Lighting Guide 2: Hospitals and health care buildings

The Society of
Light and Lighting

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Note from the publisher

This publication is primarily intended to give guidance. It is not intended to be exhaustive or definitive, and it will be necessary for users of the guidance given to exercise their own professional judgement when deciding whether to abide by or depart from it.

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Foreword

This new edition of the Lighting Guide LG2: *Hospitals and health care buildings* lighting replaces the previous 1989 version. This new edition has been produced to ensure that our guidance is up to date with modern lighting practice and to illustrate varying ways of lighting the modern hospital environment. Illumination recommendations have been aligned where appropriate with European Standards on lighting and the Society of Light and Lighting's *Code for Lighting*.

The provision of guidance on the lighting of hospitals has been available since 1968 (IES Technical Report No 12). There has been continual advancement in medical and nursing procedures during the intervening forty years; this is likely to continue in the future. Lighting technology has developed since the original IES Technical Report, hence the guidance was revised as CIBSE Lighting Guide: *Hospitals and healthcare buildings* in 1979, with a second edition following in 1989. In principle, the basic requirements for the provision of lighting for hospitals has not greatly changed. However regulations, luminaires and lamps have all developed since 1989. Although based on the 1989 edition, this new edition supersedes it as there have been important developments in legislation, illumination levels and lighting design techniques.

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Note from the Department of Health

The Department of Health (DH), through it's former agency NHS Estates, supported previous versions of CIBSE/SLL Lighting Guide LG2: *Hospital and healthcare buildings*. DH welcomes this revision and update to lighting guidance and the support given by the Society of Light and Lighting.

Lighting Guide LG2: *Hospitals and health care buildings*, addresses the complex interface and evolution of European Standards, the complimentary support given in the CIBSE/SLL's Lighting Guides and the emerging impact and opportunity provided by new lighting technology. DH particularly recognises the importance placed on energy efficiency through design and operational measures.

LG2 is referenced in the Health Technical Memorandum (HTM) series of documents and Health Building Notes (HBN). DH endorses the guidance given in this document.

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Part A: General recommendations

1 Design considerations

At an early stage in the design of any proposal for a new or upgraded hospital or health care building, full consideration of the lighting requirements, the function of each room or area, its interior decoration and the structural constraints of the building are vital to ensure complete co-ordination of design.

During the day, the major visual lighting component is likely to be daylight. The window plays many roles within a hospital including transmitting daylight, providing patients and staff with a view of the outside world, and as a source of ventilation. Current guidance on daylight ingress can be found in the CIBSE Lighting Guide LG 10: *Daylighting and window design*[2] and BS 8206[3].

The design of a health care building is complex, requiring careful and considered co-ordination within the design team where many decisions have to be made, sometimes with adverse consequences for each of its members. In an ideal scenario these decisions should be made in unison; in reality, because of contractual timescale pressures, they are often made independently, which encourages a neglect of co-ordination issues. The inevitable consequences for the affected disciplines are usually redesign, wasted effort and, potentially, additional fees. It is essential that each design team member understands how other members of the design team approach the design, and this should include lighting and its effect on the environment being created. The whole design team should actively encourage and maintain open and continual dialogue to ensure the smooth and efficient design co-ordination for lighting the project. Hospitals in particular require this increased level of communication due to the extra burden placed upon the building services engineering consultants for such a complex building type.

1.1 General

The design of the electric lighting must take account of factors beyond the obvious, i.e. its light distribution, size and location. Full consultation with the design team will produce a brief from which the finished design will evolve. It would be expected that, as a minimum, the brief considers each of the following factors. All of which should be debated and resolved for a scheme to be successful:

- the orientation of daylight, its intensity and the beneficial effects of sunlight
- any sun screening necessary for both performance and comfort of the staff and patients
- the distribution of light and the possible detrimental effects of glare from interior surfaces
- the lit appearance: its quality and its ability to enhance the medical purpose
- illumination of particular areas or tasks
- emergency and essential lighting needs
- the interior design intentions
- choice of lamp (its colour temperature and colour rendering properties)
- choice of lamp control gear
- potential for energy efficiency
- control, maintenance and cleaning of the luminaires, including easy and safe access to lighting equipment and windows for cleaning and maintenance
- co-ordination with other services and equipment
- appearance of the luminaire and its integration with the architecture.

In general, the selection of finishes should take careful account of the type of light source by which they will be illuminated. A guide to the recommended ranges of reflectance and to the relative illuminances of room surfaces can be found in SLL Lighting Guide LG11: *Surface reflectance and colour*[4]. Where uplights are used as a source of general room illumination then the reflectance values of surfaces within the room will generally need to be higher than for downlight arrangements. If reflectance values are known at the design stage then they should be used. Account should be taken at the design stage that the appearance and ambience of a building interior at night can be very different from those experienced during the daytime.

The illumination of all structural surfaces is important and, as explained in the introduction, it is not always sufficient just to provide adequate illuminance on the 'working plane'. The appearance of vertical surfaces, which form the major part of the field of view, must contribute to an overall ambience of comfort, safety and reassurance for patients and staff. This is particularly relevant to entrance halls, reception and circulation areas. These are the areas where patients and visitors will gain their first impressions of the building.

Specific lighting and glare recommendations for the various areas within hospital and health care buildings are given in Part B. The general lighting schedule at the end of Part A summarises alphabetically the recommendations and requirements for all typical areas encountered within health care buildings. The general lighting schedule is intended to be used as a quick source of reference, but it should not be used in isolation from the general text. Whilst the schedule is intended to be comprehensive it is not exhaustive. Should the reader require information on areas not covered within the schedule, they should select an area that best mirrors the task and ambient requirements, e.g. for 'en-suite' areas the appropriate information can be found under the heading of 'Bathrooms'.

Discomfort glare for situations in hospitals can be difficult to predict, so in order to avoid possible misinterpretation, this Lighting Guide does not recommend limiting values. However, in some areas where the visual requirements are exacting, guidance is given on the control of the luminance of the luminaire, ceiling and wall surfaces. For operating theatres, guidance is given in section 4.1. For further information on the assessment of glare, reference should be made to CIE Publication 117[5].

Emergency lighting and lighting under standby conditions should be considered at the same time as the general electric lighting design. Specific information is given in Part B, section 8. Summarised recommendations for standby lighting are given in the general lighting schedule but further reference should be made to BS 5266: Part 1[6].

1.2 Lighting and colour

The intricate technical and subjective aspects of design and colour could not possibly be adequately covered in this comparatively small section. Instead it is intended to complement the NHS publication: *Lighting and colour for hospital design*[7]. This publication deals with the subject in a far more comprehensive way. The present section on colour and lighting aims to be selective in highlighting only where it is of particular importance to ensure that colour and its influence will not be detrimental to the task being performed, and that complementary spectral colours should figure strongly in the selection of lamps to be used.

Colour has a vital role to play in enhancing the healthcare environment and providing information and spatial orientation. It will help occupants not only make sense of their spaces but feel better about their temporary environment. It encourages visitors to feel positive about their experiences and helps staff to appreciate their work place.

An appreciation of the important link between lighting and colour is necessary for the development of contemporary hospital design. These two factors together are the basic ingredients in the success or failure of the visual

Plate 1 Good Hope Hospital, Sutton Coldfield (photo courtesy of Charlotte Wood Photography)

quality expected in hospitals today and should not be considered independently. The use of good lighting coupled with imaginative and strategic colour design schemes can transform any environment with the minimum of costs. In addition, the use of colour and contrast will assist greatly in meeting the requirements of BS 8300: *Design of buildings and their approaches to meet the needs of disabled people. Code of practice*[8] and the Disability Discrimination Act[9] (DDA). Rooms will be far less depressing if the window wall is painted in a light colour and well illuminated to avoid the wall appearing dark when high levels of daylight are visible through the windows. The use of windows with splayed reveals will also help with the ingress and distribution of daylight.

Within entrance and reception areas, lighting and colour can aid visibility and guidance, and provide intimacy or privacy at the patient's bedside; lighting makes the public areas in hospitals more accessible by highlighting important signage and landmark features. Research has established that knowledgeable application of lighting and colour can influence a person's mood, well-being and orientation.

One vital aspect of the built environment that is often overlooked is the effect of orientation of the building on planned schemes for both lighting and colour. If a building faces north or south it can have a major impact on the internal visual quality. Deeper buildings pose another set of problems where daylight availability is minimal; this can affect all users of the buildings but especially the staff who spend lengthy periods in such spaces. Balancing their contiguous workspaces by varying both lighting and colour can boost their visual stimulation considerably.

Colours for use within the interior should only be selected when viewed under the same light source that is to be used within the area of consideration. Any key colour in a scheme that may be present throughout a building should be presented to the lighting designer to determine the optimum lamp and luminaire combination for that scheme.

Plate 2 Good Hope Hospital, Sutton Coldfield (photo courtesy of Charlotte Wood Photography)

Whether designing new or refurbishing or maintaining existing hospital environments, appropriate lighting for colour can enhance the most difficult areas of healthcare. Colour and lighting together can deal with sensitive areas such as cancer treatment unit waiting rooms where a subdued but positive outlook is required. Reception desks need a strong colour behind the person at the desk and bold lighting on the coloured wall to aid quick identification of the area as a key point in the entrance to a busy hospital. This is known to be of help for those visitors or patients who may be visually or cognitively impaired or temporarily distracted by their personal circumstances. Subtle colour harmony schemes[7] can be destroyed by the inappropriate application of light sources. All paint schemes should be checked for metameric effects with co-ordinating materials[7]. For example paint and textiles that match in daylight may be found not to do so under electric light.

