



Mains Lighting Design Guide

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Lighting Design

Designing a basic lighting scheme requires the consideration of many factors, not just the achievement of a desired lighting level. Basic objectives must first be established, such as:

- What sort of tasks will be performed in the area?
- What 'mood' needs to be created?
- What type of lighting will create a comfortable environment?

There are also standards and legislation that need to be complied with. For example:

- How energy efficient must the lighting be?
- How will Building Regulations affect the design?
- Is emergency lighting required?

When all of these objectives and requirements have been established, they can be expressed as a series of lighting criteria in order to facilitate a quality lighting design. Criteria that would normally be considered are:

Level of Illumination

Illumination levels for a wide variety of environments and tasks can be found in BS EN 12464-1: 2011 and the society of light and lighting's code for lighting. The levels stated are maintained illuminance, which is the minimum average illumination level that should be achieved at the point of scheduled maintenance.

Uniformity and Ratios of Illuminance

The combination of luminaires selected should evenly illuminate the working plane and appropriately illuminate walls and ceilings in relation to the task illumination, so that a pleasant and comfortable environment is achieved. In specific

areas, increased directional lighting may be required to create a defined or more intimate environment.

Glare

The acceptable level of glare should be established as appropriate for the application, using information in BS EN 12464-1: 2011 and the SLL code for lighting.

Colour and Room Reflectance

The colour appearance of the lamps should be chosen for the application and complement the interior colour scheme, which should be chosen with an appreciation of the reflectance values that will be achieved. Lamps should be selected with appropriate colour rendition properties as detailed in EN12464-1 and for colour discrimination and reduction of eye fatigue.

Energy Efficiency

Luminaires should be selected that meet the requirements of the Building Regulations Part L. The distribution characteristics should also match the requirements of the criteria above.

Special Considerations

Certain applications require additional considerations, such as the addition of display lighting, the arduous nature of the environment or the use of Display Screen Equipment. Luminaires should be selected and the design completed with these elements in mind, where appropriate.

After these criteria have all been considered, a lighting scheme calculation can be undertaken. The most popular method of establishing the quantity of luminaires required, the illumination level achieved and the luminaire layout, is to use computer software created specifically for lighting design. It is important to

remember that all the criteria above must still be considered prior to using computer software, if a satisfactory scheme is to be produced.

Lighting design can also be achieved using published photometric data, such as that included on the product pages of this catalogue. Average illumination via the lumen method of calculation can provide fast results that can then be assessed and facilitate more detailed design of the most appropriate option if required.

Lumen Method Calculations

This method uses the utilisation factor tables created from photometric measurement of each luminaire. Firstly, the Room Index (K) of the space must be calculated, which is the relationship and measure of the proportions of the room:

$$K = \frac{L \times W}{(L + W) \times Hm}$$

Where:
 L = length of room
 W = width of room
 Hm = height of luminaire above working plane

The result is used in conjunction with room reflectance values to obtain a specific utilisation factor for the surface illuminated from the tables.

This can then be used as part of the calculation to determine the average illuminance level, using the following formula:

$$E = \frac{F \times n \times N \times MF \times UF}{A}$$

Where:

- E = average illuminance
- F = initial lamp lumens
- n = number of lamps in each luminaire
- N = number of luminaires
- MF = maintenance factor
- UF = utilisation factor
- A = area

The maintenance factor is a multiple of factors and is determined as follows:

$$MF = LLMF \times LSF \times LMF \times RSMF$$

Where:

- LLMF = lamp lumen maintenance factor - the reduction in lumen output after specific burning hours
- LSF = lamp survival factor - the percentage of lamp failures after specific burning hours
- LMF = luminaire maintenance factor - the reduction in light output due to dirt deposited on or in the luminaire
- RSMF = room surface maintenance factor - the reduction in reflectance due to dirt deposition in the room surfaces

Guidance on calculating each of these factors is provided in the SLL code for lighting. Alternatively, contact our technical support and application department for advice.

