Electric lighting controls
– a guide for designers, installers and users

- Guidance for new build and refurbishment
- Energy savings and other benefits
- The types of controls available
- Planning a control system
- Case studies of successful installations
CONTENTS

1 INTRODUCTION 3

2 BENEFITS 4

3 LIGHTING CONTROL EQUIPMENT 5
   Local switches and dimmers 5
   Time operated controls 5
   Presence or occupancy sensor operated controls 5
   Illuminance sensor operated controls 5
   Central controller 6
   Scene-set control 7
   ‘Intelligent’ luminaires 7

4 PLANNING A LIGHTING CONTROL SYSTEM 8

5 POINTS TO REMEMBER 10

6 GLOSSARY AND FURTHER INFORMATION 11

REFERENCES AND FURTHER READING 12
1 INTRODUCTION

INTRODUCTION
Electric lighting controls have become an important element of lighting installations. They can:

- save energy as well as running costs
- improve user satisfaction
- provide flexibility of use and operation for workplaces
- make management better informed about the operation, cost and maintenance of a lighting installation.

Unless a control system meets user requirements and is easy to operate, any potential benefits may be lost.

Lighting controls for new buildings are now in the Building Regulations Part L, 1995[1].

This Guide provides an overview for anyone involved in the planning, implementation, installation and operation of lighting controls. It describes the different types of controls, discusses possible problems to be addressed when designing and installing a system, and includes seven case studies illustrating solutions adopted in a variety of buildings.

While this Guide is primarily for use with new buildings it will also apply to refurbishments, where changes to existing electrical installations may be needed.

Detailed design guidance is not provided, nor performance specifications of particular products. Expert advice on these matters should be sought from the organisations listed on page 11.
## 2 BENEFITS

### BENEFITS

#### Energy and cost savings

Major savings in both energy and running costs can be achieved by using controls to operate electric lighting only when it is required, i.e. only when daylight is inadequate and the workplace is occupied. Savings can also be achieved by adjusting the light output of a luminaire to provide the required illuminance throughout the maintenance cycle of the installation (known as ‘design maintained illuminance’). Saving energy reduces emissions of carbon dioxide and other gases harmful to the environment.

#### User satisfaction

People value being able to adjust their lighting to suit the job in hand. This can be achieved by providing task lighting with switch or dimmer control. Changes in the appearance of the light pattern can sometimes provide a visual stimulus which enhances user performance.

#### Flexibility of space use and organisation

Modern workspaces need to be flexible. When new tasks are introduced requiring different lighting, dimmer-controlled lighting provides a solution. When changes to a workspace mean walls or partitions must be moved, major expense can be avoided if lighting circuits and light output can be altered without disturbing the fixed wiring. This is possible with luminaires that can be individually controlled remotely rather than from wall-mounted switches.

#### Provision of management information

By addressing individual luminaires through central control systems, management can record hours of luminaire use and therefore energy consumption. It is also possible to assess maintenance requirements, identify faults and provide a facility for the testing of emergency lighting equipment. Operating costs will be reduced and the efficiency of the company improved.

Developments in technology may bring further benefits. To ensure these are considered for a projected lighting installation, particular user requirements should be discussed at the time with the system designer.

---

### POWERGEN OPERATIONAL HEADQUARTERS, COVENTRY

PowerGen’s headquarters is a long, narrow three-storey open-plan office building with a top-lit central atrium. Offices are daylit from side windows and from the atrium. The windows on the south side and the atrium rooflight have fixed solar shading. Electric lighting is provided from suspended direct/indirect high frequency fluorescent lamp luminaires which fit into boat-shaped ceiling coffers. Near windows the electric lighting is controlled by photo-sensors – the lighting is switched off when daylight reaches a predetermined level. The lighting can also be switched off at set times during the day, currently at 0800, 1200 and 1700 hours. Occupants can override the lighting controls for their area via the telephone system and their own personal number.

The lighting controls form part of a building management system.

---

### WALLACE COLLECTION, LONDON (REFURBISHMENT)

The Wallace Collection comprises paintings, sculpture and furnishings displayed in a 19th century London town house. A refurbishment programme is underway to provide adjustable lighting comprising two main elements: low voltage spot lights to light the exhibits and a central pendant fitting. A ‘scene-set’ controller provides switching between ‘scenes’ – currently it provides:

- display lighting to supplement daylight
- display lighting for night-time
- display lighting combined with the central pendant luminaire when the gallery is used for social functions.