Thoughtful and careful illumination of colour on walls can affect the performance of staff as well as encourage patient recovery. Appropriate lighting and colour can create environments that feel as if the sun is shining into a room even where there is no external glazing. Variations in lighting levels and a change in colour within staff rooms can greatly assist staff to relax during their rest periods

Lighting and colour strategies call for careful planning at the development stage to ensure that the correct lighting service is available in those crucial areas. Strong colours in hospitals need not be avoided if supplied with sufficient illumination. Wall washing large coloured areas can be invigorating and obviate the need for expensive visual effects to make spaces interesting.

Lighting and colour can be strong partners in aiding navigation and also help make sense of confusing spaces. They can also aid orientation and be useful in assisting with direction. Accent colours well illuminated can provide an accessible and easy form of wayfinding for both visitors and staff.

Plate 3 West Middlesex University Hospital (photo courtesy of Charlotte Wood Photography)

Corridors occupy a large percentage of the hospital environment; they can be both uninteresting and disorientating. Lighting and colour together can provide interest or establish landmarks and also show for example where critical pathways intersect.

The change in ambience within a hospital from daytime to night-time may be extreme but the change should not be so low as to detract from the provision of wayfinding information. Providing adequate lighting levels at night to areas where art or foliage may be present could be advantageous. Lighting trees outside may be an effective way of bringing an uplifting visual entity into the building. Many areas within hospitals take advantage of successful planting with daylight from atria; these need to be carefully illuminated at night to retain their visual interest for staff, patients and visitors. Certain colours can lose their vitality or appear grim if the colour temperature of the lamp is not matched. Yellows can be difficult and take on a greenish hue; oranges can appear dark brown or even grey at twilight. Sometimes coloured surfaces can be used to reflect back onto walls and enliven a dismal corner.

Plate 4 Good Hope Hospital, Sutton Coldfield (photo courtesy of Charlotte Wood Photography)

Confinement for long periods in monotonous drab interiors is detrimental to a sense of well-being. Skillful use of colour with good illumination can overcome potential problems of sensory deprivation. This is obviously more critical when the environments may have elderly, distressed or patients whose mobility is severely limited.

The search for the ‘correct’ colour to use in hospitals has been tried in the past and is futile since each building’s orientation or user group, for example, demand a customised approach to colour and lighting. Colour preferences vary considerably by age, gender and culture. Colour and lighting can do much to create pleasing spaces with the minimum of effort and expense. However, none of this is achievable without an understanding of the diversity of lighting sources, from daylight to electric light, and the way they interact with coloured surfaces.

Windows and daylight give a building the variety and interest that can rarely be achieved in any other way. People respond positively to daylight and it is well understood that daylight has a beneficial role to play in the recovery and wellbeing of the patients and staff. Daylight is particularly important in hospitals as it has excellent colour rendering properties making clinical tasks easier to perform. It offers the potential for significant energy savings and

because it is dynamic in nature it can help patients maintain their body clocks and provide stimulation and visual interest[7]. Current guidance on daylight ingress can be found in the CIBSE Lighting Guide LG 10: *Daylighting and window design*[2] and BS 8206[3]. See also section 9.1.

1.2.1 Designed illuminance and energy considerations

It is important to understand that the values given within the schedule, although harmonised with the requirements of BS EN 12464-1: *Light and lighting. Lighting of work places. Part 1: Indoor work places*[10], should still be considered as recommended and not absolute values.

The actual requirements applicable to a specific area can only be correctly assessed by studying the general text given in Part B and through consultation. It is very important that, if available, the advice of competent and experienced staff familiar with medical procedure or with specific local conditions be considered before reaching the final design value.

The recommended illumination levels within the schedule are based on good current practice, principally relating to the visual abilities of a group of normally sighted people with an average age of 40 years.

Consideration has been given to the requirements of the various visual tasks being performed in each area. In non-critical task areas or where the task is of short duration, the appearance of the room may be the dominant factor in establishing the recommended illuminance level. It is worth noting that when designing for the visual requirements within the health care sector there is likely to be a greater number of elderly people whose vision will be impaired with age. While it may not always be necessary to increase general illumination levels, consideration should be given to the expected activities of this group, and the appropriate illumination level selected, guidance can be obtained in the SLL's *Code for lighting*[11].

Areas with similar requirements may occur in different departments. Where rooms with specialised needs occur in more than one department, they are listed individually in the general lighting schedule.

The maintained illuminance to be provided on the visual task is the minimum illuminance required throughout the life of the installation or throughout the duration of a maintenance period. It is also averaged over the relevant task area. This area includes that for the visual task and its immediate surroundings. The area surrounding the visual task should be lit to not less than one third of the illuminance on the task itself. In multi-purpose rooms in which the task position is unknown, the whole area should receive the recommended maintained illuminance.

In this Lighting Guide, where two or more illumination values are given for the same area, e.g. 50/100 lux or 150/300/500 lux etc., it means a value may be selected between the stated values; this will help to cater for the different activities which need to be undertaken within the same area. The range of illuminances required should be provided by dimming to ensure that spatial quality and uniformity will be maintained.

1.2.2. Design energy efficiency rating (DEER) system

It is now a statutory obligation that any lighting scheme proposed within England and Wales meets the requirements of Building Regulations Approved Documents L1/L2[1] on the conservation of fuel and power. In Scotland any lighting proposal should meet the requirements of the Building (Scotland) Regulations 2004 as stated in section 6 of the 2007 Technical Handbook[12]. The requirements within both of these documents, although executed slightly differently, are aimed at increasing the energy efficiency within new and existing buildings. They are aimed at maximising the conversion of electrical energy to light and then minimising its usage through the effective use of controls during periods of non-occupation and within areas sufficiently illuminated by natural light. This Lighting Guide also encourages energy controls to be considered to all areas that would show a positive return in user benefits or energy savings. The current proposed efficiency levels are mainly set to

discourage the use of inefficient light sources such as incandescent lamps (i.e. GLS types). However, the energy targets are expected to increase in severity over time to take advantage of developments in materials, light sources and construction techniques.

In an effort to increase further the installed efficiency of any lighting design proposals, this publication introduces a 'design energy efficiency rating' (DEER) system aimed at encouraging responsible lighting design. In line with the above statutory requirements, the DEER system uses the target values published within these documents as a base level or 'statutory minimum'. It then extends the scheme by introducing two higher levels of efficiency called 'best practice' and 'exemplary'. The three levels and the corresponding energy target values are as follows:

— DEER level C (statutory minimum): 45–59 luminaire lumens per circuit watt inclusive
— DEER level B (best practice): 60–65 luminaire lumens per circuit watt inclusive
— DEER level A (exemplary): 66 and above luminaire lumens per circuit watt.

Compliance with the DEER must be proved by calculation; it cannot be achieved by the exemption rule, i.e. using lamps with an efficacy $\geqslant$ 45 lumens/watt (*note*: this value is likely to increase during the lifetime of this Lighting Guide). The calculation should be carried out in much the same way as detailed within Approved Documents L1/L2[(1)]. This includes the method for determining the control factor, as follows:

(*a*) If the luminaire is in a daylit space and is controlled by photoelectric switching or dimming control, with or without manual override: control factor = 0.9
(*b*) If the luminaire is in a space that is likely to be unoccupied (apart from plant rooms) and is switched off by a sensor in the absence of people but the switching on is done manually: control factor = 0.9
(*c*) Areas that employ a combination of (*a*) and (*b*): control factor = 0.85
(*d*) None of the above: control factor = 1.00.

This is illustrated in the sample work sheet shown in Appendix A1. The DEER calculation deviates from the Approved Document method in one respect. To find the total circuit watts and luminaire lumens used within each area, Part L requires a calculation to be carried out for all the individual areas or rooms of a building. The values for the individual areas or rooms are then added together and divided by the total number of areas or rooms considered to give the average installed efficacy for the whole building. To calculate the corresponding DEER it is necessary to evaluate each area separately to find its installed efficiency value. The efficiency values for the various areas are then added together and divided by the number of areas considered; the value obtained is the DEER.

The DEER method rewards greater attention to detail during the design process but still allows visual expression to be displayed in all areas. It also allows the specification of a project to be centred on energy efficiency if required. Lighting designers and specifiers should also be aware that the DEER system is partially 'aspirational' in that it encourages lighting application methods and the luminaires to be developed before it's possible to constantly achieve the highest level set. So at present while it may not be possible to achieve an 'overall' exemplary level in every case; it should be possible to achieve it within certain areas, so the task should be to identify and set achievable targets while encouraging the development of energy savings.

In order for the DEER method to be effective it must consider all of the areas of a project. However, in large projects many areas are replicated so it makes sense to base the DEER on a number of the fundamental areas that make up a large part of the building. The number and types of areas used to determine the DEER can be set down in the specification but, except for very small projects, the minimum number should be not less than 10. In addition, the 10 selected areas should include the following areas:

- minimum 12 m section of corridor $\leqslant$ 2 meters wide
- minimum 12 m section of corridor $>$ 2 meters wide
- single bedded ward
- multi-bedded ward (either 4- or 6-bedded)
- public reception desk including waiting area
- administration office greater than 40 m^2
- doctor/consultant examination room
- recovery room or area greater than 25 m^2
- minor operating theatre including any scrub-up and anaesthetics areas (general lighting only)
- major operating theatre including the scrub-up and anaesthetics areas (general lighting only).

