Standard specifications, layouts and dimensions

4 FOUR

Lighting systems in schools

department for
children, schools and families

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Contents

Introduction

This guidance is one of a series of Standard Specifications, Layouts and Dimensions (SSLD) notes produced to inform the Building Schools for the Future (BSF) programme.

Who this guidance is for

- Teachers and governors acting as clients for school capital projects
- Local authority officers responsible for procuring school capital projects
- Diocesan building officers
- Local authority and private sector school designers and specifiers
- Manufacturers and suppliers
- Contractors

How the guidance should be used

This guidance sets out the standards of performance for lighting systems in the Building Schools for the Future (BSF) programme and shows through some examples how they might be delivered. It is one of a number of publications on various building elements within the SSLD series. The aim is to disseminate best practice and avoid 'reinventing the wheel' every time a school building is designed, so that consistently high quality environments can be delivered, offering best whole-life value for money.

School building clients, their professional advisers, contractors and their supply chains should use this guidance to inform their decisions on lighting systems at the early stages of a project's development – whether new build, extension or refurbishment – at RIBA Stages A-F.

To help encourage the take up of these performance specifications, this guidance will become the standard in BSF programme documentation and the Government will expect it to be adopted in the majority of situations where it is reasonable and appropriate to do so.

While we would expect projects to comply with the standards, other solutions – possibly based on new products or technologies, or reflecting local factors – may equally comply with the performance specification and could be used. We do not want to stifle innovation by being too prescriptive.

It will be for users to exercise their own skill and expertise in deciding whether a standard or example shown in this document is reasonable and appropriate for their own circumstances. This guidance does not affect obligations and liabilities under the law relating to construction and building.

Though principally aimed at secondary school building projects delivered through the BSF programme, the specifications and examples may also apply to other educational buildings.

We will keep this guidance under review and update it as necessary to reflect the development of new products, processes and regulations. There is a web-based version at www.teachernet.gov.uk/schoolbuildings

Background to Standard Specifications, Layouts and Dimensions (SSLD)

The BSF programme offers a unique opportunity over the next 10-15 years to transform our secondary schools, providing innovative learning environments that will inspire pupils to achieve more. High quality, modern school buildings will help to raise standards and play a crucial part in the Government's programme of educational reform.

With the huge increases in funding associated with this programme, there is considerable scope for using standardised specifications, layouts and dimensions to speed up design and construction, reduce whole-life costs and deliver consistently high quality and better value school buildings. Standardisation will support the use of more off-site fabrication and modern methods of construction, which should help to improve health and safety performance, reduce waste and deliver more sustainable solutions. For the supply industry, being involved in standardisation will help to demonstrate market leadership – and help firms reduce risk and increase sales, profitability, and market size.

The examples in this document and the others in the SSLD series have been developed based on extensive consultation under the auspices of the SSLD Forum. Set up by the Department for Children Schools and Families (DCSF), this forum represents key stakeholders in the building design, research, contracting, and supply industry communities, as well as local authority construction client bodies.

Aims and scope of this guidance

This document provides standard performance specifications and some examples to help with the choice of lighting systems in BSF secondary schools.

Specifically it:

- sets out minimum standards of performance and quality expected by the DCSF
- provides design guidance for project designers formulating technical specifications
- standardises lighting requirement types so that efficiencies and economies of scale can be generated within the supply chain
- enables caretakers and facilities managers to manage lighting systems.

It is structured as follows:

Section 2

The generic performance requirements for lighting systems in secondary schools.

Section 3

A summary of the minimum performance requirements of lighting systems for each of the school areas as defined in Building Bulletin 98, together with some examples.

Section 4

References to relevant European, British Standards, DCSF and other design guidance.

A glossary of terms.

This guide has been produced to inform rather than replace detailed project specifications. Descriptions are given in generic terms and are not intended to promote the products of specific manufacturers. Contractors and specifiers should consult with relevant manufacturers to establish which products are appropriate and compliant.

When client bodies are compiling output specifications, they may decide simply to state a 'lighting type' (A to G) for a particular space (see Section 3 for details), or alternatively develop with their professional advisors a particular specification that meets their requirements.

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Key performance requirements

The following key performance requirements set the minimum standards that DCSF would expect to be adopted in BSF schools wherever it is reasonable and appropriate. Section 3 defines the specific lighting requirements for each space and provides some examples that address them.

This document is not a lighting design guide. Its purpose is to make clear the client requirements, the minimum standards to be reached or exceeded and what is expected to provide the best lighting environments for BSF and other school projects. More detailed information is available in DCSF Building Bulletin 90 Lighting *Design for Schools*[1] and further references listed in Section 4. While technical terms are explained in the Glossary in Section 4, it may be helpful to explain some of the terms here to assist understanding of the subject:

- **Illuminance**

  Average light level required which makes it easy and comfortable to carry out school activities. This is the minimum illuminance that should be provided on the activity area.

- **Uniformity ratio**

  Excessive variation of illuminance across the area where activities take place can be distracting and reduce visual performance. Uniformity ratio establishes minimum value in order to avoid excessive contrast and distraction.

1 www.teachernet.gov.uk/lighting

- **Limiting glare rating**

  For electrical lighting installations, in order to avoid bright sources in the line of view, the limiting glare rating indicates its maximum value permitted.

- **Colour rendering**

  Colour plays an important role in learning; a good colour rendering performance enables accurate colour judgements to be made. This value indicates the minimum colour rendering value of the lamps to be used.

Lighting to support teaching and learning

The primary objective of good lighting design in any type of building is to provide a well illuminated and safe working environment, which provides occupants with a feeling of well-being and allows them to perform their visual tasks.

The key performance requirements below refer to lighting over the activity areas but the electric lighting design should also enhance the space so that it appears attractive and interesting. Walls and ceilings should be illuminated to contribute to these impressions. Spaces that have areas of light and shade are generally liked and interesting but it is important that this variation is not too great. The colour appearance of the electric light needs to be considered because different lamp types produce different degrees of 'warmth' or 'coolness'.

Modern learning and teaching is more personalised and diverse, resulting in pupils learning in a variety of spaces and in various ways. A dining area, for example, may be used for group discussion or individual reading; a circulation area, such as part of an atrium, could be used for informal tutoring or project work; and laptops could be used everywhere. It is important to find out in the early stages of briefing and design how spaces will be used by the school so that lighting flexibility is designed in.

NB To ensure that secondary schools get the best possible learning environments, attractive and efficient for all the people who use it, it is essential to appoint an experienced lighting engineer and installation contractor.

In most types of buildings, users prefer rooms to have a daylit appearance during daytime hours. In schools, natural lighting during daylight hours should always be the main light source for reasons of quality of light and sustainability. Electric lighting and natural lighting should be complementary. Electric lighting will take over during the hours of darkness and should supplement natural lighting when it fades.

This guide covers electric lighting together with controls that encourage the use of electric lighting only when it is required. To make sure that running costs and maintenance are reduced to a minimum, light sources, luminaires and lighting controls need to be highly efficient, with a long life. Advice on the specification of energy efficient light sources and controls is provided here, together with information on how to reduce unnecessary variation in lamp and luminaire types.

