CPNI
Centre for the Protection of National Infrastructure

SECURITY LIGHTING

Guidance for Security Managers

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Contents

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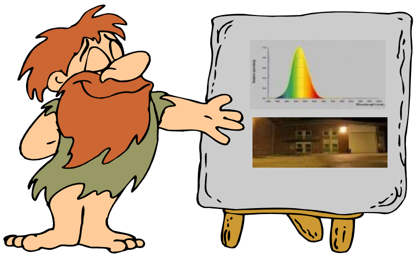
Foreword

The advice relating to high security installations, covering the critical national infrastructure, is that while security lighting on its own has value it must be considered as part of a total security package. Given time, a determined intruder with appropriate knowledge can defeat any PIDS, IDS, barrier or other security measure. As well as providing a measure of deterrence, security lighting can increase the uncertainty and vulnerability of an intruder during an intrusion.

This guidance document is intended to provide guidance and to support CPNI sponsored training. It should be used in conjunction with CPNI's Operational Requirements process and other guidance documents, particularly CCTV for Perimeter Protection. Following this guidance does not in itself confer immunity from legal obligations. Users of this guidance should ensure that they possess the latest issue and all amendments.



Acknowledgements

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Overview

Lighting is an often over-looked security measure but as well as providing a necessary component for other security elements such as manned patrols or CCTV, it can also stand in its own right providing deterrence against intruders and reassurance to users.

The purpose of this guidance manual is to inform Security Managers and those responsible for determining the operational requirements of security lighting and ensuring the performance of the installed systems is maintained.

The guide explains the principles and concepts behind artificial lighting, the technologies used and how they should be applied. It includes good practice advice on installation, commissioning, operation and the maintenance necessary to keep the system operating reliability.

Security Managers new to the role should find the guide an invaluable source of information, whilst those more experienced will have a useful tool for reference.

References

Specific reference is made to a number of documents:

1 CPNI Guide to producing Operational Requirements for Security Measures, February 2010. www.CPNI.gov.uk.

2 Security Policy Framework, (SPF). https://www.gov.uk/government/publications/security-policy-framework

3 CNI Security Systems Implementation Guide, CPNI: 2012.

4 Achieving successful integrated electronic security measures, CPNI: 2012.

5 BS 5489-1:2013 Code of practice for the design of road lighting, Part 1: Lighting of roads and public amenity areas.

6 BS EN 12464-2:2007 Lighting of work places – Part 2: Outdoor work places

7 PD CEN/TR 13201-1:2004 Road lighting – Part 1 Selection of lighting classes

8 BS EN 13201-2:2003 Road lighting – Part 2: Performance requirements

9 CIBSE Lighting Guide LG6 The outdoor environment

10 CIBSE Application Guide: Lighting in hostile and hazardous environments

11 The Crime and Disorder Act 1998, Section 17

12 The ACPO Secured by Design, ‘Lighting against Crime’

13 The Health and Safety Executive (HSE) guide HSG38, ‘Lighting at Work’

14 The British astronomical Association’s Campaign for Dark Skies handbook on light pollution, ‘Blinded by the Light?’

15 Rea MS: The lumen seen in a new light: Making distinctions between light, lighting and neuroscience. Lighting Research Centre, Troy, New York.

Abbreviations & Acronyms

AACS	Automatic Access Control System
ACPO	Association of Chief Police Officers
BSI	British Standards Institute
CAST	Home Office Centre for Applied Science & Technology
CCT	Colour Corrected Temperature
CCTV	Closed Circuit Television
CfDS	Campaign for Dark Skies
CFL	Compact Fluorescent Lamp
CIBSE	Chartered Institution of Building Services Engineers
CIE	Commission internationale de l'éclairage
CPNI	Centre for the Protection of National Infrastructure
DEFRA	Department for Environment, Food & Rural Affairs
EN	European Norm
ELI	Ergonomic Lighting Indicator
HID	High Intensity Discharge lamp
H&S	Health & Safety
HSE	Health & safety Executive
IDS	Intruder Detection Systems
ILE	Institution of Lighting engineers
IP	Ingress Protection as defined in EN60529
IR	Institution of Lighting Engineers
LED	Light Emitting Diode
LENI	Lighting Energy Numeric Indicator
LUX	Lumens/M^2
MOD	Ministry of Defence
OR	Operational Requirement
PD	Published Document (A document published by BSI which is not a standard)
PIDS	Perimeter Intrusion Detection Systems
PIR	Passive Infra-Red
Ra	Colour Rendering Index
SLL	The Society of Light and Lighting
SON	Common name used for High Pressure Sodium Lamp
SOX	Common name used for Low Pressure Sodium Lamp
SSG	Security Services Group, part of MOD Defence Infrastructure Organisation
TH	Tungsten Halogen Lamp
UPS	Uninterruptible Power Supplies
VBD	Visual Based Detection, VMD, Video Analytics and Intelligent Scene Analysis.
$V(\lambda)$	Standard Photopic Observer

Welcome to Security Lighting

Lighting is perhaps the most significant element of any of the security elements which a manager may be asked to specify and implement. Lighting's visible nature means that it will draw attention if not correctly managed.

Lighting is unique among the other security elements such as CCTV, PIDS, AACS & IDS with which it integrates. The components which are used come from an industry where security forms a very minor element. The main drivers in the lighting industries' market are Domestic, Office and Road Lighting, luckily the desirable criteria for these, which focus on 'operational' and 'H&S' issues, also have a direct application to security.

Purpose

The principal purposes of security lighting can be summarised as follows:-

- **To deter the intruder by creating a feeling of uncertainty.** In the case of 'Glare' lighting an intruder is directly illuminated and will find it difficult to see what may be facing them behind the lights.

- **To provide light to assist the detection of intruders.** Whether using CCTV or just patrolling guards a well illuminated perimeter will permit the observation of intruders, left objects or damage to the fence line.

- **To avoid creating shadows that could offer concealment.** How often has lighting been installed without the uniformity to avoid dark patches. Consideration must be given to the way in which either the human eye or a camera will adapt to the visual scene.

In addition lighting may be required to:

Conceal guards. Either patrols or at entranceway and checkpoints

Support other detection methods Particularly important as more use is made of video analytics or intelligent scene analysis. Also the application of infra-red to allow Vehicle Licence Plate recognition.

Crime and lighting

It must be remembered that lighting can also be a major factor in both reducing crime and importantly, 'reducing the fear of crime'. Back in 1417 the Lord Mayor of London decreed that,

> *"Lanthorns with lights were to bee hanged out on Winter evenings*
> *betwixt Hallowtide and Candlemasse".*

That this was an attempt at crime prevention is further borne out by the traditional cry of the watchman:

> "A light here, maids, hang out your lights
> and see your horns be clear and bright,
> That so your candle clear may shine
> Continuing from six till nine;
> That honest men that walk along
> May see to pass safe without wrong".

Although a laudable idea it was not totally successful and some 200 years later, Daniel Defoe, then a politician, wrote a pamphlet decrying the crime levels in London and blaming the darkness. His exhortations were somewhat successful and in the ensuing years a number of oil burning lamp standards were installed in London peaking at some 15,000 by 1738.

While interesting the history of street lighting falls outside the scope of this document, suffice it to say that over the last half-century many schemes using different light sources have been implemented and developed showing the benefits which can be gained. Bringing us to recent times the real breakthrough came first with research carried out by Bennet and Gelsthorpe in 1996 looking at car parks and CCTV. Their findings indicated just how effective good lighting can be. (Although it is still interesting how willing people are to spend money on sophisticated CCTV systems compared with the relatively inexpensive lighting solution based on this research).

The ‘Stoke on Trent’ project proved to be a significant milestone following years of painstaking research and not a little lobbying. The outcome from upgrading the lighting showed significant results, (relating to crime and public perception), of using a targeted approach with ‘good’ lighting.

Images, (before and after), from the Stoke Project

Research by Bennett and Gelsthorpe in the 1990’s found lighting to be second only to police foot patrols and ahead of CCTV as a crime prevention measure. Important in this paradigm are the words “good lighting” and “can be”. Lighting per se is not a crime deterrent. To be a deterrent, good lighting needs to be thought out and go hand in hand with other crime reduction disciplines

While generally accepted that good lighting can be an effective measure against the ‘fear-of-crime’, and lighting is one measure contained in Section 17 of the Crime and Disorder Act 1998(11), some bodies such as ACPO and CfDS(14) challenge the long-held view that lighting alone produces a reduction in crime. There can be circumstances where lighting could actually help the criminal. With adequate lighting the intruder can see what to attack / steal, appreciate more fully the “quality” of his graffiti, more easily combat locks, identify more clearly potential victims ... and when the police / response force arrive he can more easily climb over the wall using the handy lamp post

Since 2000 there have been a number of studies into the effect of installing or improving lighting. The results, as may be expected, are varied with the outcome being influenced by a range of differing social and geological factors. The underlying trend from academic studies show criminal activity reduced sometimes by as much as 30%, however it must also be recognised that a proportion of the criminal activity will have been simply displaced into other areas. It is noted that in some areas particular crime, such as burglary, have been seen to rise, however it is unclear if other factors may be involved.

Advice on the use of lighting for crime reduction is available from a number of sources including Secure-by-Design, “Lighting Against Crime” (12). In the first instance the local Police Crime Prevention Officer should be approached.

Basic requirements

Whatever form of lighting is installed it must meet certain requirements in addition to the security function.

It must not cause a hazard. Particular consideration must be given to drivers (road, rail or air) who may be travelling in the vicinity.

It must not be a nuisance. As well as neighbours whose property may be illuminated consideration must be given to the wider community.

It must not disadvantage the guard force. Where patrolling guards are deployed consider the effect on their night-adaption if moving between areas of differing illumination.

It must be cost effective. Any installed security measure must give value for money and must be affordable to operate.

It must be reliable. A system which is unreliable will soon be discredited, for lighting schemes this means giving advanced thought to how the system will be maintained.

It must be safe. Many lamps contain toxic metals or other materials which can be a hazard to personnel or the wider environment if not controlled. Measures should be a clearly defined part of the maintenance regime.

It must comply with Local Authority and other statutory requirements. Since the Clean Neighbourhoods and Environment act allowed 'Light' to be treated in the same way as 'Noise', systems installed must be able to withstand challenge regarding their design.

Where to start – the Operational Requirement

Whether a manager is looking to implement a new lighting scheme, or review an existing installation the starting point must be the production of a clear and comprehensive Operational Requirement. In particular the performance required and the acceptance criteria which will allow an audit to be undertaken and if required a specification produced.

This guide does not include guidance on writing operational requirements, however advice can be found in the CPNI Guide to producing Operational Requirements for Security Measures[1].

Unlike many other security elements the operation and performance of a security lighting scheme is absolutely linked to a design using a particular manufacturer. In general lighting equipment manufacturers have no interest in the installation or maintenance of systems using their products (beyond selling the bits). However most manufacturers offer a no-cost design service which can then be implemented by a civil contractor.

When installing any scheme there is a balance to be struck between dictating every variable (ie undertaking the design and accepting the responsibility) and specifying only selected elements and placing the detailed design (and responsibility for meeting the performance) with others.

For Security Lighting Installations it is normally recommended that the following elements be dictated by the Client. These include:

- Minimum Illumination
- Lamp Type
- Mounting Arrangement
- Power and Control Arrangement

It is important that only the critical elements are specified allowing the lighting designer the freedom to optimise the best final solution and to ensure that the responsibility for the performance rests with the installer. For example while the lamp type, mounting arrangement and illumination are dictated the designer has free choice of lamp wattage, luminaire type and column spacing.

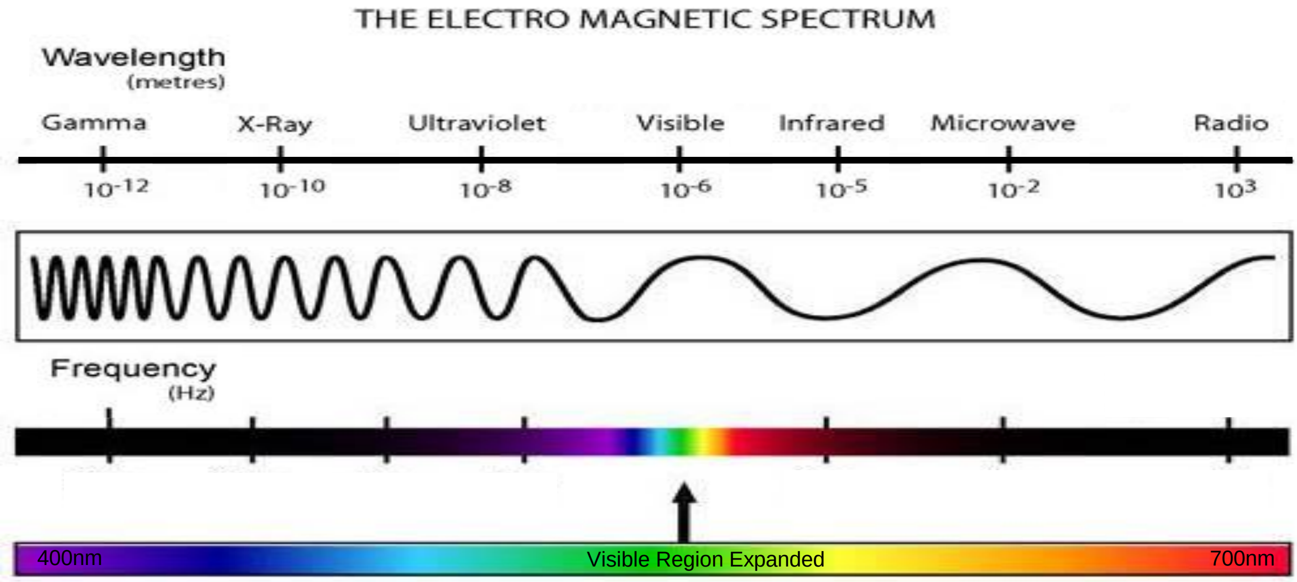
This document is structured to lead the reader through these elements with the underlying technical detail being contained in a series of appendices for reference purposes. The document applies to situations where observation is undertaken with the human eye, as well as with technical aids such as Closed Circuit Television, viewing reflected light from the scene. Techniques involving the use of radiated energy from the scene, such as thermal imaging, are outside the scope of this document.

To be able to define the minimum illumination we may need to specify for a lighting scheme, it is necessary to understand a little about the nature of light. The overview given here is supported by additional information in the accompanying appendices.

What is light?

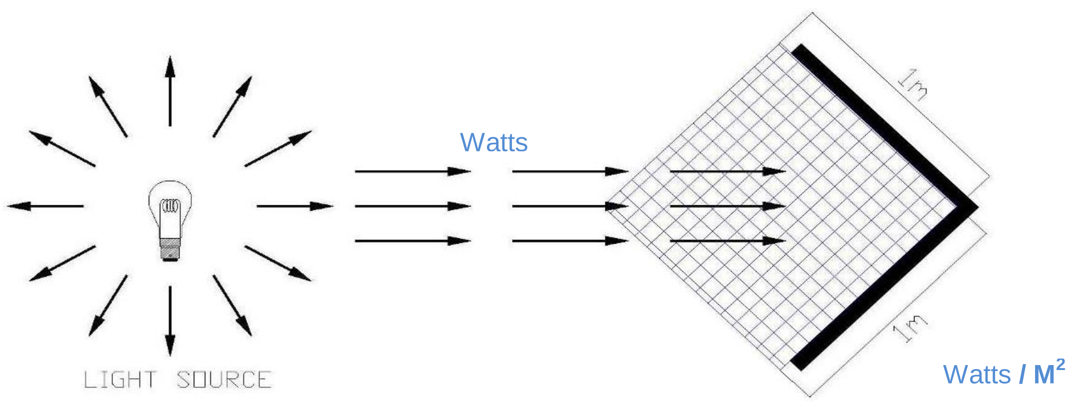
Light is what makes it possible for us to see things. Nothing is visible when light is totally absent, but light is even more important for other reasons. Many scientists believe that millions of years ago light from the sun triggered the chemical reactions that led to the development of life on Earth.

We live in a world of Electromagnetic Radiation of which 'Light' is part. This radiation may be generated naturally by the sun or artificially – for example the radio waves which allow the communication we sometimes take for granted. The electromagnetic spectrum is shown below.



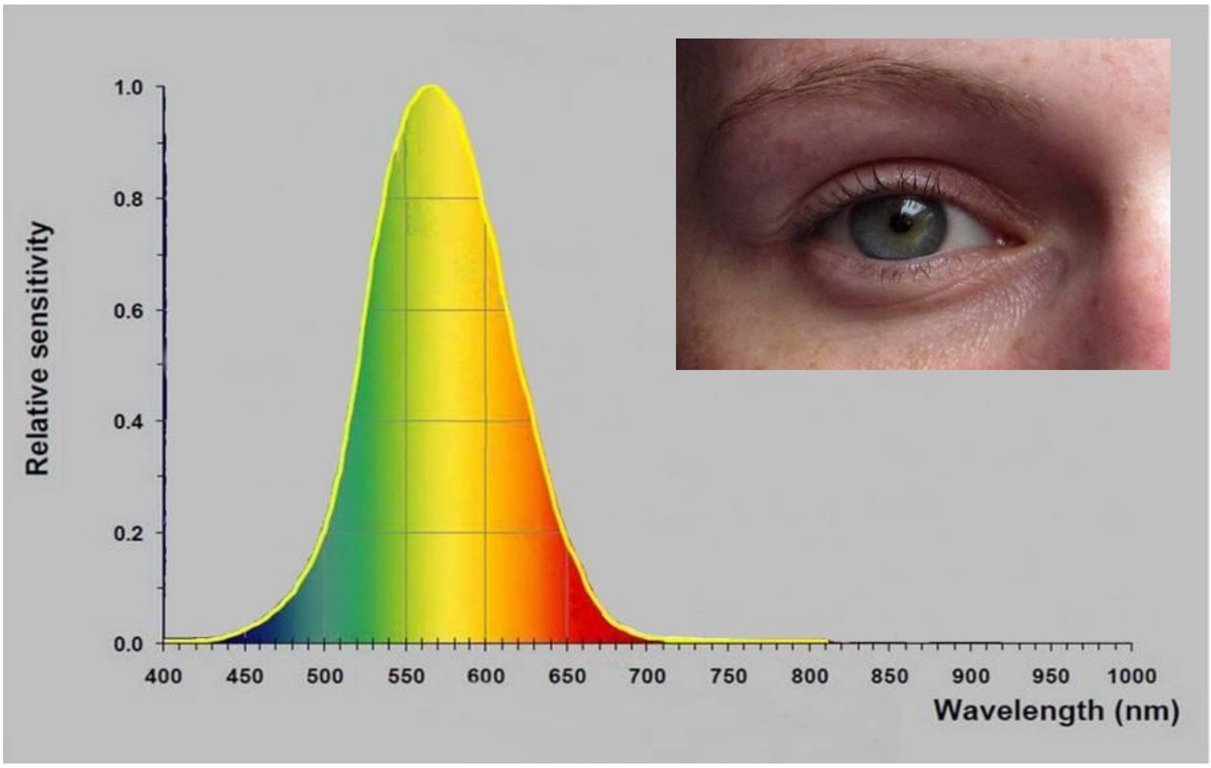
Deriving Lighting Units

For our purposes, think of electromagnetic radiation as energy travelling from a source (the sun or an electric lamp) to a destination (a wall or other surface you wish to view). The energy is transmitted in Joules per Second (Watts), and the amount falling on our surface can be expressed in Watts per Square Metre.