The normal gallery lighting switches off automatically outside public opening hours to minimise light exposure. The gallery also contains light and ultraviolet sensors to continuously monitor exhibit exposure.
LIGHTING CONTROL EQUIPMENT

There are two types of lighting controllers - switches and dimmers. These can be activated by time switches, presence (or occupancy) detectors, and light sensors (photocells). The different control circuit elements can be used on their own or in combination, depending on requirements.

Local switches and dimmers

These are either permanently wired, such as wall- or ceiling-mounted pull switches, or are remote control devices like those commonly used to operate televisions and video recorders.

Permanently wired manual switches need to be positioned near to the lighting circuit they operate, and should be easily accessible to ensure that only the lights that are necessary are switched on. Approved document Part L of the Building Regulations specifies that the operating switch should be no more than 8 m (in plan) away from the luminaire that it controls, or no more than three times the height of the luminaire above floor level if this is greater[1]. If a multi-switch panel is used it is important to label clearly the individual switches to avoid any being operated unnecessarily.

Remote control devices use either infrared, microwave or ultrasonic transmitted signals to switch or dim lighting circuits. They can be hand-held or surface-mounted. The receiver, or sensor, is often ceiling-mounted, so that walls or partitions can be removed without the need for an electrician. It is essential that the receiver or sensor can be activated from the normal control positions.

Time operated controls

These can be used to switch lights off when they are not required, such as at lunchtime or at the end of the working day, or at a time when it is estimated there will be sufficient daylight. A manual override must be provided to allow users to switch lights on if necessary. Time operated switches can also be used to control lights in any situation with a regular period of operation. Lights in a windowless circulation area, for example, can be switched on just before people arrive in the morning and switched off at the end of the day.

Presence or occupancy sensor operated controls

These can be used to switch lights on as people enter a room and off again after they have left. This avoids lights being left on unnecessarily. They can be used to operate task lighting, or lighting in rooms which are used infrequently, such as storerooms. They can be particularly useful in rooms where people are likely to have their hands full on entering.

The circuit will need to include a time delay to allow people to leave the space safely and to avoid lights being constantly switched on and off. Frequent switching of fluorescent lamps can shorten their life unless appropriate control gear is used[2].

Presence detectors can be ceiling- or wall-mounted, but the sensor must be able to detect an occupant at all times. This may require more than one sensor to cover an area. Sensors must also be sufficiently sensitive to operate when required, but not too sensitive that they respond to extraneous signals.

An option is to combine a presence operated switch with a manual switch. The occupant switches the lights on manually when required, and the presence detector switches them off. This is sometimes referred to as ‘absence sensing’.

Presence sensors can be used for switching lights on and off when security and cleaning staff move around a building outside normal hours, and for security purposes to signal the presence of an intruder.

Illuminance sensor operated controls

In areas where there is adequate daylight for part of the time, daylight illuminance sensors (photocells) can be used to ensure that electric lights are not left on unnecessarily. People will often switch electric lights on first thing in the morning when it is still dark, but they are less likely to switch them off later when daylight becomes sufficient, particularly in shared spaces and circulation areas. Illuminance sensors can switch or regulate luminaire light output, but regulation (dimming) will require the appropriate control gear.
If switch control is used, the switch-off level must be set to avoid causing annoyance, i.e. switching off the luminaires when it will hardly be noticed. If the sensor records the combined daylight and electric light this will probably need to be at least three times the required task illuminance. A time delay will be needed to avoid frequent operation of lights in rapidly changing daylight conditions.

Dimmer control can provide a near constant illuminance and is usually more acceptable to users, particularly in shared spaces. Fluorescent lamps will normally dim down smoothly to a certain level, after which they can become unstable and start to flicker. The level at which this occurs will depend on the control gear, but it is typically 10% of full light output. If the requirement is to switch lights off in the dimmed position, switch-off should occur before the lamps become unstable. Where, for appearance purposes, it is preferred to leave the light on in a dimmed position, a standard preset level will be needed for all luminaires in a particular area.

Case Study

Constant task illuminance can be achieved by designing the lighting to provide the required illuminance at the end of the maintenance cycle with the dimmer on full. The controller will reduce the light output, and hence the energy consumed, at the beginning of the maintenance cycle when the lamps are new and the equipment is clean.

For daylight-linked lighting the illuminance sensor should be positioned relative to the daylight illuminance distribution, e.g. controlling a line of luminaires parallel to a window. The sensor may be positioned on the ceiling looking down to read the combined daylight and electric light illuminance, or it can be positioned to read the external daylight level. Either way, sensors must be calibrated to provide the correct level of electric light relative to the daylight.