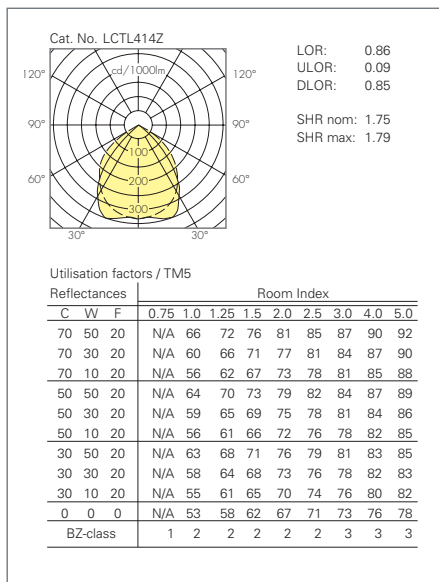
Finally, the luminaires must be spaced in the room such that acceptable uniformity is achieved. The maximum spacing to height ratio, SHR_{max}, provides the maximum spacing permissible between luminaires in both transverse and axial directions, in comparison to the mounting height and should not be exceeded if acceptable uniformity is to be achieved.

Using Photometric Data

This catalogue includes a number of different formats of photometric data, to assist in lighting design.

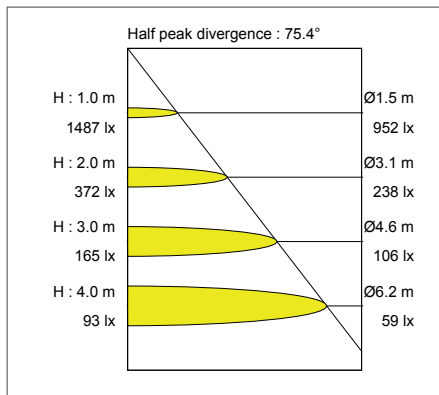
Polar Intensity Curves

This illustrates the distribution of luminous intensity, in cd/1000 lm, for the transverse (solid line) and axial (dashed line) planes of the luminaire. The curve provides a visual guide to the type of distribution expected from the luminaire, e.g. wide, narrow, direct, indirect etc, in addition to intensity. Utilisation factors show the proportion of the luminous flux from the lamp that reaches the working plan. This is for the specific luminaire and allows for surface reflectivity and Room Index. The UF is used in average lumen calculations to calculate the average illumination level for an area with a specific luminaire.



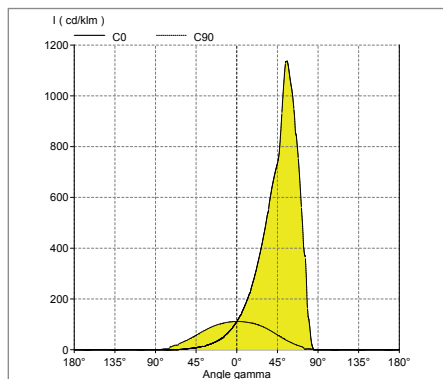
Illuminance Cone Diagrams

Usually used for spotlights or lamps with reflectors, the diagram indicates the maximum illuminance, E lux, at different distances, plus the beam angle of the lamp over which the luminous intensity drops to 50%. The beam diameter at 50% peak intensity, relative to distance away, is also shown.



Cartesian Diagrams

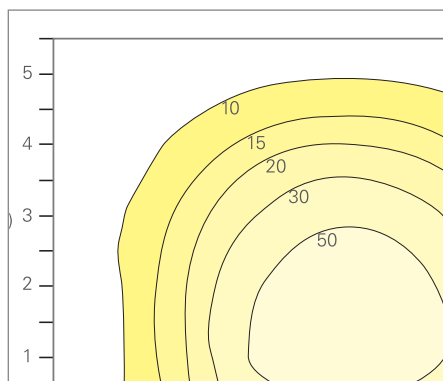
Generally used for floodlights, this indicates the distribution of luminous intensity, in $\text{cd}/1000 \text{ lm}$, for the horizontal (solid line) and vertical (dashed line) planes of the luminaire. The diagram provides a visual guide to the type of distribution expected from the luminaire e.g. narrow or wide beam etc, in addition to intensity. The associated data illustrates the beam angle to 10% peak intensity.