Of course, not all projects will include all of the areas listed above so the list should be revised to include as many of the above as are present, or modified to reflect the types of areas present in the building under consideration.

1.2.3 Position of measurement and UGR values

The position of measurement for task illuminance for purposes of design or calculation is on a horizontal plane at that part of the room in which the primary task is performed, unless some other specific location is given.

The working plane is nominally 0.85 metres above the floor and this height should be used if the actual height of the task is unknown. The letters 'WP' in the general lighting schedule and the words 'working plane' in the specific recommendations in Part B are used to indicate that the recommended maintained illuminance is to be averaged over the whole of the utilised area of the room.

Freedom from discomfort caused by glare is an important criterion of lighting quality. The sensation of glare in a lighting installation is experienced by people in the form of discomfort, annoyance, or irritation is a complex function of the imbalance within the luminance pattern experienced by the visual mechanism, certain parts (glare sources) lying above the range to which the eye is adapted at the time.

Experimental work has shown that the main factors influencing discomfort glare are the luminance of the sources and their apparent size, their position in the field of view and the luminance of the general environment. These factors can be combined in a formula to determine the degree of discomfort glare and is known as the unified glare rating (UGR) system. The UGR formula may be used to evaluate the glare stimulus within a given environment. However the actual perception of glare varies from person to person. The calculated index for a particular interior and lighting system can then be compared with the limiting value given in the UGRL column within the general lighting schedule (1.2.7). If the calculated value is greater than the recommended limit, modifications to the lighting system or the interior will be required.

1.2.4 Light source groups

The type of light source is important. Section 9 lists most of the lamps commonly available and gives their principal properties. All areas should use fluorescent lamps with high colour rendering properties, i.e. an RA index $\geqslant$ 80–90. In addition to the colour rendering, all fluorescent lamps should be of the same colour temperature, especially throughout all the clinical areas, this will also help with the future maintenance.

1.2.5 Type of control

See also section 11. The letters which appear in the general lighting schedule under the heading 'Control' and the statements given in the tables in Part B suggest methods for the control of luminaires in the rooms or areas they serve. The methods suggested are as follows:

- N (normal): control of luminaires by a single on/off switch or by two way or intermediate switching, to suit the requirements of the task, room or area. Generally, the luminaires directly associated with the task or for the local inspection should be on a separate local switch from those luminaires providing the general area illumination.
- S (selective): control of luminaires within these areas should be such that the illuminance can be varied by simple switching methods. This can apply to individual lamps, luminaires or groups of luminaires.
- V (variable): control of the light output of the lamps within the luminaires.
- EM (energy management systems): energy management systems in hospitals are more likely to be installed for the control of heating, ventilating and air conditioning plant. However, there are certain situations where an interface with the lighting control system may be an advantage. Indications of where energy management systems can be considered are also given in the relevant paragraphs of section 3.
- Sp (special): details of any special switching arrangements are given in the relevant paragraph in Part B.

1.2.6 Emergency lighting classification

See also section 8. Although not specifically mentioned in the general lighting schedule, escape route lighting will be required to cover all parts of a hospital or health care building. This should be in line with the requirements of BS 5266[6]. Design guidance can also be obtained in the SLL Lighting Guide LG12[13].

Standby lighting will be required in some areas to enable essential activities to be carried out during an emergency, see section 8. The two grades of standby lighting recommended are:

(*a*) Grade A: lighting of the level and quality equal or nearly equal to that provided by the normal lighting.

(*b*) Grade B: a reduced standard of lighting, i.e. between 35% and 50% of the normal mains standard, sufficient to enable general hospital activities to be carried out.

The grade of standby lighting indicated in the general lighting schedule is a guide to the requirements. All areas of high medical dependency generally require grade A. For other areas, the standby lighting should be directly related to the essential tasks. The absence of a grade in the column headed 'Standby' does not necessarily mean that no standby lighting should be provided.

1.2.7 General lighting schedule

The general lighting schedule (Tables 1 and 2 below) gives in tabular form recommendations for the illuminance, switching and the emergency lighting requirements for the many different departments and rooms in hospital and health care buildings.

The values shown within the schedule reflect the figures published as an addendum to the 2002 edition of LG2 in order to harmonise with the requirements of the then newly published BS EN 12464-1: *Lighting of work places*[10]. For those unaware of the 2002 addendum, an outline of the derivation of these values is given below.

European Standards for lighting do not quote illumination ranges, only single figures. As a result, a range previously expressed as 300–500 lux is now

Table 1 General lighting schedule; internal lighting

Area, unit or department	Service illuminance, E_m / lux	Max. point illuminance / lux (not to be exceeded)	UGR_L	Min. R_a	Position of measurement	Type of control (see 1.2.5)	Standby grade (see 8.2)
Common areas (see section 3):							
— changing room	100–150	N/A	22	80	Floor	N	—
— chapel	100–150	N/A	22	80	Pews	N	—
— classroom	300	520	19	80	Desk	N	—
— consulting room (general)	300	520	19	80	WP	N	B
— core room (deep plan)	300	520	19	80	WP	—	—
— day room	200	350	22	80	WP	—	—
— disposal (clinical, domestic waste)	200	350	22	80	Floor	N	—
— doctor's office	500	850	19	80	Desk	N	B
— domestic services room	100	170	19	80	Floor	N	—
— drug store (ITU/HDO)	500	850	19	80	Desk	N	B
— general office	300	520	19	80	Desk	N	B
— seminar room	100–150	N/A	19	80	Floor	N	—
— seminar room	300	520	19	80	WP	S/V	B
— staff change	100	170	22	80	Floor	N	—
— staff rest room	50/200	N/A	22	90	WP	—	—
— utility room (clean)	150	260	19	80	WP	N	B
— utility room (dirty)	200	350	22	80	WP	N/S	B
Corridors (screened from bed bays) (see section 3.6):							
— by day	200	350	22	80	Floor	S/V	B
— by night	5–10	N/A	22	80	Floor	N	B
Circulation/communal areas (see section 3.6):							
— corridors (general)	200	350	19	80	Floor	N	B
— day room	200	350	—	80	Floor	S/V	B
— entrance canopy	50 (min)	N/A	—	80	Road surface	N/S	B
— entrance lobby	200 (min)	N/A	22	80	Floor	N/S	B
— hairdressing salon	300	520	—	80	Chair	N	—
— hospital street	200	350	19	80	Floor	N/EM	B
— library	300	520	19	80	Desk	N	—
— lift car	150	260	—	80	Floor	Sp	—
— lift lobby	200 (min)	N/A	19	80	Floor	N/S	B
— loading bay	100	170	22	80	Platform or floor	N	—
— reception area	300	520	19	80	Floor	N	B
— relatives overnight	150	260	—	80	WP	N	—
— rest areas	150	260	19	80	Floor	N	—
— shop/kiosk	300	520	—	80	Counter	N	—
— storage (general)	200	350	22	80	Floor	N	—
— toilets	200	N/A	22	80	Floor	N	—
Restaurant/catering/breakout areas (see section 3.7):							
— beverage bay	100	170	—	80	Floor	N	B
— counter	300	520	22	80	Counter	N	—
— general	50	100	—	80	Floor	S	B
— servery	300	520	22	80	Counter	N	—
— tables	50/200	N/A	—	80	Tables	N	—
— washing up	300	520	22	80	Sink	N	B
Wards and bedded areas (see sections 3.10 and 3.11):							
— children's play area	300	520	22	80	Desk	N/EM	B
— circulation space	100	170	19	80	Floor	N	B
— circulation space (night)	5	10	—	80	Floor	N	B
— examination/treatment	1000 (local)	N/A	—	90	Bed level (usually provided by examination lamp)	N	A
— general nursing care/examination	300	520	19	80	Bed	S	A
— night light	5	10	—	80	WP	N	B
— nurses' station (day)	300	520	19	80	Desk	S/V	A
— nurses' station (night)	30/200	250	22	80	WP	N	—
— observation/night watch	20	40	—	80	Bed head	N	B
— observation/night	1 to 5	N/A	—	80	Bed head	N/Sp	B
— mental illness care wards	200	350	19	80	Floor	N	B