Central controller

Luminaires can be controlled by a dedicated personal computer or a building management system. Depending on the sophistication of the

L’OREAL GOLDEN LTD, GLAMORGAN

The factory is an open-plan, single-storey building, with rooflights covering 10% of the roof area and vertical-view windows along one side. There is an access route along one side of the building. Electric lighting is provided by ceiling-mounted twin fluorescent lamps with high frequency ballasts, and reflector luminaires. There are three main zones: the area under the rooflights, the remainder of the factory area and the access route, all controlled independently. The luminaires in the rooflights are controlled by a photocell which switches them on and off to provide the required illuminance. The rest of the factory area is split into sub-zones controlled from ceiling-mounted photocells which monitor the illuminance on the working plane. These luminaires are dimmer-controlled down to 25% of full light output. Corridor lighting is controlled from manual switches.
system and the wiring of the luminaires, almost anything is possible. Switching can be related to time, daylight level and occupancy, and luminaires can be linked into groups which can be changed when necessary. Dimming is also possible if the luminaires are equipped with appropriate control gear.

Luminaires can be controlled in particular sequences, so that room lighting is operated independently of, but linked to, circulation lighting. This can be used to prevent circulation lighting from being switched off if rooms are still occupied, thus allowing people a safe exit from the building. It is essential that adequate lighting is always provided to allow people to exit a building safely.

The emergency lighting installation must not be connected to the building lighting control system.

Central controllers can also monitor the length of time a luminaire or group of luminaires is on. This can provide important management information concerning energy consumption and maintenance requirements.

At times it will be necessary for users to access the system to alter the standard conditions the central controller is programmed to operate. This may be to take account of space reorganisation or revised occupancy patterns. The changes can be made with override switches or via a computer or telephone network.

At least one person should be available within the organisation who can operate and reprogramme the system when necessary. Equipment should therefore be easily reprogrammable and readily accessible, otherwise the resulting delays and frustration could undermine the usefulness of the whole control system.

**Scene-set control**

This allows lighting to be changed simply from one ‘light scene’ to another. In a restaurant, for example, appropriate lighting scenes can be created for breakfast, lunch and dinner by setting different luminaires to different light output levels. The scene-set controller achieves this via a multi-position switch, with one position for each of the ‘scenes’. The unit is programmed to store the individual luminaire settings and will switch or cross-fade from one to another as required. Someone who understands the lighting requirement will be needed to reprogramme the unit when necessary.

**‘Intelligent’ luminaires**

Luminaires are now available with their own control sensors designed for occupancy and illuminance monitoring. The sensors can signal either a switching or dimming action, and can be overridden with a hand-held infrared controller. The luminaires can be programmed to provide a constant maintained illuminance throughout the maintenance cycle of the installation. Illuminance and time delay, which operates when the occupancy sensor ceases to record movement, can be adjusted manually by using controls within the luminaire or remotely.

**SEEBOARD CUSTOMER SERVICE OFFICE, CROYDON (REFURBISHMENT)**

Seeboard has developed a refurbishment electric lighting design which comprises a regular array of ‘intelligent’ fluorescent lamp luminaires with high frequency dimming control gear and incorporating both light sensors and presence detectors. The large open plan offices have good levels of daylight. There is no need for a central control, as the lighting is off unless the area below the luminaire is occupied and there is insufficient daylight. Presence detectors have a 10-minute delay after recording the space is unoccupied before switching off the luminaire. User response has been favourable after earlier concerns that if people worked late they might feel insecure when working in a single lit area. The concerns were unfounded as anyone approaching the area would automatically activate other luminaires.
4 PLANNING A LIGHTING CONTROL SYSTEM

A control system is an element of a lighting installation which aims to provide a number of facilities, including:
- functional lighting, which enables people to carry out their particular tasks
- lighting aesthetics, which enhances the visual quality of the building.

Both aspects can affect user performance either directly or indirectly. Lighting installations must also be energy efficient, using no more energy than is absolutely necessary for the application. This will limit the environmental impact and also help to minimise the client's operating costs.

A well-designed lighting control system can contribute to all aspects of lighting.

The first priority when designing a control system is to determine the control requirements of occupants and management. Designer and client must then ensure that the system incorporates all the control operations necessary.

It should be tested using a ‘what if’ approach, aided by a flow diagram produced by the designer indicating the sequence of operations produced by all possible user scenarios.