Isolux Diagrams

The contours provide the points of equal illuminance, in lux, on the floor or wall plane, from a specific stated mounting position.

The diagram can be used to assess the distribution characteristics of the luminaire in addition to determining lighting levels.



The society of light and lighting produce a number of design guides (LG) for specific applications which offer useful design advice for best practice approach to illuminating these areas. A sample of the available guides are: Lighting Guide 02: Hospitals and Healthcare Buildings, Lighting Guide 04: Sports Lighting, Lighting Guide 05: Light for Education, Lighting Guide 07: Office Lighting and Lighting Guide 08: Lighting for Museums and Art Galleries.

Useful Website Addresses

www.sll.org.uk - The Society of Light and Lighting

www.cibse.org - The Chartered Institution of Building Services Engineers

www.bsi-global.com - British Standards

Using Photometric Data (cont.)

There is a wide range of lighting application standards and guides available to aid the designer in creating a comfortable and efficient working space.

The recent updated edition of BS EN 12464-1:2011, which not only sets a standard for illumination levels for specific tasks but, also provides advice on how to achieve a lighting solution to meet the human need. Also the SLL lighting design guides provides a very good source of guidance for the design of working spaces, and can be considered as best practice. Lighting guide (LG) 7 is possibly the one most commonly referred to, but it is often misunderstood being used to specify luminaires rather than the total environment of the space.

LG7 was written to supersede the original LG3 which had very restrictive cut off criteria for the luminance of luminaires. With the development of improved and flatter VDT screens this could be relaxed, allowing for higher luminance values from the luminaire. The increase being 3000 cd/m² or 200 cd/m² if the screen type is unknown. This can be increased up to 1500 cd/m² and 500 cd/m² respectively if positive polarity software only is used. LG7 also recommends values for the wall and ceiling illuminance, which are based on a direct percentage of the working plane level. The intention being to alleviate the “cave like” appearance that the single use of the original Category 2 cut off luminaires produced.

The LG7 lighting guide for office lighting was amended in 2012 to align with EN12464-1. This changed the recommendation for the wall and ceiling illuminances to be a percentage of that of the working plane to specific levels

of illumination (lux) with a minimum uniformity.

In addition the recommended range for the cd/m² for luminaires at the relevant cut off angle was changed and now has a range of 1000-1500 cd/m² for screens having luminances (brightness) of less than 2000 cd/m² which increases to 3000 cd/m² for screens with higher luminances.

It must be stated that LG7 is often referred to as being guidance for luminaires but it was written as a complete guide for lighting of the office environment, taking into account the total need of the occupants to create pleasant working space.

Recommendation for Wall and Ceiling Illuminance

The guide provides recommendations to address the dark and gloomy effect that can be created by ‘categorised’ louvres, including the sharp wall cut off and bright scalloping. To avoid this, walls and the ceiling should be lit as follows:

- The average wall illuminance above the working plane should be at least 75 lux with a uniformity of >0.1
- The ceiling average illuminance should be at least 50 lux with a uniformity of >0.1

The other misconception is that office lighting is all about creating a uniform lighting level across the whole space. What is needed is uniform lighting across each task area, which normally consists of relatively small areas on each desk. The lighting in the wider office space can, and indeed should, vary somewhat to create visual interest. Even the most dedicated office worker looks up from his or her work from time to time, and when they do they

need to see an interestingly lit office space and, ideally, a more distant view out of a window.

If the building and the visual requirements of the users of an office space are understood and all possible lighting options are considered, a lit environment can be created for each office space that not only provides the required levels of lighting for each task but also provides an interesting and stimulating lit environment for people to work in.

This is a direct quote from the introduction of LG7 which goes on to discuss the whole design process. The overall intention of the guide has not been fully utilised by the majority of users and the reliance on a “single luminaire solution” has still been widely requested. The single luminaire approach when used in regular arrays to produce a high level of uniformity across the whole working space can be in contradiction to the original intent.

If designing to LG7 the certificate of conformity should be used to show the criteria of the design.