Table continues

Table 1 General lighting schedule; internal lighting — *continued*

Area, unit or department	Service illuminance, E_m / lux	Max. point illuminance / lux (not to be exceeded)	UGR_L	Min. R_a	Position of measurement	Type of control (see 1.2.5)	Standby grade (see 8.2)
Wards and bedded areas (*continued*) (see sections 3.10 and 3.11):							
— patient reading (adult)	300	520	19	80	Bed head	N	B
— reading lights	300	520	19	80	Patient activity area (see section 3.11.3)	N/S	A
— ward corridors (day)	200	350	19	80	Floor	N	B
— ward corridors (night)	50	75	19	80	Floor (50% uniformity required)	N	—
Orthopaedic (see section 3.14.6):							
— pacemaker	500	850	19	80	WP	S/V	B
— treatment (general)	300	520	19	80	WP	N	B
— venesection	300	520	19	80	Chair	N	B
Critical care (see section 3.14.7):							
— intensive care (night)	5 (max)	N/A	—	80	Circulation	N/Sp	B
— observation/night watch	20	40	—	80	Bed-head	N/Sp	B
— high dependency unit (HDU)	100	170	19	80	Circulation/general	N	A
— intensive care unit (ICU)	100	170	19	80	Circulation/general	N	A
— bed head (day)	30 to 50	N/A	22	80	Bed head	N	A
— night light	5 to 10	10	—	80	Bed head	N	A
— simple observation/examination	300	520	19	80	Bed	S	A
— examination	1000 (local)	N/A	—	90	Bed level (to be provided by examination lamp)	N	A
Coronary care (see section 3.14.7):							
— bed head (day)	30 to 50	N/A	19	80	Bed head	N	A
— observation/night watch	5 to 10	N/A	—	80	Bed head	N	A
— simple observation/examination	300	520	19	80	Bed	S	A
— examination	1000 (local)	N/A	—	90	Bed level (to be provided by examination lamp)	N	A
— staff base (day)	300	520	19	80	Desk	N/S	A
— staff base (night)	30/200	250	19	80	Desk	N/S/V	A
Nurse's station/staff base (see section 3.14.8):							
— day	300	520	19	80	Desk	N/S	A
— night	30/200	250	19	80	Desk	N/S/V	A
— interview	300	520	19	80	Desk	N	B
Operating theatres (see section 4.1):							
— anaesthesia (examination)	1000 (local)	N/A	—	80	Trolley head	N	A
— anaesthesia room (general)	500	850	19	80	WP	S	A
— angiography room	500	850	19	80	WP	S/V	A
— endoscopy	300	520	19	80	WP	S/V	B
— operating room general	1000	1500	19	90	WP	S/V	A
— operating table/cavity	10 000 to 100 000	N/A	—	90	WP	S/V	A
— porters' area	300	520	19	80	Trolley/bed	N/S	A
— post anaesthesia recovery	500	850	19	90	WP	N/S	A
— preparation	500	860	19	80	Bench	N	B
— scrub-up	500	860	19	80	Sink top	N	B
— transfers	300	520	19	80	WP	N	B
— utility rooms	100 to 150	N/A	19	80	Floor	N	—
Accident and emergency (see section 5.1):							
— admissions/reception (see also section 3.5)	300	520	22	80	Desk	N	B
— supplies stores	300	520	22	80	WP	N	A
— minor treatment area	500	850	19	80	WP	N	B
— minor operations	15 000/30 000	N/A	—	90	Adjustable to suit treatment area	N	B
— couch (general area)	750	1000	19	90	Over couch area	N	A
— couch (local)	500	850	19	80	Couch level	S/V	A
— general examination areas	500	850	19	80	Couch level	S/V	A

Table continues

Table 1 General lighting schedule; internal lighting — *continued*

Area, unit or department	Service illuminance, E_m / lux	Max. point illuminance / lux (not to be exceeded)	UGR_L	Min. R_a	Position of measurement	Type of control (see 1.2.5)	Standby grade (see 8.2)
Accident and emergency (*continued*) (see section 5.1):							
— procedure room	30 000/60 000	N/A	—	90	Task illumination provided by minor treatment lamp	N	A
— resuscitation room	500	860	19	80	WP	N	B
Audiology (see section 5.2):							
— audio testing	300	520	19	80	WP	S/V	B
— consulting room	300	520	19	80	WP	S/V	B
— ear examination	1000 (local)	N/A	—	90	(Examination lamp)	—	—
— vestibular testing (labyrinth)	100	170	19	80	Couch head and instruments	N	B
Dentistry (see section 5.4):							
— laboratories	500	850	19	80	Bench	N	B
— reception/administration areas	300	520	19	80	WP	N/S	B
— surgeries/theatres	8000 to 20 000	N/A	—	90	Mouth	N/V	A
— treatment rooms	500	850	19	90	Bench work surface	N	B
— white teeth matching	5000	N/A	—	90	WP (TCP ⩾ 6000 K)	N	B
Diagnostics support services (see section 5.5):							
— aseptic laboratory	300	520	19	80	Bench	N	B
— blood bank	300	520	19	80	WP	N	A
— colour Inspection laboratory	1000 (local)	N/A	—	90	Bench (TCP ⩾ 6500 K)	N	A
— hot and cold rooms	200	350	19	80	WP	N	B
— inspection	500 (local)	N/A	—	80	Bench	N	A/B
— laboratories	500	850	19	80	Bench/desk	N	A/B
— laboratory (with computers)	300	520	19	80	WP	N	A/B
— pathology laboratory	500	850	19	80	Bench	N	A/B
— relatives' waiting room	300	520	19	80	WP	S/V	B
— seminar room	300	520	19	80	WP	N	B
— viewing/bier room	30 to 150	N/A	19	80	Bier	S/V	B
Womens' services (maternity) (see section 5.8):							
— applying sutures	1000 (local)	N/A	—	90	Couch, chair or bed (usually provided by examination lamp)	N	A
— circulation space (day)	100	170	19	80	Floor	N	B
— delivery	500	850	19	80	WP	N/S	A
— day	50 to 100	N/A	19	80	Cot	N	A
— night	5	20	—	80	Cot	N	A
— neonatal	1000 (local)	N/A	—	80	Cot	N	A
Mother and baby rooms (see section 5.8.3):							
— circulation space (day)	100	170	22	80	Floor	N	B
— day	50 to 100	N/A	19	80	Cot	N	A
— night	5	20	—	80	Cot	N	A
— nurseries (day)	100	170	19	80	Floor	N	B
— nurseries (night)	5	20	—	80	Floor	N	B
— milk kitchen	300	520	22	80	Bench	N	B
— special care baby unit	1000 local	N/A	19	80	Cot	N	A
— teaching areas	300	520	19	80	Bench/WP	N	—
Records (see section 5.9):							
— administration (computerised)	300	520	19	80	Desk	N	—
— administration (medical records)	500	850	19	80	Desk	N	—
— general storage areas	200	350	19	80	Floor between racks	N	—
Occupational therapy (see section 5.11):							
— gymnasium	300	520	22	80	Floor	N	—
— hydrotherapy pool	200	350	19	80	Water level	N	A
— physiotherapy	200	350	19	80	Floor	N	—
— rehabilitation	200	350	19	80	Floor	N	B

Table continues

Table 1 General lighting schedule; internal lighting — *continued*

Area, unit or department	Service illuminance, E_m / lux	Max. point illuminance / lux (not to be exceeded)	UGR_L	Min. R_a	Position of measurement	Type of control (see 1.2.5)	Standby grade (see 8.2)
Ophthalmology (see section 5.12):							
— consulting room	50/300	N/A	19	80	WP	S/V	B
— examination of outer eye	1000 local	N/A	—	80	Chair	N	—
— reading/colour vision test screen (if not internally illuminated)	300	520	16	90	Over vision chart (vertical plane) (good uniformity required)	N	—
— vision test area	100 (max)	N/A	16	80	Bjerrum screen	S	—
Radiology (see sections 5.14 and 5.16):							
— angiography	300	520	19	80	WP	N	A
— CT/MRI rooms	300 (dimmable)	N/A	19	80	Trolley/WP	N	A
— ECG/EEG	300	520	19	80	Equipment	N	A
— electro-medical	300	520	19	80	Trolley or chair	N	A
— fluoroscopy	300	520	19	80	Bench	N	A
— isotope store	300	520	19	80	Bench	N	B
— lavage	150	260	19	80	WP	N	B
— radiology (general)	100	N/A	19	80	Bench and instruments	N	B
— radiotherapy	100	N/A	19	80	Couch	V	A
— ultrasound	300	520	19	80	Bed level	N	A
— X-ray	300	N/A	19	80	1 m AFFL*	V/Sp	B
Autoclave (sterilising) (see section 5.15):							
— inspection	500 (local)	N/A	19	80	Bench	N	A
— loading	300	520	22	80	Floor	N	B
— maintenance (including rear of unit)	200	350	22	80	WP	N	—
— storage	150	260	19	80	Floor	N	—
Sterile supply department (SSD) (see section 5.15):							
— loading area	200	350	19	80	Floor	N	B
— medical equipment (working and testing areas)	300	520	22	80	WP	N	B
— washing area	300	520	22	80	WP	N	B
Photographic (see section 5.16):							
— darkroom	50	90	19	80	Bench	Sp	—
— dayroom	100 to 200	N/A	19	80	WP	N	—
— studio (photographic)	150	260	19	80	WP	N	—
Outpatients (see section 6):							
— examination area	1000 (local)	N/A	—	90	Couch, chair or bed	N	A
— general treatment	300	520	19	80	WP	N	B
— GP's examination room	300	520	19	80	WP	N	B
— seminar office	500	850	19	80	WP	N/S/V	—
General treatment areas:							
— autopsy (dissecting) table	5000	8600	—	90	Table top	—	—
— autopsy rooms and mortuaries	500	850	19	90	WP	—	—
— dermatology	(higher values could be required)	N/A	19	90	(Local operating lamp)	—	—
— dialysis	500	850	19	80	WP (dimmable)	—	—
— dispensary	500	860	19	80	Bench	N	A
— minor surgery/treatment	15 000/30 000	N/A	—	90	Couch/bench (provided by a minor surgery lamp)	N	A
— plaster room	500	850	19	80	WP	N	B
— resuscitation (general)	500	850	19	90	WP	N	A
— resuscitation/examination	15 000 (local)	N/A	—	90	Head of trolley	N	A
— pharmacy	500	850	19	80	WP	N	A/B
Mortuaries and animal houses:							
— autoclave	150/200	N/A	19	80	WP	N	B
— body store	200	350	19	80	WP	N	B

