# The installer's guide to lighting design

*GOOD PRACTICE GUIDE* 300

LIGHTSWITCH

ECA
The Electrical Contractors' Association

EDA ELECTRICAL DISTRIBUTORS ASSOCIATION

SELECT

LIF

Society of Light and Lighting

BEST PRACTICE PROGRAMME

ENERGY EFFICIENCY

# CONTENTS

# 1 INTRODUCTION

Lighting can form a major part of an electrical contractor's business. This Guide aims to help contractors to develop their business in this important area by providing an introduction to interior lighting design. The lighting installer may be required to check the final lighting performance of an installation, so information has been included to help with this also.

A well-designed lighting installation can bring substantial benefits to clients and users; it can help improve productivity and energy efficiency and hence reduce operating costs. Therefore it is in the client's interest to have the best.

But what is the best? It is lighting that illuminates the task for safety and good productivity, creates a bright and pleasant interior, avoids visual discomfort through glare and flicker and uses energy wisely. Good lighting also requires good maintenance to ensure good quality throughout the life of the installation.

This Guide is intended to help electrical contractors to design effective and economical installations in straightforward situations, particularly those that are best provided by a regular array of ceiling-mounted light fittings, often known as luminaires. Information is also given on emphasis or accent lighting. These approaches will be appropriate for many small to medium-sized establishments such as offices, shops, factories, etc.

At times a contractor may be asked to provide lighting for more complex situations. Then additional help may be necessary and places where this can be obtained are given at the end of this Guide.

The Guide deals mainly with design calculations and the selection of equipment, but includes some advice on installation testing and maintenance. Worked examples are provided to illustrate how the guidance should be applied, and checklists are incorporated where considered appropriate.

The Guide has a fold-out sheet (from the back cover) that contains a summary of typical lamp characteristics and colour performance, plus a summary of typical luminaire types and their characteristics.

The fold-out sheet is designed to assist the reader by providing a quick and easy reference to lamp and luminaire data while reading through the main sections of the Guide.

Section 3 incorporates a 'Lighting Installation Information Data Sheet' to assist installers in arriving at the most appropriate design for a particular room and task. The sheet should be copied so that it can be used for different lighting installations.

Once completed the sheet should be checked against the checklist on page 6.

## 2 LIGHTING DESIGN CONSIDERATIONS

Before designing a new lighting installation it is essential to consider what needs to be achieved for the particular application.

The main objectives of an interior lighting design are to ensure:

- the safety of the occupants
- that the users of the interior can carry out their tasks effectively
- that the lit appearance of the interior is appropriate for its application and the architecture
- reasonable initial and operating costs that ensure a cost-effective solution
- good energy efficiency.

### ASSESSING THE NEED

Before beginning the design, the particular requirements needs to be determined, for example, what are the main and subsidiary tasks? This will determine the amount of light required on the task, the way the light is provided and the type of equipment to be used, all of which are considered later.

### SAFETY

Safety is not just confined to the need for an easy and safe evacuation from a building in an emergency – which may coincide with a power failure or something more serious.

The designer needs to consider less obvious hazards, such as the following:

- Are there any deep shadows, which could hide obstructions, affecting safe movement?
- Is there any impairment of vision caused by glare, either directly from a light source or indirectly by reflection?
- Is there rotating machinery, which could appear to be stationary under electric lighting on an ac supply? This is known as the stroboscopic effect.
- If potentially dangerous tasks are to be carried out, can this be done safely?

The Health and Safety Executive Guide HS/G 38 'Lighting at Work' deals with work-related safety issues.

The current requirements for emergency lighting are given in British Standard BS5266: Pt 1: 1999 and additional parts. The Industry Committee for Emergency Lighting (ICEL) provides further guidance and design advice (see further information on page 31).

### TASK LIGHTING LEVELS (ILLUMINANCE)

The amount of light provided on the task will affect performance. It is described by the term 'illuminance' and the units are lux or lumens/$m^2$. The UK authority for recommended task illuminance is the CIBSE Code for Lighting (described as the 'Code'). Typical values are given in table 1 and more guidance is given in Section 2.6.3 of the Code. Because lamp and luminaire light output will deteriorate with time, it is necessary to allow for this when calculating the number of lamps and luminaires required. Because of this the designed illuminance is described as the 'standard maintained illuminance'. This is the minimum illuminance value, which should be provided at any time in the maintenance cycle.

Although the general level of illuminance is important, the task may also need directional lighting to reveal shape and texture, and colour rendering requirements may call for a careful choice of lamps.

| Lighting application | Illuminance (lux) |
|---|---|
| Entrance halls/enquiry desks | 200/500 |
| Corridors, passages and stairs | 100 (at floor level) |
| General offices and computer work stations | 300 - 500 |
| Banks, public areas/counters | 300/500 |
| Shops/supermarkets | 300 - 500/500 - 1000 |
| General purpose halls/auditoria | 300/100 - 150 |
| Rough/medium/fine bench and machine work | 300/500/750 |
| Rough/medium/fine/precision electrical equipment manufacture | 300/500/1000/1500 |
| Bulk storage/small item racking/packing and dispatch | 100/300/300 |

Note: The figures separated by '/' indicate values for different situations, eg entrance halls/enquiry desks. While those separated by ' - ' indicate a range of values depending on the particular situation, eg general offices and computer workstations.

*Table 1 Examples of recommended standard maintained illuminance*

# LIGHTING DESIGN CONSIDERATIONS

## GLARE

Glare can cause discomfort or even disability, and should be avoided to ensure a safe and productive workspace. It is caused by excessively bright sources (lamps, luminaires and windows) in the normal field of view, whether seen directly or by reflection. Reflected glare may be from shiny paper or computer screens, for example.

However, if luminaires with very narrow light distributions are used in order to control glare, there may be insufficient light on walls or ceilings and the interior may seem gloomy. This can sometimes be overcome by preferentially lighting some room surfaces.

The degree of discomfort glare can be described using the unified glare rating (UGR). This is a numerical system that enables the limiting discomfort glare to be specified and checked for an installation. For this the CIBSE Code should be consulted and it may be necessary to consult a qualified lighting designer.

Further advice on avoiding glare for interiors using computers and other visual displays is given in CIBSE Lighting Guide 3 'The visual environment for display screen use'.

## LIGHTING AND COLOUR APPEARANCE

Light has a major impact on the appearance of a room. Consider how the design will influence the appearance of an interior. Lamps can have different colour appearance performances that will determine whether a room has a cold or warm appearance (guidance on lamp selection is given in section 3).

The distribution of light in an interior is important, for example, upward lighting can increase the apparent height while light on the walls will help the room to appear 'light'. The direction of light influences the creation of shadows, which reveal the form of objects and the texture of materials. All are important in creating a space with an effective and pleasant appearance. More information on this topic is included in the CIBSE Code.

## ECONOMY AND ENERGY EFFICIENCY

Economy and energy efficiency go hand in hand. Avoiding over-design keeps costs down and prevents excessive energy use. Many other efficiency measures quickly repay their cost. However, the relative importance placed on initial and operating costs will vary from customer to customer. The designer's role will usually be to point to opportunities and to ensure compliance with regulations. A further consideration is that the lighting load will have an affect on the heating and cooling of the building.

The basic rules for energy-efficient lighting are:

- design for adequate but not excessive levels of lighting
- use the most efficient light source that is suitable for the task
- employ the most efficient luminaires appropriate for the situation
- ensure that the room surfaces are light coloured and reflect light well
- use the minimum number of luminaires that will achieve the target illuminance and meet the project brief
- use appropriate controls
- establish an effective maintenance programme.

## ENERGY CONSERVATION LEGISLATION

The Building Regulations require that new and refurbished buildings comply with energy efficiency measures for the lighting of buildings. The Regulations (2000) require that energy-efficient lamps and luminaires are used in conjunction with controls that avoid the use of electric lighting when there is sufficient daylight and the building is unoccupied. For more details see 'Installer's Lighting Guide Number 4' and BRE Report 430 'Energy efficient lighting – Part L of the Building Regulations explained' (see page 31).

Financial incentives are sometimes available for installing energy-efficient lighting systems. Information on current availability may be obtained from the Energy Saving Trust (EST) and the Carbon Trust's Energy Efficiency Best Practice programme (EEBPp) – see page 31.

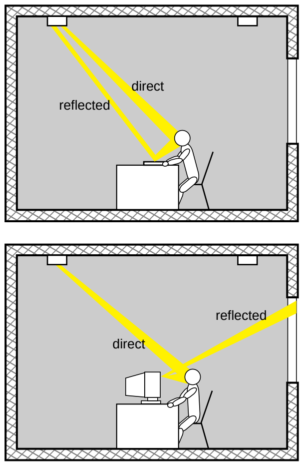



*Figure 1 Possible sources of direct and reflected sources of glare*

# LIGHTING DESIGN CONSIDERATIONS

## DAYLIGHTING

Effective provision of daylighting is an important element of lighting design in new buildings. However, the electrical installer will usually have little or no influence on the window/rooflight arrangement in a room so this Guide does not address daylighting issues.

## ENERGY EFFICIENCY BENEFITS

### Energy efficiency benefits for the end user

The main benefit for the end user is lower energy costs, although the skillful designer may be able to use efficient lamps and luminaires to reduce the amount of equipment and initial cost.

### Energy efficiency benefits for the installer

Client satisfaction will be increased by an effective, economical installation, improving goodwill and effecting the possibility of future business. By keeping the number of lighting points to a minimum, installation tenders can be justified more easily and competitiveness maintained. The use of measures that have higher initial costs but lower lifetime costs will increase the value of an installation.

### Energy efficiency benefits for society

About 20% of the electricity used in the UK is consumed by lighting, and burning fossil fuel generates much of this electricity. Efficient lighting reduces the amount of carbon dioxide ($CO_2$) and other pollutants that are emitted to the atmosphere during electricity generation.

## LIGHTING DESIGN CHECKLIST

### Safety

- Is emergency escape lighting required/provided?
- Have potential hazards been properly illuminated?
- Is there a problem with rotating machines, eg stroboscopic effect?

### Task requirements

- Have the tasks been properly analysed and illuminated?
- Does the lighting scheme provide suitable quantity and direction for the task?
- Has the colour rendering requirement for the task been properly assessed and provided?
- Have any possible glare problems, both direct and reflected, been considered and dealt with?
- Will further local lighting or optical aids be required for special tasks?

### Lighting appearance

- Will the lighting installation be appropriate for the application and the architecture?
- Has light source colour appearance been properly assessed/provided for the particular situation/application?

### Energy efficiency

- Has the most appropriate and energy-efficient equipment been used/specified?
- Has the lighting design properly addressed energy efficiency?
- Have appropriate lighting controls been used/specified?
- Has daylighting been used to the best effect?
- Has the lighting design taken full account of the current Building Regulations?