A further check needs to ensure that the system is logical and user friendly. Many control systems fail because the designer has not adequately considered all the user requirements, or the way in which the controls operate. Controls must not be perceived by the user as intrusive. Users must also be able to override the system in certain situations, either directly or on request.

The control system must default to a safe condition if a fault develops, and return to the pre-fault condition after the fault has been rectified. At no time should the building be without lights.

It is advisable to use one manufacturer when selecting equipment. If this is not possible, ensure that the different components are compatible before finalising a system design. Different manufacturers have different operating protocols and, while there are moves to establish a standard protocol, agreement may be a long way off.

In common with other electrical equipment, lighting control components must conform to the required European Community directives (indicated by CE marking on the product). For lighting this includes the Low Voltage, Electromagnetic Compatibility and Construction Products Directives.[3]

Light sensors and presence detectors must be positioned with respect to their response area profile. Remember, it may be necessary to have more than one sensor to cover an area adequately, particularly if there are obstructions like partitions or high filing cabinets. Sensors should not see beyond the area being controlled, otherwise lighting could be operated unnecessarily, for example by a person walking past an open door. This can both waste energy and cause annoyance.

IONICA HEADQUARTERS, CAMBRIDGE

The Ionica building is a three-storey, general purpose office. It has a linear plan running east/west with glazing on the north and south façades. In addition, there is a central atrium. The south-facing windows have manually controlled venetian blinds. The electric lighting is mainly from ceiling-mounted HF dimmer-controlled linear fluorescent lamp luminaires, which provide both indirect light reflected from the ceiling and direct downlight. The electric lighting operates from a central controller with mains-borne communication. It incorporates time control, which switches lights off outside the normal working day. It also provides daylight-linked supplementary electric lighting. The daylight linking also controls the exterior lighting. The control system incorporates user override for both the time operation and daylight linking.
Once the control system is finalised, its integration with the lighting circuits needs to be planned. Circuit wiring details should be transmitted to the electrical engineer in good time to ensure that luminaires are connected correctly and can be controlled in the required manner.

Lighting control systems can be outside the experience of some electrical installation companies because of their complexity and use of electronics. Unless the proposed contractor is familiar with control systems, it may be advisable to use a specialist company.

It is not only the electric lighting itself that the system can control. It can be designed to:
- record lamp burning hours
- indicate lamp failures
- record the energy used by particular luminaires, or groups of luminaires.

In a building with multiple occupancy, therefore, separate billing is possible. It is also possible to integrate the system with the control of adjustable window blinds or sun shading devices. These commonly operate when there is a problem such as glare caused by direct sunlight, but often fail to be readjusted when the problem passes. Hence there could be advantages in coupling the control of daylight and sunlight to the control of the electric light.

There should always be someone in the client’s organisation who understands the system and can deal with problems. This could be the facilities or accommodation manager.

The manufacturer of the system, or the agent, should provide an easy-to-follow handbook, in-house training for all users and preferably a telephone help-line.

Expert advice should be obtained on system design and equipment specification, except for the most simple control systems (see list of organisations to contact under Further Information, page 11).

**Boots the Chemist (Refurbishment)**
New lighting equipment fitted as part of a store refurbishment programme comprises a regular array of high frequency, dimmable fluorescent lamp luminaires combined with wall lighting and illuminated signs. Time controls provide for three different lighting levels: cleaning and restocking, and two different trading levels (busy and quiet). This control also ensures that all display lighting and illuminated signs are switched off when the store is closed. Photocell control provides a constant maintained illuminance to ensure maximum efficiency and increased lamp life. Stockrooms are fitted with occupancy sensors to reduce the light level to a low illuminance when unoccupied. All lights are switched off manually when the last person leaves the building.

**Railtrack Control Room, Brighton (Refurbishment)**
Most of the work in the control room, which operates 24 hours a day, involves visual display units and a large wall-mounted display panel. Lighting comprises ceiling-recessed, high frequency fluorescent lamp luminaires, with high frequency dimming control gear. These are combined with ceiling-suspended uplights equipped with metal halide lamps. Control is from a ‘scene-set’ pre-programmed system which provides the required working illuminance. Operators are free to override the basic setting to adjust the lighting to their requirements using a hand-held infrared controller. The option of different lighting conditions for different times of the day has proved popular.
This is a summary of the main points to remember when designing and installing a lighting control system. It can be photocopied and used as a checklist whenever required.

