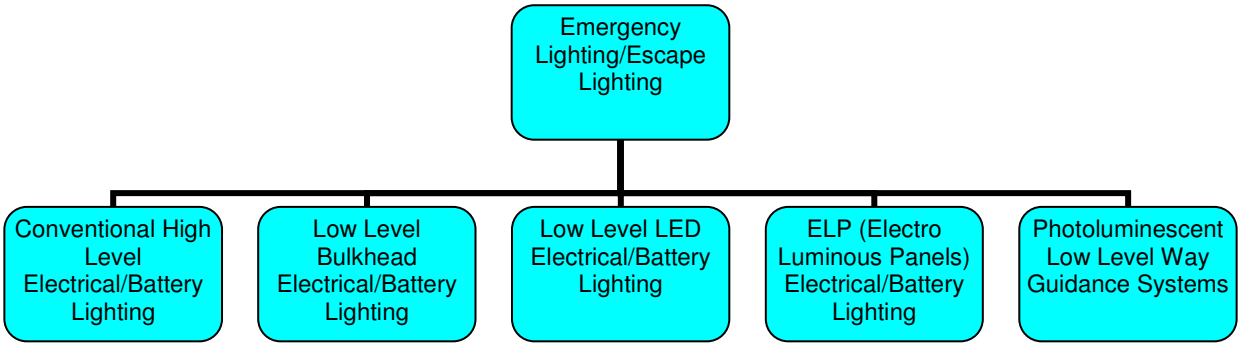
UK legislation imposes a duty on people, including employers and other people with control of premises, to carry out risk assessments and to take such precautions as to ensure as far as reasonably practicable the safety of the occupants. These measures include the provision of safe means of escape, including emergency routes and exits, together with, where necessary, signs indicating them. Adequate illumination needs to be provided, together with emergency lighting of sufficient intensity in case of failure of the normal lighting (i.e. where people can see and have visual orientation without the need for any other external factors).

There are many ideas and notional methods with regards to fitting emergency lighting within buildings. Selection of systems within the U.K. usually come from approved codes of practice with a preference in using British Standards as the bench mark, which is understandable as they are viewed by many as the only options available probably because it makes it a very easy and safe option. However there are many other studies carried out by independent and highly qualified people that through study and experimental situations provide valuable information that can be used to corroborate alternative theories and methods outside of the standards provided by the British Standards.

This paper attempts to explore the avenues available and the suitability of each type of system, with arguments for and against each. Emergency lighting can be broken down for use in the following ways;



This paper is going to concentrate on the different systems of emergency and escape lighting which can be broken down yet again into system groups as follows;



Extract from BS5266 Part 1 - 2011
"The safe movement of people along escape routes towards and through the exits provided to a place of safety depends upon the illumination and the ability to see hazards, changes of level and direction.
The stimulus for vision is not the light which falls on objects but the light reflected to the eyes. Different objects are distinguished by contrast of the changes in light reflected to the eyes. A light coloured object on a dark background can be made conspicuous with far less light than a dark coloured object on a dark background."

It should be understood that illuminance (luminous flux) is measured in a variety of different units, including candela (for luminous intensity) and not lux (lx) levels which many people seem to think is the relative light levels required. This paper will attempt to provide the reader with valuable information to make an informed judgement and decision of what type or types of system that could be employed for premises of different types.

For reference it should be understood that a lux is one lumen per m^2, the word lux is derived from lumens, which itself derives from candelas. It is important for the reader to understand that the fovea in the eye, which is the part of the body that