**There is one simple but important point to bear in mind. Control of electric lighting should normally be arranged so that it may be progressively switched on in bands parallel with the windows.**

# 3 SELECTING LIGHTING EQUIPMENT

There is a wide range of lamps, luminaires and controls available to the designer, but five main criteria need to be considered:

- lighting the task well
- lighting the space well
- being energy efficient
- being good value for money
- looking right in the space.

## LAMP SELECTION

There are three main categories of lamps:

- tungsten filament lamps
- fluorescent lamps
- high-intensity discharge lamps.

Each category has different operating characteristics and is appropriate in different circumstances, depending on the relative importance of cost, life, colour appearance, colour rendering and efficiency. The main performance characteristics are supported by the tables on the fold-out sheet from the back page of this Guide.

It should be noted that the Building Regulations now require the use, in most cases, of energy-efficient lamps and the installer is advised to check the requirement with the current document.

### Filament lamps

Filament lamps (of which GLS lamps are an example) are the most common type of lamp. They are cheap but relatively inefficient, and are available in many different shapes, colours and bulb finishes. They can also have built-in reflectors to direct the light. A major variation of the basic design uses a halogen additive to the gas filling in the lamp. These incorporate a quartz envelope that permits the use of a higher operating temperature, a more compact lamp, a higher efficiency and often a longer life.

### Fluorescent lamps

Light is generated mainly from the phosphor coating on a glass envelope. The phosphors convert invisible ultraviolet radiation from a low-pressure mercury discharge to visible light. Different blends of phosphor powders allow a choice of lamps of different colour rendering and colour appearance properties.

A fluorescent lamp requires control gear for its correct operation and most have near instantaneous switch-on. In some cases they can take a short time before reaching full light output but this is rarely more than one minute.

Compact fluorescent lamps (CFLs) with built-in control gear are intended as direct replacements for filament lamps, enabling the lamp to be inserted in the socket vacated by the filament lamp and operate without any external control gear.

A recent addition to the family of fluorescent lamps is the induction lamp. It is similar to other versions except that the discharge is generated by a magnetic field. Because this eliminates the need for electrodes, which deteriorate with time, the lamp can have an extremely long life, typically 60 000 hours. This makes it useful for lamp positions that are difficult to reach. The lamps are compact in size and have similar colour performances to other fluorescent lamps.

### High intensity discharge (HID) lamps

The commonly used types of HID lamp are sodium and mercury lamps. They have the advantages of a large light output for their size, relatively high energy efficiency and a long life. Light is produced directly by a high-pressure gas discharge, although some mercury lamps also employ a phosphor coating. The gas discharge (together with additives) determines the properties of the light produced. Applications for most types of HID lamp are limited by the colour performance and their run-up and re-strike times.

All HID lamps require control gear that should be matched to the particular lamp. Standard types of control gear and lamp combinations involve a time delay before full light output is reached after switch-on. Also when a lamp is switched on while still warm, there will be a short delay before the lamp re-strikes. Special control gear packages are available with instant re-strike capability for some lamps.

## SELECTING LIGHTING EQUIPMENT

### Control gear for discharge lamps (including fluorescent lamps)

All discharge lamps require some form of control gear to start the arc discharge and limit the operating lamp current. Without this restriction the lamp would continually draw more and more current and ultimately destruct. Other functions of the control gear include power factor correction, and with some types to shut down the lamp circuitry in the event of lamp failure. The control gear consumes energy and it is desirable to employ types using the minimum amount of power.

Wire wound ballasts (chokes), including low-energy versions, have been available for many years, but more efficient electronic types are now available. They provide instant or rapid starting and are usually smaller and lighter than traditional types. High-frequency (HF) electronic ballasts provide flicker-free lighting and good energy efficiency. Some ballast and lamp combinations provide increased lamp life and reduced light depreciation. Also some types of electronic control gear enable fluorescent lamps to be dimmed. The lighting industry is beginning to label ballasts in terms of their energy consumption by classes A-D, where A is good energy efficiency and D is poor. For further information consult the Lighting Industry Federation (LIF) – see page 31.

The ambient temperature in which it operates will have an influence on the longevity of the control gear; special gear should be used for extreme environments.

Some types of CFL have built-in control gear. For space and cost reasons, power factor correction may not be included, which makes for a less efficient source – check with the manufacturer.

Lamps for voltages other than mains (230 V) require transformers, for example 12 V and 24 V lamps. These are classified as extra-low-voltage (ELV) lamps. Care should be taken to ensure that cable sizing and length are appropriate to accommodate the current required and to minimise voltage drop. Similar energy considerations for discharge lamp gear apply to standard and electronic forms of transformer.

Different makes of control gear have their own individual properties and may not be universal in application, requiring them to be matched with specific types and manufacturers' lamps. Always seek the manufacturers' advice on the compatibility of lamp and control gear to avoid mismatching, which can lead to premature lamp and gear failure as well as poor performance.

### LUMINAIRE SELECTION

Luminaires need to be aesthetically pleasing, efficient in use, sufficiently robust for the application and – crucially – distribute light from the lamps in an appropriate manner. A number of British and International Standards apply to luminaires, which must comply with the Electricity at Work Regulations (SI 198 No 635).

### General lighting luminaires

Reference to any manufacturer's catalogue will demonstrate the wide variety of luminaires available in a way that is not possible within the confines of this Guide. Consequently the classification of luminaires and their methods of light control is restricted here to the broad types used for general lighting and outlined in the table on the fold-out sheet inside the back cover of this Guide.

An example of typical photometric data supplied by manufacturers is shown in figure 2 and table 2. This includes a description of the luminaire. There is also usually an indication of the light output distribution often by a polar curve. Light output ratio data includes upward, downward and total.

The light output ratio (LOR) is the proportion of the lamp light output that emerges from the luminaire:

- upward – that above the luminaire centre
- downward – that below the luminaire centre
- total – the sum of the two.

This gives an indication of the luminaire's efficiency and where the light is going. Also

## SELECTING LIGHTING EQUIPMENT

Luminaire type: single 1.5 m, 58 W fluorescent lamp fitting, incorporating a white louvre attachment.

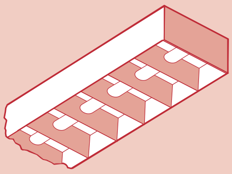


*Illustration of luminaire*


*Luminous Intensity Distributions (polar curves) – axial (A) and transverse (T)*

**Light output ratio**: upward – 0.0; downward – 0.55; total – 0.55.
**Spacing/height ratio**: nominal – 1.5; maximum (square) – 1.7, maximum (continuous) – 2.0.

*Figure 2 Example of luminaire photometric data – see table 2 for typical values of utilisation factor*

| Room index | 0.75 | 1.0 | 1.25 | 1.5 | 2.0 | 2.5 | 3.0 | 4.0 | 5.0 |
|---|---|---|---|---|---|---|---|---|---|
| **Room reflectances C W F** | | | | | | | | | |
| 70 - 50 - 20 | 0.36 | 0.42 | 0.47 | 0.51 | 0.56 | 0.60 | 0.63 | 0.66 | 0.69 |
| 30 | 0.31 | 0.36 | 0.42 | 0.46 | 0.52 | 0.56 | 0.59 | 0.63 | 0.66 |
| 10 | 0.27 | 0.32 | 0.37 | 0.41 | 0.47 | 0.52 | 0.55 | 0.60 | 0.63 |
| 50 - 50 - 20 | 0.33 | 0.38 | 0.43 | 0.46 | 0.51 | 0.54 | 0.57 | 0.60 | 0.62 |
| 30 | 0.29 | 0.34 | 0.38 | 0.42 | 0.51 | 0.51 | 0.53 | 0.57 | 0.59 |
| 10 | 0.25 | 0.30 | 0.35 | 0.38 | 0.44 | 0.48 | 0.50 | 0.54 | 0.57 |
| 30 - 50 - 20 | 0.31 | 0 35 | 0.39 | 0.42 | 0.46 | 0.49 | 0.51 | 0.54 | 0.55 |
| 30 | 0.27 | 0.31 | 0.35 | 0.38 | 0.43 | 0.46 | 0.48 | 0.52 | 0.54 |
| 10 | 0.23 | 0.28 | 0.32 | 0.35 | 0.40 | 0.44 | 0.46 | 0.50 | 0.52 |
| 0 - 0 - 0 | 0.20 | 0.24 | 0.28 | 0.30 | 0.34 | 0.37 | 0.39 | 0.42 | 0.44 |

**Using the table**
Calculate the room index – see section 4, page 15
Decide on the appropriate reflection factors for ceiling (C), walls (W) and floor (F) – see section 4, page 15
Locate utilisation factor at intersection of appropriate column and row

*Table 2 Typical utilisation factor data for nominal spacing-to-height ratio, SHR (NOM)*

included are details of luminaire spacing for achieving a uniform task illuminance. Some light reaches the horizontal working plane by reflection from room surfaces, and in addition to the LOR, it is necessary to know the utilisation factor (UF), shown in table 2. UFs indicate the proportion of lamp light output that will reach the horizontal working plane, both directly and by reflection, for a range of different room sizes and room surface reflectances. This will enable the number of luminaires required to provide a particular task illuminance to be determined. More information on UFs is given on page 15.

### Display lighting luminaires

Display lighting luminaires are usually used to emphasise a feature or artefact and provide a directional beam of light. Filament lamps with integral reflectors are the most commonly used because of their simplicity and ease of beam control, although other types of lamp can be used. Lower-wattage discharge lamps have the advantages of high output and small light source size. Fluorescent lamps are less easy to control in the directional sense and more suited to applications where a wash of light is wanted rather than spotlighting.

## SELECTING LIGHTING EQUIPMENT

### Lighting track
Nearly all display luminaires may be obtained in versions that can be mounted either directly onto a surface or onto lighting track. The main advantage of track mounting is that it permits luminaires to be easily repositioned without having to modify the electrical supply wiring. It is also equally simple to change the type of luminaire. These facilities are valuable in display situations where changes in a display and its lighting are frequently required. Lighting track systems can be very versatile – some systems include junctions and multi-circuit capability.

### Lighting structures
Lighting structures, as well as providing mounting facilities for luminaires, are usually self-supporting and capable of carrying quite substantial loads. Detailed product knowledge is required to be sure that everything has been included for building a system and ensuring its mechanical stability. Therefore it is always advisable to consult the manufacturer on this aspect.

### LIGHTING CONTROLS
Modern lighting controls enable lights to be used only when required. They range from the simple switch to more automatic systems. Controls can also include:

- dimming, sometimes via photocell control, to provide a top-up of electric light when daylight is insufficient
- presence detectors for intermittently occupied spaces
- time switches to switch lights off at set times during the day.