Pupils like spaces that are interesting and unique. They enjoy learning in them even though lighting conditions may not be ideal. There is a place for imaginative lighting environments in schools and this publication aims to encourage creativity, not create blandness or uniformity.

Health and safety

Learning and teaching rely upon good lighting. Although poor lighting is easily identified in use, it is often overlooked at the design stage. Our eyesight is resilient, so we may be unaware of the problems caused by poor lighting in our schools. Yet it can result in slower reading, poor posture, diminished concentration and long-term weakened vision.

Lighting in schools is required not only for general safety but also for visual tasks. The two main issues to guard against are glare and flicker.

Glare

Glare is a common problem in the classroom. It occurs when a bright image (which is not the object one is trying to see) is seen either directly or by reflected light. This can cause significant difficulty with visual tasks.

Although pupils try to compensate for glare by turning their heads or squinting, glare causes eyestrain and headaches and can sometimes be disabling. It can also cause loss of concentration and reduced productivity.

Glare can be divided into two types:

- **Discomfort glare** is not necessarily detrimental to vision but it produces feelings of visual discomfort.
- **Disability glare** occurs when a bright light source is close to the line of vision and makes the task more difficult to see.

This problem is controlled by assessing the lighting installation in terms of its glare rating and ensuring that it does not exceed the recommended maximum.

Glare can be minimised by:

- the correct choice, orientation and positioning of the room furniture
- the use of internal or external blinds, which can reduce problems caused by excessive sunlight or daylight
- the use of louvres on fluorescent luminaires and/or the use of indirect lighting solutions, which will help reduce direct vision of the light source and therefore the instance of glare
- correct choice of computer screen with anti-glare filters if necessary, together with orientation to avoid sunlight and daylight reflection
- careful design of the illuminance of the whiteboard relative both to sunlight and daylight glare and glare from luminaires.

Flicker

Flicker can cause discomfort or annoyance to some people. It can also produce stroboscopic effects with moving objects, which can be dangerous. For example, rotating machinery in a workshop can appear to be stationary. Epilepsy can be triggered by low frequency flashes of light, which can occur with some compact fluorescent lamps at ignition, or with discharge lamps towards the end of their life. Problems relating to balance, and some brain disorders, can also be exacerbated. All these can be avoided by using high frequency control gear.

Disability issues

Good quality lighting is important to help pupils learn, especially those with special educational needs (SEN) and/or any disability. Natural lighting with additional artificial light should be used where necessary, avoiding glare and revealing good visual contrast and colour rendering. Light levels should be adequate on the working plane and for people to clearly see the teacher's face, the whiteboard and computers without creating reflections, shadows and harsh contrasts. For an even better effect, light sources should not be visible, flicker should be avoided and uplighters should be used.

Hearing impaired people need to be able to see lip movements clearly, so the correct lighting level and direction are crucial. For example, if light is directed too much in a downward direction, it will produce harsh shadows, which will make lip reading difficult.

The design of specialist accommodation for pupils with SEN and/or any disability is beyond the scope of this document and specialist advice should be sought. However, there are relevant design issues that should be considered for all schools:

- The colour rendering of the light source and the extent of contrast are particularly important. Some visual impairments involve a degree of colour blindness and it is important that contrast of tone as well as colour should be produced on the objects illuminated.
- Careful use of colour can help pupils recognise and identify objects. For instance, using a darker colour for a door frame (contrasting with door leaf and wall) will help in locating the door. A handle that clearly contrasts with the surface of the door and is non-reflective will also make it easier to distinguish.
- Students with visual impairment often require higher than normal levels of illuminance. It is not necessary to install this as a feature of the primary lighting system but provision should be available for supplementary task lighting.

There is more detailed information in Building Bulletin BB 77[2] and Building Bulletin 90.

Sustainability

The Sustainable Development Commission estimates that schools contribute 2% of the UK's overall carbon emissions, with around half of this arising from the use of electricity and fossil fuels within school buildings. It is important that we take action to reduce this. The Government has allocated an additional investment of £110 million over the next three years to test the aim of reducing carbon emissions by 60% in new schools built in the BSF programme.

To meet this aim it will be necessary to use the most energy-efficient lighting and to use lighting controls wherever there is a whole-life cost justification for doing so. Designers must consider the specification of lamps, luminaires, control systems, and illuminance levels in conjunction with optimum daylighting design to deliver significant energy savings over current practice.

2 www.teachernet.gov.uk/management/resourcesfinanceandbuilding/schoolbuildings/designguidance/SENanddisabilities

Artificial lighting currently accounts for the highest proportion of all energy costs in schools, at around 28%. For this reason, the lighting installation offers the greatest potential for saving energy by applying good management, design, specification and controls. **The use of automatic lighting controls can save as much as 30 to 40% of electricity consumption when compared to manual switching**[3].

Most electricity is generated by burning fossil fuels, which cause carbon dioxide emissions, contributing to climate change. Schools must now comply with Part L of the Building Regulations and will need to use carbon calculations as prescribed in the approved document. Part L2 (2006) states:

a) For classrooms, seminar rooms, conference rooms and office areas, "reasonable provision would be to provide lighting with an average initial efficacy of not less than 45 luminaire lumens/circuit watt[4] as averaged over the whole area of these space types in the building."

b) For spaces not included above, "it may be appropriate to provide luminaires for which photometric data is not available or luminaires that are lower powered and use less efficient lamps. For such spaces, the requirements would be met if the installed lighting has an average initial (100 hour) lamp plus control gear efficacy of not less than 50 lamp-lumens/circuit watt[5]."

c) For display purposes, "reasonable provision would be to demonstrate that the installed display lighting has an average initial (100 hour) efficacy of not less than 15 lamp-lumens per circuit-watt[6]. In calculating this efficacy, the power consumed by any transformers or control gear should be taken into account."

Building Bulletin 87, 2nd Edition Version 1 (May 2003) Guidelines for Environmental Design in Schools[7], states that for school buildings, "A minimum of 65 lamp-lumens/circuit watt[8] should be adopted." For normal types of luminaire this is slightly in excess of Building Regulation Standards but should be attained wherever possible.

3 'Academy examination' BSRIA Delta t, June 2007

4 The average luminaire-lumens/circuit-watt is calculated by the lumen output of the luminaire summed for all luminaires in the relevant areas of the building, divided by the total wattage of all the luminaires.

5,6,8 Lamp-lumens are the initial lumens of the bare lamp on measurements taken after 100 hour usage of the lamp. The efficacy of the bare lamp (lamp-lumens/circuit-watt) is calculated by dividing the lumen output by the wattage of the lamp.

7 This edition replaces Building Bulletin 87 (1997) as referenced in building regulations Approved Document Part L2 2002.

Energy efficiency

The energy efficiency of artificial lighting depends on:

- The penetration of natural lighting indoors – if there is good daylight distribution in the classroom and good daylight levels, artificial lighting may not be required
- The luminaire efficiency and its electrical components, lamps and control gear
- The successful specification of the lighting controls, eg, their usability and response to changing conditions
- The operation, cleaning and maintenance regime.