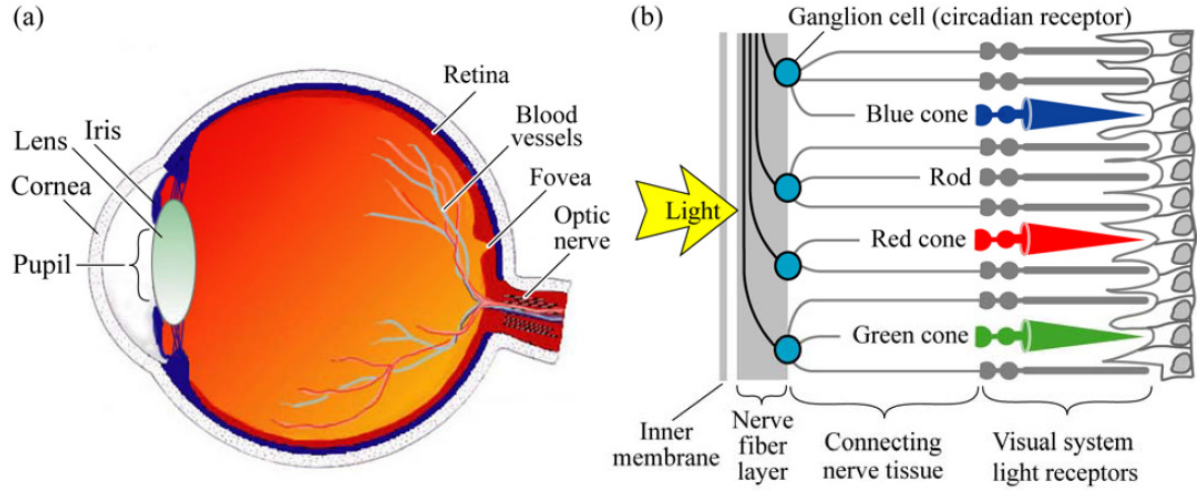
allows people to see light in candelas. It is also interesting to point out that torches are measured in 'candles' (candelas) and we, hopefully, all can understand that torches can be a suitable lighting alternative within a dark situation as well as a smoke filled fire situation dependant on the density of the smoke within any given area.

1.2 THE HUMAN EYE

In order to understand a bit more about the human eye and to get a better understanding of the type and intensity of light required to be of a suitable and sufficient quality, not only for people to see but the purpose that they may need it for.

The recipient of the light emitted by most visible-spectrum LEDs (Light Emitting Diode) is the human eye. In this chapter, the characteristics of human vision and of the human eye are summarised, in particular as characteristics that relate to the human eye sensitivity and photometric quantities.

Figure 1.1

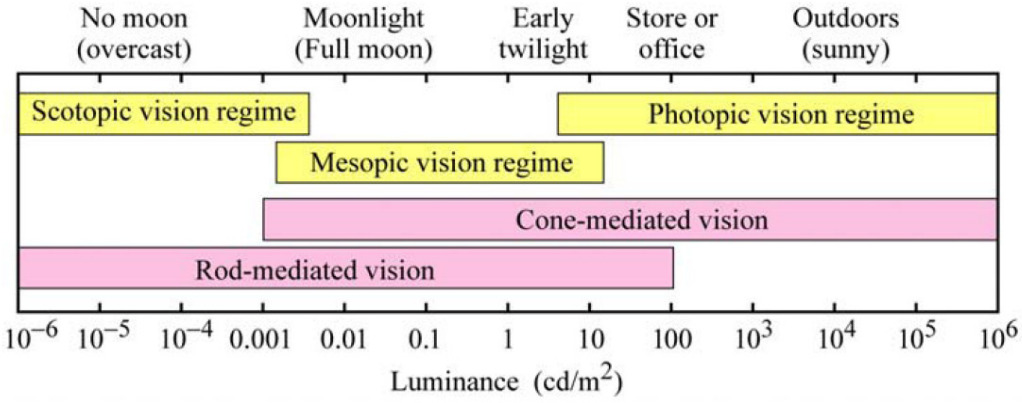


(a) Is the cross section of the human eye. (b) Schematic view of the retina including rod and cone receptors light receptors.

Figure 1.1 (a) shows a schematic illustration of the human eye. The inside of the eyeball is clad by the retina, which is the light-sensitive part of the eye. The illustration also shows the fovea, a cone-rich central region of the retina which affords the high acuteness of central vision. Figure 1.1 (b) shows the cell structure of the retina including the light-sensitive rod cells and cone cells. Also shown are the ganglion cells and nerve fibres that transmit the visual information to the brain. Rod cells are more abundant and more light sensitive than cone cells. Rods are sensitive over the entire visible spectrum. There are three types of cone cells, namely cone cells sensitive in the red, green, and blue spectral range. The cone cells are therefore denoted as the red-sensitive, green-sensitive, and blue-sensitive cones, or simply as the red, green, and blue cones.