Appropriate lighting controls can save both energy and money and are a valuable element of a lighting installation. They are also a requirement of the Building Regulations – check the current requirements. Also make sure that the lighting controls are user friendly.

### Switches
Switching off lighting when it is not needed is the basic control. To minimise the use of the installed lighting and to save energy, switching must be arranged to operate in conjunction with daylight. In particular, electric lighting circuits and switching should be in rows parallel to the windows so that the electric lighting can complement the daylight. Switches should be near and easily accessible to the occupants of the interior. For practical purposes a local switch controlling a luminaire should be no more than 8 m from it, or three times the mounting height of the luminaire above the floor if greater. When groups of switches are required, they should be clearly labelled and arranged logically.

### Dimmers
The ability to reduce lighting levels over a period of time so that the change is imperceptible is a valuable part of managing lighting in an unobtrusive fashion. Reducing light levels by dimming provides energy savings, which is one of the main objectives of using lighting controls.

It is possible to dim many types of lighting. Excellent flicker-free dimming down to 1-2% levels is available for most types of tungsten and fluorescent lamps, including some CFLs. High-intensity discharge lamps, on the other hand, may be dimmed but only with the use of special control circuits. However, they have limited flexibility and fairly high minimum light levels (30-50%).

The life of tungsten sources is normally extended – sometimes quite dramatically, when operated on a reduced voltage, and at the same time energy consumption is reduced. Fluorescent lamps also use less energy when dimmed, but a small base level of energy (say 10%) is retained to operate the lamp cathode filaments.

## SELECTING LIGHTING EQUIPMENT

### Time switches
To avoid putting people at risk, time switches should only be used for areas that will be unoccupied when the lighting is switched off. Time switches are available that will control multiple switching periods, have solar dials and other automatic features. However, users can find complex time switches difficult to understand and they are best used for simple applications – for example, regular switching of exterior lighting from, say, 19.00 until midnight. Electronic controllers are more flexible, but are more expensive.

### Photocells
Photocell operation of lighting circuits is more flexible than time switch operation when the function of the control is to operate lighting for the hours of darkness. The combined use of a photocell with a time switch is often a convenient way of controlling exterior lighting, permitting light to be available at a preset level of ambient light for a defined period or to a set time.

### Presence detectors
Presence detectors are best used in areas that are only occupied intermittently, or for security applications. There are various types of presence detectors. They may be actuated by movement, sound or heat, and will switch lighting on, as long as the presence continues to be detected. Time delay facilities must be built in to ensure that the controlled zone is unoccupied before the lighting is extinguished.

### Intelligent luminaires
Rather than using separate controls, it is sometimes convenient, particularly in smaller interiors, to employ luminaires incorporating some form of control mechanism within them, eg photocell-actuated dimming or a presence detector. Such luminaires are often known as intelligent luminaires. Some types are able to control more than one, or other types of luminaires, according to the manufacturers' instructions.

### Complex controls
There is a range of more complex lighting controls, for example linked to computerised or building management systems. These generally require specialist knowledge and are not covered by this Guide.

It is important to realise that well-designed lighting control systems have important benefits for energy efficiency, but user requirements must also be carefully considered to avoid possible user annoyance. People often object to being controlled so manual override should always be provided, otherwise the system may be unacceptable. Further information on this important topic can be found in Good Practice Guide 160 'Electric lighting controls' (see page 32 for details).

## SELECTING LIGHTING EQUIPMENT

### LIGHTING EQUIPMENT CHECKLIST

**Lamps**

- Are the lamp's operating characteristics appropriate for the application, eg lamp switch-on, run-up and re-strike?
- For the application, are there implications for lamp size and/or shape?
- Does the lamp type have a suitable lamp life and lumen depreciation?
- Does the lamp have a suitable colour performance, eg colour rendering and colour appearance?
- Is the lamp type applicable for the control strategy?
- Will the lamp operate in the intended environment/climate?

**Luminaires**

- Does the size and shape of the luminaire fit in with the building and its systems, eg ceiling systems, etc?
- Does the luminaire provide an appropriate luminous intensity distribution?
- Does the luminaire provide suitable glare control?
- Does the luminaire have an appropriate efficiency, eg utilisation factor?
- Does the luminaire have an appropriate control system, eg ballast, etc?
- Will the luminaire be appropriate for the application/environment, eg is the atmosphere corrosive or dusty?
- Do luminaires need to operate under emergency lighting conditions, which will require special circuits and power supplies?
- Can the luminaires be suitably maintained and repaired?
- Will the luminaires integrate well with the application and the architecture?

**Lighting controls**

- Will manual switches operate the lighting in terms of energy efficiency and user requirements? Check the position and marking of switches.
- Could any time switches put people at risk?
- Will any daylight-linked electric light controls, either switched or dimmed, be appropriate for the users? Check position of photocells, photocell sensitivity and suitable time delay.
- If presence detectors are to be used, do they have an appropriate sensitivity and are they positioned properly for energy efficiency and user satisfaction?
- Has allowance been made in the contract for user education and support?

Note: While every attempt has been made to list the most important issues that need to be addressed, there may be others.

## SELECTING LIGHTING EQUIPMENT

### LIGHTING INSTALLATION INFORMATION DATA SHEET

This sheet can be copied and used as a form for collecting information about the room that is to be lit and its lighting requirement. Once the design is completed it can be checked against the information contained in the checklist on page 6.

| **Room details (dimensions in metres)** | | | |
|---|---|---|---|
| Room size (length, width, height) | | | |
| Horizontal working plane height above floor level | | | |
| Room surface reflectance (ceiling, walls, floor) | | | |
| Window size/s and position | | | |
| Room index (calculate from above – see page 15) | | | |
| **Task/s details** | | | |
| Type of task/application<br>(eg office, industrial, retail, etc) | | | |
| Task position<br>(eg horizontal/vertical, general/local, etc) | | | |
| Special task lighting requirement<br>(eg critical inspection, computer use, etc) | | | |
| Special hazards<br>(eg wet or dusty environment, rotating machines, etc) | | | |
| **Task/s lighting requirements** | | | |
| Task illuminance (lux)<br>(see page 4, also CIBSE Code) | | | |
| Task illuminance uniformity<br>(eg uniform (0.8), non-uniform (as appropriate)) | | | |
| Light colour rendering quality and index (Ra)<br>(see fold-out sheet from back cover, also CIBSE Code) | | | |
| Average installed power density target (W/m$^2$)<br>(see page 18, also CIBSE Code) | | | |
| **Room lighting requirements (additional to the task lighting requirement)** | | | |
| Accent lighting<br>(eg display lighting, decorative lighting, etc) | | | |
| Wall lighting<br>(eg display lighting, lighting to create room lightness) | | | |
| Ceiling lighting<br>(eg lighting to create room lightness) | | | |
| Light colour appearance (eg warm, intermediate, cool (CCT))<br>(see fold-out sheet from back cover) | | | |
| Emergency and/or escape lighting requirement<br>(see CIBSE Code) | | | |

The designer will find it helpful to produce a sketch of the room indicating: the position of the doors and windows; the positions of the task/s; the positions of the escape routes if appropriate; and anything else that affects the lighting design.

# 4 DESIGN CALCULATIONS FOR STRAIGHTFORWARD SITUATIONS

This section explains how to work out:

- the number and layout of luminaires needed for general lighting
- what additional luminaires are needed to provide local emphasis or accents
- the energy efficiency of the installation and financial benefits.

The worked examples on pages 22 to 26 illustrate how this information is actually applied in practice.

## LIGHTING UNITS

The basic units used in calculations are explained in the next few paragraphs. More definitions are given in the glossary.

The first measure of light to consider is the amount of light emitted by a lamp or luminaire. This is described as luminous flux and the unit is the lumen (lm). A particular lamp will consume a total amount of energy in Watts (W) to produce the light output. The ratio of these two units describes a lamp's efficiency, or more correctly its luminous efficacy (lm/W). Table 3 compares the performance of three different lamp types.

The performance of a luminaire depends not only on the total light output in lumens but on the light output distribution. The strength of the light in any particular direction is described by its luminous intensity (or just intensity) measured in candelas (cd).

| Lamp type and wattage | Light output (lumens) | Lamp efficacy (lm/W) |
|---|---|---|
| 100 W tungsten filament | 1360 | 13.6 |
| 58 W fluorescent tube | 5200 | 90.0 |
| 400 W high-pressure sodium | 48 000 | 120.0 |

*Table 3 Performance of three lamp types*

The next unit to understand is the light level or more correctly the illuminance ($lm/m^2$ or lux). This is the quantity of light incident on a surface per unit area. For example, if there are 500 lumens incident on an area of 1 $m^2$ then the illuminance is 500 $lm/m^2$ or 500 lux (see figure 3).

## GENERAL LIGHTING – HOW MANY LUMINAIRES?

Many electric lighting installations comprise a regular array of luminaires distributed evenly over the ceiling to provide a uniform illuminance on a horizontal working plane. The following shows you how to plan for this situation.

The data required can be divided into three parts:

- information about the room, which includes its size, described by its room index (RI), and the room surface reflectances; you will also need to know the height of the working plane
- information about the lamp and luminaire, which includes the lamp light output, the luminaire UF and its maximum allowable spacing
- information about the cleanliness of the room/environment and the regularity of the cleaning, which are both encompassed in the maintenance factor.

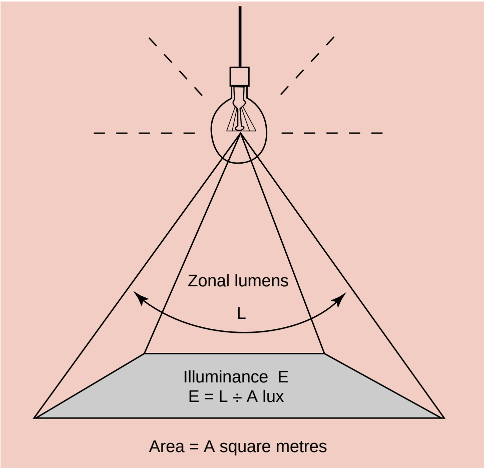



*Figure 3 Relationship between zonal lumens and illuminance*

# DESIGN CALCULATIONS FOR STRAIGHTFORWARD SITUATIONS

## Information about the room

***Room index***

For the purpose of the calculation the room size is described by its room index.

$$\textit{Room index} = \frac{L \times W}{H(L+W)}$$

Where:

L = room length (m)

W = room width (m)

H = height of luminaires above the horizontal working plane (m)

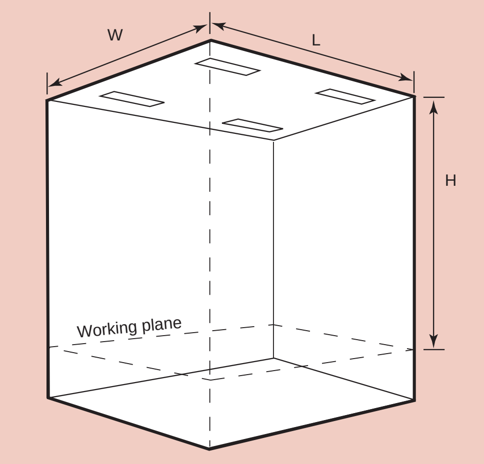



*Figure 4 Room index dimensions (Note: When luminaires are suspended below the ceiling, then H is the dimension between the plane of the luminaires and the working plane)*

***Room surface reflectance***

To determine the UF from the luminaire data sheet it is necessary to know the average room surface reflectances. The ceiling is normally considered to be light in colour and an average value of 70% (or 0.7) is normally used. The floor is usually considered to be dark and an average value of 20% (or 0.2) is normally used. The walls, however, can vary from light to dark depending on the wall surface colours.