Certificate of Conformity

The guide requires that the designer and installer of the installation complete and sign a Certificate of Conformity to demonstrate that all known visual and ergonomic criteria were fully considered during the design process and installed as specified.

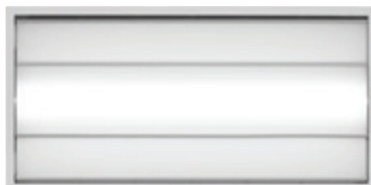
Due to the regular development of these guides, Eaton recommends you visit CIBSE on www.cibse.org to ensure the latest guides are being referred to.

EN12464-1:2011

The lighting design standards detailed in EN12464-1:2011 break the design process into a number of key elements to aid the design process. It however is not intended to provide specific solutions, nor restrict the designer from exploring new techniques or restrict the use of innovative equipment. Daylight, as well as artificial light, should also be fully utilised for both quality and to reduce energy.

- Luminous environment
- Luminance distribution
- Illuminance
- Glare
- Lighting in the interior space
- Colour aspects
- Flicker and stroboscopic effects
- Maintenance factor
- Energy efficiency
- Additional benefits of daylight
- Variability of light

Terzetto



Luminous Environment

For good lighting it is essential that as well as the required illumination level being achieved, it is important that the requirements of the occupant are considered. Lighting should meet the three basic human needs:

- Visual comfort
- Visual performance
- Safety

By meeting these basic requirements the lighting scheme will offer a feeling of wellbeing and allow all tasks to be safely and efficiently carried out.

Luminance Distribution

The distribution of the source of illumination is important as this will have a direct effect on the individual and it is important to ensure that the level of adaption is balanced throughout the space.

This will increase visual acuity and contrast, as positive aspects, but good distribution will reduce the risk of excess levels of brightness which in turn can lead to glare which can lead to fatigue and poor performance. However a good level of contrast is important so as to create an interesting environment for people.

A well balanced luminous environment can only be achieved by taking into consideration the reflectances and illuminance of all surfaces. To avoid a gloomy environment and to raise the level of comfort in the building it is highly desirable to have bright interior surfaces particularly walls and ceilings. The recommendations are:

- Ceilings; 70-90%
- Walls; 50-80%
- Floor; 20-40%

Additionally the reflectance of any major items of fixed equipment or furniture should be in the range of 20-70%.

The standard states the minimum levels of wall and ceiling illumination along with the maximum uniformity of these surfaces:

- Walls and major vertical surfaces:
Em > 50 Lux
- Ceilings: Em > 30 Lux

For offices these should be increased to:

- Walls and major vertical surfaces:
Em > 75 Lux
- Ceilings: Em > 50 Lux

Illuminance

The recommendations for minimum illumination levels are detailed for specific task areas based on the following factors:

- Comfort and well being
- Actual task requirements
- Functional safety
- Economy

The standard is based on illuminating the task area and not the total space with references to areas referred to as "immediate surround" with a minimum band width of 0.5 metres, and "background area" with illumination ratios to the task and each other. The standard also details the uniformities of the respective areas in place of the whole work space.

Typically if the task is illuminated to 500 lux the immediate surround should be at least 300 lux, whilst the background should be illuminated to a 1/3 the value of the immediate surround.



Glare

Glare must be limited to avoid errors, fatigue and accidents.

Glare can be experienced as either:

- Discomfort glare
- Disability glare

If the limits of discomfort glare are met, disability glare is not usually a problem. The glare rating for a scheme should be calculated using the Unified Glare Rating (UGR) tabular method and must be below the rating listed for the application.

It should be noted that high brightness reflections in the visual task should be avoided and these can be prevented by correct arrangement of work spaces, choice of finishes, control of luminances and bright ceiling and wall surfaces.

Minimum shielding angles for bright light sources are also specified for a range of lamp luminances.

Combiform Ultra - Louvre Option



Combiform Ultra - Panel Option



Lighting in the Interior Space

It is important to ensure that illumination of the space fully considers the human need and ensures that the lighting solution provided has a good level of cylindrical illumination.