As humans we have three different vision regimes which are Photopic, Scotopic and Mesopic which can be seen in Figure 1.2 below.

Figure 1.2



Three different vision regimes are shown in Fig. 1.2 along with the receptors relevant to each of the regimes. Photopic vision relates to human vision at high ambient light levels (e.g. during daylight conditions) when vision is mediated by the cones. The photopic vision regime applies to luminance levels > 3 cd/m² (300mcd/m²). Scotopic vision relates to human vision at low ambient light levels (e.g. at night) when vision is mediated by rods. Rods have a much higher sensitivity than the cones. However, the sense of colour is essentially lost in the scotopic vision regime. At low light levels such as in a moonless night, objects lose their colours and only appear to have different grey levels. The scotopic vision regime applies to luminance levels < 0.003 cd/m² (0.3mcd/m²). Mesopic vision relates to light levels between the photopic and scotopic vision regime (0.003 cd/m² < mesopic luminance < 3 cd/m²).

The luminous intensity of a light source can thus be characterized by giving the number of standardised candles that, when combined, would emit the same luminous intensity. Note that candlepower and candle are non-SI units that are no longer current and rarely used at the present time.
The luminous flux, which is also a photometric quantity, represents the light power of a source as perceived by the human eye. The unit of luminous flux is the lumen (***lm***). It is defined as follows: a monochromatic light source emitting an optical power of (1/683) watt at 555 nm has a luminous flux of 1 lumen (***lm***). The lumen is an SI unit.
A comparison of the definitions for the candela and lumen reveals that 1 candela equals 1 lumen per steradian or cd = ***lm /sr.*** Thus, an isotropically emitting light source with luminous intensity of 1 cd has a luminous flux of 4 π ***lm***= 12.57 ***lm***.
The illuminance is the luminous flux incident per unit area. The illuminance measured in lux (lux = ***lm*** /m²). It is an SI unit used when characterizing illumination conditions. Table 1.1 gives typical values of the illuminance in different environments to provide the reader with a better understand of the type of light levels generally available within

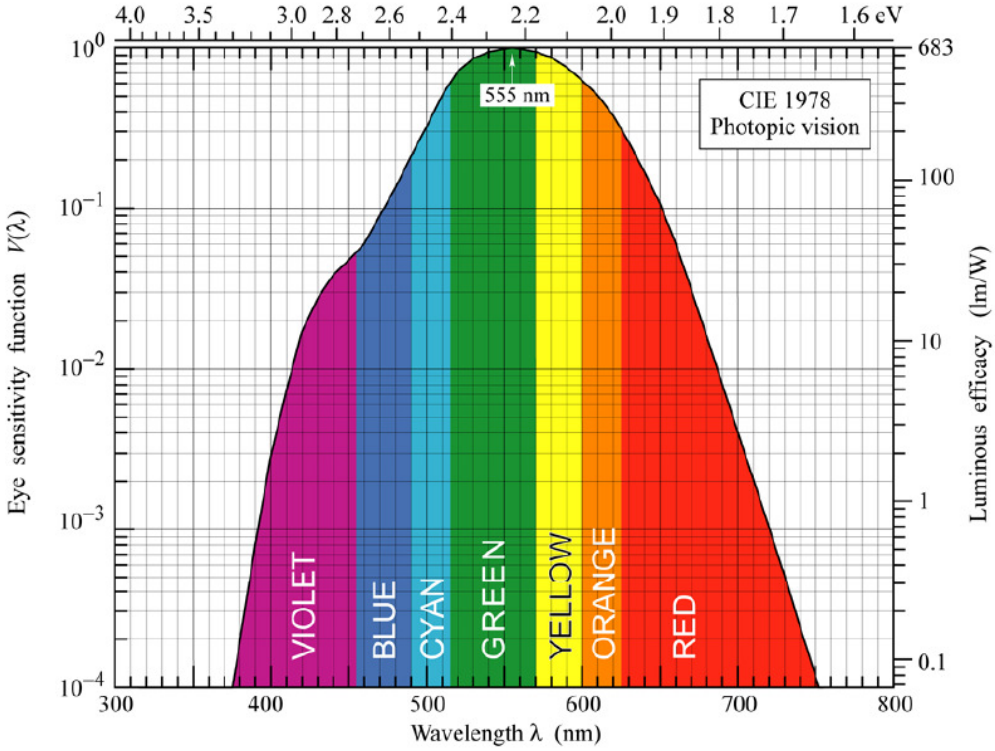
Table 1.1

Illumination condition	Illuminance
Full moon	1 lux
Street lighting	10 lux
Home lighting	30 to 300 lux
Office desk lighting	100 to 1 000 lux
Surgery lighting	10 000 lux
Direct sunlight	100 000 lux