These issues are considered in the following sections of this guidance.

New school design

New build schools should use all four of these approaches but the optimisation of daylight should always be considered as one of the most cost-effective options. Staff and pupils should always take advantage of available daylight. Through much of the year the levels of daylight should be sufficient for electric lighting to be switched off in parts of the school. Most people prefer to work in a daylit space, provided that solar glare and overheating are minimised.

There are a number of daylight prediction techniques available to designers, ranging from rules of thumb, manual calculations and graphical analysis, to physical model studies and computer simulation. There is more detailed information on natural lighting in Building Bulletin 87[9], BB 90 Lighting Design for Schools[10] and CIBSE Lighting Guide LG10 Daylighting and Window Design.

Existing school buildings

Existing buildings may be more restricted in their options for available levels of daylighting. Existing luminaires should be replaced with low-energy fittings and signage used to encourage teachers and pupils to switch lighting off when it is not needed.

NB Improved lighting controls that can respond to daylight levels can be expected to cost more than standard lighting controls that do not. Further details are included in the cost comment on page 22.

9 www.teachernet.gov.uk/energy
10 www.teachernet.gov.uk/lighting

Lamps

The purpose of a lamp is to convert electrical power (watts) into visible light (lumens). The efficacy of the lamp is measured in lumens of light per watt of electricity (excluding any local losses in lamp control gear). The energy (watts) largely ends up as heat; highly inefficient lamps with excessive lighting will cause the building to overheat.

Currently the most energy efficient lamps are:

- Compact fluorescent
- Linear fluorescent
- High intensity discharge (metal halide or high pressure sodium).

The table below shows that the common incandescent lamps have low efficacy. They should not be used except in some exceptional circumstances for display lighting. Coloured LEDs are currently used in some lamps and used for display/accent lighting.

Table 1

Lamp group	Type of lamp	Efficacy (lumens/lamp watt)
Incandescent	Tungsten filament – common GLS (general lighting source)	8-12
	Tungsten halogen	12-24
Linear fluorescents	Triphosphor T5, 16mm	88-104
	Triphosphor T8, 26mm	88-100
Compact fluorescent		50-85
High intensity discharge	High pressure sodium	65-140
	Metal halide	70-100

Compact fluorescent

Compact fluorescent lamps are now the most usual replacement for the common incandescent lamps. Compact fluorescents can have integral or separate control gear. Lamps with integral gear are a direct replacement for standard incandescent lamps.

Linear fluorescent

Triphosphor T5 and T8 linear fluorescents are efficient in many situations due to their high efficacy. The light output is higher than that for compact fluorescents and they should be used in areas where illumination requirements are relatively high. This would be appropriate in general teaching areas, light and heavy practical areas, staff, administration and resource areas. However, the higher light output demands greater glare control by the luminaire.

High pressure discharge

High pressure discharge light sources are suitable for large volume spaces that require high light output. Although high pressure sodium light sources present very high efficacy, the quality is not good enough to distinguish colours clearly, so metal halide discharge lamps are preferred because of their good colour rendering. However, it should be remembered that fluorescent lighting can be used effectively in sports halls.

The characteristics that influence lamp selection are:

- Efficacy, lumens of light per watt of electricity
- Colour perception of the lamp – does the light appear warm or cool?
- Colour rendering accuracy – does the lamp show true colours?
- Lamp life
- Dimming capabilities
- Instantaneous light – does the lamp take some time to reach full output?
- Instantaneous re-strike – does the lamp take some time to switch on when hot?

Table 2: Lamp data

Lamp type		Designations and dimensions	Efficacy (lumens/ lamp watt)	Lamp life (hours)	Control gear required	Colour rendering Ra/colour temperature (K)/colour appearance	Lamp start-up/ lamp re-strike	Dimming possible	Linking with lighting control
Tubular fluorescent	Linear	T5 (Ø16mm)  288mm-1449mm	88-104	10000-15000	Yes	50-98/ 2700-6000/ warm to cold	1-3 seconds	Yes	Yes
		T8 (Ø26mm)  590mm-1764mm	88-100	10000-15000					
	Circular	T5C (Ø16mm)  Ø225mm-Ø375mm	60-80	5000-8000	Yes				
Compact fluorescent	External control gear Internal control gear	 Various	50-85	10000	Yes No	82-98/ 2700-4000/ warm to intermediate-cold	1-3 seconds	Yes	Yes
Metal Halide	Various shapes	 Various	70-100	6000-20000	Yes	60-93/ 3000-10000/ warm to cold	3-6 minutes	No	No
High pressure sodium	Various shapes	 Various	65-140	9000-28500	Yes	25-80/ 2000-3000/ warm	3-6 minutes	No	No

NB In the future there may be developments in lighting using light emitting diodes (LED). These incorporate a high purity semiconductor which, when activated electrically, generates light. Currently LEDs are commonly used for signalling and feature lighting. They need further development to give reliable white light, in terms both of quantity and quality of light, before they can be used for general working lighting purposes. White and colour LEDs can be used for feature and display purposes but not as the sole light source. Some of the latest developments use lenses to the top of the LED to direct the light coming out, either concentrating it in narrow and long light beams or wider and shorter light beams.

Luminaires

The luminaire holds the lamp and directs light in the required direction. It includes all components for fixing, protecting the lamps and connecting them to the electricity supply. It also provides the optical control which ensures that the light is directed to where it is required as well as shielding it from those areas where it is not needed. This involves the use of reflectors, refractors and/or diffusers.

Although a high efficacy lamp is critical for an efficient lighting installation, lighting choice should be based on luminaire efficiency. The optical elements of the luminaire absorb light, so not all the light from the lamp will emerge from the luminaire.

The efficiency of a luminaire is defined by its light output ratio (LOR).

LOR equals the total light output of the luminaire/total light output of the lamp(s) contained in the luminaire. A luminaire which only emits half the lamp light output, LOR = 50%, would be seen as very wasteful. In all cases, luminaires with LOR over 80% should be used.

Eliminating reflection

Some recent developments in luminaire design were generated by the need to eliminate bright reflections on computer screens. Although it is important to avoid these unwanted reflections, the problem may have been over-emphasised and the pendulum swung too far in favour of downward-only lighting. In the past, the horizontal surfaces were properly illuminated but walls and ceiling illumination were neglected. Good lighting design in working areas should highlight the vertical surfaces and the ceiling as well as the horizontal plane.

Another issue is the lighting of traditional chalk blackboards or whiteboards used with marker pens. A dedicated luminaire needs to be placed above the board to highlight the area.