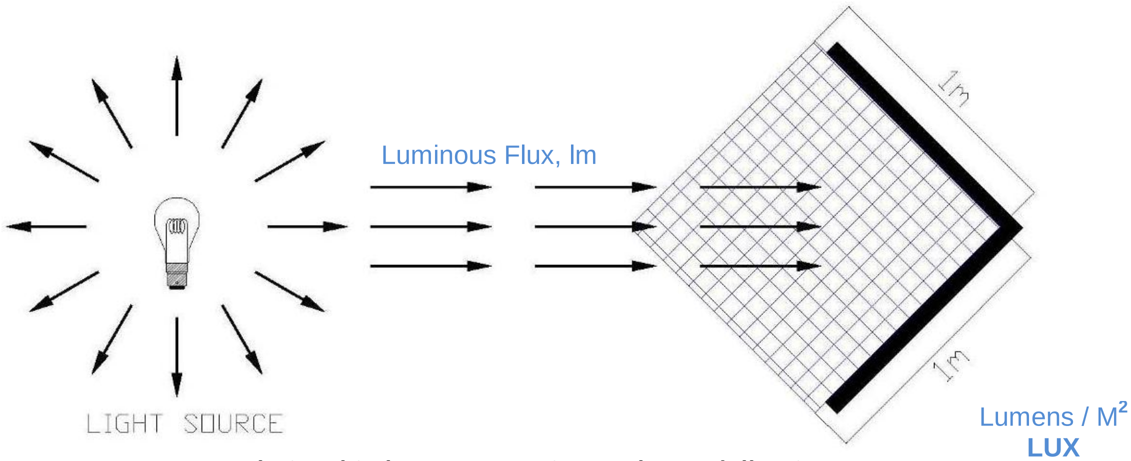
Transfer of Energy from a Source to a Surface

Visible light is that part of the electromagnetic spectrum to which our eyes respond. We 'see' this as colours although everyone's eye response will be different. Back in 1924 the International Commission on Illumination, (usually abbreviated CIE for its French name, Commission internationale de l'éclairage), defined the 'Standard Photopic Observer' which is expressed as the Photopic or *V*(*λ*) curve shown below.



Illuminance

By applying the Photopic or *V*(*λ*) curve we arrive at the principal lighting unit the Lumen (just think of this as a 'modified' Watt). By association, the visible light falling onto a surface is measured as Lumens per square metre which is given the name LUX (from the Latin word for Light) and is referred to as Illuminance.



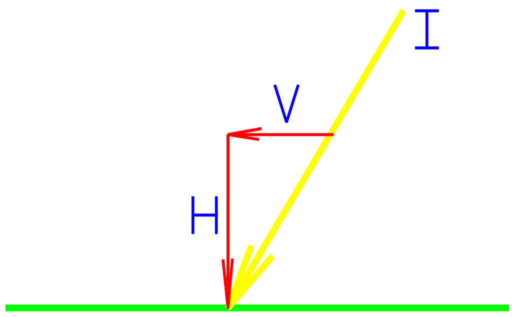
Relationship between Luminous Flux and Illuminance

For the purpose of defining and specifying security lighting the most important unit is the Lux. This defines the Illuminance, the amount of light which is falling on or arriving at a surface the value of which will form part of the specification for installed systems. In reality, of greater importance is the amount of light arriving at the observer, (either the security guards eye or a camera face plate), but this is harder to define and measure, relying as it does on the reflectance values of surfaces and the angles and distances of the observer from the scene.

To give perspective to the unit of illumination the following typical figures in Lux are given:

Direct sunlight	**100,000**
Overcast	**1000**
Office	**350**
Typical home	**150 to 300**
Street lighting	**5**
Twilight	**1**
Moonlight	**0.1 to 0.25**
Starlight	**0.01**
Overcast night	**0.001**

Illuminance can be specified as light falling vertically onto a horizontal surface, **Horizontal Illumination (H),** or as light travelling horizontally and falling onto a vertical surface, **Vertical Illumination (V)**.



It is important to note that while horizontal illuminance may be safely specified as a simple value (in Lux), together with the location for the measurement, vertical illuminance must also contain the direction from which the measurement is to be made.

Other Lighting Units

In addition to Luminous Flux and Illuminance there are other lighting units which may be encountered. Some are listed below and discussed in greater detail in Appendix A.

Common Lighting Units			
Φe	RADIANT FLUX	W	WATT
Φ	LUMINOUS FLUX	lm	LUMEN
E	ILLUMINANCE	lm/m²	LUX
M	LUMINOUS EXITANCE	lm/m²	LUX

Common Lighting Units			
I	LUMINOUS INTENSITY	cd	CANDELA
L	LUMINANCE	cd/m²	
K or *η*	LUMINOUS EFFICACY	lm/W	

Reflected Light (Luminous Exitance)

From birth we visually perceive the world around us based on the light reflected off objects. This self-evident fact is so obvious we take it for granted. Photographers old enough to remember cameras which did not have through-the-lens metering will recall holding their light-meter pointing at the target to measure the reflected light. This is the incident light (illumination) reduced by a factor depending on the reflectance of the surface of the objects.

Typical values of reflectance

Asphalt	**5%**	**most light absorbed**
Foliage	**10 - 20%**	
Concrete	**25 - 30%**	
Red Bricks	**35%**	
White Matt Paint	**60%**	
Glass	**70%**	
Snow	**95%**	**most light reflected**

The value of reflected illumination is still measured in Lux and in an ideal world would be the value to be specified. However in the outdoor environment where the values of reflectance are varied and complex it is easier to simply specify values of incident illumination. What security practitioners must be aware of is that reflectance values will change depending on a surface's ability to absorb differing wavelengths (colours) of light. This becomes a particular issue where, in place of the human eye, CCTV cameras are used which have a response outside the photometric curve. This is discussed further in the section covering Lighting for CCTV.

Brightness (Luminous Intensity & Luminance)

For lighting engineers Luminous Intensity and Luminance are critical in allowing lighting designs to be undertaken. Luminous intensity is simply the Luminous flux (Lumens) in a particular direction and may be thought of as brightness, measured in Lm/unit-solid-angle which is called the Candela, Cd. The Luminance is the brightness of an area in Cd/M^2.

The advice for Security engineers is to beware of confusing Luminance (Brightness) with Illuminance (the light arriving/leaving on a surface). See Appendix A for further information.

Efficacy

Efficacy is the measure of how efficiently an artificial light-source will convert the input energy, (usually electricity which can be directly related to cost), into useable visible light. The units are Watts/Lumen, W/Lm. This is covered further in the section on lamp selection

Where figures are quoted for lamps ensure that losses due to any control-gear are also included.

Levels of illumination

The value of illumination specified will depend on the particular lighting scenario which is to be used. Further, it is unlikely that a security lighting installation will be installed in isolation. Instead there will be both operational and health and safety requirements to consider.

Human vision

When the eye has become low light adapted it is just possible to detect an intruder, having a good contrast with the background, with a light level of 1 Lux. A much higher light level is required if there is a need to recognise an individual. Time is required for the eye to become adapted to a change in light level. Adaption from dark to light occurs quickly as the brain can attenuate the signals from the eye coupled with the contraction of the pupil, however adaption to darkness levels, (night adaption) can be from five minutes for a young person to more than twenty minutes for an elderly person. For this reason guards should not be subject to large light level changes if they are to perform at their best.

Practicalities

Unless specified otherwise figures given for illumination will normally refer to the Horizontal Illumination at the scene. This is done for convenience; horizontal illumination is easy to measure and for most practical applications in the field of security gives a workable result.

In reality, if the objective is to view a person in the field of view, it is more important that the vertical illumination of their head and body is achieved not the horizontal illumination (on top of their head). In applications where this is critical, for example where sporting events are to be filmed, designers look to establish the 'average' illumination around the person. This measure of 'mean cylindrical illuminance' however would be inappropriate (not to mention producing a difficult to measure over-engineered solution), for security scenarios where it is only required to illuminate one 'face' of the target!

Van Bommel identified that with white light, (using CFL source), 1.0 Lux was enough to identify sufficient detail from a person's face at 4.0 metres to trigger fight or flight reaction. Raynham / Saksvikronning further identified that for high pressure Sodium, (SON), the required value increased to around 3.0 Lux. This was verified back in the 1980's when the Forcible Attack Working Group, FAWG, undertook research into the minimum levels of illumination which would be appropriate on UK government sites to meet security needs. At that time the range of lamps was limited and the only CCTV cameras were thermionic tube types. The outcome produced recommendations which are still applicable as minimum standards today. These are:

- The key factor in any installation is not the absolute level but the uniformity.
- For Horizontal illumination the figure of 3:1 (Average to Minimum) is recommended.

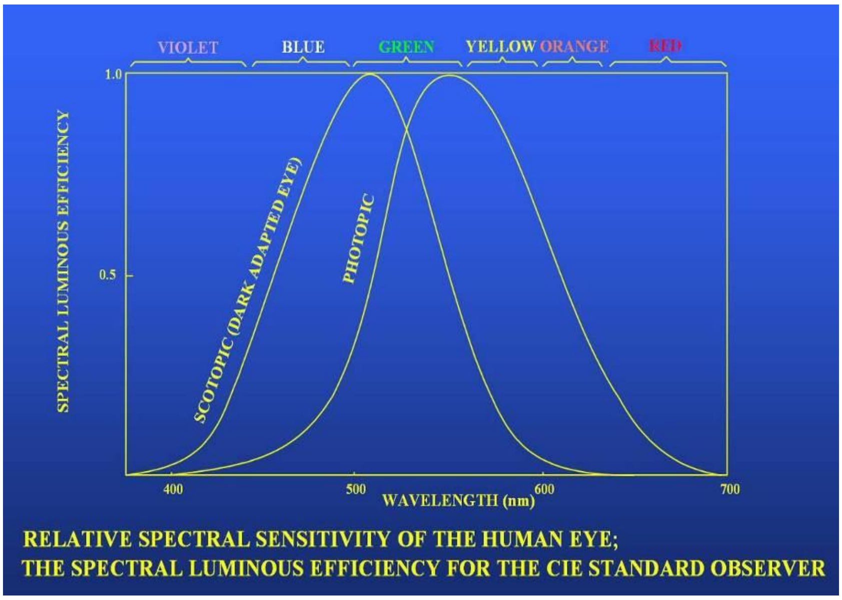
- For Vertical illumination (for walls and fences) this figure may be relaxed to 4:1
- The minimum operational value should be 3.0 Lux
- Recognising the fact that lamp output will vary over time a more practical specification is 5.0 Lux on commissioning with 3.0 Lux 'operational'. This will also allow a leeway for dirt build-up on the luminaires.
- The measurement position for illumination should be 100mm above ground level. This avoids the practical problem of ground undulation or undergrowth.

Early recommendations called for increased minimum values for CCTV cameras, however improvements in camera technology means this is less of an issue. In most cases, due to the way that both the human eye and most sensors tend to adapt to the 'brightest' things in a scene, it is found that the key value in achieving a successful result will be the uniformity of the illumination as opposed to any absolute minimum value. Increased values are important for particular scenarios such as site entrance and inspection points. These are discussed in more detail together with reference to commercial standards in Appendix F

A problem with using the Lumen?

In simple terms, the way in which the human eye reacts to light involves two distinct sensors; Cone cells and Rod cells. The cones provide colour vision and are dominant for brightness above that found for street lighting, their sensitivity corresponding to the photometric curve. The biological pigments of the cones have maximum absorption values at wavelengths of about 420 nm (blue), 534 nm (Bluish-Green), resp. 564 nm (Yellowish-Green). Their sensitivity ranges overlap to provide vision throughout the visible spectrum. The maximum efficacy is 683 lm/W at a wavelength of 555 nm (green)

Below this level of brightness there is a shift towards the rods which are monochromatic and have a response shifted to the blue end of the spectrum, the response for rods being referred to as the Scotopic curve.



The change from cones to rods occurs over what is called the Measopic region (between the photopic and scotopic curves). In the early 19th century Jan Evangelista Purkinje documented this 'Purkinje Effect' which is named after him.

Where a light source's performance is based around the Photopic response, a very different performance may be produced when operating at the lower lighting levels common for security installations.

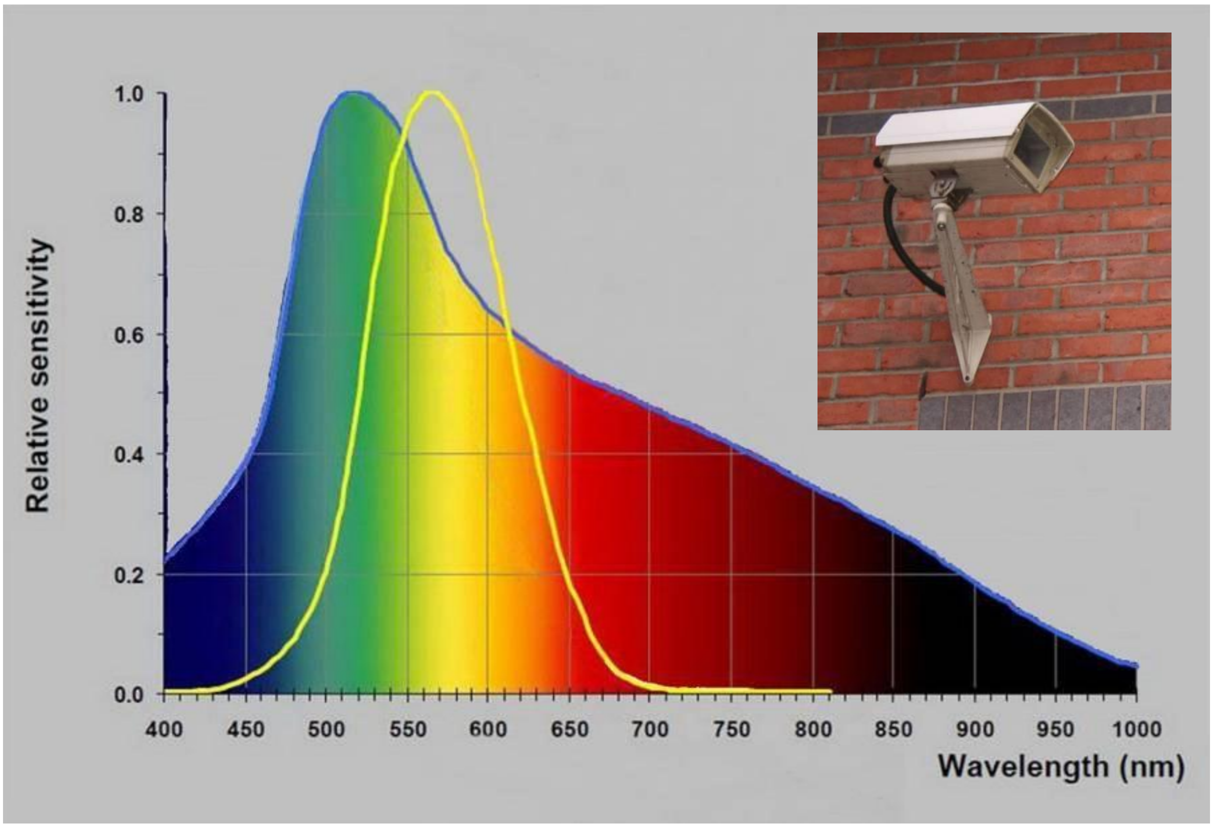
The whole issue of lighting metrics is a topical subject in the lighting industry including discussion being held on revising the definition of the Lumen, possibly by revising the $V(\lambda)$ curve to create a 'universal lumen' which would encompass the full spectral sensitivities of the human eye[(15)].

Lighting for use with CCTV

While the response of CCTV CCD Camera Sensors do not match the Photometric curve for the human eye it is close enough that the guidance for 'visible' light will apply to CCTV Camera installations. However CCTV cameras have the advantage of providing extended sensitivity into the Near Infra-Red region of the Electromagnetic Spectrum allowing 'non-visible' electromagnetic radiation to be used for imaging. While technically untrue, (as mentioned illumination is derived from the visible response of the human eye), the security industry refer to this as IR Illumination.

The method of generating Infra-Red (IR) illumination using an incandescent source, such as a tungsten halogen lamp with a filter to cut off the visible element of the emitted radiation was an inefficient and expensive method as typically only 1% of the light was passed through the filter, the rest being retained as heat. The use of incandescent sources has been superseded by the use of Light Emitting Diode, LED, Sources.

For colour imaging a filter is applied over the CCTV sensor to cut-off non-visible IR content. This avoids de-focussing issues particularly apparent in sunlight. At night this filter is removed allowing the use of IR illuminators.



It should be noted that the peak response for a camera is shifted toward the blue end of the spectrum. In this respect it more closely follows the Scotopic or night adapted human eye response.

Monochrome cameras, (and many colour cameras utilising dual sensor or removable IR filters), can take advantage of non-visible IR 'lighting'. The advantages and the main uses include:

- Reduction of Glare and Nuisance
- Covert Surveillance
- Additional Illumination to supplement visible lighting schemes

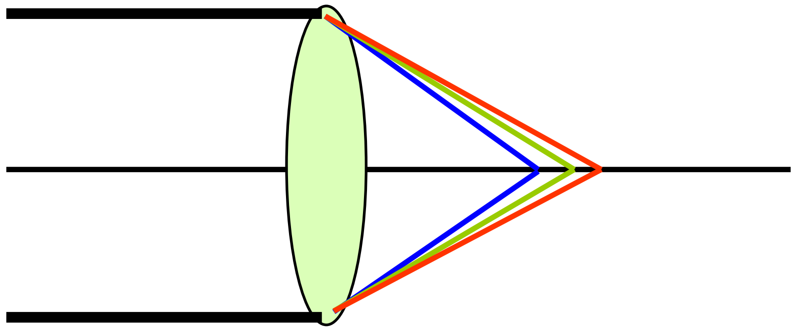
Issues with IR Illumination

Lighting quality

One disadvantage of IR illuminators is that they often offer poor quality lighting; the tendency being to install the illuminators co-located with the camera which produces a 'flat' image with little shadow-depth. This is coupled with the inability to specify levels as there is no practical method of measuring the output of IR illuminators other than a subjective assessment of CCTV 'Picture Quality'. Attempts to introduce equivalent units to those for visible lighting (using the response from a typical camera sensor instead of the photopic curve for the eye) have met with little enthusiasm.