Luminaire manufacturers usually provide UFs for three average wall reflectances of 50%, 30% and 10%. A value of 50% applies to walls of light décor, 30% moderate décor and 10% dark décor.

## Information about the lamp and luminaire

For the lamps it will be necessary to find the initial light output in lumens. For most situations this is taken as the value after 100 hours of burning when the lamp has stabilised. These values can be obtained from manufacturers' data.

To determine the number of lamps and luminaires required to produce an illuminance you need to know the proportion of the lamp light output that will arrive on the working plane either directly or by reflection. This is described by the utilisation factor (UF). UFs are provided by the luminaire manufacturer for particular luminaires, for particular room sizes and room surface reflectance. An example is shown in figure 2 and table 2 (see page 9).

The luminaire performance data will also include details about the maximum luminaire spacing that should be used to provide an acceptable illuminance uniformity. Uniformity is described by the minimum to average illuminance on the working plane and a minimum acceptable value is usually 0.8. If this is met then the task in question can be carried out anywhere in the room or designed task area except for a band approximately 0.5 m wide around the edge.

## Information about environmental cleanliness and maintenance factors

The performance of lamps and luminaires deteriorate with age – we allow for this by assigning a maintenance factor to the installation. This takes into account lamp light output reduction through life, the cleanliness of the environment and the deterioration of luminaire light output through life. It will also be affected by the regularity of re-lamping, as well as the regularity of cleaning the lamps, luminaires and room surfaces. This is a complicated procedure and the designer is encouraged to study this further in the CIBSE Code, Section 4.5.2.

The installer is recommended to encourage the client to clean the equipment regularly and for interiors of average cleanliness at least every 24 months. Re-lamping times will depend on the

## DESIGN CALCULATIONS FOR STRAIGHTFORWARD SITUATIONS

lamp type and the hours of use. Figure 5 illustrates how the light output depreciates over time.

Table 4 gives approximate values for well-maintained installations, but these are only provided as a guide.

| Environmental condition | Maintenance factor |
|---|---|
| Clean | 0.9 |
| Average | 0.8 |
| Dirty | 0.7 |

***Table 4 Approximate values for well-maintained installations***

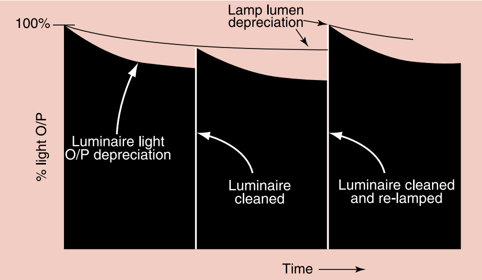



***Figure 5 Light depreciation with respect to time***

### The number of luminaires required

Knowing the details of the interior and from this the particular luminaire UF and the initial lamp light output, and from the situation the maintenance factor, the number of luminaires required can be deduced using the following formula.

$$N = \frac{E \times A}{L \times UF \times M}$$

Where:

N = the total number of luminaires required
E = the required illuminance in lux
A = the area of the working plane
L = the initial total lamp light output for each luminaire
UF = luminaire utilisation factor
M = the maintenance factor

It may be necessary to calculate the illuminance from a number of given luminaires. This can be found by rearranging the formula.

### Planning the luminaire layout

Having found the number of luminaires required to provide the illuminance needed for the task, the next stage is to work out a regular layout of luminaires to provide it with an acceptable uniformity. Firstly, it will mean rounding the number found to provide a whole number that will divide into a regular grid.

Acceptable spacing (S), centre to centre, depends on the height of the luminaire above the working plane (H) – see figure 6. If the luminaires are fixed, into or onto the ceiling, then the mounting height (H) will be the distance between the ceiling and the working plane. But if the luminaires are suspended below the ceiling plane, then H will be the distance between the plane of the luminaires and the working plane. Luminaire manufacturers provide this information (in the form of spacing/height ratios) generally with tables of UF. In the case of linear luminaires, the spacing may be different in the axial and transverse planes. If the luminaires are in continuous rows the spacing between rows may also be different.

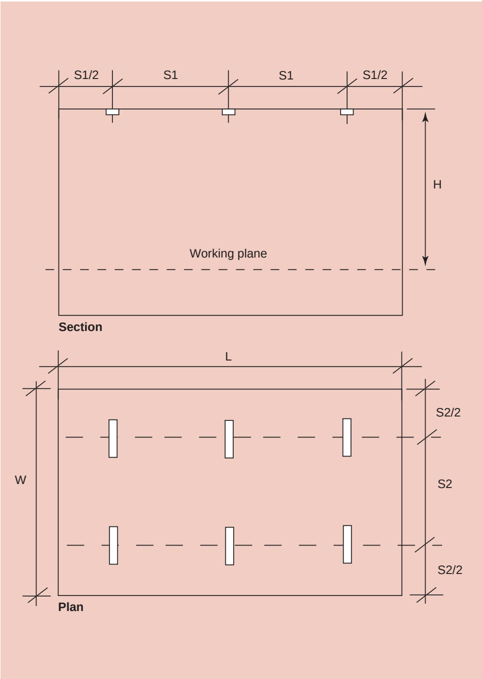



***Figure 6 Luminaire layout and spacing***

# DESIGN CALCULATIONS FOR STRAIGHTFORWARD SITUATIONS

Although the preceding calculation method provides the ideal positioning, at times it will be necessary to accommodate other features. These include other pieces of equipment such as air input or extract units. There may be a ceiling system, which has a grid of ceiling tiles that needs to be accommodated. Because of this the designer may need to adjust the design to accommodate all the requirements. This may mean that additional luminaires are required.

## CALCULATIONS FOR LIGHTING TO PROVIDE LOCAL EMPHASIS

Emphasis or accent lighting is used to draw attention to an area or an object. This might include a reception desk in an entrance area or a display in a shop.

The amount of light needed to emphasise or draw attention to an object depends on the level of general lighting. Once the required illuminance has been calculated, suitable lamps can be selected with the aid of manufacturers' data.

If a 'subtle' effect is desired then the ratio of display light to general lighting should be of the order of 5:1. 'Moderate' emphasis requires about 15:1 and 'strong' emphasis requires about 30:1. These values assume there is a neutral background. For example, 300 lux general lighting in a retail store will require a local illuminance of 9000 lux for strong emphasis on displays.

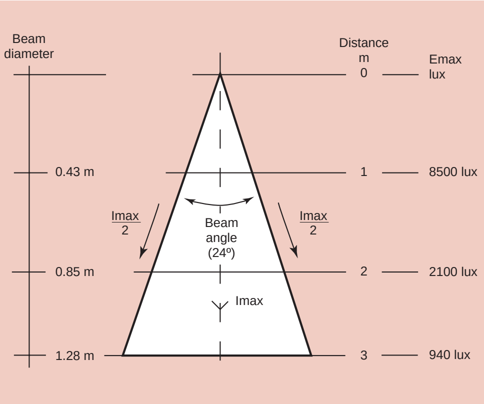



*Figure 7 Typical spotlight performance data*

Manufacturers usually provide information in a diagrammatic form showing the effect of a particular spotlamp at various distances, ie the width of the beam and either the illuminance at the beam centre or the average illuminance across the beam. Each manufacturer may use a slightly different approach, so it is important to understand exactly how and what information is being displayed before using it. Figure 7 illustrates the different types of information available.

It is possible to calculate the illuminance from a spotlight or any other small source using the 'point source formula'. To do this, the luminaire's intensity distribution must be known. This can usually be obtained from manufacturers but it is often not available in the catalogue. Details of this form of calculation are given in the CIBSE Code, Section 5.13.

Another area of emphasis lighting is wall washing. This uses luminaires that usually have an asymmetric beam shape. For this type of luminaire the manufacturers usually provide details of the luminaire layout and illuminance performance (see figure 8).

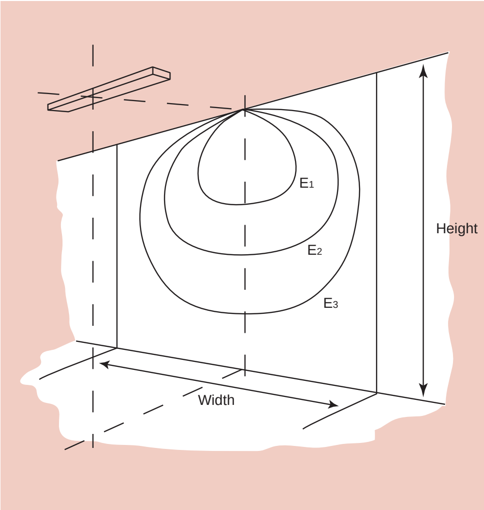



***Figure 8 Typical wall-washing luminaire performance data (Note: illuminance may be given in lux/1000 lumens. In this case the data needs to be multiplied by the total lamp lumens ÷ 1000)***

# DESIGN CALCULATIONS FOR STRAIGHTFORWARD SITUATIONS

## CHECKING FOR ENERGY EFFICIENCY

The first thing is to ensure that the installation meets the current Building Regulation requirements.

In addition, most installations should be able to meet the CIBSE Code targets for average installed power density, which are quoted in terms of W/m$^2$ for a range of situations and illuminances (see table 5). The values are based on current good practice using efficient lamps and luminaires in good-quality installations. The targets are for an average-sized space (room index of 2.5), with high surface reflectances (ceiling reflectance: 0.7; wall reflectance: 0.5; and floor reflectance: 0.2) and a high degree of installation maintenance.

If a design exceeds these values, for the particular application, then it should be revisited to see whether a more efficient solution is possible. It is possible, however, that these values could be improved on.