Interactive whiteboards

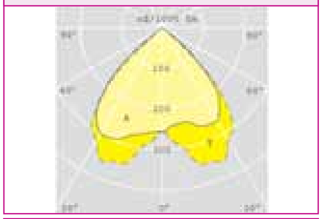
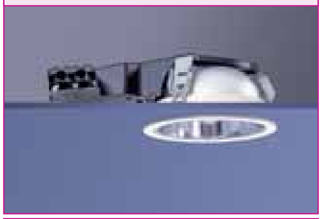
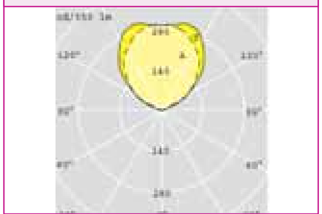
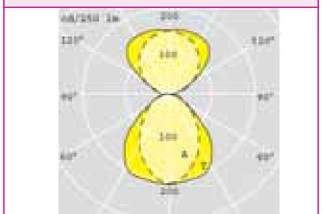
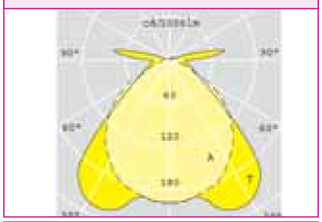
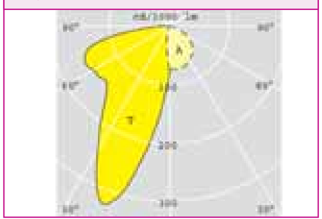
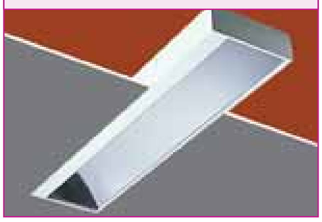
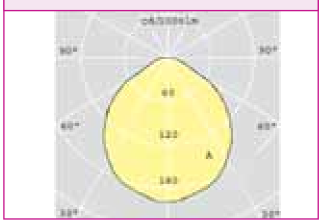
A more significant issue is achieving the correct lighting environment where interactive whiteboards are used. There have been problems with poor visibility of boards because of incorrect location, orientation, lighting levels, direction and glare. It is important to consult a lighting engineer to develop a design that coordinates the daylight, artificial system and whiteboard location. However there may be more than one whiteboard position required to allow for flexibility.

The tables below show various ways of mounting luminaires and types of light distribution.

Table 3: Luminaire mounting

Ceiling recessed		Pendant, suspended	
Ceiling semi-recessed		Wall mounted	
Ceiling semi-recessed			

Table 4: Types of light distribution

Light distribution	Examples of luminaires		
Direct or downwards 	Surface 	Recessed 	Pendant 
Indirect or upwards 	Pendant 	Wall mounted 	
Direct-in direct, up and down 	Pendant 	Pendant 	
Direct-in direct, up and down 	Semi-recessed 		
Asymmetric 	Pendant 	Recessed 	
Decorative 	Wall mounted 		

Lamp control gear

Compact fluorescent, linear fluorescent and metal halide lamps are discharge light sources. All these discharge lamps need current stabilising control gear – apparatus to start and control the electrical current through them. Control gear is also referred to as 'ballast'.

High frequency electronic control gear is available for linear and compact fluorescent lamps and some high-pressure discharge lamps. This type of gear offers flicker-free operation and reduces the control gear energy consumption in comparison with early types. Some manufacturers also claim that the lamp life is increased by high frequency control gear. High frequency control gear should be used in all cases.

The light output of most light sources can be controlled so that it can be reduced, dimmed down, in some cases as low as 1% of its full light output. This can be done by using high frequency dimmable control gear.

Modern control gear usually consumes less energy than earlier types, which means that the overall efficacy of the lamp circuit is improved. For a fluorescent lamp, the control gear is defined by a CELMA[11] energy class, which should be marked on the control gear casing. These are classified from A to D, although current EU regulations demand that all control gear should be either a type A (A1, A2, A3) or B (B1, B2), where A1 is the most efficient and B2 the least[12]. Only these categories should be specified for school use.

Compact fluorescent lamps can house control gear either integrally to the lamp or separately but close by. Fluorescent control gear usually has a longer life than that of the lamp, so when the lamp fails, another lamp can be inserted using the existing control gear. Thus new compact fluorescent installations should always use separate control gear. When replacing lamps in existing lighting installations that use incandescent lamps, compact fluorescents with integral high frequency control gear should be used wherever possible. In the case of metal halide lamps, the control gear can be relatively large when wattages of the lamp are high, with limitations on its location.

Controls

Lighting controls and switching

Often when lights are switched on first thing in the morning, they tend to be left on for the rest of the day, even if daylight in the room is sufficient to carry out the required task. Well-planned lighting controls save energy in two ways:

1. They make good use of available daylight, thus reducing electric lighting used.
2. They ensure that electric lights are switched off when a space is unoccupied.

If the location and lighting of whiteboards allows, the zoning arrangement of the luminares should allow lights to be switched in rows, parallel to windows, so that lights close to windows can be switched off to take advantage of available daylight.

11 Federation of National Manufacturers Association for Luminaires and Electrotechnical Components for Luminaires in the European Union.

12 www.celma.org

There are variuous types of automated lighting controls appropriate for schools:

Manual – e.g. local switch, wireless control.

Manual switches must be simple, carefully considered and conveniently located, usually near the door.

Automated – e.g. time switch control, photoelectric control, occupancy/absence detection and key or card control.

Automated lighting controls should take into account the type of space, how it is used and the amount of daylight available. To avoid a feeling of alienation, it is essential that teachers and pupils appreciate what is automated and why. There are various types of automated control appropriate for schools:

- **Time switch** control could be used for switching off the main lighting outside opening hours.
- **Photoelectric** control involves the lamps being switched or dimmed in response to daylight.
- **Occupancy detection sensors** can switch lights on automatically when the sensor detects occupancy. The sensor requires a time delay, which can vary from 15 seconds to 30 minutes. The lights remain on during the time delay, after which, if no-one is detected, lights automatically switch off. These can be infrared or microwave technology.
- **Absence detection** systems switch lights on manually, switching them off again automatically after a time delay when no-one is detected in the space. These can be infrared or microwave technology.
- **Key or card** switches are sometimes used in occasionally visited spaces. The key or card is used to switch the lights on; when it is removed, the lighting is automatically switched off. However, they can cause annoyance if access to the card or key is difficult.

Suitable types of controls for various types of spaces are identified in Section 3.

Maintenance

Over time, dirt accumulates on windows, luminaires and room surfaces. Dirty windows encourage unnecessary use of electric lighting, so they should be properly maintained and cleaned regularly to maintain good lighting levels. A dirty diffuser or reflector can cut light output by 20%, so a regular cleaning programme is also essential for reflectors, diffusers and lamps, taking advantage of holiday periods to minimise disruption.

Failed fluorescent lamps should be replaced promptly. A fluorescent lamp with a blackened end indicates that it has passed its economic life, although it will last a long time before there is any blackening or other visible indication of a drop in performance. Regular lamp replacement on a planned maintenance cycle is important to avoid lamps operating at reduced output but still using the same amount of electricity. Specialist luminaire maintenance and lamp replacement contractors can offer an efficient cost effective service, including disposal of used lamps. See Building Bulletin 76 Maintenance of Electrical Services for detailed information on cost effective replacement cycles for lighting.

Discharge light sources (high pressure sodium and metal halide) seldom fail outright. The failure is preceded by an increased tendency to flicker, and they might flash on and off repeatedly. Teachers and caretakers should watch for these signs.