This is important in environments where good inter-personal communication is required. Additionally the appearance of a space can be enhanced by providing a degree of modelling by controlled use of directional lighting. EN12464 offers good advice on achieving a balanced environment.

Colour Appearance and Colour Rendering

The colour appearance of the lamps refers to the apparent colour (chromaticity) of the light emitted, and the colour used should suit what is deemed as natural for the application, e.g. relative to wall colours, furniture, climate etc.

For visual performance and a feeling of comfort and wellbeing lamps with a suitable colour rendering index should be selected. Lamps with a colour rendering index value of Ra 80 must be the minimum used where people work or stay for long periods. For special applications, colour rendering may be acceptable with a lower index, but for other areas such as healthcare and retail, a higher value may be appropriate.

Flicker and Stroboscopic Effects

Lamp flicker and stroboscopic effects, which create discomfort and dangerous situations, should be avoided. This can be achieved by use of high frequency control gear in typical applications.

Energy Efficiency

Lighting should be designed to meet the lighting requirements of a particular task or space in an energy efficient way; however it is important not to compromise the visual aspects of the lighting scheme just to reduce energy usage. The use of relevant lighting controls should be considered in any design to take account of daylight, occupancy patterns, and by using dimming control gear the benefit of maintained illuminance.

A procedure for estimating the energy requirements for a lighting installation is given in BS EN15193 Lighting Energy Numeric Indicator.

(LENI), as this is based on a complete building and as such it should only be used as guidance if used for single rooms.

RXS Gimbal



Additional Benefits of Daylight

A good lighting design should also utilise any available daylight which can have a beneficial effect on the occupants. Creating variance in lighting level, direction and spectral composition throughout the day creates a feeling of wellbeing and comfort, it is however important to ensure that windows and skylights do not cause visual or thermal discomfort, or a loss of privacy. Additionally the use of natural daylight is beneficial in reducing the overall total lighting energy for the installation.

Variability of Light

Light is important to health and wellbeing as it can affect the mood, emotions and general alertness, so it is important to create a lighting solution that is not just a design by “numbers”, but one which truly takes into account the person.

Practical Scheme Design

In order to comply with the wide-ranging requirements of the SLL guides and BS EN 12464-1 (interior), each element briefly described should be carefully considered before choosing the luminaires to achieve the desired effect for the installation. It is unlikely that one luminaire type alone will meet the requirements in full and provide a satisfactory result. Each installation will also differ in design, as each application varies in terms of surface colours, furniture, ergonomics, task, limiting glare requirements, available daylight etc.

These documents aim to encourage the designer to look more closely at the working environment required and to create a comfortable and balanced lighting solution. It should take into consideration the factors listed, rather than reverting to a default luminaire or single light source suitable for all applications. It is therefore more likely that schemes that successfully

achieve the standard and guidance documents whilst creating a feeling of wellbeing will consist of a combination of luminaire types.

The combination of luminaires can include:

- Recessed or surface direct downlight luminaires
- Semi-recessed or recessed direct/indirect luminaires
- Suspended direct/indirect luminaires
- Wall washer luminaires
- Wall mounted or floor standing uplighters

The resultant installation will provide efficient illumination of the task area, whilst walls and ceilings are evenly illuminated to provide a visually comfortable lit environment.

This catalogue provides data on lamp colour rendering and appearance properties. Further information and advice on the application of SLL lighting guides, BS EN 12464-1 (Light and lighting - lighting of the work place), BS EN 15193 (Energy performance of buildings - Energy requirements for lighting) and many other standards and guides is available from our technical support and application department. They are also able to offer guidance on selecting the appropriate luminaires for the application from the Eaton's range of mains and emergency luminaires.