different environments and can appreciate the levels of lighting that are being spoken about and the potential suitability of the lighting such as night time street lighting opposed to a night with need electrical light source and a full moon providing illumination from the reflection of the sun upon it.

Looking at Fig. 1.2 it can be seen that 0.003 cd/m² (3 mcd/m²) and is pretty much the minimum limit of light we need to see. It should also be noted that the colour that the human eye is must receptive to seeing is green as shown in Fig. 1.3.

Figure 1.3



1.3 DOCUMENT REFERENCE

Please note that the most recent and relevant guide for Fire Safety Engineering and Way guidance systems is CIBSE Guide E – Fire Safety Engineering, May 2010. CIBSE is a significant contributor to the British Standards. (See BS5266-1 2005 page 2).

- ***BS5266-1 Dec 2011***
- ***CIBSE Fire Guide E 3rd Edition May 2010***
- ***BS5266-6 April 1999***
- ***CLG BD 2518 June 2007***
- ***BRE Guides***
  - IP1/93
  - IP17/89
  - IP17/94
  - IP10/97
- ***CLG Fire Safety Risk Assessment Guides***
  - Education May 2006
  - Healthcare May 2006

- Large places of assembly May 2006
- Small and medium places of assembly May 2006
- Offices & shops May 2006
- o Residential Care Premises May 2006
- o Sleeping accommodation May 2006
- o Theatres, cinemas & similar June 2006
- o Open air events June 2006
- o Transport premises & facilities Feb 2007
- o MOE for disabled people March 2007
- o Stables Oct 2007

- ***Coroner's Rule 43 Letter "Bannon & Shears" February 2013***

1.4 COMPETANCY

The author of this paper has been produced by Mr Paul Williams who has the necessary qualifications, competency and experience in Fire Risk Management and Engineering principles that give would him the status of a "Competent Person" as described in articles 15 and 18 of the 'Regulatory Reform (Fire Safety) Order 2005', for properties in England & Wales, and the 'Fire Safety (Scotland) Regulations 2006' for those in Scotland. This legislation now supersedes all previous fire legislation for England, Wales & Scotland and forms the 'Fire Regulations'. He is an ex-fire enforcement officer by profession; has been trained through the Fire Service College in all necessary disciplines of fire safety, building design and building behaviour under fire conditions and is considered to be sufficiently practised in the necessary skills to enable him to understand the legislation and safety requirements.

2. Different systems of emergency lighting

As mentioned in the introduction there are several different systems that can provide back up lighting when adequate illumination needs to be provided, together with emergency lighting of sufficient intensity in case of failure of the normal lighting.

The emergency lighting system should be fitted in system design to provide some form of lighting/illumination to provide the safe movement of people along escape routes towards and through the exits provided to a place of safety which will depend upon the illumination and the ability to see hazards, changes of level and direction.

2.1 CONVENTIONAL HIGH LEVEL ELECTRICAL

This type of system is the most common system that is used throughout the UK within buildings and open spaces citing BS5266-1 as the bench standard for design, fitting and maintenance.
The relevant standard uses minimum lux levels as a guide in order to provide adequate illumination within the building but does refer to other British Standards with regards to illumination recognising that lighting is very much dependant on the reflected light or as we know is referred to as illumination and as such the system should be tested with a photometric meter rather than a lux meter.

These types of lighting units normal come in many forms some of the most common, being a strip or L.E.D light fitting which are fixed at ceiling level.