Sometimes the lamp itself – whether fluorescent or a discharge light source – is not the problem. Instead, the control gear may be faulty. A fail-safe circuit that disconnects the control gear if the lamp fails is required. An old lamp should always be replaced with a new lamp of compatible rating and of the same colour. Discharge lamps must be matched to suitable control gear. It is better to keep the right lamps in stock than to rely on a commercial supplier at short notice.

Lamp replacement is made considerably easier if the number of different lamp types is kept to a minimum when the installation is designed. Lamps must be disposed of safely and in accordance with environmental legislation. The Waste Electrical and Electronic Equipment (WEEE) regulations aim to reduce the amount of such electrical and electronic equipment being disposed of in landfills by promoting separate collection, treatment and recycling. It is important to ensure that lamps are recovered, recycled and disposed of in compliance with the WEEE regulations.

Emergency lighting

Emergency lighting must provide sufficient illumination in the event of a failure of the normal electric lighting supply, so that the building can be evacuated quickly and safely.

There are considerable benefits in integrating the general and emergency installations. Some luminaires can incorporate emergency lighting as well as normal lighting. Standard fittings can be modified to integrate an emergency facility.

Emergency lighting in schools should be provided on:

- Escape routes
- Escape stairways
- Corridors without any windows
- Areas with dangerous machinery
- Areas accessible to the public during the evenings.

These include halls and other spaces used for performances. For details on areas that require emergency lighting, please refer to:

- The Code of Practice for the emergency lighting of premises BS 5266
- Luminaires for emergency lighting BS EN 60598-2-22:1999
- Emergency escape lighting systems BS EN 50172
- Emergency lighting guide LG12, CIBSE
- Building Regulations Approved Document B, Fire Safety
- Building Bulletin 100 *Designing and managing against the risk of fire in schools.*

In areas used by the public during the hours of darkness, the emergency lighting should be of the maintained type, meaning that the lamps contained in a luminaire will operate from the normal supply or from the emergency supply at all times. Where part of the premises is licensed, additional provision may be required and it will be necessary to seek the advice of the local authority.

There is more detailed information in Building Bulletin 90 and BS 5266.

Cost comment

The lighting costs for a building can be divided into two parts:

- **Capital cost of equipment**, including the cost of installation. The cost of this element will typically be around 3% of the total construction cost of the building.
- **Running costs**, including both maintenance and energy cost.

It is important that professional advisers take due regard of both these factors when developing project budgets and carry out appropriate option appraisals in order to secure best whole-life value for money.

The cost impact of installing a high-efficiency lighting design as described in this specification – i.e. with daylight linking, absence detection and central manual switches – is compared in the case study below with the cost of current standard, high frequency, controls.

Figure 1 shows an efficient lighting/luminaire layout in a typical classroom. The window arrangement is such that an average daylight factor of 2% is achieved in the room. The lighting layout comprises 12 No. 35W luminaires with 50% up – 50% down distribution. (Please note that all the detailed information above refers to particular luminaires and that these will change from one manufacturer to another, from one luminaire to another.)

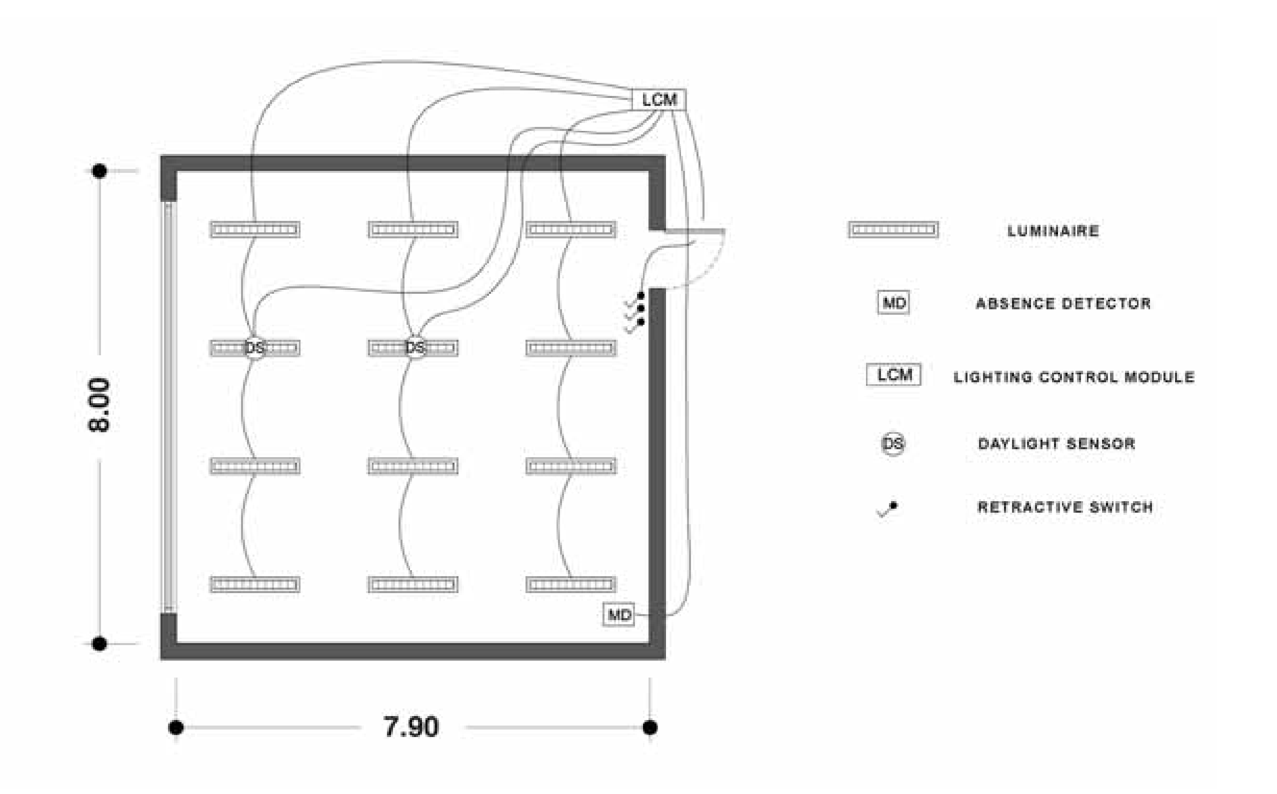
The luminaires are switched in rows away from the windows and are dimmable so as to be either dimmed or switched off during daytime, depending on daylight availability. There are two daylight sensors (photocells) and one absence sensor (a microwave detector). Lighting is switched on, off and dimmed up and down with retractive switches. A dedicated luminaire could also be placed above the whiteboard to highlight the area, controlled locally with the facility for dimming.
(For interactive whiteboards, local lighting should not be necessary.)

Though the initial capital cost is about 20% higher than a current high frequency system of controls, the resultant energy savings of around 36% will have a payback period of 10-13 years at current energy prices. What's more, the system should reduce carbon emissions from 448kg to 286kg per classroom per year, and the payback period is even shorter if the social costs of saving carbon[13] are considered. These benefits assume:

- the diversity of luminaires is minimised wherever possible. This will help to ensure that contractors obtain good discounts from lighting manufacturers and suppliers for bulk orders. It will also simplify maintenance and arrangements for holding stocks of spares
- the majority of luminaires in teaching areas, offices and dining halls are suspended from exposed soffits without suspended ceilings. This should generate cost savings, even allowing for some acoustic treatment to the soffit.