## ENERGY-SAVING PAYBACK CALCULATIONS

The usual way of demonstrating to a client that the additional cost of installing efficient equipment is worthwhile is by calculating payback period – the length of time before the savings match the extra initial cost. After this period, the user has saved more than he has spent and continues to save money.

The payback period is simply:

$$\textit{Payback} = \frac{\textit{the extra initial cost}}{\textit{annual running cost savings}}$$

| Lamp type | CIE general colour rendering index (Ra) | Task illuminance (lux) | Average installed power density (W/m$^2$) |
|---|---|---|---|
| **Commercial and other similar applications, eg offices, shops and schools*** | | | |
| Fluorescent – triphosphor | 80-90 | 300 | 7 |
| Fluorescent – triphosphor | 80-90 | 500 | 11 |
| Fluorescent – triphosphor | 80-90 | 750 | 17 |
| Compact fluorescent | 80-90 | 300 | 8 |
| Compact fluorescent | 80-90 | 500 | 14 |
| Compact fluorescent | 80-90 | 750 | 21 |
| Metal halide | 60-90 | 300 | 11 |
| Metal halide | 60-90 | 500 | 18 |
| Metal halide | 60-90 | 750 | 27 |
| **Industrial and manufacturing applications** | | | |
| Fluorescent – triphosphor | 80-90 | 300 | 6 |
| Fluorescent – triphosphor | 80-90 | 500 | 10 |
| Fluorescent – triphosphor | 80-90 | 750 | 14 |
| Fluorescent – triphosphor | 80-90 | 1000 | 19 |
| Metal halide | 60-90 | 300 | 7 |
| Metal halide | 60-90 | 500 | 12 |
| Metal halide | 60-90 | 750 | 17 |
| Metal halide | 60-90 | 1000 | 23 |
| High-pressure sodium | 40-80 | 300 | 6 |
| High-pressure sodium | 40-80 | 500 | 11 |
| High-pressure sodium | 40-80 | 750 | 16 |
| High-pressure sodium | 40-80 | 1000 | 21 |

*Values do not include energy for display lighting

*Table 5 Target average power density values (CIBSE Code)*

## DESIGN CALCULATIONS FOR STRAIGHTFORWARD SITUATIONS

The extra initial cost is the difference in cost between more efficient and less efficient lamps and luminaires and the cost of any extra controls. The savings are the differences in electricity consumption between the two alternatives and – where the energy-efficient option also provides longer lamp life – the savings from less frequent replacement. The latter will usually include labour costs as well as lamp costs.

Electricity consumption is usually calculated by multiplying the installed luminaire load (lamps and control gear watts) by the estimated hours of use.

Remember that financial incentives may be available for installing energy-efficient installations. Contact the EST and the EEBPp for information on current schemes.

### COMPUTER-ASSISTED CALCULATIONS

Many of the calculations can be carried out using a computer, which saves time and provides a presentation for the client that is reliable and attractive.

Software available for lighting designers falls into three types:

- manufacturers' programmes, normally linked to detailed databases of their own equipment
- general design programmes without links to any particular lighting manufacturer
- advanced programmes, often linked with visualisation techniques.

Manufacturers' programmes are readily available and are often supplied free-of-charge to specifiers. Usually a programme will have extensive and reliable up-to-the-minute photometric data linked to it. It is unusual to find a programme that allows the input of data from other sources. Consequently, accurate comparisons between the performance of luminaires from different suppliers can be difficult to make.

# 5 LIGHTING INSTALLATION AND TESTING

## ELECTRICAL INSTALLATION

All installations have to comply with the IEE electrical wiring regulations (BS7671: 2001) and should be carried out by competent installers. It is not the purpose of this Guide to give instructions on installing and testing lighting equipment, because competent installers will be familiar with the necessary procedures. Nevertheless, it should be remembered that electronic devices, eg high-frequency ballasts, should be disconnected prior to any insulation resistance or earth fault loop impedance tests are carried out, otherwise the devices may be damaged or destroyed.

It is also worth emphasising that time spent in reading, understanding and carrying out manufacturers' instructions for any equipment is seldom wasted. If equipment does not operate properly or fails prematurely there may be no possibility of obtaining redress if it has not been installed in accordance with the manufacturer's instructions. This also applies to the handling of aluminium reflectors and louvres, which may become marked if they are handled without proper protection. Manufacturers usually supply gloves to avoid this – be sure to use them.

Similar cautions are appropriate about lighting design, if data supplied by the manufacturer has not been properly applied, or the luminaires used incorrectly. Should this prove to be the case the lighting designer may be required to take full responsibility for the situation and rectify it.

## CHECKING LIGHT LEVELS

It is good practice to measure lighting levels (illuminance, lux) after the installation is completed, as an increasing number of clients require formal verification that design illuminance targets have been achieved. If a thorough check and survey are required, the specific procedures for the verification of lighting designs detailed in the CIBSE Code should be followed. The Code gives information on two methods – either a full grid of measurement points is employed or a simpler two-line method of measurement.

It is important to understand that light meters (as illuminance meters are commonly described), although straightforward to use, can produce misleading readings if not handled correctly. The following are common causes of error so care should be taken to avoid them.

- Ensure the meter used is appropriate for the installation. Confirm that it will be able to cope with the range of the illuminance and the type of light sources. Some hand-held meters are not accurate enough for verification work and may have limitations on the types of lamps covered.
- Check that the meter has been calibrated properly and within the previous year. Meter sensitivity varies with time, and it is important to use equipment that cannot be challenged on accuracy for verification work.
- Extraneous light, from whatever source, can render measurements of an installation useless. It is pointless to conduct investigations that involve accurate measurement if any stray light is present. Therefore, much of this type of work has to be done at night unless adequate daylight screening is available.
- Make sure the light sensitive cell is properly positioned – slightly tilting the cell can cause significant errors.
- Do not shade the light-sensitive cell. Cosine corrected cells, used for light measurement, have a wide acceptance angle and it can be surprising how far away it is necessary to stand to avoid screening light from more distant light sources. Dark clothing should be worn by all personnel involved to minimise reflections that can exaggerate readings.
- Ensure that a constant measuring height is used. A measuring stand or tripod may be useful.
- The preparation for a proper survey of a lighting installation is time consuming in all aspects, ie prior to going to site, setting out the measurement grid on arrival and doing the actual measurements. Unless such operations have been conducted before, be prepared for the whole activity to take more time than expected.

# 6 MAINTENANCE OF LIGHTING INSTALLATIONS

## LAMP LIFE AND REPLACEMENT

Assumptions about the deterioration of lamp and luminaire performance with time can have a significant effect on the number of luminaires required. It follows that a knowledge of the lamp replacement policy is important at the design stage – and that the client should understand and agree with the assumptions. A maintenance programme is part and parcel of the design, and greatly influences the number of luminaires required to achieve a maintained illuminance. In the reverse situation the design process is fundamental in deciding what the maintenance programme should be.

If failed lamps are to be replaced as and when they occur or within a sensible time (spot lamp replacement) this will minimise the number of luminaires needed. Spot replacement, however, can be expensive, and it is possible that bulk or group replacement of lamps at agreed intervals may be preferred. In practice, maintenance may be related to burning hours, lamp life, or cleaning intervals.

Some HID lamps depreciate faster than modern fluorescent lamps and, in such cases, light depreciation must be properly included.

## CLEANING OF LIGHTING EQUIPMENT

Accurate information on the accumulation of dirt on luminaires and lamps is still a subject for research, but it is a fact that dirty surfaces reduce light transmission. If interiors are particularly dirty or dusty then it is best to employ enclosed luminaires to maintain the efficiency of reflecting surfaces within the luminaires and protect the lamps themselves from transmission losses. However, this will not stop the exterior of the luminaires becoming dirty and reducing the amount of light available. Regular cleaning of the lighting equipment should be a feature of all well-maintained installations if the benefits connected with energy saving are to be maintained.

Luminaires are constructed from a wide range of materials, some of which require special cleaning treatment for which manufacturers' advice should be sought. However, the bulk of materials will respond to wiping with non-abrasive cloths using a weak solution of neutral detergent that does not leave a residue and allowed to air dry. Items such as polished or semi-specular aluminium reflectors and louvres are easily finger marked. The marks can be very difficult to remove so appropriate plastic or cotton gloves should be worn by operatives to avoid the problem.

## LUMINAIRE INSPECTION

It is wise to inspect luminaires at regular intervals to determine if any of the components need to be replaced. This is best done in conjunction with cleaning or lamp replacement, particularly if access is difficult. Items such as broken hinges, clips or diffusers could probably be reported and cleared by cleaning personnel. However, a qualified electrician will be required if failures involve internal or electrical components.

## CARE OF CONTROL SYSTEMS

Other than the replacement of failed components, little maintenance will be needed or is possible for the controls. In any case, this is not seen as something usually done by non-specialist staff. It is recommended that the manufacturer's advice should always be sought on problems that occur with this type of equipment.

## LAMP DISPOSAL

The Control of Substances Hazardous to Health (COSHH) Regulations require employers to protect employees and others who may be exposed to included substances. There has been confusion about how this applied to the disposal of lamps, but this is clarified by Technical Statement 10 from the LIF. Those involved with lighting maintenance are recommended to study and act on the statement's advice.

# 7 WORKED EXAMPLES – WORKED EXAMPLE 1

## DESIGNING A GENERAL LIGHTING INSTALLATION USING A REGULAR ARRAY OF CEILING-MOUNTED LUMINAIRES FOR AN OFFICE

### The design brief or problem

The office measures 10 x 7 m with a floor-to-ceiling height of 3 m. It has continuous windows on one long side providing a good level of daylight. The windows are fitted with light-coloured blinds to control excessive brightness from the sun and sky. The room has two doors to a corridor in the wall opposite the window wall. The walls are light in colour with a flat, white suspended ceiling. The office is used for general office duties including some computer use. The long wall, opposite the windows, is used to display progress charts, which need referencing and updating.

### Step 1 Determine the required maintained illuminance

The CIBSE Code recommends a maintained illuminance of 300-500 lux for offices with computer workstations.

### Step 2 Choose a suitable lamp and luminaire

For an office it would be appropriate to use linear fluorescent lamps with a colour rendering index (Ra) of at least 80. Because they will need to combine with daylight when necessary, a lamp correlated colour temperature (CCT) of around 4000 K should be selected.

As some computer work is involved, luminaires that have a limited brightness in the normal viewing angles should be selected. These will probably have white or aluminium louvres to control the brightness in these areas. Because the ceiling is suspended, ceiling-recessed luminaires can be used – these will give a clean appearance to the room. The UF data for a single lamp luminaire of this type is shown in table 2 (page 9) and has been used for this example. In reality the designer will need to consult the luminaire manufacturers' data for the particular luminaire proposed.