- ***Advantages;***
  - Provides very well lit areas at around 20-50% of the normal lighting, which would be more than enough for people to see, albeit excessive to what is required.
  - Very good for health and safety purposes and in some cases used as task lighting.
  - Provides comfort to the responsible person safe in the potential knowledge in using a conventional system that those without specialised knowledge will be happy to accept having trust in the electrical supplier who may not necessarily be a lighting specialist.
  - The Fire Service in the main will accept this type of system again in the comfort that BS5266-1 has been employed and has been recognised as the norm for many years without full questions about the applied risk assessment for this particular type of system.
  - Some intelligent systems can inform the building maintenance team that there is a defect and where it is when they carry out a self test.
- ***Disadvantages;***
  - Can be subject to costly maintenance expenditure and resource requirements needing tests monthly, yearly, three yearly and five yearly.
  - When fitted to the ceiling the light units are subject to becoming obscured by smoke as identified by BS5266-1 clause 6.4. Therefore not really suitable under fire condition. We know the ceiling is a

smoke reservoir because this is where we fit smoke detectors for alarms and AOV systems.
  - Two light units are recommended within BS5266-1 for an area as a contingency that one may fail leaving the area in darkness.
  - Within certain buildings the lights can be subjected to damage from anti-social behaviour and vandalism which can leave a whole area in darkness.
  - Does not necessarily deal with highlighting step and stair edges without some other materials being used which would be an added cost compared to a low level guidance system.
  - The retro fitting of emergency lighting can mean that the building's entire electrical system needs to be replaced to meet with new electrical regulations which can be extremely costly.
  - When batteries are no longer serviceable it normally means the whole light fitting needs replacing within 12 to 18 months, requiring a qualified electrician.

2.2 LOW LEVEL BULK HEAD ELECTRICAL

This type of system is when the light units are fitted between 100mm and 1000mm from the floor level in order to be below any smoke layer that may accumulate within a smoke reservoir and therefore suitable under both fire condition and health and safety purposes. The system would either be fully maintained or operate on power failure and smoke detection.

- ***Advantages;***
  - Provides very well lit areas at around 20-30% of the normal lighting, which would be more than enough for people to see, albeit excessive to the requirements.
  - Very good for fire condition and health and safety purposes.
  - Provides comfort to the responsible person safe in the potential knowledge in using a conventional system that those without specialised knowledge will be happy to accept having trust in the electrical supplier who may not necessarily be a lighting specialist.
  - The Fire Service in the main will accept this type of system again in the comfort that BS5266-1 or BS5266-2 has been employed and has been recognised as a norm for many years although may be questioned about the applied risk assessment for this particular type of system.
  - Some intelligent systems can inform the building maintenance team that there is a defect and where it is when they carry out a self-test.
- ***Disadvantages;***
  - Can be subject to costly maintenance expenditure needing tests monthly, yearly, three yearly and five yearly.
  - Two light units are required within an area as a contingency that one may fail leaving the area in darkness.
  - Within certain buildings the lights are subject to damage from anti social behaviour which can leave a whole area in darkness.
  - Does not necessarily deal with highlighting step and stair edges without some other materials being used which would be an added cost compared to a low level guidance system.

- The retro fitting of emergency lighting can mean that the building's entire electrical system needs to be replaced to meet with new electrical regulations which can be extremely costly.
- When batteries are no longer serviceable it normally means the whole light fitting needs replacing within 12 to 18 months, requiring a qualified electrician.

2.3 LOW LEVEL LED ELECTRICAL

Low mounted luminous tracks positioned on escape routes in combination with exit indicators, exit markings and intermediate exit direction indicators along the route, provided for use when the supply to the normal lighting fails or on detection of smoke, which operate from an electrical supply independent of the normal supply under emergency conditions.

- ***Advantages;***
  - Provides adequately lit areas of lighting, which would be more than enough for people to see and used to be used on ocean liners and aircrafts until photoluminescent solutions replaced it due to reliability issues.
  - Very good for fire condition.
  - The Fire Service in the main will accept this type of system again in the comfort that BS5266-2 has been employed, although this system may be questioned about the applied risk assessment for this particular type of system.
  - Highlights the dangers of staircases even during normal lighting conditions in line with indg225 from the UK's HSE.
  - Can be green in colour which is the best spectrum of colour for the human eye.
  - Some intelligent systems can inform the building maintenance team that there is a defect and where it is when they carry out a self-test.
  - Works from a central battery system and therefore replacement of battery is relatively straight forward and more cost effective then single unit batteries regarding labour.