* AFFL = above fitted floor level

Table continues

Table 1 General lighting schedule; internal lighting — *continued*

Area, unit or department	Service illuminance, E_m / lux	Max. point illuminance / lux (not to be exceeded)	UGR_L	Min. R_a	Position of measurement	Type of control (see 1.2.5)	Standby grade (see 8.1)
Mortuaries and animal houses (*continued*):							
— general	300	520	19	80	WP	Sp	—
— mortuary	150	260	19	80	Bier room	S/V	B
— operation	500 local	N/A	—	90	Bench	N	B
— post-mortem	500	850	19	90	WP/table	N	B
— staff change	100 to 150	N/A	19	80	Floor	N	B
— store room	150	260	19	80	WP	N	—
— viewing room	50/100	N/A	19	80	WP	S/V	B
— waiting room	200 (min)	N/A	19	80	Floor	N/S	B
Engineering services:							
— ducts	20 to 50	N/A	—	80	Floor	N/SP	—
— plant room	300	520	22	80	Floor	N	A
— roadways	7	12	—	80	Road surface	—	—
— workshop	300/500	N/A	22	80	Bench	N	B
Facilities support services:							
— laundry	300	520	19	80	Bench	N	A
— linen store (Linen Department)	100	170	19	80	Floor	N	—
— pack and despatch	300	520	19	80	Bench	N	A
— pressing	300	520	19	80	Equipment	N	A
— sewing room	500 (local)	N/A	19	80	Machine	N	A
— wash and dry	300	520	19	80	Equipment	N	A

Table 2 General lighting schedule; external lighting

Area	Maintained average illuminance / lux	Maintained minimum illuminance / lux	Overall uniformity (not less than stated figure)	Threshold increment	Colour rendering (minimum), R_a	Environmental lighting class
CCTV:						
— monochrome	0	5	0.4	≥10%	≥60	—
— colour	—	15	0.4	≥10%	≥60	—
Roads	15	6	0.4		≥20	E1 and E2
	20	8	0.4		≥20	E3
	30	12	0.4		≥20	E4
General pedestrian areas	10	4	0.4		≥20	E1 and E2
	15	6	0.4		≥20	E3
	20	12	0.4		≥20	E4
Information and display signs	100 (vertical)					
Car park	15	6	0.4		≥20	E1 and E2
Vehicle drop-off points	10	5	0.4		≥20	E1 and E2
Steps or stairways	100	40	0.4		≥20	E1 and E2
General area lighting	20	12	0.4		≥20	
Hazardous open storage areas	50	20	0.4		≥20	

given as 500 lux in the standard. In addition, the Society of Light and Lighting decided to adopt the preferred illuminance steps as laid down by the Commission Internationale de l'Eclairage (CIE) and followed by the Comité Européen de Normalisation (CEN). These generally follow the pattern: 20, 30, 50, 75, 100, 150, 200, 300, 500, 750, 1000, 1500, 2000 etc. So a previously stated figure of 400 lux would either have to change to 300 lux or 500 lux. However, if 400 lux was considered the recommended task level it would be presumed that 300 lux was felt to be insufficient so in this instance the figure would rise to 500 lux. The figure could however be fixed at the lower level of 300 lux if it could be justified by experienced staff or engineers familiar with medical procedure or with specific local conditions.

It is worth noting that the CEN standardised figures cover only the immediate task area and recommend a lower but well balanced level for the surrounding area, so it is unlikely that the changes in lighting levels will have a significant effect on the overall energy efficiency of the installation. Indeed, with a responsible design approach the increase in task levels could be achieved in some areas by careful consideration to the luminaire positioning and spacing. Uniformities and the relationship between illuminance in areas immediately surrounding task areas are shown in Table 3.

Table 3 relationship in illuminance between the task and surrounding area

Task illuminance / lux	Illuminance in immediate surrounding area / lux
$\geqslant$750	500
500	300
300	200
$\leqslant$200	E_{task}
Uniformity $\geqslant$0.7	Uniformity $\geqslant$0.5

Part B: Specific recommendations

2 General

In the following, a summary of the recommendations is tabulated at the top of each paragraph, which includes specific recommendations for the maintained illuminance.

The first column of each table indicates the particular locations for which light has to be provided and the area over which the maintained illuminance should be averaged, together with a reference to the particular time of day, where appropriate. The second column gives the recommended maintained illuminance to be provided on the horizontal plane, unless stated otherwise. The third column gives any special notes, if applicable, or otherwise refers back to the general schedule of illuminance.

No specific guidance is given on escape route lighting, for which general guidance is given in section 8, but reference should be made to the general lighting schedule for the classification of standby lighting for each location.

Each tabulated summary should be considered in conjunction with the text which follows it.

3 Public areas

In public areas, the main emphasis should be on the lit appearance, i.e. the visual quality, rather than quantity, of illumination. The lighting appearance should be appropriate and convey a pleasant but comforting appreciation of the area with deliberate variations in contrast and intensity. These areas provide the opportunity for a wide variety of lighting techniques which will both address the need for functional light as well as decorative and effect lighting.

Plate 5 Good Hope Hospital, Sutton Coldfield (photo courtesy of Charlotte Wood Photography)

There is a requirement for an ‘art’ component to the building elements and appropriate lighting can be considered as satisfying part of that requirement in conjunction with architectural and interior design considerations. However, it should be noted that some narrow-beam display luminaires produce local heating which might cause personal discomfort or damage to fabrics if used incorrectly.

3.1 Entrances

The contrast in brightness between the approaches to a building and the entrance area requires careful consideration to avoid a sudden change of visual adaptation when entering or leaving the building. This occurs both under bright sunny conditions and during the hours of darkness. Where brightness contrast is excessive under daylighting conditions, the lighting of entrance thresholds and the shielding effect of entrance canopies can reduce the problem. Avoidance of highly reflective road and pathway surfaces will also help to minimise excessive brightness contrasts.

All illuminated signage used should be designed in accordance with the requirements of Institute of Lighting Engineers (ILE) Technical Report

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TR05[14]. It is essential that a dialogue is created and maintained between hospital officials, planning officers and the architect so that the best practice and consistency be achieved.

3.2 Entrance canopies

Location	Maintained illuminance (lux)	Notes
Road surface	50 (minimum)	The lighting should be comfortable but dramatic to stand out visually, and clearly express its purpose.

The lighting of an entrance canopy should draw attention to its location and the maintained illuminance should be adequate for the area immediately below. The canopy itself may be considered as a feature or particular landmark within the overall development and, as such, bespoke or special luminaires may be required as part the structure or to illuminate particular features of the canopy. The design should aim not only to provide horizontal task illumination but create good vertical illumination with a comfortable low glare quality to help with facial recognition and security. The luminaires should be located so as to avoid any potential damage to ambulance aerials.

The designer should also consider the implications of any security policy and the possible need for CCTV cameras.

3.3 Entrance halls, waiting areas and lift halls

Location	Maintained illuminance (lux)	Notes
Floor	200	The lighting while being functional should mirror the efficiency and drama created at the reception areas of major commercial buildings.

Main entrances normally form a major element of all hospitals. These areas therefore should be the subject of special design considerations requiring lighting techniques associated with other major public building entrances such as shopping malls. The architect, interior designer and lighting designer should co-ordinate their work in recognition of this and the impact that such areas have in creating first impressions.

Plate 6 Royal Berkshire Hospital (photo courtesy of Charlotte Wood Photography)

Whilst this approach may not be relevant in all healthcare projects, particularly in respect of scale, the creation of a functional and welcoming main entrance will still be a major consideration. The main entrance will still be the first point at which visitors will be looking for their initial wayfinding signage to direct them towards their destination or next point of reference. The lighting should be designed in conjunction with interior materials and finishes to clarify transit routes and points of arrival. A change of type, height or orientation of the luminaires can highlight the focal point of activity such as reception, waiting areas and lifts. This approach to design will also provide brightness variations which contribute to the pleasantness of the interior.

3.4 Lift cars

The lighting in passenger and bed-passenger lifts should form part of the lift manufacturer's specification and is usually procured as a packaged item. As part of the lift specification or schedule of requirements the lighting designer should include any special lighting needs that may be required for special lifts including the need to adequately illuminate internal signage and control panels.

Plate 7 Blackburn Hospital, Blackburn

The lighting design to the lift cars and the lift lobbies should consider the quality of light as seen from a recumbent patient. It should avoid the use of high intensity or luminaire positions that will provide discomforting glare to the patient. The need for emergency lighting is already incorporated into the relevant BS EN regulating the lift manufacturer.

3.5 Reception and enquiry desks

Location	Maintained illuminance (lux)	Notes
Reception (floor)	300	A measure of retail lighting philosophy should be employed to create a welcoming and impressionable ambience.
Enquiry desk (task area)	500	Comfortable accent lighting techniques should be employed to make the desk visually stand out from the general surroundings.