### Step 3 Work out the RI and derive the UF

With a working plane height of 0.8 m then *H = 3 – 0.8 = 2.2 m.*

$$\text{Room index} = \frac{7 \times 10}{2.2 \times (7 + 10)} = 1.87$$

Taking the reflection factors as 70% ceiling, 50% walls and 20% floor, and using the data in table 2, it can be seen that for a RI of 1.87 the installation will have a UF of 0.54. This is the value that falls between the value of 0.51 for a RI of 1.5 and a value of 0.56 for a RI of 2.0. This is called a process of interpolation.

### Step 4 Determine the maintenance factor

Section 4, 'Information about environmental cleanliness and maintenance factors' (page 15) indicates the things that need to be considered when determining this value. But for the purpose of this example let us presume that the office is in a relatively clean area and that the user will ensure that the luminaires will be cleaned at least every two years and that failed lamps will be replaced promptly (spot replacement). On this basis a maintenance factor of 0.8 would be appropriate.

### Step 5 Calculate the number of luminaires needed

The initial lumen output from a 1500 mm, T8 triphosphor fluorescent lamp, of the type required is 5200 lm.

Using the formula described in section 4, 'The number of luminaires required' (page 16) for an illuminance of 500 lux, calculate the number of luminaires required.

$$N = \frac{E \times A}{L \times UF \times M}$$

$$N = \frac{500 \times (10 \times 7)}{5200 \times 0.54 \times 0.8}$$

$$N = 15.6 \text{ luminaires}$$

## WORKED EXAMPLES – WORKED EXAMPLE 1

### Step 6 Consider the arrangement of the luminaires in the interior

Because a uniform illuminance is required to enable the tasks to be done anywhere in the space, a regular array of luminaires that meets the limiting spacing to height ratio will be necessary.

There are two options – either a 3 x 5 array using 15 luminaires, which will give slightly less illuminance than the 500 lux designed for, or a 4 x 4 array using 16 luminaires, which will give a slightly higher illuminance. Because the design was based on the high point of the CIBSE recommended range (300-500 lux), the 15-luminaire solution is likely to be acceptable.

The array of luminaires will need to be arranged and controlled to complement the daylight distribution, which flows across the room. This suggests three rows of luminaires parallel to the window and each row switched separately. In a room 7 m wide this will mean a spacing between rows of 7/3 = 2.33 m centre to centre. The spacing along the rows will be 10/5 = 2 m centre to centre. The spacing at the edge of the array will be the spacing divided by two. For the layout see figure 9.

To check whether the spacing is acceptable to meet the uniformity requirement, calculate the maximum spacing/height ratio. In this case the largest spacing is 2.33 m and hence the maximum spacing/height ratio is 2.33/2.2 = 1.06. This is well below the maximum of 1.5 recommended by the manufacturer and is therefore acceptable.

### Step 7 Calculate the maintained illuminance for the actual number of luminaires proposed

Return to the basic lumen method calculation formula and calculate the maintained illuminance for 15 luminaires in the interior.

Rearrange the formula used above so that the illuminance is the unknown:

$$E = \frac{N \times L \times UF \times M}{A}$$

$$E = \frac{15 \times 5200 \times 0.54 \times 0.8}{70} = 481 \text{ lux}$$

This is within the recommended illuminance band (300-500 lux) for this application.

### Step 8 Check energy efficiency

Assuming 63 W per luminaire, which includes 58 W for the lamp and 5 W for the luminaire control gear, the installed power density is:

$$\frac{63 \times 15}{7 \times 10} = 13.5 \text{ W/m}^2$$

This value is slightly higher than the target value of 11 W/m$^2$ given in table 5. This indicates that a more efficient luminaire might be available.

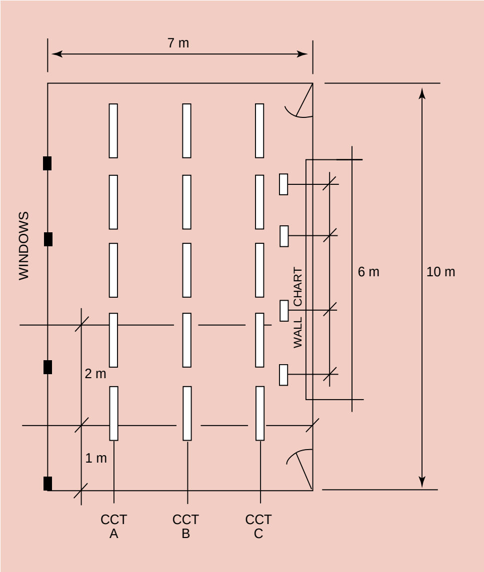



*Figure 9 Luminaire layout and circuits for example 1*

### Step 9 Add wall-washing luminaires to light the wall charts

The office has a wall chart, which needs to be referred to regularly, so it would be beneficial if this had some additional illumination. The wall chart runs for 6 m between the two doors and is 1.5 m high centred at normal eye height. The type of luminaire used for this purpose are wall-washing fittings – these have an intensity distribution that is angled towards the wall.

## WORKED EXAMPLES – WORKED EXAMPLE 1

The ceiling is suspended, so a row of recessed wall-washing luminaires adjacent to the wall are proposed. Again, the average task illuminance should be not less than an average of 300 lux. There will be some illumination from the regular ceiling array but probably not more than 100 lux. This means that at least a further 200 lux will be required.

A row of four wall-washing luminaires, each equipped with a 40 W CFL with the same colour performance as the general lighting (as shown in figure 10), will provide an average illuminance over the wall chart of 300 lux. This will provide an average wall chart illuminance of 400 lux. Note that the lighting performance of wall-washing luminaires varies, so it will be necessary to consult manufacturers' data for the actual performance.

The supplementary lighting is unlikely to cause any problems with reflections in the computer monitor screens because the lit area is large and the illuminance not excessive. Also, it will be preferential if the face of the computer screens are orientated at right angles to the windows.

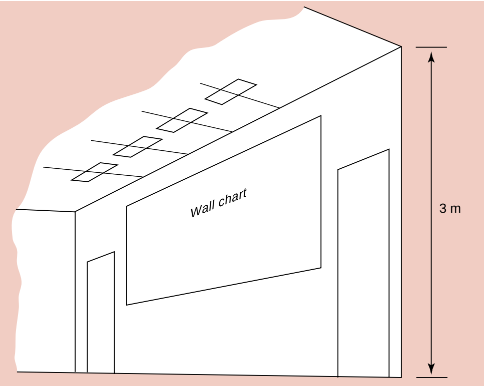



***Figure 10 Array of wall-washing luminaires to illuminate wall chart for example 1***

### Step 10 Check lighting controls

- Can the luminaires be switched relative to the daylighting?
- Are switches accessible to users and are they suitably identified?
- Would light sensor control be appropriate?
- Would automatic dimming be appropriate?
- Would individual control be appropriate?

The luminaires run in rows parallel to the window and each row can be separately controlled. This allows the electric light to complement the daylight as required. Further controls, such as daylight sensing and dimming, will need individual assessment.

**NOTE: HOW TO CALCULATE FOR IRREGULARLY SHAPED ROOMS**

Not all interiors are conveniently rectangular in shape. There are alternative ways of dealing with this problem, which will provide reasonable approximations for design purposes:

- calculate the RI for a square room having the same area
- if the interior can be subdivided into smaller rectangles, even overlapping, calculate for them separately.

Once the number of luminaires has been determined by one of the above methods, it will need to be adjusted to provide an ordered array of luminaires over the whole space.

## WORKED EXAMPLES – WORKED EXAMPLE 2

### HOW TO ADD EMPHASIS LIGHTING FOR SHOPS AND OTHER DISPLAY SITUATIONS

#### The design brief or problem

A retail area, which has a 4 m high ceiling, is lit to a general level of 300 lux on a 0.8 m high working plane by a regular array of ceiling-mounted luminaires. A number of floor-standing displays are planned that will require additional emphasis or display lighting. The displays, which can be viewed from all sides, will each be contained within a circle 1 m diameter and are not more than 2 m high. The display positions will vary, so a track system is proposed. Which spotlights should be used to provide subtle and moderate emphasis on the displays?

#### Step 1 Determine the lighting required for the desired effect

Referring to the CIBSE Code, Section 2.4.8, subtle and moderate emphasis lighting requires around five and 15 times the general light level respectively. Although the horizontal plane illuminance is 300 lux, the illuminance on a vertical display from the general lighting is likely to be less, say 100 lux. Therefore, the emphasis illuminances will need to be 500 lux and 1500 lux respectively to create the required effect.

The positions of the emphasis lighting for good modelling and visual comfort requires an aiming angle of around 30-40° from the downward vertical. Figure 11 shows the general arrangement with a 30° aiming angle.

#### Step 2 Check performance details of typical spotlights of the general type required

Figure 11 shows that a beam angle of around 25° is required for reasonable coverage of the display and the aiming distance is about 3 m.

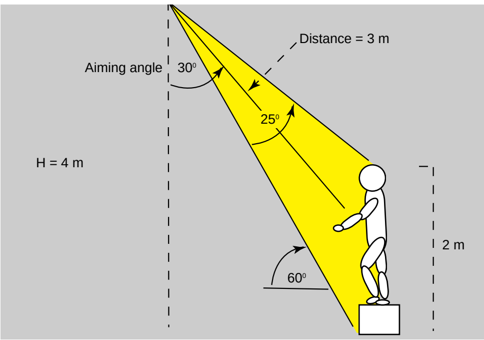



*Figure 11 Details of emphasis lighting in example 2*

From manufacturer's information it can be found that a 12 V, 100 W tungsten halogen reflector spotlight, with a 24° beam angle, will produce an illuminance of 940 lux at a distance of 3 m. This lamp provides a possible solution, but there will be others and the designer is encouraged to study all possibilities including the use of small discharge lamps in suitable spotlights.

#### Step 3 Consider the angle or plane of the display and the resulting illuminance

The above data relates to illuminance perpendicular to the spotlight beam (ie the horizontal if the spotlight is directed vertically downwards) while displays are usually viewed and assessed for vertical illuminance. To allow for this, it will be necessary to multiply the illuminance values provided by the manufacturer by the cosine of the angle between a line at right angles to the main surface of the display and the aiming angle. In this case the angle is 60°. Hence the resulting illuminance on the vertical surface of the display will be:

*Vertical illuminance = 940 x cos 60 = 470 lux*

This shows that to achieve an illuminance of 500 lux on the main plane of the display will require the 100 W lamp, and for 1500 lux three of these lamps will be necessary. Other alternatives may provide better solutions.

Some displays may require light from more than one direction to provide a pleasing and informative display. The designer is recommended to experiment with different spotlights and positions.