On this basis, the rate of return on the additional investment in a high-efficiency system can be justified and supports the Government's wider carbon reduction strategies. Furthermore, over time there is likely to be scope for efficiencies from the standardised approach, particularly in large serial programmes like BSF, which will help to offset higher initial costs.

Figure 1: Plan view of classroom with luminaires perpendicular to the window, complete with switching arrangement



13 www.defra.gov.uk/environment/climatechange/research/carboncost/index.html

3

Performance specifications and examples

This section provides performance specifications and examples for seven types of lighting in schools.

The types are:

Type A	General (for most teaching and non-teaching areas)
Type B	Practical (where more light is required)
Type C	Performance (stage lighting and lighting to enhance performing arts)
Type D	Sports (for sports and multi-purpose halls)
Type E	Reception/social (for non-teaching areas where lighting can be more diverse)
Type F	Circulation
Type G	Service areas (non-teaching spaces such as storage areas and toilets)

Space and lighting types

Table 5 below shows the majority of secondary school spaces as defined in Building Bulletin 98[14]. This can be used to identify the lighting required for particular space types.

Space types	Lighting type
General teaching	
Seminar room	A
Classroom (including open plan and small lecture)	A
Small group/interview room (FLA etc)	A
Light practical	
ICT room	A
Science laboratory	B
Large (textiles or 3D) and general (2D) art rooms	B
Kiln room	G
Electronics and control systems	B
Constructional textiles	B
Graphics room	B
Art/design resource area	B
Heavy practical	
Food technology	B
Resistant materials (incl. CADCAM)	B

Space types	Lighting type
Performance	
Music recital	C
Music classroom	C
Music group/practice rooms	C
Music ensemble rooms	C
Recording studio	C
Recording studio control room	C
Drama studio	C
A/V studio (incl. video-conferencing)	C
Halls	
4-court sports hall	D
Activity studio (incl. gymnasium)	D
Main assembly/multi-purpose hall	D
Lecture theatre (over 50 people)	D
Swimming pool	D
Resource areas	
SEN resource base	A[15]
Small group room (SEN etc)	A

14 www.teachernet.gov.uk/schoolbuildings

15 For further information, please refer to Building Bulletin 77, Designing for pupils with Special Educational Needs and Disabilities in Schools.

Space types	Lighting type
Resource areas	
Library resource centre and careers	A[16]
Study areas (incl. sixth form)	A
Staff and administration	
Meeting room (incl. interview)	A
SEN therapy/counselling/MI room	A
Offices, general office (incl. ICT technician, caretaker)	A
Staff rooms (social and work rooms and reprographics)	A
Entrance/reception	E
Storage	
All walk-in stores for basic teaching areas	G
Science prep room	B
Chemical store	G
Multi-materials prep room	B
PE store	G
Non-teaching stores (stock, secure, exam, community)	G
Wheelchair/appliances 'lay-bys' and locker areas	G
Chair store	G
Maintenance and cleaners' stores	G

Space types	Lighting type
Dining/social areas	
Dining (hot meals) and sandwich/vending areas	E
Social and common rooms (incl. sixth form)	E
Catering facilities	
Kitchen preparation areas	G
Kitchen staff and store rooms	G
Toilets (and personal care)	
Pupil and staff changing rooms and hygiene facilities	G
Pupil and staff showers	G
Pupil, staff and visitors' toilets	G
Circulation	
Atria and circulation areas	F
Plant	
Plant rooms	G
Electrical cupboards and ducts	G
Server rooms	G

16 Vertical illumination required for the book stacks.

Performance specifications

The lighting requirements for each type of space are given below.

This does not preclude the designer from using other solutions to achieve particular aesthetic or functional effects. However, it is recommended that the proposed lighting meets the key performance requirements for the intended space.

The examples below offer guidelines – it is for those involved to use their own skills and expertise in deciding what will be a reasonable and appropriate final design solution in their particular situation.

Please refer to Tables 3 and 4 on pages 17 and 18, which show the various ways of mounting the luminaires and the different types of light distribution. For more information on lamps, please refer to Table 2 on page 15.

Well lit walls and ceilings, in addition to lighting on the working plane, both direct and indirect lighting, can be achieved in many ways.
For example:

1) a suspended luminaire that has both upwards and downwards distribution
2) a combination of ceiling luminaires that provide upward lighting and wall-mounted luminaires that provide downward lighting
3) ceiling luminaires that have some reflectors or diffusing elements suspended below the ceiling level that can reflect some light back up onto ceiling.

Lighting type A: General (for most teaching and non-teaching areas)

Teaching spaces

The activities taking place in teaching spaces fall into the following categories:

- Presentations, where students sit addressed by a teacher or pupil speaking from a specific location. In these rooms the lighting has three principal roles: to light the desks, the speaker and the board (in new schools there are often interactive whiteboards)
- Interactive learning, where teaching takes the form of group discussion, where the teachers and the students might sit anywhere. In these rooms the lighting needs to reveal the space without creating shadows in any part of the room.

The lighting in an informal teaching space should be gentle and unobtrusive. Luminaires should be carefully chosen to provide a relaxed atmosphere. Light switches should be accessible and flexible. In open plan teaching areas block switching is not suitable, as it does not give sufficient flexibility. As face-to-face communication is important, lamps chosen should be of good colour rendering.

Vertical surfaces should be illuminated as well as horizontal ones. Desktop illumination should not be over emphasised and a dedicated dimmable luminaire should be placed above the whiteboard to highlight the area.

Administrative offices and staff areas

A wide range of tasks is carried out in a general office. Almost any surface might be used for reading, so vertical plane illuminance should be considered as well as the horizontal.

One of the main problems is unwanted reflections on computer screens, which can be bright enough to make it difficult to differentiate between screen characters and the background. Luminaires in offices with high computer use should have a louvre or other suitable type of control, with low luminance above critical angles to prevent glare on the screens.

Luminaires and windows with high illuminance in directions affecting screens must be avoided. Positive lighted screens – dark letters on a light background – will have relatively high brightness, which will significantly reduce the effect of reflected images. Negative polarity screens – light letters on a dark background – will have relatively low brightness, and reflections on the screen will make it difficult to see the display. Negative polarity software is now very uncommon except in specialist applications such as some CAD programmes. The vast majority of software used in schools is positive polarity. Where negative polarity programmes are in use special lighting design will be required.

There is more detailed information in:

- CIBSE Lighting Guide LG3, for VDU Use Environments
- CIBSE Lighting Guide LG7, Lighting for Offices
- BREEAM Schools Assessment Manual, available from www.breeam.org/schools.html
- CIBSE Lighting Guide LG5, Lecture, Teaching and Conference Rooms.

Libraries

The lighting of library spaces must be co-ordinated with the furniture arrangement but adaptable to a number of different functions. As well as general lighting, lighting for vertical book stacks, for study and for browsing, and accent lighting for display purposes may be required.