High illuminance should be used to emphasise the desk and staff positions against other features in the area. The overall impression should be a welcoming one that avoids harsh contrasts.

It is important also to ensure that consideration is given to the vertical as well as the horizontal illumination, so that peoples' faces within the reception areas are properly lit as this will provide good facial modelling and help with the process of lip reading. Local variations in illuminance may be used successfully to direct people towards particular locations within the hospital.

Plate 8 (left) Good Hope Hospital, Sutton Coldfield (photo courtesy of Charlotte Wood Photography)

Plate 9 (right) St Mary's Hospital, Isle of Wight (photo courtesy of Charlotte Wood Photography)

3.6 Hospital streets, general corridors and stairs

Location	Maintained illuminance (lux)	Notes
Hospital street (floor)	200 (day) 50 (night)	Uniform illumination levels should be provided to avoid bright and dark patches to walls and floors. The installation should also be capable of operating at a reduced level (50 lux with 0.5 uniformity) at night for comfort and energy efficiency.
Corridors (floor)	200 (day) 50 (night)	Uniform illumination levels using low glare luminaires, positioned to avoid alternating brightness patterns being viewed by trolley-borne patients. The installation should also be capable of operating at a reduced level (50 lux with 0.5 uniformity) at night for comfort and energy efficiency.
Stairs (landings and treads)	150	Consider access for maintenance and avoid wall luminaires that expose the lamps when ascending or descending the stairs.

Plate 10 St Joseph's Hospice (photo courtesy of Charlotte Wood Photography)

Contrast between the lighting of different wall surfaces, particularly at corridor intersections, can be beneficial. Internal routes to reception, waiting or circulation areas and to lifts or stairways should be clearly indicated, e.g. by creating differences in general levels of illuminance.

Direction signs should be illuminated by the general lighting or by localised lighting, so that they are clearly legible without being masked by reflections or glare from nearby luminaires or windows. All luminaires should use lamps with good colour rendering qualities to help identify directional colour routes.

Transversely mounted luminaires are not recommended for use in corridors or circulation areas. This is to reduce glare for all users of corridors and also to reduce the visual disturbance experienced by trolley-borne patients caused by alternating high and low brightness patterns. Transverse luminaires may also obstruct other services in the corridor.

Care is needed in the arrangement of switching, both to ensure satisfactory use and economy. A combined control regime utilising time and photoelectric control provides the means of accommodating the varying conditions that exist within corridors relating to the presence of daylight and their occasional use. Automatic dimming can take effect during daylight hours

and provide a reduced level at night for both staff who are moving to and from dark wards and for the patients to avoid being disturbed by the flow of bright lights from the corridor.

The use of wall mounted luminaires or lighting designs including natural light that form part of the vertical fabric illumination gives the opportunity of providing light to both ceilings and the wall surfaces themselves. This can help in providing a more even vertical illuminance and compliments corridors where significant areas of glazing are also utilised.

3.6.1 Hospital streets

Hospital streets form the major links between clinical areas or departments and they may include public waiting areas. They have a relatively high traffic density and could be in excess of 6 m wide which may include lift lobbies, stairs or entrances. An average floor illuminance of 200 lux is usually adequate. A higher illuminance may be required in those parts devoid of daylight to balance the areas in which daylight is more profuse.

Where the width-to-height ratio of the corridor exceeds 1.5:1, a single line of spaced luminaires may not be satisfactory. In these cases consideration should be given to the provision of additional luminaires, particularly where there are lift lobbies, stair-heads etc. The lighting should be arranged to give as even an illuminance as possible over the floor, with a reasonably well-balanced lighting and brightness pattern on the walls. There may also be a requirement to provide lighting for works of art and care should be taken to avoid introducing high levels of glare or uncomfortable viewing conditions for users of the facilities or for patients on trolleys. Street installations should be designed to provide a lower level of illumination at night by either selective switching or preferably by the use of dimmable luminaires. If selective switching is used then care should be taken to maintain a reasonable level of uniformity. This will provide the staff with a more comfortable level for moving to and from dark wards and will also avoid the patients being disturbed by the flow of bright lights from the corridor.

3.6.2 General corridors

The design of the lighting for general corridors should take into account their location, function and the amount of daylight available. The location of corridors is important because the brightness pattern should be balanced with the adjoining areas. The function served by corridors may vary between linking one or two offices and a continuously used hospital street. The use of daylight will reduce running costs as well as help with people's orientation, but it requires the balance of brightness patterns to be maintained. Corridor installations should be designed to provide a lower level of illumination at night by either selective switching or preferably by the use of dimmable luminaires. If selective switching is used then care should be taken to maintain a reasonable level of uniformity. This will provide the staff with a more comfortable level for moving to and from dark wards and will also avoid the patients being disturbed by the flow of bright lights from the corridor.

Plate 11 Bolton Hospital, Bolton

3.6.3 Stairs

In practice, the recommended illuminance is difficult to achieve on all stair treads. Wall mounted luminaires, positioned close to the top and bottom of the staircase, will provide a fairly even illuminance over the stair tread. The stair tread should be clearly defined and the vertical risers should be in partial shadow. The luminaires should preferably be of a low luminance type so as to avoid distraction from the main area of concern i.e. the stair treads themselves.

Plate 12 St Joseph's Hospice (photo courtesy of Charlotte Wood Photography)

It is becoming more normal to provide enhanced lighting levels in stairwells as well as at signage and notice points to assist those with a visual impairment. In these circumstances additional luminaires are usually required at these particular points. Consideration should be given to the physical access of luminaires on stairs to ensure that maintenance can be carried out with little hindrance to users of the stairways. It is important to note that without safe and easy access to lighting equipment and the windows, cleaning and maintenance will suffer. The lighting to stairways should also be designed in full accordance with the emergency lighting requirements of section 8.

3.7 Dining, cafeteria and breakout areas

Location	Maintained illuminance (lux)	Notes
Whole floor	50	Separately provided and switched will allow for a cleaning, security and maintenance level.
Tables	200	Accented for function and atmosphere and dimmable to cater for the social event and time of day.
Serving counter	300	Comfortable accent lighting techniques should be employed for safety reasons and to provide a focal point for users of the facility.

Conventional lighting techniques are suitable but designs should take into account the need for a change in atmosphere for social functions. For the diners this is meant to be a breakout area from the working environment. As such it

should reflect a semi-public amenity or food court atmosphere for larger dining rooms and a more relaxing or comfort promoting atmosphere for smaller areas. This provides the opportunity to be creative in the lighting design solution. Increasingly sophisticated vending machines and cash tills with large graphic screens are being used; special consideration may be needed to avoid unwanted veiling reflections on the screens. For security reasons emergency illumination levels should be increased around the cash tills area.

3.8 Changing rooms, cubicles, toilets, bath, wash and shower rooms

Location	Maintained illuminance (lux)	Notes
Floor	100–150	Luminaires to be suitably IP-rated where appropriate.

The lower level of illuminance is considered adequate for small enclosed cubicles. In the interest of cleanliness, these areas should be lit to minimise shadows and no areas should have to rely solely on reflected light.

Bathrooms and shower rooms are humid therefore special attention is required in the selection and the location of the luminaires. In changing areas, the luminaires should be sited between clothes racks or lockers to provide adequate light in the lockers. The positions of wall mounted mirrors and of the general lighting should be chosen to avoid troublesome reflections.

All bathrooms, in particular women's bathrooms, should be provided with mirrors and complementary lighting that has good facial illumination for the purpose of grooming and applying make-up. Many patients benefit from a sense of well-being following attention to their facial appearance, so grooming and make-up functions should be capable of being carried out effectively and easily.

3.9 Wards and general clinical areas

Location	Maintained illuminance (lux)	Notes
Clinical areas	See Table 1 for required level in specific area	Luminaires to use lamps with a colour rendering capability of RA80.
Examination or treatment (local task area only)	See Table 1 for required level in specific area	Luminaires to use lamps with a colour rendering capability of RA90. Usually provided by a dedicated examination lamp.

Clinical areas include ward units, consulting rooms, operating departments and other areas where the observation of the patients' skin colour or eyes may be critical. Ward units include bedded areas, ward corridors, nurses' stations (now called staff bases) and treatment rooms. All fluorescent lamps within these areas should be of the minimum clinical quality colour rendering, i.e. not less than RA80, and have a colour appearance of 4000 K.

In specialist areas such as those used for examination or treatment, a minimum quality of RA90 will be required. However, only the immediate task area will require illumination by RA90 lamps and this will usually be provided by dedicated fixed or mobile examination lamps.

It is essential that light sources with differing colour rendering or colour temperature characteristics are not used in the same area. If reading lights are intended to supplement the general illumination for the purposes of patient treatment, then their colour rendering performance must be at least RA90.

The lighting of ward units must satisfy the requirements of both the patients and the nursing staff during the day, evening and night periods. During the day, bedded areas will ideally be illuminated by daylight but corridors and service rooms may not. Therefore the illumination must be to a standard which

enables both staff and patients to move between naturally and electrically lit areas without any significant variations in brightness.

Clinical areas referred to in this section relate, in very general terms, to rooms or areas in which general nursing care or a minor clinical procedures are carried out.

The recommendations in this section apply to wards of any size or arrangement.