#### Emphasis lighting for linear displays (eg bookshops and supermarkets)

In supermarkets and similar interiors, lighting on goods displayed on shelving on walls and gondolas is important. Luminaires are normally employed that have a light distribution giving more light on vertical surfaces than is the case with most types of general lighting luminaires. These luminaires are sometimes described as having 'batwing' intensity distributions. An alternative solution is to mount the luminaires on the gondola itself and have a lighting performance as the wall-washing luminaires used in example 1 (figures 9 and 10).

## WORKED EXAMPLES – WORKED EXAMPLE 3

### CASE STUDY DEMONSTRATING PAYBACK PERIOD

#### Original installation

A computer centre, built in 1979, was originally lit by 48 prismatic luminaires, each equipped with three fluorescent lamps (1.5 m, 80 W, T12 White) with a quickstart ballast. The installation was designed to provide 500 lux. The initial lamp light output was 5550 lumens and luminaire UF was 0.5.

#### Hours of use

The computer room lights are used 24 hours a day, all year round (8760 hours per year).

#### Measures taken

The existing installation was replaced with 54 specular louvre luminaires, each equipped with two fluorescent lamps (1.5 m, 58 W, T8 White) with an HF electronic ballast. The installation is designed to provide 500 lux. The initial lamp light output was 5200 lumens and luminaire UF was 0.7.

Table 6 shows the calculations (in the right hand columns) to arrive at the payback in years by installing HF fluorescent lamp luminaires.

The cost of the new system – nearly £8000 – is recovered in 2.5 years. After that time the customer saves about £3000 each year. If the installation required replacing anyway, only the extra cost should be counted, ie the difference between like-for-like replacement and the energy efficiency option. The payback period would then be even shorter.

This example demonstrates what can be achieved, although the degree of saving will depend on the particular situation.

| | Existing system | Proposed system |
|---|---|---|
| Annual hours use (a) | 8760 | 8760 |
| Lamp and luminaire type | Three fluorescent lamp (1.5 m, 80 W, T12) diffuser luminaire with a quickstart ballast | Two fluorescent lamp (1.5m, 58 W, T8) specular louver luminaire with a HF ballast |
| Electrical load per fitting (Watts) (b) | 288 | 110* |
| Number of fittings (c) | 48 | 54 |
| Total electrical load (kW) (d = b x c/1000) | 13.82 | 5.94 |
| Annual electrical use (kWh) (e = a x d) | 121 063 | 52 034 |
| Cost of electricity (pence per kWh) (f) | 4.56 | 4.56 |
| Annual electrical cost (£) (g = e x f/100) | 5520 | 2373 |
| Annual electrical cost savings of proposed system (£) (h = g for existing system – g for proposed system) | 3147 | |
| Capital cost of proposed system (£) (i) | | 7950 |
| Payback period (years) (i/h) | | 2.5 |

* Note that although the lamp wattage is labelled as 58 W, when operating on HF ballasts the total circuit watts for a two-lamp circuit is 110 W. This is because the lamp operates more efficiently under these conditions.

*Table 6 Calculating payback periods of a proposed system of computer room lighting replacement*

# 8 CONCLUSIONS

This Guide has been produced to provide general guidance on the electric lighting of building interiors. It aims to flag up the main issues that must be considered for all situations, but because it has not addressed individual building types or user applications inevitably further details will need to be considered. These will largely emerge when the designer considers the particular application and space to be lit. They will range from circulation areas, which include corridors and stairs, to working areas that can range from the electronic office to the storeroom. There will also be spaces that have more of a leisure purpose, but even these will have task requirements as well as the need for the space to be visually attractive. Safety is another important issue and will range from providing lighting that avoids accidents to providing emergency lighting to enable the safe exit from the building under failed power situations.

All installations will need regular maintenance and they all must use energy efficiently as well as be cost-effective.

On the face of it lighting seems a simple engineering discipline – in fact it is a complex set of interacting requirements. These range from human to architectural requirements as well as economic requirements.

Although this Guide is aimed at the electrical contractor others may find it of value. But it should be seen as an introduction from which the interested reader can go on to further strengths.

# 9 GLOSSARY

**Ambience**
As used in this document – the general visual appreciation of the warmth or coolness of an illuminated area.

**Angle of incidence**
The angle at which light strikes a plane of reference. It is measured as the angle between the light beam and the perpendicular to the plane at the point of reference.

**Ballast**
Part of the control gear used to regulate the electric current taken by a discharge lamp. Sometimes referred to as a '***choke***'.

**Beam angle**
This is defined as twice the angle from the beam centre to the point at which the intensity is half the maximum. Manufacturers' photometric information is not always based on this definition and the user should check which system is being used.

**Candela**
The unit of luminous intensity equal to one lumen per unit solid angle (steradian).

**Choke**
See ***ballast***.

**Colour appearance**
A term relating to the light source. Objectively, the colour of a truly white surface lit by the source. Subjectively (as used in this document) the degree of warmth associated with the light source colour. Lamps of low colour temperature (CCT) are usually described as having a 'warm' colour appearance and lamps of high CCT as having a 'cool' appearance.

**Colour rendering**
The appearance of surface colours when illuminated by a light source compared, consciously or unconsciously, with their colour appearance under light from a reference source. Good colour rendering implies similarity of appearance to that under an acceptable light source, such as daylight.

**Colour rendering index (Ra)**
A measure of the degree to which the colours of surfaces illuminated by a light source conform to those same surfaces under a reference source. The reference source situation is taken as 100 and a standard range of colours (commonly eight) assessed under it and the source in question. The assessment is expressed as a number less than 100. Note that numbers less than 25 mean the light source is very limited in its colour rendering properties. Indices of above 80 indicate colour rendering is good or excellent.

**Colour temperature**
The temperature of a 'full radiator' that emits radiation having a chromaticity (colour quantity defined by an accepted system) nearest to the light being considered, ie the colour of a full radiator at 3500 K (Kelvin) is the nearest match to that of a 'White' fluorescent lamp, which is therefore said to have a CCT of 3500 K.

**Direct lighting**
The part of the illumination that reaches the plane, or object, directly without reflection from other surfaces.

**Disability and discomfort glare**
See ***glare***.

**Emphasis or accent lighting**
Lighting intended to draw attention to the illuminated area/object.

**General lighting**
Lighting that illuminates the whole of an area nearly uniformly without other assistance.

**Glare**
Discomfort (glare) or impairment of vision (disability glare) experienced when parts of the visual field are excessively bright in relation to the general surroundings.

## GLOSSARY

**Group replacement**
A maintenance procedure where all lamps are replaced at once. This may have visual, electrical and financial advantages over 'spot replacement'.

**Illuminance**
The amount of light incident on a surface. Measured in lux (lumens/square metre).

**Indirect lighting**
Lighting in which the greater part of the light flux reaches the working plane after reflection from another surface (usually the ceiling or walls of the interior).

**Light output ratio (LOR)**
The ratio of the total light output of a luminaire to that of the lamp or lamps under reference conditions. This can be divided into the upward component, the upward light output ratio (ULOR), and the downward component, the downward light output ratio (DLOR).

**Lighting structures**
Lighting structures generally consist of extruded aluminium profiles on a larger scale than lighting track systems, in various geometric shapes, eg circular, ovoid, triangular or rectangular. They can be mounted, suspended and coupled to form versatile and flexible lighting systems.

**Local lighting**
Lighting designed to illuminate a particular small area, which usually does not extend far beyond the area of the visual task.

**Localised lighting**
Lighting designed to illuminate an interior and at the same time provide higher illuminances over particular parts of the interior.

**Lumen (lm)**
The unit of luminous flux, used in describing a quantity of light emitted by a source or received by a surface.

**Luminance**
The physical measure of the stimulus, which produces the sensation of brightness, measured by the luminous intensity of the light emitted or reflected in a given direction from a surface element, divided by the projected area of the element in the same direction. This is measured in candelas per square metre.

**Luminous intensity**
A quantity which describes the strength of a light source, or illuminated surface, to emit light in a given direction. It is the luminous flux emitted in a very narrow cone containing the direction divided by the solid angle of the cone. The unit is the candela.

**Lux**
The unit of illuminance equal to one lumen per square metre.

**Maintained illuminance**
The average illuminance over the reference surface at the time maintenance has to be carried out by replacing lamps and/or cleaning the equipment and room surfaces.

**Maintenance factor (MF)**
The ratio of illuminance provided by an installation at some stated time, with respect to the initial illuminance (ie after 100 hours of operation).

**Photometric data**
This is a general term to describe the lighting performance of a lamp or luminaire.

**Polar curve**
This is a term often used to describe the luminous intensity distribution of a lamp or luminaire. This indicates the directions in which the light is going. The units will be either candelas or candelas/1000 lm. The latter needs to be multiplied by the total luminaire lamp lumens divided by 1000. This approach is used when a particular luminaire can be supplied for different lamp types but the distribution shape is nominally the same.

## GLOSSARY

**Reflection factor**
The ratio of luminous flux reflected from a surface to the flux incident on it. The value is always less than one and expressed as a percentage or decimal.

**Room index**
An index related to the dimensions of a room used when determining the UF and other characteristics of the lighting installation.

**Run-up time**
The time taken from switching on a lamp until it is emitting 80% of its maximum light output.

**Spacing height ratio (SHR)**
A ratio describing the distance between luminaire centres in relation to their height above the working plane.

Variations of this ratio are:
- SHR maximum – for use relating to continuous rows of linear luminaires
- SHR nominal – for use where other variations are not applicable
- SHR square – for use with square arrays of luminaires
- SHR transverse – for use in reference to the spacing between rows of linear luminaires
- SHR axial – for use with reference to the spacing in rows of linear luminaires.

**Spot lamp replacement**
A maintenance procedure when individual lamps are replaced only when they fail. This procedure is sometimes used in conjunction with group replacement. It is used to replace early failures that occur between initial installation and bulk lamp change.

**Utilisation factor (UF)**
The proportion of luminous flux emitted by the lamps that reaches the working plane.

**Visual environment**
The environment, either indoor or outdoor, which is seen by the observer.

**Visual field**
The full extent in space of what can be seen when looking in a given direction.

**Visual task**
The visual element of the work being done.

**Working plane** (also **reference surface** and **task area**)
The horizontal, vertical or inclined plane in which the visual task lays. If no data is available the working plane may be taken as 0.8 m above the floor

## ENERGY EFFICIENCY BEST PRACTICE PROGRAMME DOCUMENTS

The following Best Practice programme publications are available from the Environment and Energy Helpline (0800 585794) or the programme website (see below).