CCTV lens performance

CCTV lenses used by the security industry are not generally designed to work with IR wavelengths which can further reduce performance due to low transmission values as well as giving rise to issues such as chromatic aberration which requires the focus to be a compromise between visible and IR.



Chromatic Aberration

When focussing light using a simple lens the amount the light is refracted will depend on the refractive index of the lens material (and the air) together with the wavelength of the light. In a typical CCTV camera lens the composite lenses will bring the visible light to a common focus position allowing a sharp picture to be imaged, however lenses which can also achieve this effect into the Infra-Red region are expensive.

The outcome is a camera with two focus positions from the lens (one for visible, one for IR). If the camera is expected to produce an acceptable image under both lighting conditions then a compromise must be made, in simple term this involves adjusting the 'back-focus' on the camera for the IR. Taking this approach ensures that the situation with the shortest depth of field is dominant. Some modern cameras have the ability to make this adjustment automatically (based in scene illumination) when the camera switches from Visible to IR. It is worth noting that 'daylight' has a high IR content and to avoid this 'de-focussing' the image an IR-cut filter is placed in front of the sensor used by colour cameras, for 'night-time' use with IR this must be removed or in some cases an alternative sensor can be mechanically 'swapped-in'.

Alternative options can be to use an IR corrected lens or a fixed focal length mirror lens (which does not use refraction for focussing). The first option will be expensive while the second can be restrictive to design as only a limited number of focal lengths are commercially available.

Where the scene to be viewed has both visible and IR simultaneously, particularly if a monochromatic light visible source such as Low-Pressure-Sodium is used, difficulties with image focus can occur. It is recommended that in this situation specialist advice should be sought.

Reflectance

The IR absorbance and reflectance of materials is also different to that of visible light and this will further change the scene viewed under these conditions.

Viewing a scene using a camera observing a Rotakin Test Target

Scene illuminated by sunlight

Scene illuminated by Infra-Red

The two images are dramatically different because the reflectance of foliage is between 10% to 20% in visible light rising to between 70% to 80% under Infra-red lighting. Thus the grass and trees appear white under IR. A similar effect is also observed on the clothing of the person in the scene.

This can lead to confusion for operators as targets illuminated under IR lighting can look very different from when they are illuminated by daylight.

Eye safety

There is an issue of Infra-red eye safety. Unlike visible light, to which the human eye has developed automatic responses ranging from blink reaction to dilation of the pupil coupled with the natural reaction to 'look-away' from bright sources of illumination, Infra-red radiation does not illicit the same reaction. In practice this should not present an issue for operators/users as the distances at which the radiation causes a hazard are relatively small but technicians who have to work on the equipment should be made aware of the potential risks. A report covering this issue has been compiled by SSG and is available on request.

Lamp selection

It is normal practice to include in the Operational Requirement the type of lamp which is to be used. This requires the specifier to choose the light source which best meets the needs of a particular scheme. This choice will be based on the particular characteristics which are discussed below.

Artificial light sources

During the day primitive man could see by the light that came from the sun; but night brought darkness and danger. One of the most important steps man has taken to control his environment occurred when he learned to conquer the dark by controlling fire, a source of light. Artificial lighting has been used in a number of different ways to provide safety and security.

Romans used fire baskets on either side of gateways or other openings in their walled towns. The result was that the guard could stand back in the shadows and observe approaching strangers.

In recent times the use of lighting has been recognised as both an aid to military security and as a means of combating civil crime. Development of light sources tends to be driven by political need coupled with technological innovation, for example the industrial revolution drove large numbers of people to live together in urban areas, which in turn produced the need for efficient and practical domestic and street lighting. In more recent times the drive to address the environmental climate change agenda, reducing carbon footprints and overall energy use has seen the development of alternative light sources such as CFL and LED together with luminaires with improved photometric control.

ARTIFICIAL LIGHT SOURCES	**Date**
Camp Fires and Torches from dried rushes	**Pre-History To 1790**
Stone Lamps	
Candles/Oil Burning Lamps	
Gas Burners	**1790**
Kerosene Lamp	**1850**

ARTIFICIAL LIGHT SOURCES	Date
Electric Arc Lamp	**1858**
Incandescent Lamp	**1879**
Welsbach Gas Mantel	**1890**
Discharge Tubes	**1920**
Fluorescent Lamp	**1933**
Induction Lamp	**1990**
White LED Lamps	**2000**
Electron Stimulated Luminescence Lamp	**2009**
Field-Induced Polymer Electroluminescence Lamp	**2012**

Lamp types

There are many lamp types which are used for security applications, these include:

- Low pressure sodium (SOX)
- High pressure sodium (SON)
- Mercury discharge
- Metal halide
- Incandescent
- Tubular fluorescent
- LED

All have their own distinct properties which are covered in detail in Appendix B

A key choice a security manager must make is that of which lamp and luminaire will be used, this will depend on several factors which will include:

- Area to be covered
- Cost of luminaire
- Running cost of lamp
- Lamp life
- Run-up time
- Restart time following restoration of power fail
- Colour rendering
- Maintenance considerations

Luminaire type

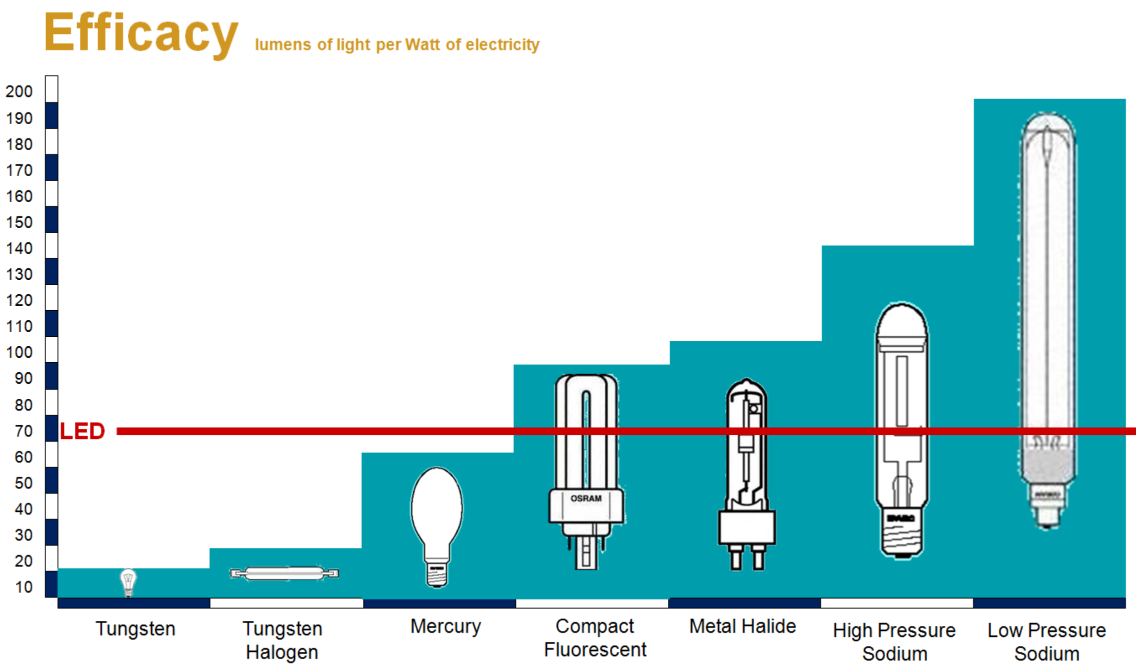
The area to be covered will determine the most appropriate type of luminaire to be used. Large open areas will require the use of floodlights whereas the creation of an illuminated strip as may be desirable for Perimeter Lighting may best be achieved using a Street Lighting Lantern. This is an example where the security industry can benefit from the design effort expended by the lighting industry to produce luminaires which will illuminate roads, minimising glare and cutting-off any light which could cause a nuisance to adjacent homes and properties.

Luminaire cost

Traditionally the cost of a luminaire would not have been an issue to a user who would only be interested in the total cost of installation. However modern luminaires, including Induction and LED sources, cannot be re-lamped but must be replaced at the end of their useful life incurring the user with additional life-cycle cost.

Running cost

The cost of operating a lamp will depend on its Efficacy, a measure of how well it converts input energy into useable light. The table below shows typical figures for efficacy quoted by lamp manufacturers. The 'red' line shown for LED lamps represents that development for this technology is rapidly improving.



It must be emphasised that the above graphic relates to performance based on the Photopic response. For this reason a near-monochromatic source such as Low Pressure Sodium lamps may not offer the best choice if using CCTV or where the viewer's eyes are 'dark-adapted' operating in the mesopic or scotopic region with a 'blue-shifted' spectral response.

Lamp life

The way in which the lighting industry defines lamp life is traditionally the point at which 50% of the lamps in an installation would be expected to have failed. In practice some lamps could fail after a short time while others would last for much longer.

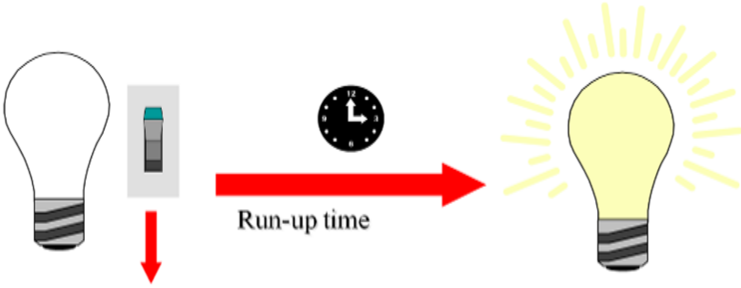
For incandescent lamps such at Tungsten Halogen the failure mode is normally due to thermal shock on switch-on as the filament heats up. As these lamps are often switched using detectors such as Passive Infra-Red devices this raises two points. The first is that the lamp can be tested to check if it is working but will likely fail when switched on; the second is that the actual lamp life will be affected by the switching cycle.

The output of discharge lighting and those utilising stimulation of phosphors will diminish over time with the lamp never actually 'failing'. For this reason the life of these lamps will be quoted as an 'L' figure. For example L70 will be the point when 50% of the lamps in an installation will have an output which has fallen below 70% of that quoted by the manufacturer. At this point the lamps (or in the case of LED the whole luminaire) should be replaced.

Recognising the difficulty of assessing the performance of individual lamps, CPNI recommend that regular spot measurement of illumination be taken for an installation. Should the recorded values be lower than acceptable the installation should be re-lamped.

Run-up time

Many lamp types do not provide full output when switched on. Fluorescent fittings typically start at 50% on switch-on and can take a number of minutes to reach full output, a time usually dictated by temperature which can make them unsuitable in cold external applications. High intensity discharge by comparison can take several minutes to produce any output.

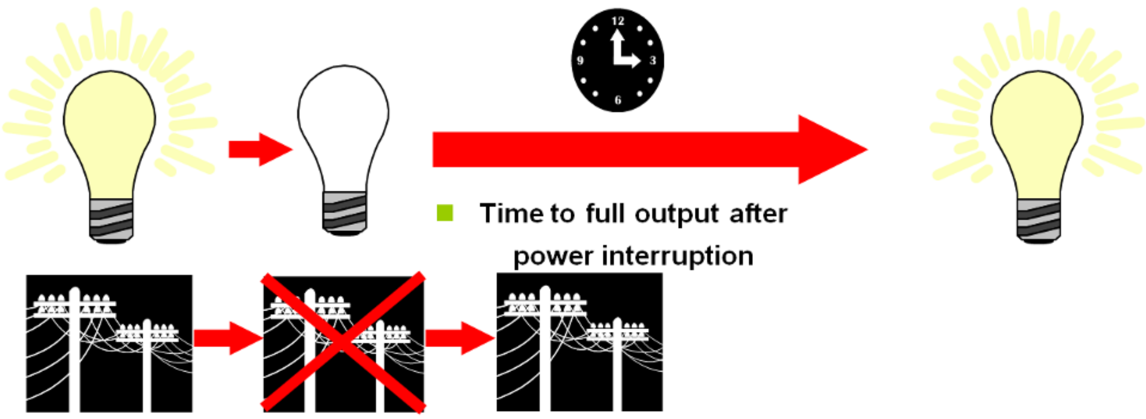


Delayed output on switch-on

The importance of run-up time will depend on the application. For example event-activated lamp must be as near instantaneous as possible.

Lamp re-strike time

For High Intensity Discharge lamps such as High Pressure Sodium, SON, there can be a significant delay in re-striking the lamp after a power-fail. This is because the arc tube must cool down, reducing the pressure of the gas, before the arc can be re-struck. While there are a number of options, such as high-voltage igniters or dual tube lamps, these tend to have their own problems.



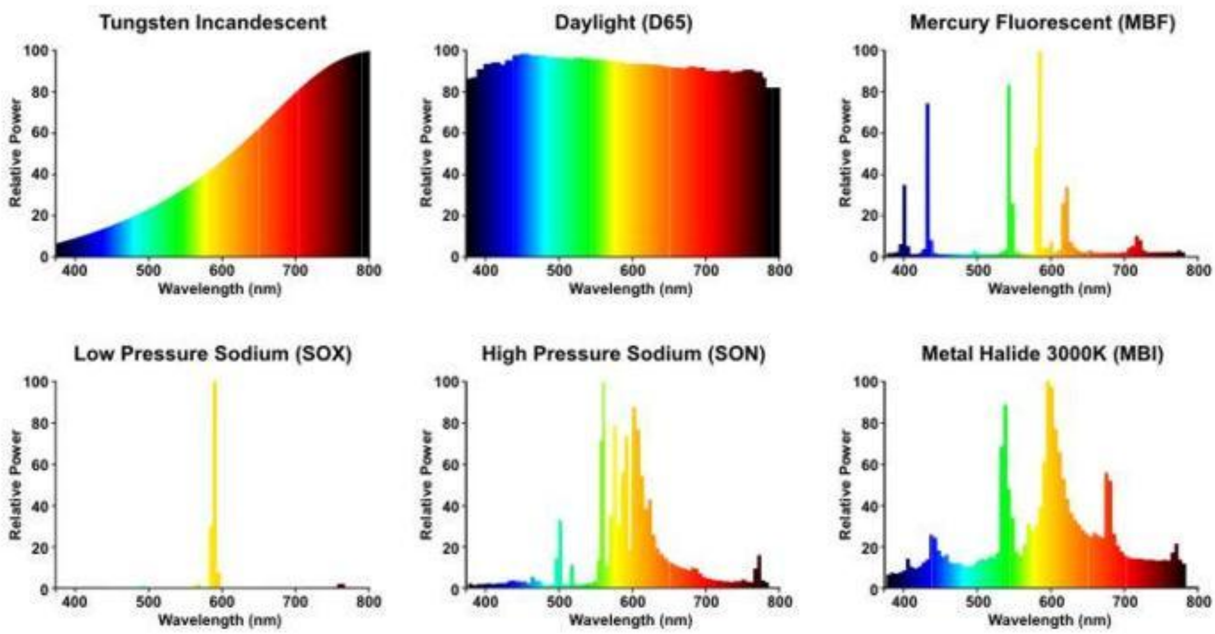
Delayed re-strike after power failure

Colour rendering

Colour rendering can be critical, particularly where the task involves differentiating colour, for example between vehicles or comparing skin tones with pass photographs. The example below shows the effect of using three commonly used artificial light sources

Effect of Colour Rendering with different lamps

All lamps can be characterised by their spectral output. In the case of an incandescent lamp where a filament is heated this will be a continuous spectrum whereas discharge lamps produce energy at discrete points producing a discontinuous spectrum. While, to the human eye these may appear 'white', they can distort the way in which colours are seen.



Spectral output from different light sources

While there is debate in the lighting industry and scientific community on how best to present the performance of different light sources most lamp manufacturers give an indication of the spectral content of lighting sources by publishing Ra values. An Ra value of 100 would equate to that provided by daylight. Examples are:

Ra >90	Excellent colour rendering
Ra >80	Very good colour rendering, no significant colour distortion
Ra >60	Good colour rendering, some distortion but adequate for most surveillance needs.
Ra >40	Marked colour distortion, basic identification only
Ra <30	Gross colour distortion, colour identification unreliable

Manufacturers may also quote Colour Temperature, (strictly for non-incandescent sources this is Colour Corrected Temperature, CCT), measured in degrees Kelvin. This relates to the way a black-body (lamp filament) will glow when heated. Typical figures are:

800^{o}K	Fire Embers
1800^{o}K	Candle Flame
2800^{o}K	Incandescent Lamp
3200^{o}K	Tungsten Halogen Lamp
4300-4700^{o}K	Fluorescent Lamp
5600^{o}K	Noon Sunlight
12000^{o}K	Skylight

Alternatively, as defined in BSEN 12464, colour appearance or apparent colour, (chromaticity), of emitted light may be quoted. This is related to Colour Temperature as follows:

Colour appearance	**Corrected colour temperature**
Warm	< 3300 K
Intermediate	3300 to 5300 K
Cool	>5300 K

Lamp safety and disposal

Many lamps contain hazardous or toxic material, in particular Mercury but also other heavy metals as well as phosphors and plastics. It is worth considering the complete usage cycle which will be involved for a particular lamp choice, from transport, storage, installation to final disposal. At each stage there will be health & safety as well as environmental requirements.

Local instructions should detail the recommendations in the event of any mishap, for example while the mercury in a compact fluorescent lamp poses no threat, should the lamp break guidance may be to open a window and evacuate the room for 15 minutes (if inside) and then use a wet rag to collect the pieces which should be sealed in a bag prior to disposal.

Luminaires

Luminaires used for security lighting inside premises will usually be identical to those used for the normal lighting, the only difference being that they cannot be turned off by unauthorised staff.

Strength

Where dedicated security luminaires are used it is as well to consider carefully the conditions to which they will be exposed. Exterior luminaires must of course be weatherproof but they may also be subject to attack by stones, air weapons, boots or hammers. It follows that it is a short-sighted policy to install the cheapest fitting available which might fail at the first attack. No luminaire is vandal proof but some do resist longer than others. Modern plastics such as polycarbonate are exceedingly tough although continuous prolonged attack can eventually break them down. Where glass must be used it should be kept well out of reach and luminaires with large flat glass surfaces should be avoided. A curved, and preferably toughened, glass shape is much more difficult to break with a stone or air rifle pellet.