Performance requirements, type A		
1	Maintained Illuminance at working plane	300 lux
2	Uniformity ratio	Not less than 0.8
3	Limiting glare rating	19
4	Colour rendering (Ra)	>80

Examples of type A lighting

Light distribution	Mounting type	Lamp	Control type
Both direct and indirect	1. Ceiling recessed and wall mounted 2. Ceiling semi-recessed 3. Ceiling surface and wall mounted 4. Pendant (downlighting) and wall mounted 5. Pendant (up and down light)	Linear fluorescent & compact fluorescent	Daylight linking, absence detection and central manual switches for teaching and office areas. Daylight linking and central manual switches for library areas

Lighting type B: Practical (where more light is required)

Good lighting is particularly important for areas where practical activities take place to help ensure that equipment is handled safely, and to avoid accidents. People may be undertaking intricate tasks that need accurate readings and subtle observation, so higher light levels than general teaching areas would be appropriate.

High level general lighting can be used, or local task lighting supplementing the general lighting. Where there is fixed benching, adjustable bench lights may be suitable, particularly where directional lighting is required. Luminaires should be corrosion resistant, IP44 rated and complete with a diffuser.

Art rooms are used for a large range of activities, which might change throughout the year. The main requirement is good general lighting. The preference is for daylight from north-facing windows and full availability of directional lighting, particularly for sculpture works and work involving texture. Some additional flexible lighting for the display of work may also be desirable. Luminaires should be robust and complete with a prismatic or opal diffuser to avoid damage to the lamp. They should be minimum IP65 rated in order to avoid water penetration at pressure.

For a typical science laboratory, preparation room or food technology area, luminaires should be complete with a prismatic or opal diffuser. They should be minimum IP44 rated to avoid water and/or moisture penetration.

Performance requirements, type B		
1	Maintained illuminance at working plane	500 lux
2	Uniformity ratio	Not less than 0.8
3	Limiting glare rating	19
4	Colour rendering (Ra)	>80*

Examples of type B lighting			
Light distribution	**Mounting type**	**Lamp**	**Control type**
Both direct and indirect	1. Ceiling recessed and wall mounted 2. Ceiling semi-recessed 3. Ceiling surface and wall mounted 4. Pendant (downlighting) and wall mounted 5. Pendant (up and down light)	Linear fluorescent & compact fluorescent	Daylight linking, absence detection and central manual switches

Lighting type C: Performance (stage lighting and lighting to enhance performing arts)

Performance spaces can be used for a wide variety of activities, so there needs to be flexibility in their lighting, with the option of luminaires being switched in groups.

It may be appropriate to install two or more independent lighting systems. Alternatively, a lighting installation that provides both upward and downward light from separate lamps within the same luminaire could be used. Switching of upward light can be independent of downward light switching.

Performance requirements, type C		
1	Maintained illuminance at working plane	300 lux
2	Uniformity ratio	Not applicable
3	Limiting glare rating	19
4	Colour rendering	>80

* For art rooms there may be a requirement for higher colour rendering than Ra >90.

Examples of type C lighting			
Light distribution	**Mounting type**	**Lamp**	**Control type**
Both direct and indirect	1. Ceiling recessed and wall mounted 2. Ceiling semi-recessed 3. Ceiling surface and wall mounted 4. Pendant (downlighting) and wall mounted 5. Pendant (up and down light) 6. Wall mounted (up and down light)	Linear fluorescent and compact fluorescent	Daylight linking, absence detection and central manual switches

Performance spaces are often used for theatrical/drama presentations with a defined stage area, so the following additional provisions may be necessary:

- lighting of the stage area should be separate from lighting in the audience area
- lighting should be dimmable smoothly and without flicker to 1% of its maximum level
- theatrical lighting installation may be needed, using professional spotlights rigged on standard industry tube and plugs and sockets. Essential locations are above the stage parallel to the front curtain immediately behind the curtain line, one metre in front of the rear wall, and in between at 1m to 1.5m intervals. Each socket should be wired individually to a theatre dimmer remote control from the control room or area.

Publications on standards and general advice about theatrical presentations are available from the Association of British Theatre Technicians[17].

Lighting type D: Sports (for sports and multi-purpose halls)

Sports halls are relatively large spaces with high soffits. In these areas, access to overhead luminaires will require specialist equipment and should be addressed in the designer's risk assessment. The luminaires should also be robust and impact resistant.

Windows and rooflights can cause both disability and discomfort glare to users, because of the sun. When daylight apertures are provided, there should also be screening facilities for use when necessary.

To enhance the visual environment, luminaires should give both upward and downward light.

There is more detailed information in the CIBSE Lighting Guide LG4: Sports.

17 www.abtt.org.uk

Performance requirements, type D		
1	Maintained illuminance at working plane	300 lux
2	Uniformity ratio	Not applicable
3	Limiting glare rating	22
4	Colour rendering	>80

Examples of type D lighting

Light distribution	Mounting type	Lamp	Control type
Both direct and indirect	1. Ceiling recessed and wall mounted 2. Ceiling semi-recessed 3. Ceiling surface and wall mounted 4. Pendant (downlighting) and wall mounted 5. Pendant (up and down light) 6. Wall mounted (up and down light)	Linear fluorescent or compact fluorescent or metal halide*	Daylight linking and central manual switches

Lighting type E: Reception/social (for non-teaching areas where lighting can be more diverse)

Lighting in an entrance area should be inviting and welcoming. The entrance space usually houses a reception desk and a display area.

There will need to be dedicated lighting systems for the reception desk and to highlight display walls or cabinets. The reception area will need local and dedicated switches. Downlighters are not recommended over reception desks as the lack of a diffuse component of light makes lip-reading difficult.

Wall-mounted luminaires are preferable for maintenance if the ceiling is high.

Entrance, dining and social areas require 175-250 lux. If these areas are to be used for reading or discussions 300 lux will be required. In social areas the walls may be used for display lighting, so a dedicated system to highlight the walls may be required.

In dining areas, food display lighting is usually located in the furniture.

* Please note that metal halide lamps are not dimmable.

Performance requirements, type E		
1	Maintained illuminance at working plane	Entrance, dining and social areas 175-250 lux Reception area 250-350 lux
2	Uniformity ratio	Not applicable
3	Limiting glare rating	19
4	Colour rendering	>80

Examples of type E lighting

Light distribution	Mounting type	Lamp	Control type
Both direct & indirect or direct and highlighting	1. Ceiling recessed and wall mounted 2. Ceiling semi-recessed 3. Ceiling surface and wall mounted 4. Pendant (downlighting) and wall mounted 5. Pendant (up and down light) 6. Wall mounted	Linear fluorescent or compact fluorescent or metal halide*	Daylight linking if daylit space, manual central switching and time clock. Manual local control to reception desk in reception areas

* Please note that metal halide lamps are not dimmable.

Lighting type F: Circulation

The purpose of the lighting in circulation areas and stairs is to allow safe movement from one place to another and to produce interesting and stimulating spaces. Emergency lighting should also be considered in the design of these areas. Learning and study areas within circulation should have lighting to Type A performance requirements.