RXS Adjustable



LSR



Combiform Ultra



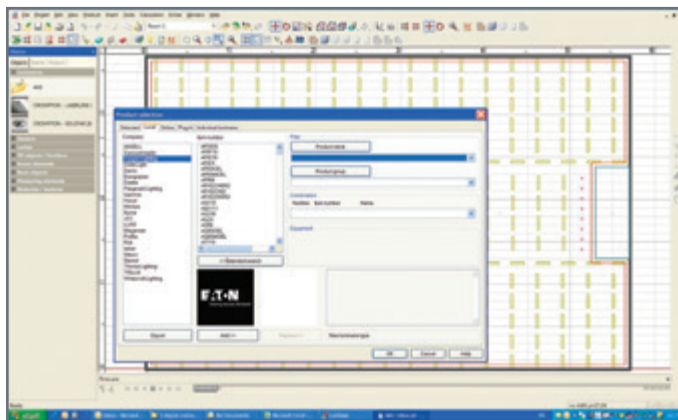


Professional lighting design requires detailed luminaire photometric and product design data. Eaton's advanced photometric facility produces accurate performance data for all product types and light sources, including LEDs.

Eaton provides its customers with this information in partnership with the leading lighting design software packages to enable accurate and detailed design to be created.

RELUX®

light simulation tools



Relux is a simple and intuitive lighting design software package which enables you to produce designs efficiently and accurately.

Construction of rooms, structural elements and the positioning of luminaires, objects and furniture, is done by a simple library driven menu system. A comprehensive selection of materials and textures can be allocated to your design elements, adding a realistic touch to rendered outputs including the facility to show effective walk through visualisations of your projects. For more complex designs the import and export functions for 2D dxf and dwg files significantly reduce your design time.

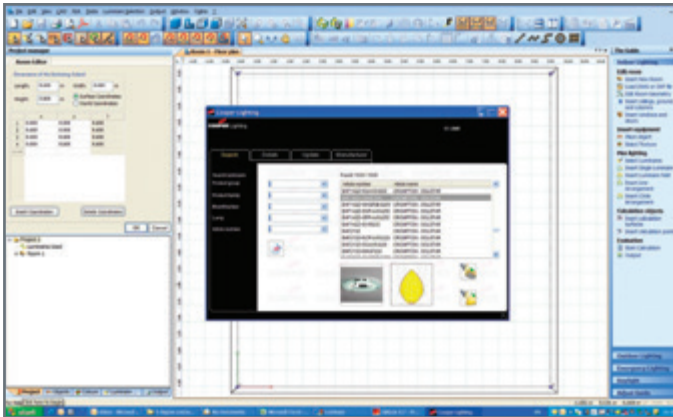
Detailed artificial light simulations can be created for interior and outdoor projects based on BS EN 12464-1 and -2, emergency lighting designs based on EN 1838, roads based on EN 13201, and sports grounds and daylight based on CIE.

Additionally with the Relux energy unit you are able to calculate the energy performance of the lighting scheme to EN15193 (LENI).

A comprehensive results list enables you to construct reports exactly to your client's needs, from simple basic calculations to full rendered imagery and results tables.

For more information and free download of the Relux software, visit www.relux.biz

DIALux



With simple to use features and powerful photo realistic visualisations, DIALux is a popular lighting design tool used around the world.

DIALux can import the CAD data from other architecture programmes to support your design and produce wild camera runs through your visualisation.

The software package also determines the energy your light solution requires and supports you in complying with the respective national and international regulations.

For more information and free download of the DIALux software, visit www.dial.de

Revit Files

Eaton is able to offer Revit® friendly Building Information Modeling (BIM) models for a wide range of our products. Architects, design-build contractor and surveyors, consulting engineers, and others are able to integrate Eaton equipment into their drawings with ease, and without cost. These product models from Eaton bring seamless integration to your building plan. These are available directly from our web site from the resources section of our website.

For more information and free download of the Revit files, visit www.cooper-ls.com/revit-files

Building Regulations

When specifying luminaires, legislation, as defined by the Building Regulations, must be considered to ensure that the installation meets with current requirements. The two most relevant pieces of legislation contained within the Building Regulations are:

- Conservation of fuel and power, which includes limits on the energy efficiency of lighting in domestic and non-domestic buildings.
- Fire Safety, which includes the requirements for emergency lighting and provisions for the use of thermoplastic materials, such as luminaire diffusers. Included below is a brief guide to each of these documents.