Choosing the correct luminaire

For external security application the practice is to deploy 'commercial' luminaires where they will meet the operational need. For perimeter lighting, where the objective is to create an illuminated strip, usually around 10 metres wide, commercial street lighting lanterns are ideal. As well as lighting long strips (ie streets!) they are also designed to have a sharp cut-off so as not to illuminate the domestic properties outside which they are located, this feature meets the need not to illuminate guards who may be patrolling inside the illuminated perimeter.

Where larger areas have to be illuminated, for example vehicle parks or external storage areas, area floodlights designed to cover large car parks both environmentally and economically meet this need. Specialist applications such as lighting to assist under-vehicle inspection can be met using commercial products in an innovative way, for example by using the luminaires designed for road bollards. In the past these items of road furniture had the lighting inside (leading to a potentially hazardous situation when they were struck by vehicles), modern bollards consist of a flush mounted luminaire, capable of withstanding light-weight traffic loading, with the 'bollard' mounted on top. Be aware that for larger vehicles, as an alternative to the traditional method of using the air-field lighting fittings, there are companies offering bespoke solutions, some of which incorporate camera imaging systems.

To ease maintenance the luminaire should be quick and easy to open to gain access for cleaning and re-lamping. Where this entails moving the fitting from its alignment, eg with some floodlights, pre-set devices may be available which enable the fitting to be returned to its exact position without the need for further specialist alignment. If within reach of vandals, however, such a fitting would not remain intact for very long. Using multi-screwed fastenings will increase the time taken for maintenance but will help the fitting to survive, particularly if the screws are recessed and have some `security' head requiring a special key.

It should be noted that luminaires of apparently similar specification but made by different manufacturers may vary in construction and appearance, and the lamps may not be interchangeable.

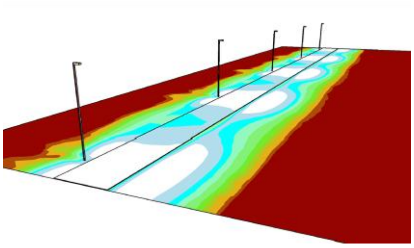
Using lamps of the wrong power or of a different type from that specified by the maker is usually inefficient and can lead to overheating, short lamp life or damage to the control gear. It is as well, therefore, to avoid mixing lamp types or wattages in any part of an installation.

Standards, guidance and advice

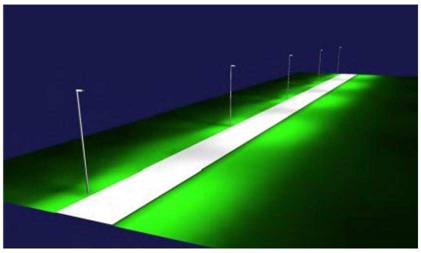
Guidance is readily available on all aspects of lighting covering from in-depth technical information to installation and specification guidance. While recent years have seen security specific guidance produced much useful information is contained elsewhere. Examples of sources of information include:

Commercial companies

Advice on lighting may be readily obtained from any of the major lighting companies. Some of these produce helpful guides but it must be recognised that these companies have their commercial interests to consider. CIBSE have defined common standards for photometric information which manufacturers use for their products, this allows computerised designs to be readily produced using different manufacturers equipment. While commercial lighting packages are available, in practice any manufacturer may be approached and will provide a, 'free', design service.



ISO-LUX



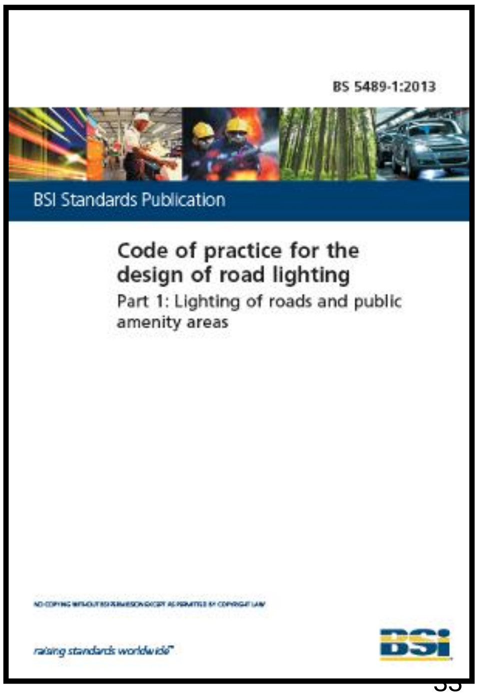
Rendered

Outcome

Computer lighting design packages can easily produce not only the ISO-LUX diagrams or rendered diagrams allowing both specifiers and users to assess what installed lighting schemes will look like but also provide a full and detailed technical assessment detailing the uniformity, power and the impact on the environment.

Public standards

Nationally, standards for particular aspects of lighting equipment are laid down by the British Standards Institute (BSI). With regard to good practice and lighting levels the Illuminating Engineering Society (IES), now part of the Chartered Institute of Building Service Engineers (CIBSE) produce a number of guides. Principal amongst these must be the Society of Light and Lighting's (SLL) Lighting code which is available in hard copy, via download or on CD-ROM and covers all aspects of lighting. While none of these is specifically aimed to security lighting they do give a good background into the subject.



Information on professional associations and bodies is attached at Appendix G

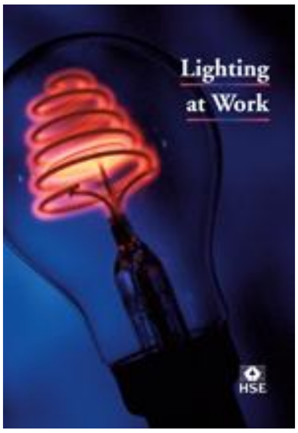
Particular public standards of interest include:

BS 5489-1 2013 Code of practice for the design of road lighting – part 1 Lighting of roads and public amenity areas(5), offers security advice as well as guidance on the siting of luminaires (columns) and minimum levels of illumination for car parks and similar areas.

CR 13201 part 1(7) & EN 13201 part 2(8) Road Lighting set the current guidance for lighting of roads and may be mandated by local authorities.

BS EN 12464-2: 2007 Lighting of work places, Part 2 Outdoor work places(6), which as well as providing guidance covering design criteria for the environment includes illumination levels for particular activities and areas. Be aware that if using the 'Risk Levels' in Annex A these pertain to 'safety' as opposed to 'security' levels

Government bodies



The Health and Safety Executive (HSE) produce guides to lighting for safety purposes(13). Other departments with particular interest areas such as DEFRA and US DoE produce guidance in the areas of environmental impact. The Home Office offer guidance relating to reduction of crime, in particular the ACPO Secured by Design, 'Lighting against Crime'(12). The Crime and Disorder Act 1998, Section 17(11), identifies the benefits of improved lighting to address crime.

Government security

Guidance on minimum standards is published as part of documents such as the 'Security Policy Framework', and finds its way into department and specialist publications such as the MOD JSP440. This advice comes from the CPNI committees drawing on experience from Defence Infrastructure Organisation, Security Services Group (SSG) and the Home Office Centre for Applied Science & Technology (CAST). Minimum recommended standards for government use are offered in Appendix F. Other guidance focused at particular applications is available, for example the CAST OR for Prison Lighting, results from which can be applied elsewhere.

Other sources:

It must be recognised that other government and CNI bodies also have their own standards drawn up to meet their particular requirements.

In the wider community; The British Astronomical Association, 'Campaign for Dark Skies', produce guidance including their Handbook, 'Blinded by the Light ? (14)' and advocate improved luminaires with their 'Better Lights for Better Nights'. An internet search will also identify many papers produced by academia although as previously mentioned these can provide opposing views and advice.

Clean Neighbourhoods and Environment Act

Background: On 7 April 2005 the Clean Neighbourhoods and Environment Bill received Royal Assent following a successful passage through Parliament to become the Clean Neighbourhoods and Environment Act 2005. The act seeks to address a wide range of problems which cause annoyance and inconvenience including nuisance parking, litter and graffiti, control of dogs, transport and disposal of waste, noise (including security alarms) to dealing with abandoned shopping trolleys. The Act is controlled by the Department for Environment, Food and Rural Affairs, DEFRA. One change introduced within the act is the introduction of an amendment to Section 79 of the Environmental Protection Act 1990, which now includes "artificial light emitted from premises so as to be prejudicial to health or a nuisance" to be included under 'Statutory nuisance: lighting'.

Implications: The design and operation of installed lighting may be challenged. The act talks of "nuisance" and the term "light trespass" has been applied.

There are a number of exceptions listed in the act, the focus being on Transport facilities, (Docks, Airports etc) and specifically 'for premises occupied for defence purposes'. However when challenged the test is still to demonstrate having used 'best practicable means' to abate a nuisance (which is a ground of appeal against an abatement notice, and a defence against prosecution), covering system 'design, installation, maintenance and manner and periods of operation', 'being reasonably practicable having regard among other things to local conditions and circumstances, to the current state of technical knowledge and to the financial implications'.

Guidance: Principal guidance is provided by DEFRA through gov.uk , amongst which is 'Guidance on Sections 101 to 103 of the Clean Neighbourhoods and Environment Act 2005', (Pages 26 to 38). The Institution of Lighting Engineers, (ILE) produce guidance notes on the reduction of light pollution which in turn references other relevant publications and standards.

Lighting schemes

General

Lighting for security purposes is normally considered as a particular generic ‘scheme’ as detailed below. Each has its particular advantages and differing schemes may be implemented on the same site. However care should be taken that advantages of one design are not compromised by another.

Before any lighting is considered it is imperative that a clear and unambiguous Operational Requirement has been drawn up covering not only the Security issues and objectives but also Health & Safety and environmental impacts the scheme may have.

Particular schemes considered are:

- Perimeter Lighting
- Glare Lighting
- Area Lighting
- Asset Lighting
- Event Activated Lighting
- Entrance/Check Point Lighting
- Displacement Lighting
- Non-Visible Lighting
- Guardhouse Lighting

Perimeter lighting

The purpose of perimeter lighting is to provide a well illuminated strip around, but usually clear of, the protected area. To be effective an intruder must have to pass through this well-lit area to reach the protected asset. To improve the performance this well illuminated strip would normally be co-located with the site perimeter fence which gives a physical delay keeping an intruder vulnerable to observation for an extended period of time. However there are times when it makes sense to move the illuminated strip away from the fence line.

Typical Perimeter Lighting using 100w SON on 8 Metre Columns

Ideally the lighting columns and their lanterns should be so located that the ground immediately outside the fence is adequately illuminated but the inside face of the fence is not, allowing guards clear vision through the fence fabric. This may be achieved by the use of an outreach arm from the column placing the luminaire above or slightly beyond the fence line.

The lighting columns should be positioned at least 2.0m inside the fence line so they will not aid an intruder to scale any physical barrier or defeat any Perimeter Intruder Detection System, PIDS.

The variation in horizontal illumination level, (uniformity), within the area to be lit should not exceed 3 to 1 (average to minimum) when all lamps are lit. When CCTV is in use, the ratio should be kept below 10 to 1 with one lamp out.

A minimum horizontal illumination level of 3 Lux operational (5 Lux on commissioning) should be the design criteria. An allowance may be added to allow for deterioration of lamp output as the lamp ages and dirt builds up on the luminaire together with possible reductions in supply voltage.

A rough guide is to assume luminaires will be spaced at 3 to 4 times their mounting height.

Glare lighting

The purpose of glare lighting is to produce a very high deterrent effect by directing light directly towards an intruder. High intensity sources produce the best results but these do not have to be high wattage. It is the point intensity which causes the glare, (a veiling reflectance in the eye) and not the overall output of the light source. The brightness of the light as seen by the eye does not change with the distance between the viewer and the source.

The greatest effect is obtained when the light is within a small angle of the intruder's line of sight. This means the fittings must be close spaced, (typically 1.0m to 1.5m high and 6.0m to 7.0m apart). This can be expensive in cabling and capital cost of fittings so a compromise has to be made.

Glare Lighting installed to cover a section of a perimeter

In addition to deterring an intruder, glare lighting also has the advantage of concealing the patrolling guards where they are behind the luminaires. Any patrolling guards are also able to see an approaching intruder more easily.

Fittings should be approximately 1.0m to 1.5m high and 6m apart. As much of the light as possible should be thrown forward. The current method of specifying performance is to define a limiting distance from the perimeter. At this distance, (nominally 10m), the vertical illumination normal to the fence line, measured 300mm above ground level and the uniformity are specified. Suggested minimum values are 4.0 Lux with a uniformity of 5:1, (Average to minimum). The height of 300mm is chosen as representing the height above the ground of a crawling intruder.

Luminaires are available where the lamp is positioned on the ground and directed up onto a reflector which throws the light forward. This has the advantage of overcoming the threat of an intruder shooting-out the lamps

Increasing pressure from environmental groups to restrict ‘light pollution’ has led, in recent years, to the number of ‘challenges’ to this type of installation. In practice its use in the UK is limited.

Area lighting

The term Area Lighting generally refers to illumination of the areas around buildings within a protected area where assets may exist. This could be vehicles or other stores or may be a critical operational area.

High pressure Sodium lamps in floodlights providing both operational as well as security lighting.

Some lighting will in many cases already exist having been installed for operational or health & safety reasons. Full use should be made of this but if it is inadequate in some areas supplementary lighting may be used. Where existing amenity lighting levels are high it may be necessary to provide higher area lighting levels than would otherwise be needed to avoid too large variations in levels.

High Pressure Sodium Lighting illuminating a secure compound

The minimum illumination should exceed 3.0 Lux over the defined area with a uniformity of 3:1, (average to minimum).

Asset lighting or Flood lighting

The principle is to provide uniform lighting on the vertical surfaces of the building of interest. In this way, any intruder will be seen in silhouette against the illuminated background. Patrolling guards can also readily see should any objects be left in the area of interest. The surroundings and background around the area to be illuminated influences the level of illumination to be provided. Dark backgrounds/surrounding require less lighting.

Building walls illuminated using 70 W SON in bulkhead fittings.

From the security perspective only the lower two to three metres need to be illuminated but in practice other considerations will apply.

For further guidance see CIBSE publication, 'The Outdoor Environment'. Security lighting does not always have to advertise itself as such, many schemes can be advanced on the fact that they highlight the building aesthetics.

Event activated lighting

Event activated lighting is that which may only be switched on when an intruder approaches the protected area. In this case it is usually activated by a Perimeter Intruder Detection System (PIDS) which senses the intruder's presence. As an alternative the lighting may be operated by the guard force under conditions of heightened alert.

Passive Infra-Red detector mounted below a 300W Tungsten Halogen Fitting

Only luminaires having an immediate output can be used, traditionally this would have been tungsten halogen but they have largely been superseded by CFL or LED lamps. Note that the life of CFL lamps will be reduced if subjected to too-frequent on/off cycling.

It should be noted that if the intruder is unaware of its existence it has no deterrent effect. Also an intelligent intruder can make exploratory excursions to determine what, if any, response occurs. It is worth considering that against these negative points such systems are cheaper to operate since the lighting is only on when it is actually required. The fact that the lighting is not always on means that attention may not be drawn to the importance or significance of the site.

Displacement lighting

One use of lighting which may be considered, particularly on sites which are already illuminated, is to 'Displace' intruders away from sensitive areas. Experience has confirmed that intruders will stay within poorer lit areas and by providing significantly higher levels of illumination around sensitive or vulnerable assets increased protection is provided. It must be noted when selecting lighting levels that the response of the human eye is logarithmic.

To assess values the following formula can be applied (in Lux):

$$\frac{\log \text{Asset } 1}{\log \text{Background } 1} = \frac{\log \text{Asset } 2}{\log \text{Background } 2}$$

For example, if the average background level of lighting on a site is 10 Lux, a suitable displacement value around an asset may be provision of an average illumination value of 50 Lux. If however, the background level was an average of 20 Lux, to achieve a similar result the asset must be illuminated to 158 Lux.

Entrance / Check Point lighting

The lighting levels around entrance points will normally be higher than normal if only for safety reasons. The choice of lighting will be affected by the need for colour rendering dependant on whether there is a requirement to identify car paint colours or skin flesh tones etc.

Typical levels would be 50 to 150 Lux using metal halide or LED lamps in flood light luminaires. There will be a need to meet the guidance in BS 5489 regarding minimum levels for road traffic.

Lighting deployed at a vehicle check point / entrance

In the photograph above the use of glare lighting floodlights forces drivers to slow down before entering through the gate. This provides an advantage to the guard-force.

Search area lighting

Specialist guidance is available from CPNI regarding the lighting levels required for search areas. For external vehicle search the area around the vehicle should be illuminated to a level which will allow the guard to carry out a search in safety**.** In practice minimum illumination for this activity will be dictated by BS5489-1 ‘Lighting of roads and public amenity areas’, however consideration will need to be given to the colour rendering which will be needed to assess vehicle paint or driver skin-tones.

Under vehicle search may be undertaken with an illuminated mirror, alternatively luminaires may be installed into the road surface. For some installations the use of integral cameras can assist the guard as well as providing an audit capability.

Vehicle Search Mirror

For baggage search the level of lighting will depend on the task to be undertaken. For example a search for an object the size of a hand-weapon will require less illumination than that required if the search was for a memory stick. The CIBSE Lighting Guide discusses the subject of Visual acuity and offers guidance on the light source and associated levels for the tasks to be undertaken.

Guardhouse and office lighting

The lighting in guardhouses and offices must be adequate to allow duties to be carried out at night but it should not reveal the activities unnecessarily to an outside observer.

Guidance for single room check posts has always been that luminaires should be mounted at low level immediately over work surfaces. Light coloured surfaces should not be present around or near windows through which the guard has to observe. Also in the guardrooms the light level should be such as to allow the guards' eyes to quickly become low light adapted if the area outside which the guard has to observe (or patrol) is only lit to a low level.

For offices the internal lighting levels will be dictated by the guidance in the CIBSE Lighting guide. In the past government offices utilised blast protection in the form of weighted net curtains which had the additional advantage of obscuring vision into the rooms from outside. These have largely been changed for alternative designs utilising glazing and film combinations which, after dark, allow free vision from outside.

Who is looking into your workspace ?

Application of controlled glazing film.

Options exist ranging from bricking-up the windows or using blinds, which unfortunately prevents occupants from viewing out, to the application of other measures utilising reflective and screen printed films or electrically controlled (Electro-chromatic or Photo-Voltaic) glazing.

Practical trials to establish minimum lighting levels

Work has been undertaken by CPNI on the effects of different obscuration methods restricting vision from outside. In practice, as well as the physical elements, the illumination levels must be controlled such that a difference of at least 7:1 (outside to inside) is achieved. This can be achieved by strategic placement of external lighting.

Further information is available, on application, to CPNI.

Installed Systems

Specifications

Once an Operational Requirement has been defined and agreed then work can begin on drawing up a specification. The specification has a number of purposes; principal amongst these is allowing competitive quotations for the implementation of the lighting scheme to be obtained.