Stairs need to be well lit to avoid accidents. The main consideration is to provide lighting which ensures that the staircase treads and risers are well defined, with a contrast between treads and risers.

Wall-mounted luminaires are preferable for maintenance if the ceiling is high.

Performance requirements, type F		
1	Maintained illuminance at working plane	80-120 lux
2	Uniformity ratio	Not applicable
3	Limiting glare rating	19
4	Colour rendering	>80

Examples of type F lighting

Light distribution	Mounting type	Lamp	Control type
Direct or indirect	1. Ceiling recessed 2. Ceiling surface 3. Wall mounted	Linear fluorescent, compact fluorescent or metal halide*	Daylight linking and presence detection

* Please note that metal halide lamps are not dimmable.

Lighting type G: Service areas (non-teaching spaces such as storage areas and toilets

Service areas such as kitchens, storage areas, toilets, changing rooms, showers and plant rooms in secondary schools require different levels of illuminance and lighting control.

In storage areas, luminaires should be complete with a prismatic or opal diffuser or wire guard to avoid damage to the lamp.

In kitchens, toilets and changing rooms, luminaires should be complete with diffusers and should be minimum IP44 rated to avoid water and/or moisture entering the luminaire.

In shower areas, luminaires should be minimum IP55 rated. Robust luminaires are required.

In plant room areas, luminaires should be robust and complete with a prismatic or opal diffuser to avoid damage to the lamp. Luminaires should be minimum IP65 rated in order to avoid water penetration at pressure.

Performance requirements, type G		
1	Maintained illuminance at working plane	500 lux in kitchens/200 lux in toilets and plant rooms/100 lux in storage areas
2	Uniformity ratio	Not applicable
3	Limiting glare rating	22
4	Colour rendering	>80

Examples of type G lighting			
Light distribution	**Mounting type**	**Lamp**	**Control type**
Direct or indirect*	1. Ceiling surface 2. Wall mounted*	Linear fluorescent or compact fluorescent	Manual central switching for kitchens, absence or presence detection for all other areas

* For toilet areas only.


South East Essex College
of Arts and Technology, Southend

4

References and glossary of terms

This document was published in September 2007. After this date readers should ensure they use the latest edition for all references.

For relevant lighting guidance, recommendations and regulations, please refer to the following:

- BREEAM Schools Assessment Manual, available from www.breeam.org/schools.html
- Building Bulletin 76, BB 76, Maintenance of Electrical Services, DCSF
- Building Bulletin 87, BB 87, Guidelines for Environmental Design in Schools, DCSF, from www.teachernet.gov.uk/energy
- Building Bulletin 98, BB 98, Briefing Framework for Secondary School Projects.
- Building Bulletin 90, BB 90, Lighting Design for Schools, DCSF, from www.teachernet.gov.uk/lighting
- Building Bulletin 77, BB 77, Designing for Pupils with Special Educational Needs and Disabilities in Schools, DCSF

- *The Code of Practice for the emergency lighting of premises*, BS 5266
- *Code for Lighting*, CIBSE, SLL
- *Emergency escape lighting systems*, BS EN 50172
- *Emergency lighting guide*, LG12, CIBSE
- *Lighting Guide LG3, for VDU use Environments*, CIBSE
- *Lighting Guide LG7, Lighting for Offices*, CIBSE
- *Lighting GUIDE LG4, Sports Lighting*, CIBSE
- *Lighting Guide LG5, Lecture, Teaching and Conference Rooms*, CIBSE
- *Lighting Guide LG10, Daylighting and Window Design*, CIBSE
- *Light and Lighting – Lighting of workplaces. Indoor workplaces,* BS EN 12464
- *Luminaires for emergency lighting*, BS EN 60598-2-22:1999
- *Part L2A Conservation of fuel and power in new buildings other than dwellings*. The Building Regulations 2000, edition 2006
- *Part L2B Conservation of fuel and power in existing buildings other than dwellings*. The Building Regulations 2000, edition 2006

Glossary of terms

Brightness: attribute of the visual sensation associated with the amount of light emitted from a given area. It is a subjective correlate of luminance. Technically defined as luminosity (obsolete): attribute of a visual sensation according to which an area appears to emit more or less light.

Colour rendering: a general expression for the appearance of surface colours when illuminated by light from a given source compared, consciously or unconsciously, with their appearance under light from some reference source.

Colour rendering index: A measure of the degree to which the colours of surfaces illuminated by a given light source conform to those of the same surfaces under a reference illuminant, suitable allowance having been made for the state of chromatic adaptation.

Colour temperature: all materials emit light when heated. The temperature to which a full radiator (or 'black body') would be heated to achieve the same chromaticity (colour quality) of the light source being considered, defines the correlated colour temperature of the lamp, quoted in degrees Kelvin.

Correlated colour temperature (CCT): the temperature of a full radiator that emits radiation having a chromaticity nearest to that of the light source being considered. The unit is the Kelvin, K.

Contrast: difference in the luminance or colour of two objects and their surroundings. The lower the contrast level the more difficult the visual task.

Daylight factor: the illuminance received at a point indoors, from a sky of known or assumed luminance distribution, expressed as a percentage of the horizontal illuminance outdoors from an unobstructed hemisphere of the same sky. Direct sunlight is excluded from both values of illuminance.

Efficacy (lamp): the quantity of light a light source emits per watt of electrical power of energy consumed. Note that both the lamp luminous efficacy and the system (lamp and control gear) luminous efficacy can be specified. The system luminous efficacy is always lower then the lamp luminous efficacy.

Efficiency (luminaire): luminaire light output ratio.

Emergency lighting: the lighting provided for use when the supply to the normal mains lighting installation fails.

Glare: the discomfort or impairment of vision experienced when parts of the visual field are excessively bright in relation to the general surroundings.

Glare rating: A numerical index calculated according to CIBSE Technical Memorandum TM10. It enables the discomfort glare from lighting installations to be ranked in order of severity and the permissible limit of discomfort glare from an installation to be prescribed quantitively.

Illuminance (E): the luminous flux density at a surface, indicated in lm/m^2 or lux.

Average illuminance: illuminance averaged over the specified area. Unit: lux.
Note: in practice this may be derived either from the total luminous flux falling on the surface divided by the total area of the surface, or alternatively from an average of the illuminances at a representative number of points on the surface.

Indirect lighting: lighting in which the greater part of the flux reaches the surface (usually the working plane) only after reflection at other surfaces and particularly at the roof or ceiling. Luminaires with a flux fraction ratio greater than 10 are usually regarded as indirect.

IP rating (ingress protection number): a two digit number associated with a luminaire. The first digit classifies the degree of protection the luminaire provides against the ingress of solid foreign bodies. The second digit classifies the degree of protection the luminaire provides against the ingress of moisture.

Limiting glare rating: the maximum value of the glare rating which is recommended for a specific lighting installation.

Maintained illuminance: value below which the average illuminance on the specified area should not fall. It is the average illuminance at the time maintenance should be carried out. Unit: lux.

Uniformity ratio: ratio of minimum illuminance to average illuminance on a surface.

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