### Good Practice Guides

160 Electric lighting controls – a guide for designers, installers and users
189 Energy efficiency in hotels. A guide to cost-effective lighting
199 Energy efficient lighting – a guide for installers
210 Energy efficient lighting in the retail sector
223 Cost-effective lighting for sports facilities: a guide for centre managers and operators
245 Desktop guide to daylighting – for architects
272 Lighting for people, energy efficiency and architecture – an overview of lighting requirements and design

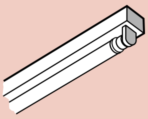
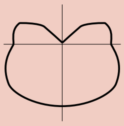
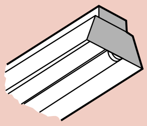
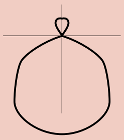
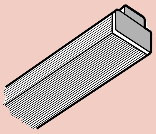
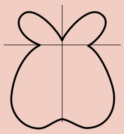
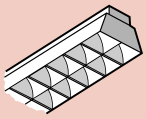
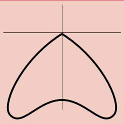
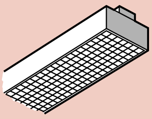
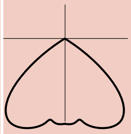
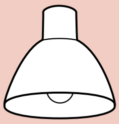
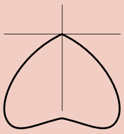
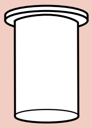
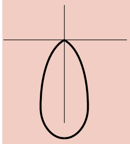
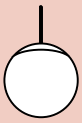
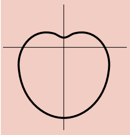
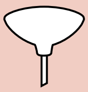
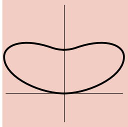
### Good Practice Case Study

361 Energy-efficient lighting for housing – exemplars for builders, installers, owners and managers

### Installer's Lighting Guides

- Installer's lighting guide number 1. Electric lighting of small offices and similar spaces
- Installer's lighting guide number 2. Lighting for small shops and other situations where display lighting is required
- Installer's lighting guide number 3. Exterior lighting for small premises
- Installer's lighting guide number 4. Lighting requirements for Part L of the Building Regulations 2000 (England and Wales) [to be published in 2002]
- Installer's lighting guide number 5. Lighting requirements for meeting the Technical Standard for compliance with the British Standards (Scotland) Regulations 1990 – Sixth Amendment [to be published in 2002]

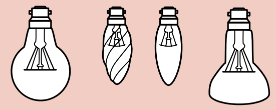
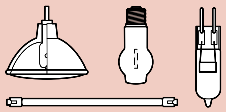
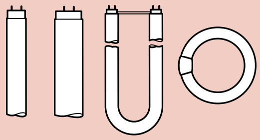
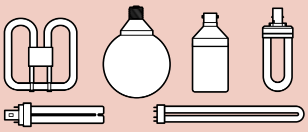
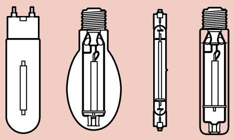
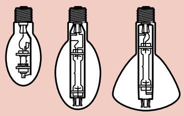
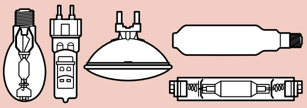
## LUMINAIRE TYPES

| Luminaire type | | Typical polar curve | Mounting possibility | Typical spacing/ height | Typical utilisation factor range | Application examples |
|---|---|---|---|---|---|---|
|  | **Fluorescent batten** |  | S, P | 1.75 | 0.23-0.82 | Industrial, high mounting height, could be glaring |
|  | **Fluorescent trough reflector** |  | S, P | 1.5 | 0.37-0.81 | Industrial, storage areas, DIY retail |
|  | **Fluorescent prismatic diffuser** |  | S, P | 1.5 | 0.13-0.65 | Industrial, commercial, retail |
|  | **Fluorescent specular louvre** |  | S, P, R | 1.25 | 0.34-0.7 | Industrial, commercial, retail, low glare |
|  | **Fluorescent diffuser louvre** |  | S, P, R | 1.75 | 0.3-0.6 | Industrial, commercial, retail |
|  | **High bay reflector** |  | S, P | 1.0 | 0.5-0.8 | Industrial, warehouse, high mounting height |
|  | **Downlight** |  | S, P, R | 0.75 | 0.3-0.75 | Commercial, retail, low glare |
|  | **Diffusing sphere** |  | S, P | 1.75 | 0.23-0.6 | General illumination, retail |
|  | **Uplight** |  | P, W, F | 3.0 | 0.1-0.5 | Commercial, retail |

S = Surface, P = Pendant, R = Recessed, W = Wall, F = Floor mounting

*Typical luminaire types and characteristics – these are provided as an indication but actual manufacturers' data should be used for design purposes*

## LAMP TYPES

| Lamp types | | Luminous efficacy (lm/W) | Average life (hours) | Colour appearance group | Colour rendering group | Run-up time (mins) | Restrike time (mins) |
|---|---|---|---|---|---|---|---|
|  | **Tungsten filament** | 8-18* | 1000 | Warm | 1A (excellent) | Prompt | Prompt |
|  | **Tungsten halogen** | 18-24* | 2000-4000* | Warm | 1A (excellent) | Prompt | Prompt |
|  | **Tubular fluorescent** | 55-100* | 5000-15 000* | Warm, intermediate and cold* | 1A-2 (excellent-moderate)* | Prompt | Prompt |
|  | **Compact fluorescent** | 50-75* | 5000-10 000* | Warm and intermediate* | 1B (good) | Prompt | Prompt |
|  | **High-pressure sodium** | 70-125* | 14 000-30 000* | Warm | 1B-4 (good-very poor)* | 1.5-6* | 1-3* |
|  | **High-pressure mercury** | 40-60* | 14 000-28 000* | Intermediate | 3 (poor) | 2-5* | 4-7* |
|  | **Metal halide** | 70-110* | 6000-13 000* | Warm, intermediate and cold* | 1A-2 (excellent-moderate) | 1-2* | 5-15 |

* Depending on type

*Typical lamp characteristics – these are provided as an indication but actual manufacturers' data should be used for design purposes*

| Colour rendering | | | |
|---|---|---|---|
| **Colour rendering performance** | **Colour rendering identification group** | **Colour rendering index (Ra)** | **Typical applications** |
| Excellent | 1A | =>90 | Wherever accurate colour matching is required, eg colour inspection |
| Good | 1B | 80-89 | Wherever accurate colour judgements are necessary, eg shops and offices |
| Moderate | 2 | 60-79 | Wherever moderate colour rendering is sufficient |
| Poor | 3 | 40-59 | Wherever colour rendering is of little significance |
| None | 4 | 20-39 | Wherever colour rendering is of no importance |

| Colour appearance | | |
|---|---|---|
| **Colour appearance class** | **Correlated colour temperature (CCT)** | **Typical applications** |
| Warm | Below 3300 K | Domestic-type situations |
| Intermediate | 3300-5300 K | Combined daylight and electric light |
| Cold | Above 5300 K | Situations where a cool appearance is required |

*Lamp colour performance*

Fold -in flap 205 x 297

# FURTHER INFORMATION

## FURTHER READING

### BRE

- BRE Information Paper IP6/96. People and lighting controls
- BRE Information Paper IP2/99. Photoelectric control of lighting: design, setup and installation issues
- BRE Information Paper IP14/00. Hospitals in the best light: an introduction to hospital lighting
- BRE Report BR415. Office lighting
- BRE Report BR430. Energy efficient lighting – Part L of the Building Regulations explained

### Chartered Institution of Building Services Engineers (CIBSE)

- Code for Lighting
- Lighting Guide LG2. Hospitals and healthcare buildings
- Lighting Guide LG3. The visual environment for display screen use
- Lighting Guide LG4. Sports
- Lighting Guide LG5. Lecture, teaching and conference rooms
- Lighting Guide LG6. The outdoor environment
- Lighting Guide LG7. Lighting for offices
- Lighting Guide LG8. Lighting for museums and art galleries
- Lighting Guide LG9. Lighting for communal and residential dwellings
- Lighting the environment: a guide to good urban lighting (published jointly by CIBSE and the Institution of Lighting Engineers)

### Industry Committee for Emergency Lighting

- ICEL 1004. The Use or Modification of Mains Luminaires for Emergency Lighting Applications
- ICEL 1006. Emergency Lighting Design Guide
- ICEL 1008. Emergency Lighting Risk Assessment Guide

### Lighting Industry Federation

- Technical Statement 10. The Handling and Disposal of Lamps
- Lamp Guide

### The Stationery Office

- The Building Regulations Approved Document Part L1 and L2: Conservation of Fuel and Power

## CONTACTS

### Electrical Contractors Association (ECA)

34 Palace Court, London W2 4HY
Tel 020 7313 4800. Fax 020 7221 7344

### Energy Saving Trust

21 Dartmouth Street, London SW1H 9BP
Tel 020 7222 0101. Fax 020 7654 2444

### Industry Committee for Emergency Lighting Ltd

Swan House, 207 Balham High Road, Balham
London SW17 7BQ
Tel 020 8675 5432. Fax 020 8673 5880

### Institution of Lighting Engineers (ILE)

Lennox House, 9 Lawford Road, Rugby Warwickshire
CV21 2DZ
Tel 01788 576492. Fax 01788 540145

### Lighting Industry Federation Ltd (LIF)

Swan House, 207 Balham High Road
London SW17 7BQ
Tel 020 8675 5432. Fax 020 8673 5880

### Scottish Electrical Contractors Association (SELECT)

Bush House, Bush Estate, Midlothian EH26 0SB
Tel 0131 445 5577. Fax 0131 445 5548

### Society of Light and Lighting

Chartered Institution of Building Services Engineers (CIBSE)
222 Balham High Road, Balham, London SW12 9BS
Tel 020 8675 5211. Fax 020 8675 5449

**This Guide is based on material drafted by Roger Gardner under contract to BRECSU for the Energy Efficiency Best Practice programme.**

**The Government's Energy Efficiency Best Practice programme** provides impartial, authoritative information on energy efficiency techniques and technologies in industry and buildings. This information is disseminated through publications, videos and software, together with seminars, workshops and other events. Publications within the Best Practice programme are shown opposite.

Visit the website at **www.energy-efficiency.gov.uk**

Call the Environment and Energy Helpline on **0800 585794**

**Energy Consumption Guides:** compare energy use in specific processes, operations, plant and building types.

**Good Practice:** promotes proven energy-efficient techniques through Guides and Case Studies.

**New Practice:** monitors first commercial applications of new energy efficiency measures.

**Future Practice:** reports on joint R&D ventures into new energy efficiency measures.

**General Information:** describes concepts and approaches yet to be fully established as good practice.

**Fuel Efficiency Booklets:** give detailed information on specific technologies and techniques.

**Introduction to Energy Efficiency:** helps new energy managers understand the use and costs of heating, lighting, etc.