The specification should contain the minimum of constraints, consistent with allowing the OR to be met. This allows the bidding companies to utilise their design skills to provide the most cost effective solution while still taking the responsibility for the result. Key to this is ensuring that the specification includes how the system will be functionally tested on completion to measure the performance.

The ‘design’ of a system is linked to the choice of the products used and as most lighting product manufacturers do not wish to be involved in the actual installation, to obtain value for money the work can be split into two competitive actions. The first step would be to choose the products which will be used by approaching lighting manufacturers for a detailed design (which most reputable companies will provide free of charge) together with a cost for their equipment. Once this decision is made a contract can then be tendered with civil engineering companies to undertake the physical installation, this contract should also make them responsible for the final performance and handover.

Lighting controls

The simplest form of control is where the ambient light level determines when the security lighting is switched on. Each light could be fitted with a light sensitive cell or one cell could be used via a contactor to control a number of lights. In this case, failure of the control circuit could result in a number of luminaires failing to light. To avoid this problem, alternate lights could be connected on a different control circuit.

A time switch can be used in which case it should be fitted with a solar dial so that it automatically adjusts for changing day length. Although more expensive, any time switch should have a reserve spring or inbuilt battery backup so that it maintains the correct time after power failures. It is possible to use a combination of photocell and time switch where the security lighting is not required to be on during all the hours of darkness.

Systems are now available which allow remote operation. These provide a high degree of control to operators where the individual lights can be overlaid on an area plan on a touch screen monitor, this then allows lamps to be operated to complement CCTV viewing.

Typical photocell mounted on the wall of a building

Power and cabling considerations

Supply and control cables should preferably be buried with suitable (to the authority involved) protective measures. The method of cabling will depend on the security of the supply which is required.

Local authorities run buried three phase and neutral cables radially from local substations to provide street lighting supplies. Each lighting column is powered by a single phase cable connected directly onto the main feed cable. The columns are split over the three phases to provide a balanced load. By coincidence this also means that only one in three lamps will be extinguished should a fuse blow.

While this radial system may be employed, a better variation will be to loop the main feed cable into each of the light columns using a “cut-out” connector. This connector allows a fused single phase feed to be taken to supply the luminaires on the column. In the event of a main cable fault the radial circuit arrangement allows the faulty section of cable to be easily isolated, allowing all the lighting up to that point to be quickly restored. To further improve supply security the main feed cable can be run back to the point of supply to form a ring. In the event of a fault anywhere on the cable the fault can be isolated at the adjacent columns which will then allow the system to be restored, fully functional, as “two radial” circuits until repairs can be made.

For higher security of supply, two three phase ring circuits can be used, the rings looping into alternate columns. This would mean that in the event of a fuse blowing only one in six lights will be lost. If required each ring could be fed from different transformers at the site substation further increasing the protection.

Where standby power supplies are provided it must be remembered that, except where Uninterruptible Power Supplies (UPS) are used, it may take up to 20 seconds for the supply to be restored after an incoming supply failure. Discharge lighting will take a further period of time before a significant level of light is produced. Generally, because of the high capacity required, battery powered UPS cannot be used (except within individual non-maintained luminaries utilising multiple lamps). Rotary UPS are available but are expensive.

Columns & Hardware

Lighting columns should conform to BSEN 40 and PD6547. The choice of columns and hardware will depend on the type of scheme chosen and the power arrangements, (will cables need to loop into each fitting?).

Lighting columns must not provide an aid to any intruder, for this reason it is always recommended that columns be positioned at least 2.0 metres from any fence line to avoid creating a climbing aid.

SL Column with outreach arm

Security measures to prevent anti-climb such as spikes or non-drying paint may be deployed. It should be recognised that outreach arms have also been used to circumvent protective measures on fences.

Covers giving access to fused cut-outs should require a tool to open or be fitted with a lock. Where a specific threat is identified intrusion detection may be fitted.

The maximum height of columns should be specified. If designers are given a free-hand they will opt for the most cost effective solution which may utilise a high-mast, the problem with this is that if the mast were to be 'lost' it will leave a large area without illumination. A recommended maximum height would be 8.0 metres.

Other consideration for choice and location of columns may include:

- Environmental situation, eg. costal salt corrosion
- Weather, in particular wind loading but also temperature.
- Need for clearance from fences to allow grounds-maintenance.
- Avoiding obstructions, eg. Buried or overhead cables, trees etc.
- Avoid creating an obstruction, eg. roads, gates, dropped kerbs.
- Operational site requirements, for example on airfields or radar sites.
- Visual impact, eg. Residential or countryside locations.
- Road safety. BS5489-1, table 2 defines minimum clearance from carriageways
- Local Authority Regulations

Consideration should be given to installing lowerable columns to assist maintenance. While more expensive to procure they can reduce the system through-life-costing where it is not practical to undertake maintenance with normal access platforms.

Manufacturers employ different approaches which range from columns hinged in the middle (Stanton), employing a ratchet arrangement (Mallatite), hinged counterbalance (Cargo Loops), or as in the picture (Abacus) where specialised lowering equipment is used. In addition to the cost of the columns, they must be regularly maintained and staff must be trained in their use.

Demonstrating a one-man column lowering tool

Maintenance

General

With any security system, the cost and effort of installing the measures will be wasted if the system is not properly maintained. Light output from a fitting falls over time due to both degradation of the lamp and build-up of dirt on the luminaire, (this can be a particular problem at some coastal sites). Figures often quoted are 15% reduction after 12 months, 20% after 2 years, 26% after 3 years.

Reference is made to the maintenance recommendations in the CPNI Guidance Document for Security Systems Implementation(3) together with BS5489-1, Annex B, table B1 which lists various maintenance factors for different environments and Annex C which addresses the particular problems with LED Luminaires.

Purpose of Maintenance

Maintenance of the Lighting System should fulfil 3 distinct functions.

Corrective Maintenance: Suitably qualified and security vetted technicians should be available to respond by attendance to carry out on-site emergency repair or replacement of lamps and luminaires. Response time will depend on how critical the lighting is to the site.

A log should be maintained of which lamps are being replaced. This can identify design issues, (column vibration, temperature issues etc), if some lamps fail more often than others.

Preventative Maintenance: Routine servicing and preventative maintenance of the system should be undertaken, typically annually, (this should be done in late summer / early autumn before the longer nights start). Luminaires should be cleaned and any defective lamps replaced.

During maintenance broken lamps or luminaries should be regarded as suspicious and any sudden 'misalignment' should be investigated. If the log of replaced lamps indicated an increasing failure rate then consideration must be given to replacing all remaining lamps.

Planned Refurbishment Cycle: Managed, planned refurbishment and replacement programmes to renew all principal system components on a repetitive cycle should be implemented. This should include the principle of 'block lamp replacement' which would be undertaken as part of the preventative maintenance visit. The length of this cycle will depend on the predicted life of the lamps, recognising that some lamps don't fail 'catastrophically' but suffer decreasing lumen output and for LED lamps this would involve replacing the luminaire.

Requirements

The maintenance should be undertaken within the provisions of:

- The Health and Safety at Work Act 1974.
- BS7671 – Institute of Electrical and Electro-Mechanical Engineers current Edition.

The system shall have quantifiable reliability and availability. The maximum unavailable time for any individual fitting should not exceed 12 hours in any calendar year with the maximum unavailability time for the overall system not exceeding 6 hours in any calendar year.

The maintenance company should set up and maintain its own system record within an authorised access only environment. System Records should be up to date and made available to the maintenance technician as required. These will include plans or sketches, maps showing the building(s), the security system design, detailing the location of columns, sensors and control equipment. All lighting columns or wall mounted fittings must be asset tagged and logged in a security asset register. Details should include type and make of luminaires, date of installation, date of last lamp replacement.

A Historical Record should be maintained and contain the date of every visit, fault, cause, repair and/or change of equipment.

A Preventative Maintenance Record should contain details of every such visit, including date, faults, causes, repair, change of lamp or equipment and name of maintenance technician. Each visit should be signed off by the nominated Site representative who retains a copy.

A Corrective Maintenance Record should contain details of date/type of request for service, date/type of attendance, record of action taken/agreed and date of completion of corrective action. Such records should be signed off by the nominated Site representative and a copy retained.

Disposal

A clear policy should be in place regarding the disposal of lamps as many of them will contain toxic metals and other material. These present a hazard not only to personnel but also to the wider environment.

Audit, Review & Operation

To retain the capability of any security system it must be controlled and monitored. For security lighting installations this will involve carrying out regular audits together with reviews of the system Operational requirements.

Why take readings?

The main reason we would wish to take measurements is to establish the existing conditions on a site, to make reference to standards and following an installation to confirm that requirements have been met.

The key to any measurement can be summarised in one word, '**Repeatability**'. This means being clear about what readings are being taken, exactly where the measurement is made and having confidence that the instrument being used is accurate. Guidance on light meters and their use is included at Appendix D.

Audit Requirements

As with all security measures, Security Lighting schemes should be regularly reviewed, not only to assess that they are still functional and still meet the requirement but further, that the Operational Requirement should be reviewed in the light of any changes to security policy and threat.

It is not unusual to be asked to reduce energy consumption while still maintaining specified levels. New innovations / improvements are always being made but usually these can only be realised on new / replacement systems and not through upgrading existing installations. Any reduction in energy consumption costs (for example by fitting higher efficiency ballasts for discharge lighting or changing the light source to compact Fluorescent or LEDs) will be gained by a measure of capital expenditure which must be considered as part of the through-life-costs. Difficulties tend to arise because of the physical aspects which can be costly to alter (Column spacing, mounting heights etc).

Matching Threat Levels

The issue regarding reducing lighting (levels) at lower security threat levels is one which is constantly being considered. Work has been undertaken in the past, examining the usefulness of 'dimming ballasts', the aim being primarily to provide a minimum level of lighting which could then be 'stepped-up' in the event of an intruder being detected by an external detector. This offered the ability to give both lighting for the guards plus deterrent 'scare' lighting against an intruder.

Where, as has happened in the past, one lamp in three is taken out to save running costs, the system is compromised with dark and light patches which both aid any intruder and disadvantage the guard force.

Ultimately the lighting should be designed to meet the need. The key to good lighting being the uniformity – not the illumination levels. The operation and function of the whole system can be reviewed. If the security levels drop such that the lighting is not needed then it should be switched off and put on a ‘care-and–maintenance’ regime until it is needed. Alternatively circumstances may allow switching off sections and leaving others. It must be recognised that this may have the effect of ‘displacing’ any intruders into the ‘darkened’ sections.

Future Trends

The lighting industry reacts to influences placed upon it; these can take many forms but include:

Social. The industrial revolution created urban conglomerations to house workers which resulted in the need to provide night time illumination to create a safe environment. Over time more people have moved to suburbs where they expect minimum quality of lighting. The industry has reacted with the development of lighting schemes to meet what have become demanding needs. Those involved with security lighting must recognise that expectations are changing not only with regard to quality but also to cost.

Specifications. New methods of specifying lighting (metrics) are being examined to ensure desired outcomes in terms of both efficiency and human needs are met. For indoor lighting EN15193 defines the Lighting Numeric Indicator, (LENI), which can be quoted as part of building specifications while the Ergonomic Lighting Indicator, (ELI), balances Performance, Appearance, Comfort, Emotion and Individuality. These have been promoted for over ten years. For external lighting it has been recognised that defining Horizontal illumination is a compromise which has been accepted because of the difficulty of measuring semi-cylindrical illuminance, however developments in measuring instrument technology may make this viable in the future. Consideration is also being given to redefining the Lumen to take into account knowledge gained from neuroscience insight into the way the human eye functions.

Technical. Technological innovation has allowed the development of new light sources which offer improved spectral performance, increased life and lower running cost. At the end of the 20th century, CFL was seen as the answer to expensive incandescent lamps but in the first decade of the 21st century these were being replaced by LED technology which held out the promise of low cost 'white' lighting, although as experience showed, the early LED lamps had significant problems which were not resolved for several years. Work is currently underway on other alternative lighting technologies such as Electron Stimulated Luminescence and Field-Induced Polymer Electroluminescence Lamps which in time may supplant LED based lighting as the dominant technology. Other innovations include the ability to use LED lamps to transmit data offering the possibility of using external lighting to create wire-free communication network.

Environmental. Pressure to improve the environmental impact of not only installed lighting schemes but also of the equipment being used has, and will continue to drive the lighting industry. To reduce the effect of installed systems limits have been placed on upward light output effecting not just luminaire design but also lamp choice. Manufacture of inefficient light sources such as the GLS Incandescent Lamp have been banned in Europe and the removal of toxic material, such as mercury in High Pressure Sodium lamps has been taken in North America and is likely to follow here. This drive to remove toxic material may also lead to the demise of the once championed CFL lamps.

Many roads, including motorways like the one shown, are being illuminated by LED luminaires in place of SOX or SON lamps. These reduce running cost, give improved colour rendering and as can be seen minimise the contribution to light 'pollution'. For anyone travelling on a night-flight into a modern city the change can be dramatic with older lamps standing out as individual points of light while LED illuminated road appearing as low-glare 'rivers-of-light'.

Final Word. We are living in a time of rapid and dramatic change in the way we artificially light the environment in which we live and work. Security Lighting may only form a small part of these changes but those who are involved should embrace the benefits which will ensue.

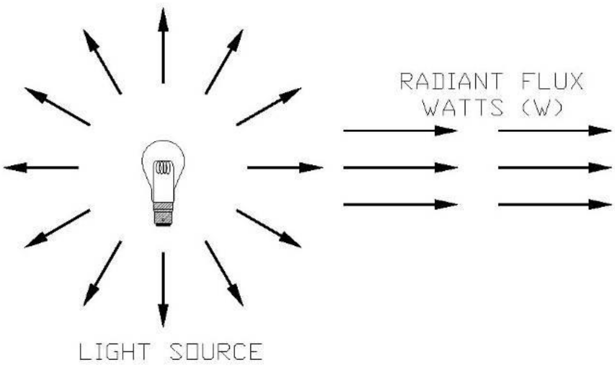
APPENDIX A - LIGHTING UNITS

Transfer of Energy

The energy emitted from a light source, Electromagnetic Radiation, can be measured in terms of its heating effect by the use of a thermopile.

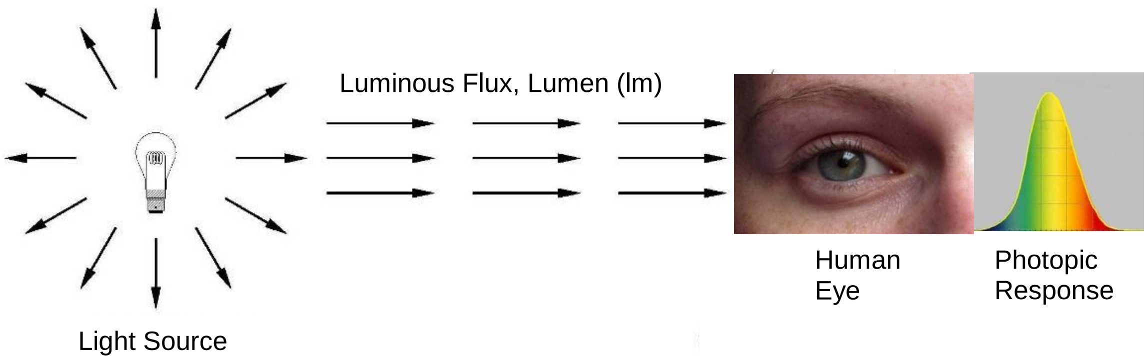
This measures the RADIANT FLUX in JOULES per SECOND or WATTS.

This does not take into consideration the Wavelength, (Spectral Response), of the radiation.

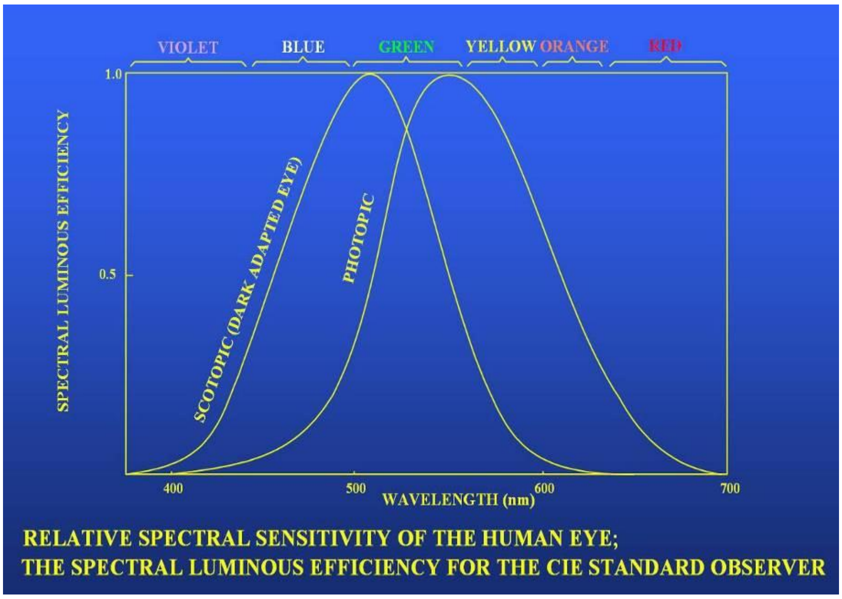


Human Observer

Humans see light in what is called the visible range of the Electromagnetic spectrum. This includes all the colours beginning with red and continuing through orange, yellow, green, blue, and violet. Some people can see farther into the violet region or the red region than other people.



To provide an indication of how the human eye will respond to Electromagnetic radiation a typical response curve for a human eye was drawn up and internationally agreed. This is the Photopic or Vλ curve which when applied to the measure of Radiant Flux gives the LUMINOUS FLUX of which the unit is the LUMEN. By definition one Watt of radiation at 555 nm is equal to 682 lumens.



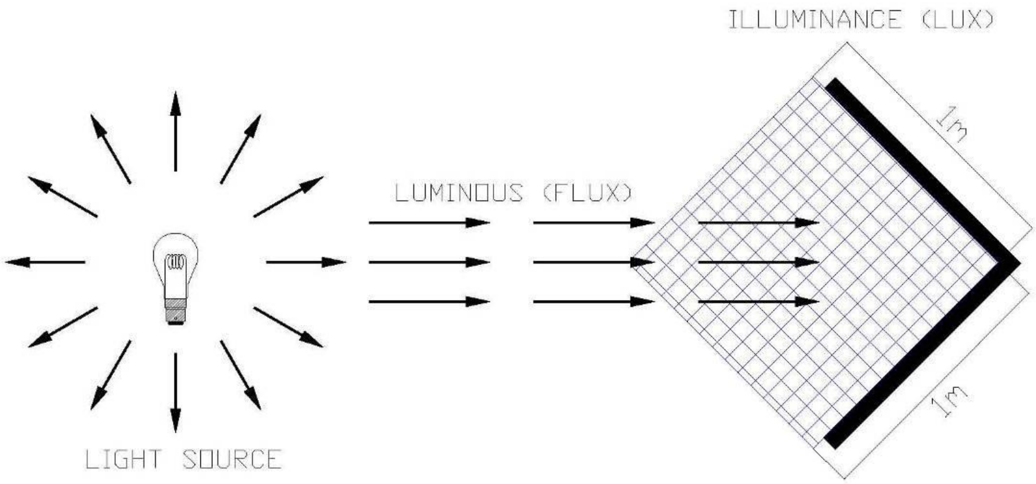
The Photopic curve applies when lighting levels are above 1.0 LUX. Below this level the eye becomes increasingly responsive to shorter wavelengths, (Purkingie effect), until at levels below 0.1 LUX the Scotopic curve applies. Between the two curves is the Mesopic region and occurs as the dominant receptors in the eye change from cones to rods.