- ***Disadvantages;***

  - Can be subject to costly maintenance expenditure needing tests monthly, yearly, three yearly and five yearly.
  - Within certain buildings the lights are subject to damage from anti-social behaviour which can leave a whole area in darkness.
  - The retro fitting of this type of emergency lighting can mean that the building's entire electrical system needs to be replaced to meet with new electrical regulations which can be extremely costly. It is also not really feasible to retro fit this type of system due to the works that would be required to accommodate the lighting strips.
  - Not really suitable for large open spaces or open planned offices.
  - Batteries will have a limited service life and can be expensive to replace.

2.4 ELP ELECTRICAL

Low mounted luminous tracks positioned on escape routes in combination with exit indicators, exit markings and intermediate exit direction indicators along the route, provided for use when the supply to the normal lighting fails or on detection of smoke, which operate from an electrical supply independent of the normal supply under emergency conditions.

- ***Advantages;***
  - Provides adequately lit areas of lighting, which would be more than enough for people to see and used to be used on ocean liners and aircrafts until photoluminescent solutions replaced it due to reliability issues.
  - Can be green in colour which is the best spectrum of colour for the human eye.
  - Very good for fire condition.
  - The Fire Service in the main will accept this type of system again in the comfort that BS5266-2 has been employed, although this system may be questioned about the applied risk assessment for this particular type of system.
  - Highlights the dangers of staircases even during normal lighting conditions in line with indg225 from the UK's HSE.
  - Can be suitable for large open areas (most common places have been seen on large boats).
  - Some intelligent systems can inform the building maintenance team that there is a defect and where it is when they carry out a self-test.
  - Works from a central battery system and therefore replacement of battery is relatively straight forward.

- ***Disadvantages;***

  - Can be subject to costly maintenance expenditure needing tests monthly, yearly, three yearly and five yearly.
  - Within certain buildings the lights are subject to damage from anti-social behaviour which can leave a whole area in darkness.
  - The retro fitting of this type of emergency lighting can mean that the building's entire electrical system needs to be replaced to meet with new electrical regulations which can be extremely costly. It is also not really feasible to retro fit this type of system.
  - Batteries will have a limited service life and can be expensive to replace.

2.5 PHOTOLUMINESCENT LOW LEVEL WAY GUIDANCE SYSTEM NON-ELECTRICAL

Low mounted luminous tracks positioned on escape routes in combination with exit indicators, exit markings and intermediate exit direction indicators along the route, provided for use when the supply to the normal lighting fails, which does not need to operate from an electrical supply independent of the normal electrical supply under black out or emergency conditions.
The system is constantly providing a glow but under normal lighting conditions cannot be seen by the human eye, however as soon as the light diminishes or is removed completely the system will provide a bright "afterglow" emitting light that is reflected off other light coloured surfaces to provide a green aura of light within the area it has been fitted.
The system would be fitted using BS5266 Parts 1 and 6 but also taking into account the latest ACOPs (approved code of practice) CIBSE Fire Guide E 3rd Edition.

- ***Advantages;***
  - Provides adequately lit areas of lighting, which would be more than enough for people to see (under mesopic vision) and as used on ocean liners, aircrafts and many buildings/premises in other countries under legislative requirements.
  - Very good for fire condition without the need for smoke detection or electrical start up.
  - Operates within milli-seconds opposed to 2-5 seconds which can be the case for electrical systems.
  - Highlights the dangers of staircases even during normal lighting conditions in line with indg225 from the UK's HSE.
  - Extremely unlikely to be subject to system failure when incorporated within a robust lighting management regime.
  - Predominantly green in colour which is the best spectrum of colour for the human eye.
  - Very cost effective due to fitting and on-going maintenance costs.
  - Better for the environment as there are no batteries used that would need recycling and that are harmful to our environment.
  - Very sustainable with most manufacturers guaranteeing these products for at least 20 years (N.B. the photoluminescent system installed within the Berlin bunkers in Germany back in 1943 is still glowing today).
  - Less susceptible to damage even with anti-social behaviour.
  - Will remain effective even if subjected to water.
  - Does not need an electrician to fit and can be a competent semi-skilled worker with a lower cost than an electrician.

- ***Disadvantages;***

  - Not really suitable for large open spaces although it could be employed if enough materials were used.