It should be noted that these documents are specific for each part of the UK, England, Scotland, Wales and Ireland, and you should refer to the relevant versions for the project.

The latest information and requirements can be obtained by contacting our technical support and application department. A list of recommended websites is also included below.

Consideration of fuel and power

This requires that energy efficient lighting be used in all buildings. The regulations currently apply to all new buildings and refurbishments of over 100m² floor area. The document provides design information in non-domestic buildings.

The 2014 version now provides two ways to provide the energy information during the design stage.

Option 1 is based on the installed load and uses the metric of luminaire lumens

per circuit Watts for office, industrial and storage areas. Lamp lumens per circuit Watts are used for all other areas. There is a small allowance for display lighting where relevant.

Option 2 is a simplified version of EN15193 known as LENI (Lighting Energy Numeric Indicator). This is based on an energy consumption model with actual usage targets for a selection of areas and operating hours in Kwh/m² per annum.

The requirements can be met by selecting an efficient lamp, control gear and luminaire performance combination, along with lighting controls that make maximum use of daylight and avoid unnecessary lighting during times when spaces are unoccupied.

Solutions include using high frequency dimmable control gear linked to photocells to provide constant illumination and daylight linking. Intelligent luminaires, such as Intellect, provide a straightforward solution to providing lighting control with user selectable functionality.

It is strongly recommended that reference be made to the current edition of Approved Document L, to ensure compliance with the latest requirements. Full details of Part L can be found on www.communities.gov.uk, or alternatively, a direct web address would be www.planningportal.gov.uk/buildingregulations.

Fire safety regulations

Includes the fire safety requirements for emergency lighting and the use of thermoplastic materials. The impact on emergency lighting of Approved Documents defines the provisions that apply to the use of luminaire diffusers, which form part of the ceiling. It should be

noted that surface mounted and suspended luminaires are not currently covered by the regulations.

Luminaire with diffusers must not be used in fire protecting or fire resisting ceilings, unless satisfactorily tested as part of the ceiling system.

The following information is provided on the limitation of use of thermoplastic (TP) materials in other ceiling types (except protected stairways):

- Diffusers classified as TPa construction have no restriction on extent of use
- Diffusers classified as TPb construction have limitations on size, total area coverage and spacing between diffusers

In areas with general ceiling types, except protected stairways, the requirements can be met most simply by specifying TPa classification diffusers when using recessed luminaires. TPb materials can be used, but will require careful reference to Part B and calculation to ensure the regulations are complied with in full. All recessed luminaires with diffusers in this catalogue have TPa classification materials as standard or as an option.

It is strongly recommended that reference be made to the current edition of Approved Documents, to ensure compliance with the latest requirements. Information is available online from the relevant authority.

Additional Considerations

There are many schemes both nationally and locally in operation, offering advice and financial support to end users, such as the Carbon Trust Implementation Scheme. This can provide full surveys, introductions to approved designers and installers and facilitate finance through the scheme.

Enhanced Capital Allowances (ECA)

This allows companies to claim 100% first year capital allowances on investments that meet the ECA product criteria.

Product groups eligible for ECAs are published in the Energy Technology List at www.eca.gov.uk.

Currently Lighting products are listed in three categories, however it is planned to incorporate LED in to the HELU:

- HELU High Efficient Lighting Units
- Lighting Controls
- White LED

Luminaires must meet minimum efficiency standards calculated as luminaire lumens per circuit watts, as these minimum values are subject to variation the latest information should be checked on the ECA Scheme website www.eca.gov.uk.

Luminaire efficiency ratings for Eaton luminaires are available by contacting our technical support and application department.

Note: that due to the wide variation in luminaires these are not individually listed as products but are self-certified against the energy criteria calculation.

Useful Website Addresses

www.communities.gov.uk - Building Regulations

www.eca.gov.uk - Enhanced Capital Allowances

www.thecarbontrust.co.uk - Promotion of low carbon technologies/energy efficiency

www.defra.gov.uk - Climate Change Levy

www.decc.gov.uk - Department of Energy and Climate Change

www.bis.gov.uk - Department of Business Innovation and Skills

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