There are moves within the lighting community to develop a 'mesopic lumen' following work by Dr Lewin in the early 1990s. This work recognised that the human visual experience changes under lower lighting levels and suggested 'correction factors' which could be applied to different light sources. If adopted this will change the way the efficacy of different sources are considered (benefiting LED arrays and the Metal Halide lamps over Sodium – particularly low pressure Sodium - sources)

When scenes are viewed with a CCTV camera, benefit is made of the sensors extended sensitivity into the infra-red. It is important to recognise that the visible lighting units defined will no longer apply.

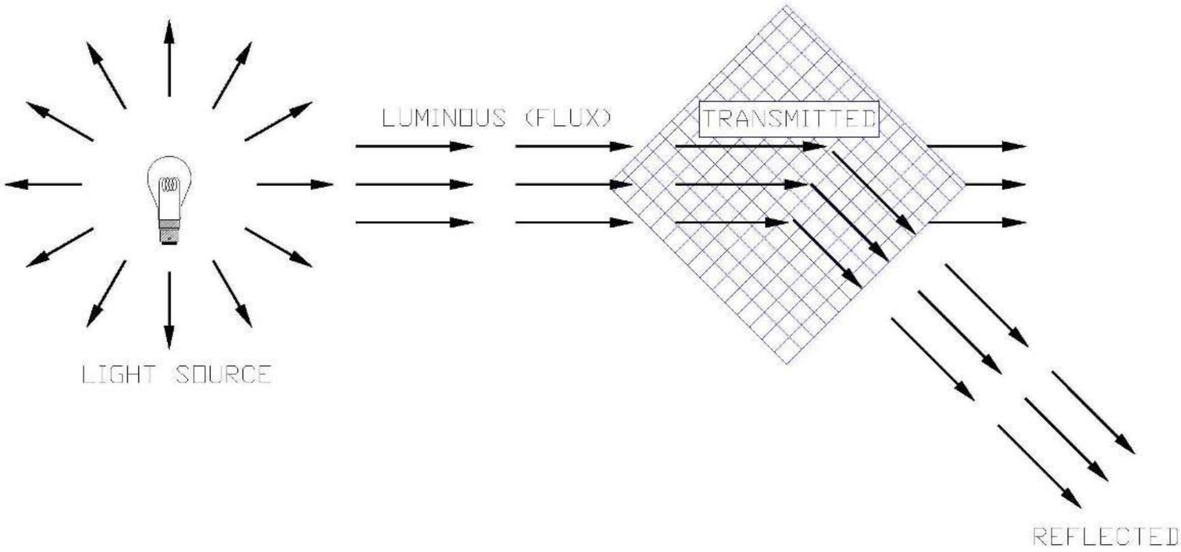
Light on a Surface

For design purposes it is required to know the amount of Luminous fLux incident on a particular surface. This is known as the value of ILLUMINANCE unit of which is the Lumen per Metre Squared or more commonly the LUX. This is an illuminance of one lumen over an area of one square metre.



Reflected or transmitted

Light falling on a surface may be absorbed (totally, if black) with a proportion being reflected back (or transmitted through). This is the 'Luminous Exitance' and is the illuminance multiplied by either a reflectance factor when the light is reflected back or a transmission factor. The units are lm/m².



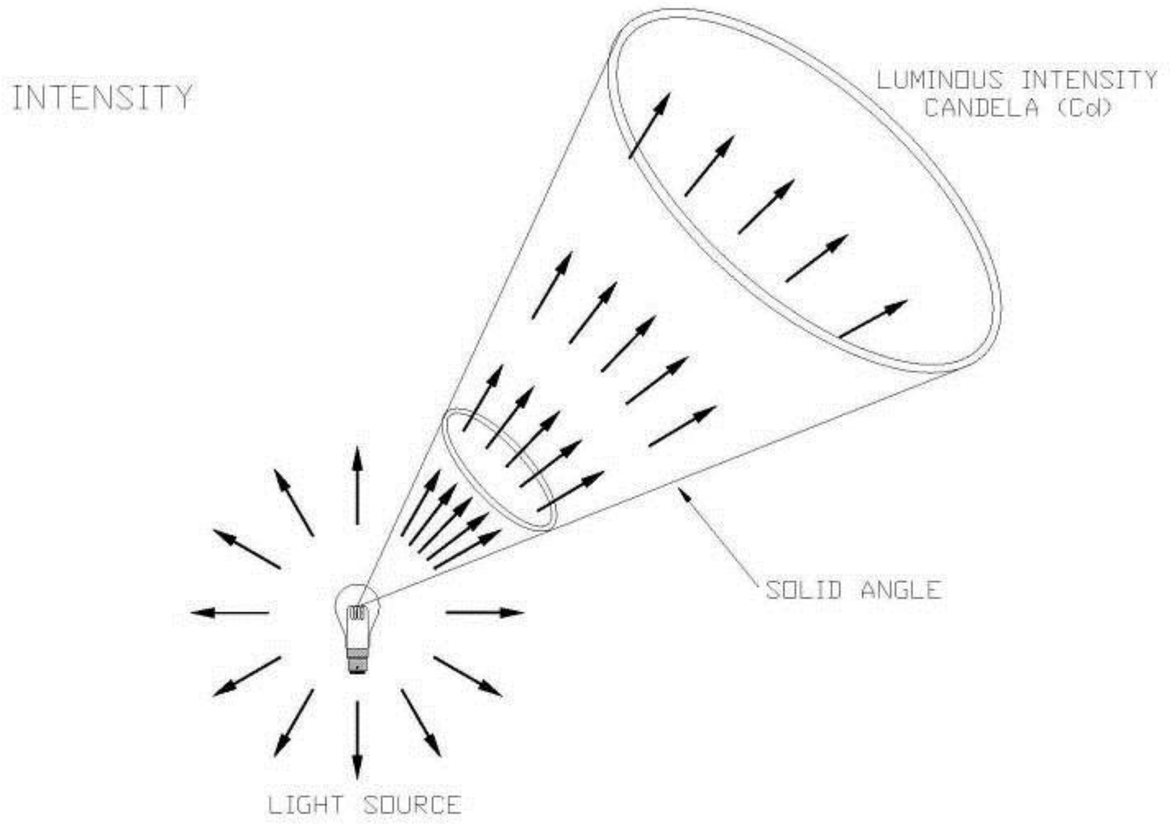
Typical Reflectance values for visible light include:

- Asphalt 5%
- Foliage 10 - 20%
- Concrete 25 - 30%
- Red Bricks 35%
- White Matt Paint 60%
- Glass 70%
- Snow 95%

Intensity

The illuminating power of a light source is dependent on the number of Lumens radiated in a given direction, which is the number of Lumens per unit solid angle, (Steradian).

This is the LUMINOUS INTENSITY the unit of which is the CANDELA.



.
The clarity with which an object can be seen depends in part on the amount of light that falls on it, i.e. how well it is illuminated. The amount of light that a light source gives off in a particular direction (called its intensity) is one factor in determining how well a surface will be illuminated by it. Other factors are the angle of the illuminated surface in relation to the light source and the distance between the surface and the source.

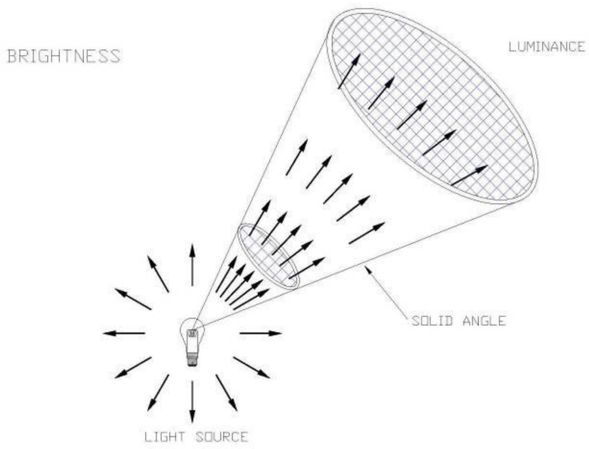
As light travels outward from most light sources the beam spreads to cover a larger area, (the exceptions include lasers and searchlights). Distance reduces illumination from such sources. The same amount of light will cover a larger area if the surface it reaches is moved farther away. This results in weaker illumination, following the inverse-square law. If the distance from the source is doubled, the amount of light falling on a given area is reduced to one fourth, (the inverse of two squared). If the distance is tripled, the area receives only one ninth of the original illumination, (the inverse of three squared).

Brightness

A surface can become like a light source. The physical brightness of the surface or luminance is the intensity per unit area in a given direction.

The unit of luminance is the CANDELA per SQUARE METRE (of apparent surface in a given direction).

It should not be confused with Illuminance.



Efficacy

To be able to determine the cost effectiveness of a lighting installation it is required that the ability of the lamp to convert electrical energy into useable light be established. This is called the LUMINOUS EFFICACY and is measured in LUMENS per WATT. It is Important to note that the actual power dissipation of a complete luminaire will include the losses for the control gear and may not be the same as for the lamp alone.

The principal lighting units are summarised in the following table:-

LIGHTING UNITS			
Φe	RADIANT FLUX	W	WATT
Φ	LUMINOUS FLUX	lm	LUMEN
E	ILLUMINANCE	lm/m^2	LUX
M	LUMINOUS EXITANCE	lm/m^2	
I	LUMINOUS INTENSITY	cd	CANDELA
L	LUMINANCE	cd/m^2	
K	LUMINOUS EFFICACY	lm/W	

APPENDIX B – LAMP CHARACTERISTICS

Lamp types

There are many lamp types which are used for security applications, these include:

- Low pressure sodium (SOX)
- High pressure sodium (SON)
- Mercury discharge
- Metal halide
- Incandescent
- Tubular fluorescent
- LED

All have their own distinct properties which are covered below

Summary of Lamp Properties						
Lamp	**Wattage range Watts**	**Efficacy**	**Life Hours**	**Re-strike Minutes**	**Colour rendering RA**	**Colour temperature (Deg K)**
Tungsten Halogen	40 - 2000	16 - 36	2000	Instant	100	3200
Fluorescent	8 - 12	0 -75	5000	Instant	50-98	2700 – 6500
CFL	7 – 120	45 – 90	8000	Instant	82 – 89	2700 – 6000
Mercury	50 – 2000	30 - 70	7500	5	42 – 52	3300 – 4200
Metal Halide	75 – 2000	65 – 115	15000	4 – 5	60 – 93	3000 – 10000
SOX	18 – 131	67 – 165	8000	Instant (when hot)	0	1800
SON	50 – 1000	55 – 110	10000	1	60 – 80	2000 – 3000
Induction	80 – 100	65	60000	Instant	80	3000 – 4000
LED	50 – 270	50 – 85	20000	Instant	80	3000 - 10000

Incandescent Filament lamps (GLS & Tungsten Halogen)

These provide full light output instantly and have lives from 1000 to 2000 burning hours. Their efficacy (light output for energy consumed) ranges from about 12 lumens per watt (12 lm/W) to 25 lm/W. They are suitable for a range of applications from lighting domestic premises to industrial checkpoints where higher lighting levels may be necessary for vehicle checks and where lamp failures can be readily replaced. Their low efficacy may be unimportant if only a few lamps are involved, however high energy consumption make them uneconomic for use on a large scale.

Tungsten halogen lamps are the more efficient and have the longer lives. Filament lamps are not recommended for perimeter systems because of the maintenance problems and their high power consumption. Failure mode is usually due to thermal shock on switch-on. This means that no amount of 'testing' will ensure the lamp will work when you need it.

European legislation stopped the manufacture GLS lamps above 100W from September 2009 with lower wattages following the following year. This was to encourage domestic users to change to more energy efficient alternatives.

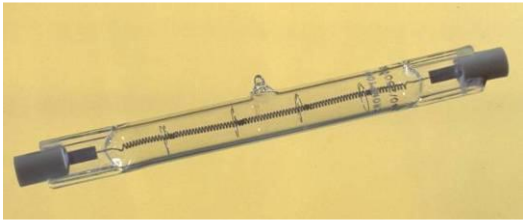
GLS lamps

Wattage range:	40 to 2000
Efficacy:	10 to 18 lm/W
Life:	1000 h
Starting –	Instantaneous
Restrike -	Instantaneous
Colour rendering	Ra 100
Colour temperature	2500 – 2700 (K)

TH Lamp in a luminaire

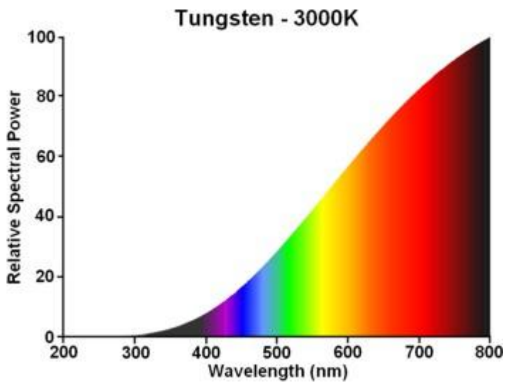
TH Tungsten-halogen lamps

Wattage range:	200 to 2000
Efficacy:	16 to 36 lm/W
Life:	2000 h
Restrike:	Instantaneous
Colour Temperature	3200 (K)



Tungsten Halogen Lamp

Colour Chart illuminated by TH Lamp



Typical Spectral Output

Tubular Fluorescent lamps

Largely superseded by Compact Fluorescent and other lamps these can still be found inside buildings for surveillance of secure areas, safety of patrols, etc. At temperatures below -5^{o}C these will come on at 50% output which will increase over time as the temperature increases, at lower temperature the manufacturers quoted output may not be reached.

MCF Tubular fluorescent lamp

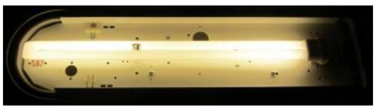
Wattage range: 8 to 125

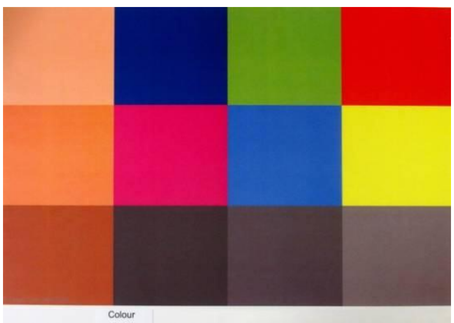
Efficacy:	0 to 75 lm/W (Efficacy depends on 'colour' chosen)
Life:	1.2 m and longer 7500 h; others 5000 h
Starting -	quick (1-3 sec.) at around 70-80% output indoors,
Restrike:	Immediate
Colour rendering	50 to 98
Colour temperature	2700 – 6500 (K)

CFL Compact fluorescent lamps

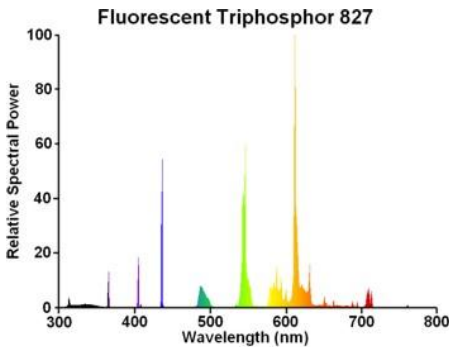
Marketed as a replacement for GLS lamps this technology has been largely superseded by LED and other lamps. Can be used for event-activated-lighting (not recommended) but switch must be suitable for inductive loads. A larger version employing 55W lamps has been successfully used on the government estate providing perimeter lighting which can be turned on at 50% light output (subject to temperature being above -5 deg). The long length of the tubes does not allow good optical control of the light requiring luminaires to be spaced at 16 meters with mounting height of 4 meters.

Wattage range:	7 to 120
Efficacy:	45 - 90 lm/W
Life:	8000 to 10,000h
Restrike:	Immediate
Starting -	quick (1-3 sec.) but initially at low output, particularly in cold weather. Full lighting output can take several minutes.
Colour rendering	Ra 82 – 89
Colour temperature	2700 – 6000 (K)





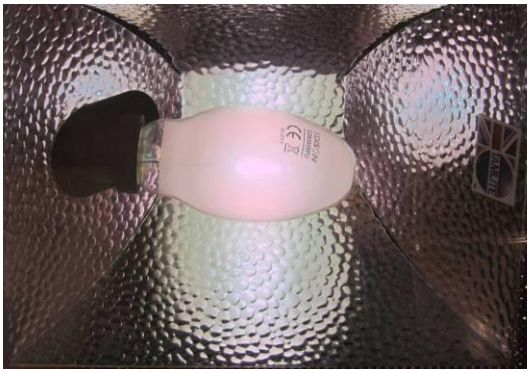
Colour Chart illuminated by CFL Lamp



CFL Typical Spectral Output

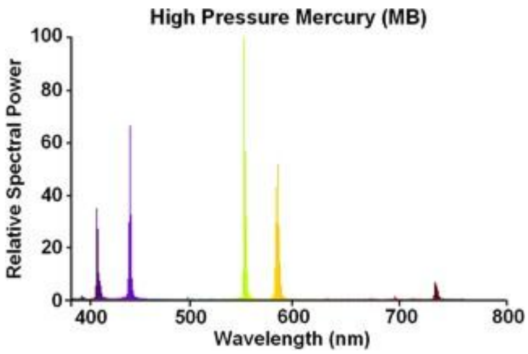
Mercury discharge lamps

While popular in the past (for reasons unknown) these are now seldom seriously considered for security lighting. They do have the merit of reasonable colour rendering but are not as efficient as other discharge lamps. Their biggest disadvantage is that when extinguished by even the briefest supply interruption they must cool down before they will relight, which can involve a 20 minute delay.