- Has their limitation with regards to needing a light supply of at least 21mcd for a minimum of 15 minutes every 18 hours to receive a full charge.
- The Fire Service in the main are unsure of this type of system as they do not know of any other places fully where this type of system has been employed, although this system has been accepted and legislated for within many other countries including USA, Germany, Japan, Canada and New Zealand to name just a few.

3. Conclusion

3.1 WHAT THE LAW REQUIRES

With regards to fire, the primary legislation used is the **Regulatory Reform (Fire Safety) Order 2005** (RRFSO) and under Article 14 paragraph (2) sub paragraph (h) it states *"emergency routes and exits requiring **illumination must be provided with emergency lighting of adequate intensity** in the case of failure of their normal lighting."* This means quite simply as long as people can see (the reader needs to refer back to 1.2 of this document to understand how we see).
There is also a point that the means of escape *"in the event of danger, it must be possible for persons to **evacuate the premises as quickly and as safely as possible**"* as required under Article 14 paragraph (2) sub-paragraph (b) which would mean that stair treads and ramps would need to be highlighted to prevent slips trips and falls (N.B. Falling down stairs is known as the second biggest killer in the UK) as recommended by the HSE within their document indg225.
It should be understood that the Fire Authority are the enforcing authority with reference to non-compliance of the RRFSO.

With regards to Health and Safety there is the **Health and Safety at Work etc. Act 1974** (HSWA) which is a bit more ambiguous in its definition but states in Section 2 paragraph (2) sub-paragraph (2) *"so far as is reasonably practicable as regards any place of work under the employer's control, the maintenance of it in a condition that is safe and without risks to health and the provision and **maintenance of means of access to and egress from it that are safe** and without such risks"* which is there for the protection of employees but then carries on in Section 4 paragraph (2) *"It shall be the duty of each person who has, to any extent, control of premises to which this section applies or of the **means of access thereto or egress there from** or of any plant or substance in such premises to take such measures as it is reasonable for a person in his position to take to ensure, so far as is reasonably practicable, that the premises, all means of access thereto or egress therefrom available for use by persons using the premises, and any plant or substance in the premises or, as the case may be, provided for use there, is or are safe and without risks to health."* There is also **the Management of Health and Safety at Work Regulations 1999** (MHSWR) which states in Regulation 4 Schedule 1 the following;

a) ***avoiding risks**;*
b) *evaluating the risks which cannot be avoided;*
c) *combating the risks at source;*
d) *adapting the work to the individual, especially as regards the design of workplaces, the choice of work equipment and the choice of working and production methods, with a view, in particular, to alleviating monotonous work and work at a predetermined work-rate and to reducing their effect on health;*
e) *adapting to technical progress;*
f) ***replacing the dangerous by the non-dangerous or the less dangerous**;*
g) *developing a coherent overall prevention policy which covers technology, organisation of work, working conditions, social relationships and the influence of factors relating to the working environment;*
h) *giving collective protective measures priority over individual protective measures; and*
i) *giving appropriate instructions to employees.*

Whilst the MHSWR relates to working areas it cannot be denied that the HSWA covers everyone not within a single private dwelling/ However the ethos is to have a safe place for people to enter etc. neither legislation actually mentions emergency lighting or indeed any British Standard such as 5266, this is taken that the premise will be kept safe and non-dangerous. It is the Health and Safety Executive that enforces these laws and not the Fire Authority.

3.2 CLOSING DISCUSSION

Taking all of the above information into account and understanding that emergency lighting can take many forms for many different hazardous situations it can therefore be said that it would be acceptable to have the following;

Type of lighting required	Suitable emergency lighting system
Task lighting such as working near machinery, cooking appliances, mains electrical panels, HV & MV electrical panels, administrating medicines or intrusive medical treatment/examination, security within prisons and mental health institutions etc..	Electrical High level only providing at least 40-50% of lighting levels
Egress route lighting during blackout, power failure	1) High Level electrical 2) All low level electrical 3) Photoluminescent way guidance system.
Emergency lighting under fire condition	1) All low level electrical 2) Photoluminescent way guidance system.

All of the systems listed above would be subject to an assessment of the risks within a building, taking into account the diverse occupancies that a building may have including the partially sighted and be subject to a robust light management programme and maintenance schedule as required.

Document Ends