3.10 Bedded (ward) areas, general

Lighting levels within the ward areas should be high enough to allow the staff to care for the patients, but not too high that it disturbs the patients' rest or sleep.

There is an increasing trend to provide interactive computer facilities at the bed head. These can be used either by ward staff to access patient information and medical records, or by the patients as an entertainment centre. Such systems allow the patient access to television, radio, computer games, e-mail and administrative facilities at the bed position. For obvious reasons, most of the systems available are generally fixed around the bed head position with an articulated arm so that staff or patients can orientate the screen to a comfortable viewing position. This flexible viewing position alleviates the need to prescribe technical solutions to overcome problems of veiling reflections or poor viewing conditions. Simply re-orientating the screen will overcome most problems and, for this reason, this publication makes no mention of specific lighting requirements for these systems. However, if a bed head luminaire is to be used, the reading light, if integral to the luminaire, should be switched separately to the luminaire's upward component. It follows that the recommendation is for the bed head luminaire to have two separate lamps, one for reading and one for the upward room lighting component. In addition the use of bed head luminaires should meet the requirements of section 3.10.3.

3.10.1 Daylight in bedded areas

In bedded areas situated at the perimeter of the building the major lighting component during the day will be daylight. The window has the dual role of transmitting daylight and of providing the patients with a view of the outside environment.

Plate 13 St Joseph's Hospice (photo courtesy of Charlotte Wood Photography)

During the day, the illuminance from daylight will vary across the width and length of the ward, ranging from 50 lux on a dull day to 30 000 lux near or under the windows on a bright day. In wards that have windows on one side only, the daylight may fall rapidly across the width of the ward. The amount of daylight depends to some extent upon external obstructions, window size and its orientation, so consideration may need to be given to the electric lighting and its control.

Where bed-bays are open to corridors or separated from them by glazed partitions, the lighting design for the corridor should take into account the effect of daylight.

3.10.2 Electric light in bedded areas

Location	Maintained illuminance (lux)	Notes
General lighting	100	Luminaires to use lamps with a colour rendering capability of RA80.
Patient reading	300	To be controlled by the patient and to be provided over the patient activity/reading area (see section 3.11.3).
General nursing care	300	To be provided over the general bed area with a uniformity of $\geqslant 0.5$.
Night light	5	To be provided at the general ward area with a maximum of 0.5 lux over the pillow (see section 3.11.6).
Watch lighting	15–20	To be provided at the bed head pillow position (see also section 3.11.7).
Examination or treatment at bed position	1000	It is rare to require this level of lighting but, if required, a portable examination light must be used.

The general lighting must be adequate for the clinical care of patients. The lighting should be well diffused and free from distracting glare or harsh contrasts. For nursing care to be performed efficiently the task illuminance over the general area of the bed should be at least 300 lux with a uniformity level (minimum:average) of 0.5 or better. However, providing a continuous level of 300 lux over the bedded area using the general ward lighting will result in a very inefficient lighting solution in terms of energy. Therefore a combination of general and task lighting may be used to provide this supplementary level of illumination at the bed head. However, the general level of illuminance in the central space between the beds, and which is to be provided solely by the general lighting, should be not less than a minimum average of 100 lux at floor level. This level will be sufficient for the general activities of ambulant and recumbent patients without causing disturbance to other patients in the room who may be at rest. Reference should also be made to the advice given in section 3.10.3.

Plate 14 Norfolk and Norwich University Hospital, Norwich

3.10.3 Methods of lighting for bedded areas

The lighting of bedded areas has for many years presented lighting designers with a most difficult problem. The general lighting has always needed to provide sufficient light for nursing procedures while providing an amenable environment to aid the patients' recovery. However, medical and nursing practices are continually being updated, resulting in changes to the lighting requirements. The recommendations contained in this Lighting Guide seek to balance the needs of modern nursing care with those of the patients to produce a stimulating yet comfortable visual environment for all.

It is now a common, and often demanded, practice that the higher levels of illumination required to administer medical or general patient care by nursing staff be provided within the bed space to exclude the need for a separate portable luminaire. The lighting should also provide illumination in the centre of the ward to enable safe circulation and general cleaning procedures to be carried out. Most importantly, the lighting should aid in the provision of a pleasant and amenable ambience. Lighting to bed spaces should also be individually switched to encourage energy efficiency if the bed space is unoccupied.

Bedded areas with floor-to-ceiling heights of 2.7–3.0 m can pose particular problems for lighting designers, especially when privacy curtains are drawn around individual beds. With modern medical and nursing techniques there is an increase in the number of inspections/examinations taking place in the ward bed space which must be carried out with the bed curtains drawn.

These changes in clinical practice alter the philosophy of lighting the bed space and also change the requirements for bed head lighting as set down in the previous (1989) edition of this Lighting Guide.

An energy saving solution for providing a uniform illuminance over the bed space is to use compact fluorescent lamps in ceiling recessed luminaires. Luminaires should generally be positioned centrally over the bed area; these should be switched separately to provide the higher illuminance (300 lux) to allow medical staff to observe/inspect the patient. Glare from these luminaires should be controlled to restrict any direct view of the lamps from the patient being treated and patients in adjacent beds. Ceiling mounted luminaires in the centre of the ward will still be required. However, by using the above approach, they can sometimes be reduced in number.

Another solution that has been successfully adopted is to mount linear fluorescent luminaires, facing upwards, on a strengthened curtain track between beds to provide uplighting. The reflector should give a wide light distribution. The exception is where it is necessary to install an upward facing luminaire near to the end wall, in which case an asymmetric reflector (similar to that for wall mounted luminaires) is required to direct the light away from the wall. This approach needs to be considered carefully with the nursing/medical staff to ensure that patient safety is maintained. The health and safety risks could depend on the patient's medical condition, for example where apparatus is required for orthopaedic treatment. Curtain tracks intended to support linear fluorescent uplights should be strengthened and provided with additional support to ensure that any movement of the luminaire (i.e. 'bounce') is not apparent when the curtains are drawn. If this solution is to be considered, the technical requirements of section 3.11 should be met. Linear fluorescent uplights mounted on curtain track can present a cleaning problem. The top surfaces should avoid flat ledges on which dust could settle; they should also be easily cleaned and incorporate protection over the lamp such as laminated glass. This solution will not normally be appropriate where the distance between the curtain track and the ceiling is less than 1 m and/or where the floor-to-ceiling height is greater than 3 m.

A further solution for lighting multi-bedded areas and single-bed rooms is by means of wall mounted bed-head luminaires either integrated within the bed-head services trunking or independently fixed.

It is recommended that wall mounted indirect luminaires used to provide general or patient care lighting be mounted at a minimum of 1.8 m from finished floor level to the lamp centre. This is deemed the optimum mounting height in order to provide greater efficiency by virtue of its reduced task-to-source distance. Luminaires mounted at this optimum height will also aid the visual comfort of staff or ambulatory patients by avoiding the possibility of a direct view of the light source.

If the optimum height cannot be achieved the designer should ensure that any visual discomfort to patients and staff, especially that arising from views of the indirect source, is kept to a minimum. If the indirect component is to be mounted lower than 1.8 m then the luminance limiting value of 700 cd/m^2

(average) between the angles of 90° and 145° (as shown in Figure 1, section 3.10.5) should be achieved

Care should be taken to ensure that the lighting design solution does not compromise the mounting height of other services provided at the bed head, i.e. medical gases, electrical outlets, medical equipment rails, communication systems etc.

A source of concern with wall mounted luminaires in multi-bedded rooms is the control of glare with respect to patients in opposite beds (referred to as 'prone recumbent patients'). The sharp contrast between areas immediately around a wall mounted luminaire together with any bright edges of the luminaire in view can be a source of discomfort. One way of avoiding this is by demonstrating compliance using the measurement grid described in section 3.11.2. This has been developed to provide an acceptable contrast graduation which is intended to include the luminaire and its background, thereby providing patients with an attractive low glare environment. Indeed, it is a specific stipulation of this Lighting Guide, irrespective of which lighting design solution is chosen, that the designer provides this evidence. Designers should also aim to use modern lighting design software, now widely available, which can render images to 'photo-realistic' standards. This will help non-technical people associated with the project to visualise the final scheme.

To help patients move around safely at night and to allow nursing staff the facility of observing patient movement when the main lighting is switched off at night, it will be necessary to make provisions for a night lighting level of 5 lux average at a 0.85 m working plane with a maximum of 0.5 lux on the pillow; see section 3.11.6 for details.

Design solutions for multi-bedded areas may not necessarily cater satisfactorily for single bed areas therefore it is important that these areas are considered separately.

3.10.4 Centrally mounted ceiling luminaires

Suspended luminaires require a minimum ceiling height of at least 3.5 m. This will ensure adequate clearance for the use of mobile apparatus at the bedside once the luminaire is installed. The mounting height above the floor should not be less than 2.7 m nor greater than 3.5 m. Ideally, if the luminaire has an upward light component, the suspension length should be between 700 mm and 1000 mm to achieve a satisfactory spread of light across the ceiling.

3.10.4.1 Suspended luminaires

Traditionally, when higher ceilings were more common, many wards were lit with centrally mounted suspended luminaires. Ceiling heights in recent hospitals are more likely to be around 2.7 m, which tends to preclude the use of suspended luminaires. However, where circumstances permit, this is still a desirable option.