MBF Colour-corrected mercury discharge lamps

Wattage range: 50 to 2000	
Efficacy:	30 to 70 lm/W
Life:	7500 h
Restrike:	5 minutes or longer.
Starting -	slow 4-5 minutes to 80% output.
Colour Rendering	Ra 42 – 52
Colour Temperature	3300 4200



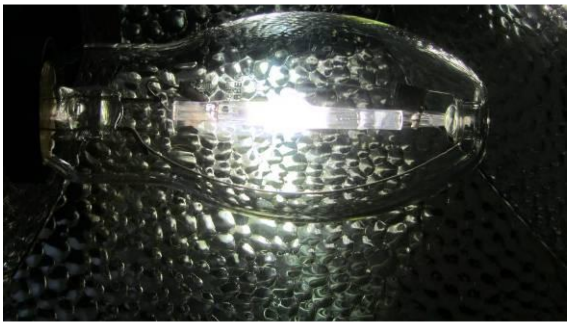
Typical Spectral Output

Comparison of MBF lamp against ‘daylight’

Metal halide lamps

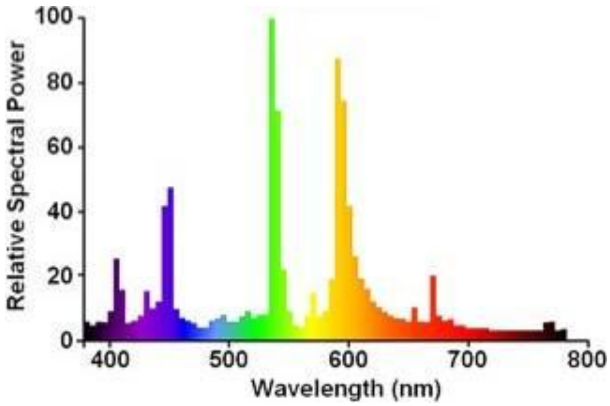
These have quartz or sintered alumina (ceramic) arc-tubes. Most lamps have an outer glass bulb. Light output is from mercury and from other metallic elements introduced in the form of halides. Lamps with very low ultra violet output have now been introduced which incorporate UV absorbing quartz. Efficacy is better than mercury discharge cool white light gives reasonable colour rendering

Wattage range:	75 to 2,000
Efficacy:	65 to 115 lm/W
Life:	15000 hours
Restrike:	4-5 minutes
Colour rendering	Ra 60 - 93.
Colour temperature	3000 - 10000



Metal Halide Lamp

Colour Chart illuminated by MBI Lamp

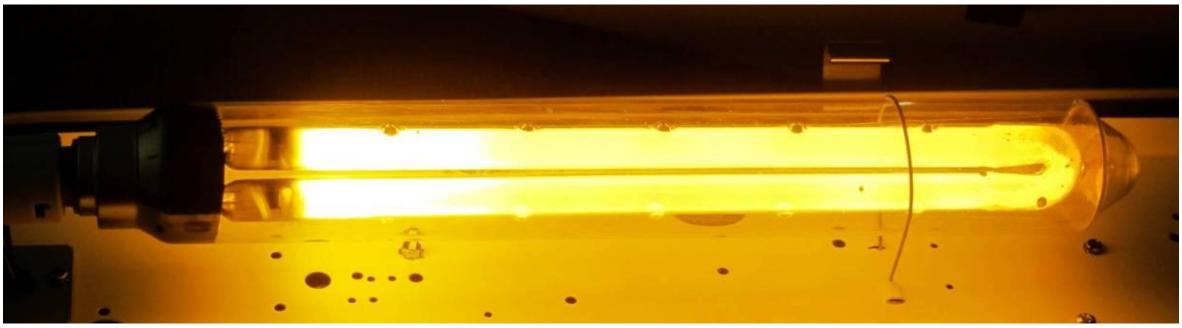


Typical Spectral output

Low pressure sodium lamps (SOX)

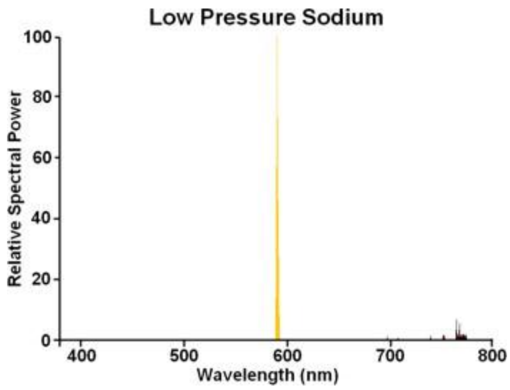
SOX was the lamp-of-choice in the 1990s but has been superseded by other lamp technologies since. In terms of efficacy this type of lamp gives around 130 lm/W, but without any colour rendering, being an almost monochromatic orange-yellow. It must be noted at lower lighting level where the sensitivity of the eye moves to the blue end of the spectrum, Purkinje effect, or with CCTV cameras where peak sensitivity is in the blue end of the visible spectrum the real efficiency of this source is reduced.

When first switched on they take several minutes to reach full light output, but modern electronic control gear ensures an instantaneous restrike after a supply interruption if they are still hot. Their life is around 8000 burning hours.



SOX Low pressure sodium lamp

Wattage range: 18 to 131	
Efficacy:	67 to 165 lm/W
Life:	Circa 8000 h
Restrike:	Igniter circuits instantaneous
while lamp is hot.	
Starting -	slow 4-5 minutes to 80% output
Colour Rendering	0
Colour temperature	1800 (K)



Monochromatic Spectral Output

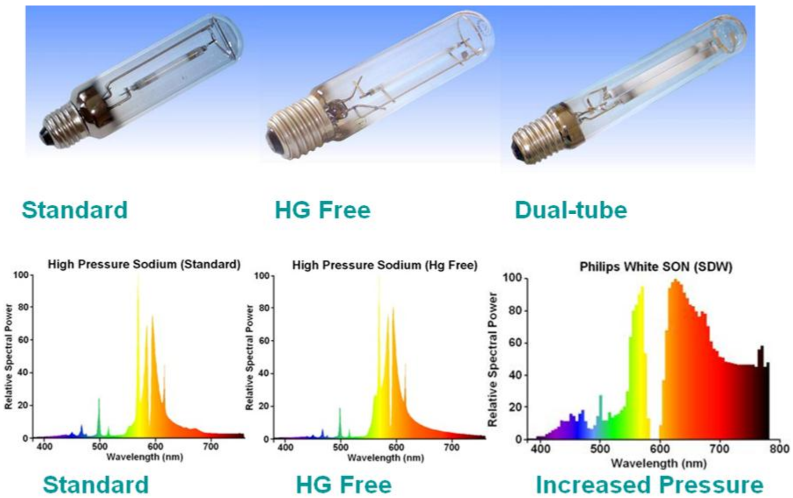
Comparison of MBF lamp against 'daylight'

High pressure sodium lamps (SON)

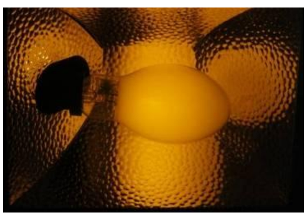
SON was the lamp-of-choice up to 2010 but has been superseded by other lamp technologies since. They have a high efficacy - around 80/100 lm/W, a life in excess of 8000 hours, and reasonable colour rendering. Igniter circuits ensure starting at low temperatures and a restrike within one minute in the event of a supply interruption extinguishing the lamp.

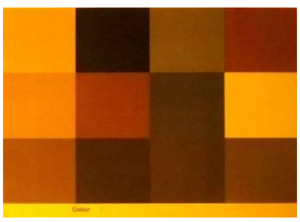
The light is generated by an electrical discharge in a gas containing sodium and mercury (sodium amalgam), contained in a sintered alumina arc-tube. Mercury free versions are available. The compact size of the lamp lends itself to good optical control and luminaires range from recessed units for commercial interiors to medium beam floodlights.

Wattage range:	50 to 1000
Efficacy:	55 to 110 lm/W
Life:	Most ratings in excess of 10000 h
Restrike:	Igniter circuits usually within one minute.
Colour rendering	Ra 25(Std)
Ra 60 (DeLuxe)	
Ra 80 (White SON)	
Colour temperature	2000 -3000



Spectral Output from different Sodium Lamps





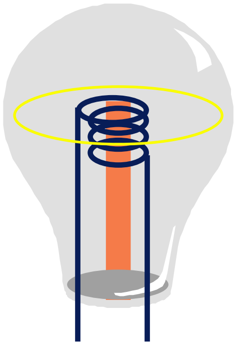
Colour Chart illuminated by standard SON

Colour Chart illuminated by ‘white’ SON

Induction Lamps

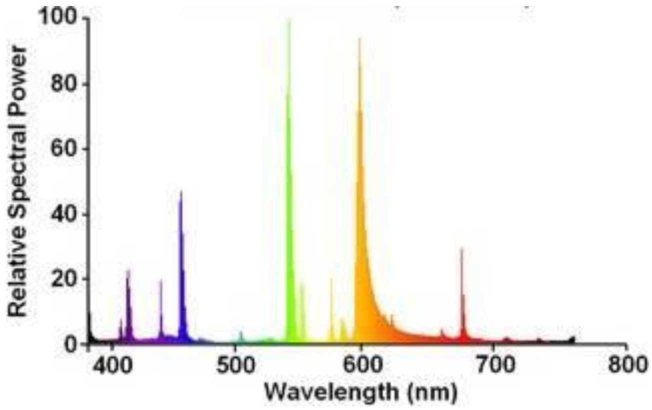
Induction lamps utilize a coil inside the lamp envelope through which a high-frequency electrical signal is passed. The resulting RF field excites phosphors on the inside of the lamp envelope, (much the same way that UV radiation excites the phosphor in the mercury lamp), producing visible light. This simplifies construction and extends lamp life.

In essence these are fit-and-forget lamps which due to the requirement for RF screening would normally be supplied as part of a luminaire, (recognising that the luminaire will still need cleaning). Applications include difficult access locations such as oil rigs or nuclear installations.



Low power consumption – 85 watts

Efficacy –	65 lumens per Watt
Life –	60,000 hours
Colour rendering	Ra 80



Typical Spectral output

Colour Chart illuminated by MBI Lamp

Induction Lamp Demo unit

Light Emitting Diodes LEDs

The White Light Emitting Diode was developed in 2000 and is essentially a 'blue' LED which makes use of phosphors in the LED encapsulation to produce 'white' light. Once LEDs were the province of specialist illuminators (ie. Infra-red) but since the development of 'White-light' LEDs they represent the 'lamp-of-choice'.

LEDs offer long life, high efficiency, instant start, fully dimmable, low toxicity solid state vibration resistant components, however there are design issues. One problem is that the life of the components is temperature critical and as the output from a single LED is relatively small manufacturers initially 'bundled' LEDS together which gave heat dissipation issues dramatically reducing lamp life. This has been overcome by the expediency of separating the LED in the luminaire providing each with a suitable heat-sink and utilising individual optical control on each LED.

Small LED Luminaire

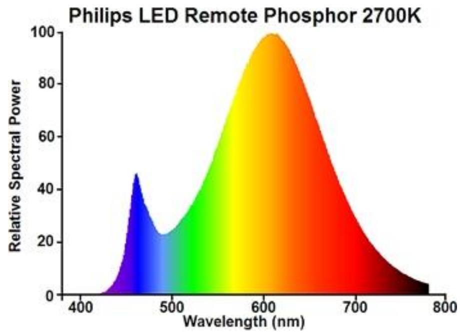
Some manufacturers offer LED arrays designed to replace existing High Intensity Discharge Lamps. These offer the same lumen output as the lamps they are to replace, however the luminaire photometric output is designed around a much smaller arc tube so the results can be unpredictable. If in doubt ensure that any change is undertaken against a clear Operational Requirement detailing the required illumination required in the scene.

LED Retro-fit Lamp

LED Street Lighting Lantern.

Wattage range: 50 to 270 W

Efficacy:	50 to 85 lm/W
Life:	in excess of 50000 hours
Restrike:	Instantaneous
Colour rendering	Ra 80.
Colour temperature	3000 – 10000



Colour Chart illuminated by LED Lamp

Claimed Spectral Output

APPENDIX C - LIFE CYCLE COSTS

When procuring any security system it is important that the whole life cycle costs be considered. It is not unknown for systems to be installed only for sites to find that they cannot afford to operate them. In the case of Security Lighting options to reduce running costs are limited, usually to the replacement of the luminaire/lamp combination. Sites are advised not to adopt the expedient where every second or third lamp is extinguished, this has the effect of reducing the value of the scheme – in practice sites considering this would be better advised to switch all the lights off, leaving the installed system for use should their threat level or other circumstance change.

Comparison between HID and LED

The following table offers a comparison of the life cycle costs between a conventional High Intensity Discharge Lamp (HID), and a two Light Emitting Diode (LED), luminaires available in 2013.

Assumptions made are:

Lamp Usage 4300 Hours per year (British Standard Hours of Darkness)
Life Cycle Period 15 years

HID Lamp High Pressure Sodium, SON with RA >80, 150 Watt lamp + 15 Watt gear loss. 15000 hr life to 20% fail

LED Luminaire 170 Watt + 2 Watt drive loss. Operating Temperature >25°C, 50000 hour life to 70% lumen output, L70.

LED Luminaire 288 Watt + 2 Watt drive loss. Operating Temperature >25°C, 128000 hour life to 70% lumen output, L70.

Aspect	**HID**	**LED 1**	**LED 2**
Unit Cost of Luminaire	£240	£345	£657
Life Expectancy	15000 hours	50000 hours	128000 hours
Re-lamp/replace every	3.5 years	11.6 years	29 years
Maintenance Material cost	£15	£345	n/a
Maintenance Labour cost	£15	£30	n/a
Annual Replacement cost	4 x lamps £8.00/year	1 x lamp £25.00/year	n/a
Electricity Cost	£0.10 KWH	£0.10 KWH	£0.10 KWH
Annual running power	709.5 KWH	309 KWH	430 KWH
Annual running cost	£70.95	£30.96	£43.00
Average Annual Cost	£78.95	£55.96	£43.00

Exclusions

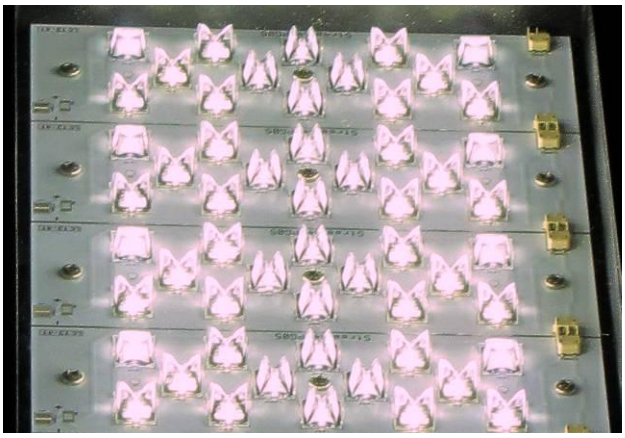
Disposal There is a cost associated with the disposal of Sodium lamps and while the LED Luminaires are deliberately designed to be recyclable there will be both a functional and administrative cost burden.

Comments

1) A particular variable is the unit cost for electricity. This will be different for each site and significant discounts are offered to some users, particularly local authorities and government bodies. A low figure can make it hard to justify a realistic pay-back time if considering replacing an existing lighting installation. If a justification is necessary it may be better done on the reduced environmental impact a change to the design may have.

2) Manufacturers' claims for lamp life can be difficult to authenticate with a product which has only recently been available on the market.

3) At the time of preparing this document the quality and performance of LED illuminators has gone through a radical change. Early designs saw LEDs clustered closely together with the associated problems with heat dissipation. Later designs with the LEDs separately spaced had difficulty with optical control of the light. Problems also occurred with the electronic control, the internet abounding with horror stories of poor reliability and failure rates. In recent time, LED technology has advanced producing higher output elements with individual optical control and higher reliability.



Individual Optical control applied to LEDs in a street-lighting luminaire

4) Maintenance factors for LED luminaires differ from those for HID luminaires. Advice is included in Annex C of BS 5489-1 and in the Lighting Industry Liaison Group document, 'A guide to the specification of LED lighting products, 2012'.

APPENDIX D - MEASURING LIGHT

Why take readings?

The main reason we would wish to take measurements is to establish the existing conditions on a site, to make reference to standards and following an installation to confirm that requirements have been met.

There are a number of properties which can be measured which include:

- Horizontal Illuminance.
- Vertical Illuminance.
- Uniformity (of Illuminance)
- Luminance.
- Spectral Content (colour temperature)

It is essential that any readings taken are repeatable. To achieve this, the following points should be observed:

- The measuring instrument must be calibrated, preferably showing traceability back to a National Standard.

- The response of the instrument must be checked to ensure that it is suitable for the light source being measured. Photocells do not have a totally linear response and must be suitably corrected for the intensity being measured. Also the spectral response of the cell will differ from the photometric response of the human eye, Vλ, and a correction filter must be fitted or a correction factor applied appropriate to the light source.

- The measuring instrument must be corrected for cosine error due to light falling on the cell at an angle. This is normally done by placing a dome above the cell.

- The conditions under which the readings were taken should be recorded, including temperature, if there were any extraneous light sources which could not be avoided etc.

- Readings should be taken at known positions. For uniformity measurements this may involve marking out the area in a grid using stakes and tape. For reference purposes the Lighting columns should be numbered.

- Readings should not be taken at ground level but at a height above, recommended 100mm, to avoid problems with uneven ground, reflection from grass etc.

- Shadows and reflections should be avoided this includes the person taking the measurements as well as from surrounding walls, fences and columns. Beware the contractor who comes to take readings wearing a white shirt!!!

- The age of the installation should also be noted, directly after installation the lumen output may be higher than after a few hundred hours operation.

Measurement instruments

Photoelectric cells

A photoelectric cell is a device that is activated by electromagnetic energy in the form of light waves. Three basic kinds of photoelectric cells exist, corresponding to the three different forms of the photoelectric effect that they employ: the photoconductive cell, the photoemissive cell, and the photovoltaic cell, or solar cell. The first two are passive devices, depending on an external current or voltage. The photovoltaic cell is active, converting light energy directly into electricity.

Photoconductive cells

First developed in the late 19th Century, the photoconductive cell or photo resistor is the oldest of the photoelectric devices. The device may be considered as a resistor whose resistance changes dependent on the quantity of light falling on it. The resistance can change from a few hundred ohms in sunlight to approaching a meg-ohm when dark.

The principal photoconductive material is cadmium sulphide which is sensitive to light in the visible range. Lead sulphide, lead selenite and lead telluride can also be used although these substances are also sensitive to infra-red radiation.

They may be found as the principal component in the photocells used to switch street lighting and are sometimes used for the more 'cost effective' light meters for photographic use.

Photoemissive cells

First produced in the 1920s the phototube consists of a thermionic valve whose cathode is coated with a photo emissive material. As photons of light impact the cathode electrons are freed and then attracted to the anode. The resulting flow of current is proportional to the light falling on the cathode. Materials used include caesium, potassium or rubidium.