### System design
- Determine precisely the user's requirement – for both individuals and management – and draw up a proposal.
- Produce a flow diagram to test the proposal.
- Test the proposal from the user's perspective, eg will it provide the lighting required at all times? Can the lighting be changed for different user requirements?
- Test the proposal for the manager’s requirement, ie will it save energy and money? Will it provide information on maintenance and energy use?
- Ensure that the system can be operated easily by the users as well as by the person responsible for the system. Does the system have a logical operation and is it user friendly? Can it be reprogrammed easily when necessary?
- Does the system have sufficient flexibility for the range of likely future building uses, or can it be modified?
- Does the system allow for changes to the layout of work areas and for changes in room organisation?
- Is the lighting system, including the lamps and luminaires, appropriate for the control strategy?
- Are all the elements of the proposed control system compatible with each other?
- Is the control equipment and its interface with the building visually acceptable?
- Ensure that space is provided for housing the control equipment hardware and its associated wiring.
- Will the appearance of the lit environment be acceptable under all control situations?
- Check that the cost of the installation includes commissioning and testing as well as user training.
- Is the control system proposed good value? This may be measured in human, environmental or financial terms.

### System installation
- Ensure that the electrical contractor is competent to install and test lighting controls which include electronic circuitry.
- Ensure that the electrical contractor has all the necessary installation information, ie wiring requirements and positions of sensors and switches.
- If there are specific wiring requirements, ensure that the electrical contractor is informed, eg that luminaires parallel to the window are grouped as one circuit.
- If sensors or luminaires need to be adjusted or maintained, are they accessible?
- Ensure that daylight sensors are correctly calibrated.
- Ensure that occupancy sensors are not obstructed and will operate only the luminaires in the appropriate zone.
- Are manual switches, dimmers and remote controllers suitably labelled?

### System operation
- Ensure that users receive in-house training about the purpose of the system and its operation.
- Provide control system user manuals and, if possible, a telephone help-line.
- Ensure that there is at least one person in-house who can reprogramme the system and deal with operation problems and system faults.
- Establish service contracts and repair procedures, including call-out response times if a fault develops.

Remember - aim to keep the lighting control system as simple and logical as possible.
**Control gear (or ballast).** Apparatus to start a discharge lamp and control the current through it.

**Designed maintained illuminance (unit: lux).** The maintained illuminance used in a lighting specification.

**Efficacy (or luminous efficacy) (unit: lumen/Watt).** The ratio of luminous flux emitted by a lamp to the power consumed by the lamp. When the power consumed by control gear is taken into account this term is sometimes known as lamp circuit efficacy.

**Illuminance (unit: lux).** The amount of light falling on a surface of unit area.

**Luminaire.** The correct term for a light fitting. An apparatus which controls the distribution of light from a lamp and includes all the components necessary for fixing, protecting it and connecting it to the supply.

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

**Maintained illuminance (unit: lux).** 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 cycle.** The point in time when maintenance needs to take place. This could be lamp and luminaire cleaning, room surface cleaning and lamp replacement.

**Task (or local) lighting.** Lighting designed to illuminate a task area, eg a desk light.

---

**FURTHER INFORMATION**

Details of lighting control designers and equipment suppliers may be obtained from the following:

Lighting Industry Federation  
207 Balham High Road, London SW17 7BQ  
Tel 0181 675 5432

The Chartered Institution of Building Services Engineers (CIBSE)  
222 Balham High Road, London SW12 9RS  
Tel 0181 675 5211

The Energy System Trade Association  
PO Box 16, Stroud, Gloucestershire GL6 9YB  
Tel 01453 886776
REFERENCES AND FURTHER READING

REFERENCES


FURTHER READING

The following publications are available from the BRE Bookshop, or the BRE’s publisher, CRC Publications. Tel 0171 505 6622.

- Lighting controls: an essential element of energy efficient lighting (IP5/87)
- Comfort, control and energy-efficiency in offices (IP3/95)
- People and lighting controls (IP6/96)
- Lighting controls and daylight use (Digest 272).

Code for interior lighting (1994) is available from CIBSE. Contact details are given on page 11.

DOE ENERGY EFFICIENCY BEST PRACTICE PROGRAMME DOCUMENTS

The following Energy Efficiency Best Practice programme publications are available from BRECSU Enquiries Bureau. Contact details are given below.

Good Practice Guides
158 Energy efficiency in lighting for industrial buildings – a guide for building managers
189 Energy efficiency in hotels. A guide to cost-effective lighting
199 Energy efficient lighting – a guide for installers

Good Practice Case Studies
158 Energy efficient lighting in factories. L’Oreal Golden Ltd, Llantrisant, Glamorgan

REFERENCES AND FURTHER READING