Applications include the receiver for active IR beams or as photomultipliers (used for astronomy).

Photovoltaic cells

The most widely used photoelectric cells are photovoltaic cells developed shortly after the photoemissive types. These consist of a solid-state diode structure of either selenium or silicon constructed such that incident photons of light can reach the junction region. The effect of incident lighting is to generate an open circuit voltage which can then be measured.

The use of photovoltaic cells ranges from solar cells, (used to collect energy from the sun), to use for accurately measuring incident light in illuminance meters.

APPENDIX E - SURVEY & AUDIT MEASUREMENTS

Introduction

The key to taking survey measurement can be summarised in the one word:

"REPEATABILITY"

In practice, this means that some thought must be given to the positions on site at which measurements will be taken. This will be dependent on what lighting scheme is employed. Set out below is a suggested approach for a perimeter lighting scheme.

Reference Measurements

The first step is to obtain a site plan which shows the location of all the lighting, if possible down to the positions of individual lighting columns. Each column should be given a unique reference identification.

The area of interest should be identified. For a perimeter scheme this may be an illuminated 10 metre strip outside the boundary fence. Figure 1 shows such a scheme with the lighting columns set 2 metres inside the fence.

Measurements of horizontal illuminance should be taken at the column centre line and midway between the columns (worst case position) as shown on figure 1. The measurements will be taken 100mm above ground level, (to avoid shadows/reflections from grass to ground undulations), at the fence base and the edge of the illuminated strip. These measurements should be tabulated and stored for future reference.

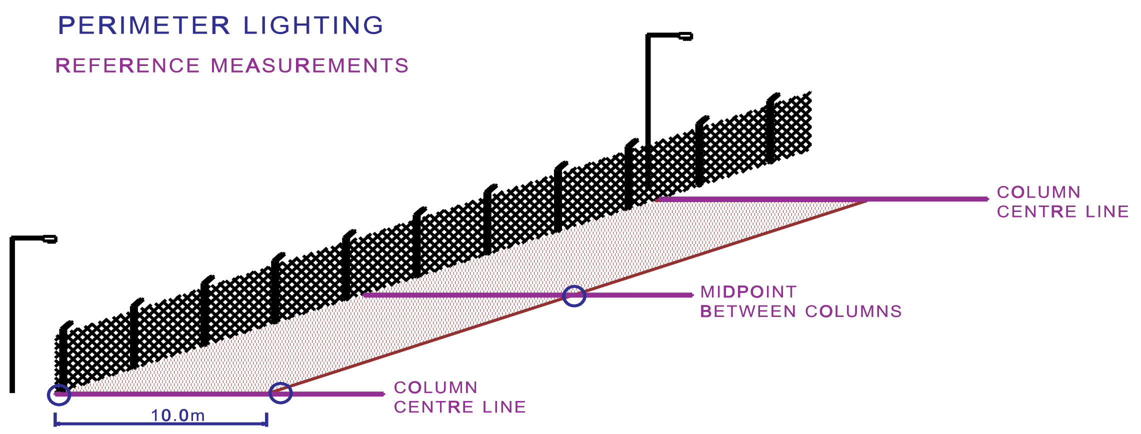


Figure 1 Reference Positions for measurement of illumination

If required a measurement of vertical illuminance may also be taken at the edge of the illuminated strip. This would be measured in the direction facing (normal to) the fence at a height of 300mm above ground level (the notional height of the head of a crawling intruder).

Uniformity Measurement

Uniformity should be measured at a selected point(s) around the perimeter. It should be noted that the following assumes that the lighting between any two adjacent columns will be symmetrical about the centre line drawn at a midpoint between the columns (see figure 1). This means that we only need to consider the uniformity of the illuminated strip between a column centreline and the mid-point centre line as shown on figure 2. Should there not be 'symmetry' it will be necessary to define the area over which the measurements will be taken.

To calculate the horizontal uniformity of the lighting we divide the illuminated strip up into a number of squares. We then measure the illumination at the centre of each square, taking the average of the values recorded. See Figure 2. The minimum value for the strip is taken as the minimum of the values recorded, (not the absolute minimum in the strip which would probably be at the base of the fence). The uniformity is then the ratio of the average value to the minimum value recorded.

The size of the squares taken will determine the accuracy of the value obtained. In the example on figure 2 the columns are taken to be 32 metres apart, illuminating a 10 metre wide strip. A realistic measurement grid would be to use 2 metre squares giving a total of 40 readings.

To achieve repeatability the area should be marked out in a grid as shown on figure 3. The grid marks the measurement positions, (not the boundary), of the notional squares. Measurements would be taken at the grid intersections. In practice the grid can be constructed using wooden pegs and tape or by the use of spray paint. The important thing is that the grid can be set up at a future date and the readings duplicated at the exact original locations.

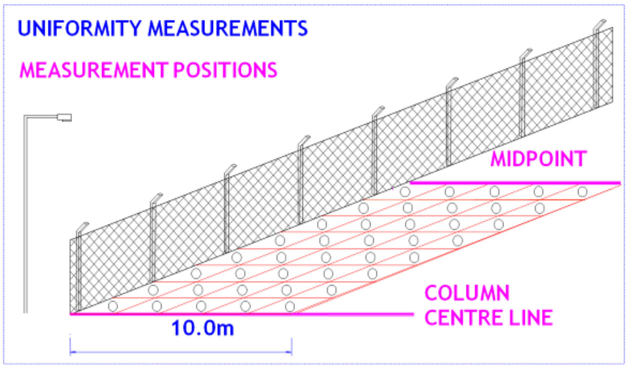


Figure 2 Illumination measurement positions in the centre of the squares

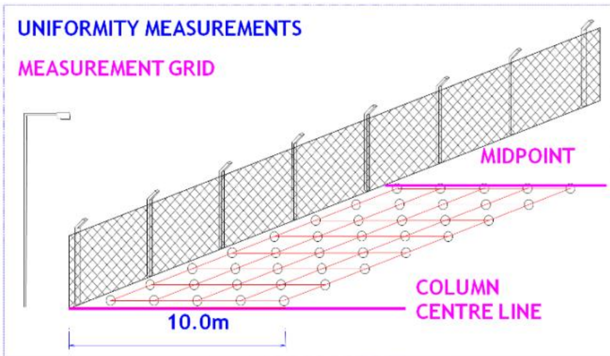


Figure 3 In practice a 'measurement-grid' is created as shown

APPENDIX F - Minimum Illumination Levels for Security Lighting on the UK CNI Estate

The following figures are offered as a guide to minimum values for visible security lighting on the government estate. They are intended to be used as the basis of specifications for new installations or as a baseline against which security audits of legacy systems can be carried out.

Unless there is an overwhelming reason otherwise all new schemes will be defined in terms of minimum illumination levels together with a maximum permissible value of uniformity.

A suggested approach, based on the CPNI OR Guide, is given below:

- Define the area to be illuminated.
- Specify the minimum Illumination.
- Specify the maximum uniformity allowed.
- Define maximum column/mounting height.
- Define power and control requirements.

The value of illumination specified will depend on the particular lighting scenario which is to be used. Further, it is unlikely that a security lighting installation will be installed in isolation. Instead there will be both operational and health and safety requirements to consider.

General installations

Unless specified otherwise figures given for illumination will normally refer to the Horizontal Illumination at the scene. Where there are no other factors the following values are suggested:

- The key factor in any installation is not the absolute level but the uniformity. For horizontal illumination a figure of 3:1 (Average to Minimum) is recommended. For vertical illumination (for walls and fences) this figure may be relaxed to 4:1
- The minimum operational value of illumination should be 3.0 Lux
- Recognising the fact that lamp output will vary over time a more practical specification is 5.0 Lux on commissioning with 3.0 Lux ‘operational’. This will also allow a leeway for dirt build-up on the luminaires.
- The measurement position for illumination should be 100mm above ground level. This avoids the practical problem of ground undulation or undergrowth.
- The maximum column/mounting height to be 8.0 metres.

Mitigation against lamp failure

Consideration should be given to the impact on security in the event of a lamp failure. It is recognised that the uniformity will be lost, for perimeter lighting this can create striations making target identification difficult. To provide a measure of mitigation the scheme may be designed to provide a minimum value of illumination with one-lamp-out of 0.5 Lux.

Colour rendering

The minimum value should be Ra>60 unless colour CCTV is deployed or the lighting is intended to support check-point identification where the minimum value should be >80. (Note: The Crime and Disorder Act 1998, section 17 recognises that colour rendering can help in crime detection by permitting better identification of objects and people, and this should be taken into account when choosing a light source).

Roads and access points

The requirements for Road Lighting are outside the scope of this document and it is advised that specialist advice should be taken. However where a protected area covered by a Security Lighting scheme includes roads then consideration should be given to specifying compliance with BS 5498-1:2013 'Code of practice for the design of road lighting, Part 1: Lighting of roads and public amenity areas'. It is emphasised here that the intention is to provide a security lighting scheme which does not conflict with other lighting measures.

It is not sufficient to simply include reference to the BS 5498 standard in a specification. To be effective it is necessary for the designer to further define the following parameters:

- Define the lighting column location from the edge of any carriageway. For carriageways carrying vehicles travelling below 50 km/h this should be a minimum of 0.8 metres. This distance should be increased for faster vehicles in accordance with BS 5489, Table 2

- The lighting situation and class should be specified from CEN/TR 13201-1. For most security situations this will be situation E2, which relates to the main user being pedestrians with slow moving motorised vehicles and cyclists. This will then be modified depending on the situational variations based on table A10 of CEN/TR 13201-1 (simplified version at Table 1) reflecting the flow of pedestrians, the crime risk and if facial recognition is required. For situations where sites are prepared to invest in security lighting the resulting class would normally be S1

Crime risk	**Facial Recognition**	**Pedestrian Traffic Flow**	
		Normal	High
Normal	Unnecessary	S4	S3
	Necessary	S2	S2
Higher than Normal		S1	S1

Table 1 Recommended lighting class based on lighting situation E2

- From EN 13201-2:2003, Table 3 for S-series lighting classes, the appropriate horizontal illuminance should be specified, (simplified version at Table 2). The standard offers an ES-series of lighting classes for use when facial recognition is important, this utilises Semi-cylindrical illuminance values. At present these are not recommended for CNI use due to the difficulty of undertaking practical measurements.

Class	Horizontal Illuminance	
	Average	Minimum
S1	15	5
S2	10	3
S3	7.5	1.5
S4	5	1

Table 2 Illuminance values for S-series lighting classes

Note: the S1 values of 5 Lux minimum with 15 Lux average, giving a uniformity of 3:1 fits with the general guidance for government use. Standard EN 13201-2 however does permit the average to be up to 1.5 times higher than the table value which would reduce the uniformity.

Be aware that scenarios such as busy entrance points may be defined as 'conflict areas' where a CE-series of lighting classes would apply instead of the S-series. These may demand a higher minimum illumination level.

- Define the light source in terms of Energy efficiency; Colour rendering; Colour appearance; Lamp life and luminous flux depreciation; Mesopic vision and scotopic/photopic (S/P) ratio. (The significance of the S/P ratio is that there is a correlation between spectral power distribution of a lamp and visual performance under low lighting conditions. The target illuminance for S-classes can be adjusted according to this ratio).

- Define the Environmental zone. This relates to control of obtrusive light, (Light Pollution), and is defined in BSEN 12464-2:2007, Lighting of work places – Part 2: Outdoor work places. Four zones are defined as follows:

  E1 Intrinsically dark areas such as national parks
  E2 Low district brightness areas, rural areas
  E3 Medium district brightness areas, residential suburbs
  E4 High district brightness areas, town centres and commercial

Below is a subset of EN 12464 Table 2 giving the maximum obtrusive light permitted for exterior lighting installations.

Environmental zone	Vertical illumination on properties, Lux		Upward Light output ratio, %
	Pre-curfew	Post-curfew	
E1	2	0	0
E2	5	1	5
E3	10	2	15
E4	25	5	25

Table 3 Maximum Obtrusive Light

Where required the information from BSEN 12464 Table 2 can be used to define the installed classes for glare restriction and control of obtrusive light defined in Annex A of BSEN 13201-2. These classes, Luminous intensity G1 to G6 and Glare index D0 to D6 are used by manufacturers to identify the 'cut-off' and 'distribution' for luminaires.

Flora & Fauna

Some species of flora and fauna are protected by legislation. CIBSE Lighting Guide 6, the outdoor environment provides some background with specific guidance given in 'Bats and lighting in the UK'. Guidance should be sought from local authorities where this may pose as issue.

Car Parks

Lighting guidance for car parks is provided in BSEN 12464-2:2007, Lighting of work places - Part 2: Outdoor work places, (Table 5.9). the illumination is linked to the type of area and usage, for Light traffic a figure of 5 Lux is quoted, rising to 10 Lux for Medium traffic and 20 Lux for Heavy traffic.

General Circulation Areas

Lighting guidance is provided in BSEN 12464-2:2007, (Table 5.1). Illumination of walkways exclusively for pedestrians is 5 Lux; Slow moving traffic areas, (max 10 km/h) is 10 Lux; Regular traffic, (max 40 km/h) is 20 Lux; Vehicle loading or turning areas is 50 Lux.

Industrial sites and storage areas

Lighting guidance is provided in BSEN 12464-2:2007, (Table 5.1). For areas involving short term handling of large units 20 Lux is suggested, this rises to 50 Lux where continuous handling is undertaken, 100 Lux where reading or use of tools may be involved and 200 Lux for demanding electrical, machine and piping installations or where inspection is carried out.

Other areas

BSEN 12464-2 offers guidance on illumination levels for a range of specific areas ranging from airports and farms to fuel filling stations and off-shore gas and oil structures.

BSEN 12464-2 also quotes lighting requirements for 'safety and security' in its Annex A, be aware however that the table defining illumination for different risk levels is referring to a Health and Safety risk NOT a Security risk. Where there is a conflict between Annex A and Section 5.3 'Lighting requirements for areas, tasks and activities', the higher value of minimum illumination should be used.

APPENDIX G - Security Lighting Consultancy Services and Manufacturers

In common with many professions, over its life the lighting industry has seen its members form into professional institutes or trade associations with the aim of protecting members' interests together with maintaining and improving standards. The benefit to 'users' of the services and products provided within the industry is that they can have a measure of confidence in the quality of products and the professional integrity of the members.

Some of the main bodies are listed below together with their contact details and information taken from their web sites or other published material. When seeking services or products, readers are encouraged to choose from those members of Professional bodies to whom recourse can be sought in the event of problems.

The Chartered Institution of Building Services Engineers

222 Balham High Road
Balham
London SW12 9BS
Tel: +44 (0)20 8675 5211

CIBSE (The Chartered Institution of Building Services Engineers) is an international body which represents and provides services to the building services profession

Brief History
In 1976 a Royal Charter was granted allowing the Institution of Heating and Ventilating Engineers, founded in 1897, to amalgamate with the Illuminating Engineering Society, dating from 1909. This created CIBS: the Chartered Institution of Building Services.

In 1985, the word Engineers was added to the Institution's name, giving CIBSE the title by which it is known throughout the world today: the Chartered Institution of Building Services Engineers. The objectives of the Institution are established in its Charter. In summary, CIBSE exists to promote the art, science and practice of building services engineering for the benefit of all, and the advancement of education and research in building services engineering.

CIBSE Today
The Institution covers all aspects of design, installation, maintenance and manufacturing associated with building services. The built environment is growing rapidly in importance and complexity. CIBSE is the vital network that underpins much of the thought and imagination that has contributed to this change. The Institution continues to evolve with the needs of its members and the industry.

Society of Light and Lighting

222 Balham High Road
Balham
London SW12 9BS
Tel: +44 (0)20 8675 5211

The Society of Light and Lighting acts as the professional body for lighting in the UK. It has over 2000 members in the UK and world wide, and carries out a full range of activities. The Society is a company limited by guarantee which is controlled by **CIBSE**. It is run by an elected Council and Executive Committee with standing committees covering its full range of activities.

The Society prepares publications on lighting, holds a programme of regular sessional meetings and regular lighting conferences, and acts as a focus for lighting professionals. It liaises with the CIBSE Regions on lighting events throughout the country.

The aims of the Society are:

- To promote the benefits of good lighting
- To provide professional recognition of those who have qualifications and/or experience in light and lighting
- To establish and promote good practice in lighting design and engineering in all their facets
- To provide a forum where people interested in all aspects of light and lighting can come together
- To set and maintain standards in education for light and lighting
- To advise government and other authoritative bodies on the best use and application of light and lighting.

Society of Light and Lighting - Directory of Lighting Consultants

The Society of Light and Lighting has compiled a Directory of Lighting Consultants available from the web site or as a free hard copy. The information is provided as a *Consultants A-Z* alphabetical listing giving their contact details and the services they offer as well as the geographical areas in which they operate.

All practices listed have at least one member of staff who holds the Lighting Diploma. This ensures that someone with appropriate qualifications and experience is available within the practice, who is currently active in lighting consultancy.

Those on the Register are also required to abide by the Society of Light and Lighting/CIBSE Code of Professional Conduct (or that of another institution of which they are members if that is more onerous). Practices listed have to be independent to ensure that the supply of consultancy or design services is not linked to the provision of contracting services or equipment supply. While recognizing that not all those competent to offer lighting consultancy are members of the Society or on the Directory, it offers an effective way for clients seeking professional advice to find a suitable firm which will offer independent advice.

The Institution of Lighting Engineers (ILE)

Regent House
Regent Place
Rugby
CV21 2PN

Tel: 01788 576492

The Institution of Lighting Engineers (ILE) is dedicated solely to excellence in lighting. Founded in 1924 as the Association of Public Lighting Engineers, the ILE has evolved to include lighting designers, architects, consultants and engineers amongst its 2,200 strong membership.

The key purpose of the ILE is to promote excellence in all forms of lighting. This includes interior, exterior, sports, road, flood, emergency, tunnel, security and festive lighting as well as design and consultancy services. The Institution is a registered charity, a limited company and a licensed body of the Engineering Council.

The Lighting Association

Stafford Park 7,
Telford,
Shropshire,
TF3 3BQ, UK

Tel: +44 (0) 1952 290905

A Trade Association founded in 1939, The Lighting Association has developed into the largest organisation in Europe for companies and professionals in the lighting industry. A privately funded company owned by its members, with an annually elected Board of Directors they are for trade professionals only and are unable to provide technical information to the general public.

Lighting Industry Federation (LIF)

Ground Floor, Westminster Tower,
3 Albert Embankment,
London SE1 7SL

Tel: 0207 793 3020

The LIF's primary objective is: To ensure that clients receive the quality of product and scheme design to which they are entitled and to safeguard the interests of the end user. Their website provides a database of their members who are manufacturers or suppliers giving contact details together with the range of products provided. Alternatively their database can be searched by generic product area.