3.10.4.2 Surface mounted luminaires

Ideally surface mounted luminaires should only be installed if the floor-to-ceiling height is 2.7 m or less. It is usually convenient to mount single-lamp luminaires to coincide with the bed spaces. Single-lamp luminaires with fluorescent lamps may be expected to give the recommended illuminance. Twin-lamp luminaires may also be used, usually spaced at one and a half times the bed spacing; however the illuminance in the circulation space could be less uniform and somewhat higher than the recommended value when using this method. Whatever spacing is eventually used the technical requirements of section 3.11 relating to illumination levels when the privacy curtains are pulled around the bed should still be achieved. In areas with ceiling heights between 2.4 m and 2.7 m, it is possible to provide the recommended illuminance at the bed head only by using surface mounted luminaires.

For dual systems, in which supplementary lighting along the side walls of the bedded area is used, surface mounted luminaires may still be suitable.

3.10.4.3 Recessed and semi-recessed luminaires

Recessed and semi-recessed luminaires may be used in ceilings between 2.4 m and 3 m high. Luminaire spacing should generally be as described for surface mounted luminaires.

Recessed luminaires that are constructed in such a manner as to provide an upward component are still considered as recessed luminaires and not uplighters. With recessed luminaires it is possible to satisfy the requirements for both general clinical functions and patient comfort. However, the number of luminaires may need to be increased but this should help alleviate the need for supplementary wall mounted luminaires.

3.10.5 Wall mounted luminaires

It is quite a common practice for designers to illuminate wards using wall mounted luminaires that provide upward and downward components. Indeed this method has numerous advantages. The downward component allows patients to do visually demanding tasks like reading or jigsaw puzzles. The upward component provides glare-free, soft illumination to the room allowing the patients to relax. When combined, the upward and downward components can provide the higher level of illumination required for examination or nursing care. For this reason and those given in section 3.10.3, the indirect component of wall mounted luminaires should be installed at the optimum height of 1.8 m to the lamp centre. Care should also be taken when selecting the mounting height for reading lights for, unless the luminaire employs a degree of articulation or has been designed specifically, there could be a danger of the patient being in his/her own shadow. The lighting component for any wall mounted luminaire installed below 1.8 m will need careful light control to avoid any unnecessary glare to patients and staff.

In order to achieve the visual comfort and performance levels required wall mounted luminaire's should aim to achieve a light distribution similar to the light flux distribution ratios shown in Figure 1. In practice it will be essential that the performance and glare control requirements for all wall mounted luminaires be fully met and demonstrated.

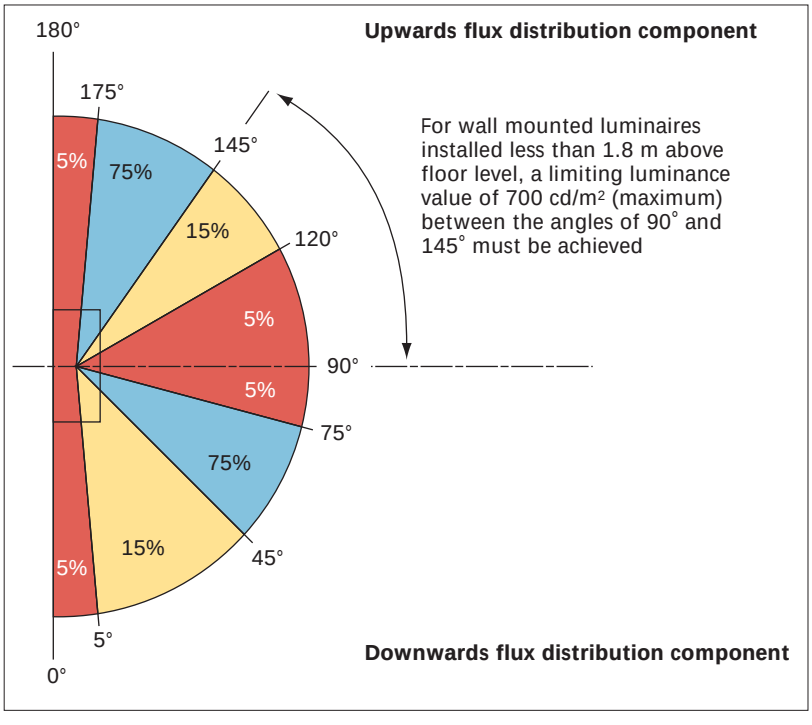


Figure 1 Typical flux distribution for the direct and indirect components of a wall mounted luminaire

3.11 Ward lighting: technical requirements

It is a specific stipulation of this Lighting Guide (irrespective of which lighting design solution is chosen), that the designer provides as a minimum either calculated or measurable evidence of compliance with the technical requirements of this section. Measurable evidence should be either in the form of a mock-up area (realistic to the specific project), or within a similar project (again

realistic to the specific project). It should be the responsibility of the designer to secure all the instrumentation necessary to evaluate the duplicated area which should include, as a minimum, fully calibrated luminance and illuminance meters.

Irrespective of which lighting solution is chosen, the quality and comfort of the lit space when viewed by the recumbent patient will be greatly dependant on controlling the direct glare from the luminaires and the luminance balance it produces on the room's surface. For this reason two calculations need to be undertaken. The first is to evaluate the average luminance of the luminaire against its background, while the second evaluates the maximum luminance produced on the room's surfaces by the luminaires. Both calculations may be easily undertaken using most of the lighting calculation software programmes currently available.

In addition to the luminance values being met, one other criteria must also be demonstrated, namely the illumination values on the bed with the privacy curtains closed, compared to the illumination values when the privacy curtains are open.

It is common practice that when patients are being attended to by nursing or medical staff, they will have curtains pulled around the bed in order to provide an element of privacy. The lighting design must demonstrate that when the bed curtains are pulled around, the average illuminance within the curtained area for both the general level and the nursing care level must not be reduced by more than 25% when compared to the unscreened bedded area; i.e. the minimum recorded average illuminance must not be less than an average of 75 lux for the general lighting level and not less than an average of 225 lux for the nursing care level. The calculation should also prove that the minimum acceptable illumination level of 75 lux (average) for the general ward lighting is maintained outside the bedded area when all the bed curtains within the ward are drawn around simultaneously.

3.11.1 Assessment of average and maximum luminance

Lighting should not cause undue glare to recumbent or ambulatory patients. Ceiling or rail mounted luminaires should be assessed for their average luminance value at elevation angles between and including angles *a* and *b*, as defined in Figures 2 and 3 below; surface fixed luminaires should not exceed 1500 cd/m^2 for all angles of azimuth. For all ceiling recessed or semi-recessed luminaires the value shall be reduced to 1000 cd/m^2. Wall mounted luminaires should not exceed 700 cd/m^2 average for all angles of azimuth between and including angles *a* and *b*, as defined in Figure 4 below, where:

— h_1 is the minimum height of the mattress surface plus 200 mm
— h_2 is the maximum height of the mattress surface plus 600 mm
— h_3 is the height above floor level to the centre of the luminaire
— d_1 is the distance from the wall to the front edge of the pillow
— d_2 is the distance from the wall to front face of bed head
— d_3 is the distance from the wall side to the luminaire centre

The average luminance of 1500 cd/m^2 (1000 cd/m^2 for recessed or semi-recessed luminaires) is defined as the intensity measured at each 5° angle between and including angles *a* and *b*, divided by the sum of all the orthogonally projected luminous areas at each of the elevation angles; this average applies at all angles of azimuth. The value of 700 cd/m^2 average for wall luminaires should not be exceeded anywhere between and including angles *a* and *b* for all angles of azimuth. The designer should use the measurement values relating to the actual or specific areas in question. However, in the absence of specific dimensional data for h_1, h_2, h_3, d_1, d_2 and d_3, the following values should be used:

— h_1 = 850 mm
— h_2 = 1450 mm

Figure 2 Elevation angles for ceiling mounted luminaires

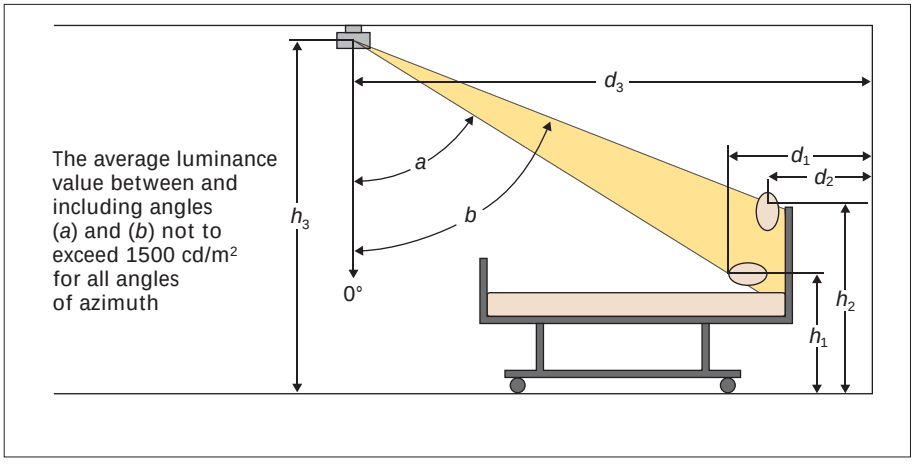


Figure 3 Elevation angles for bed head rail mounted luminaires

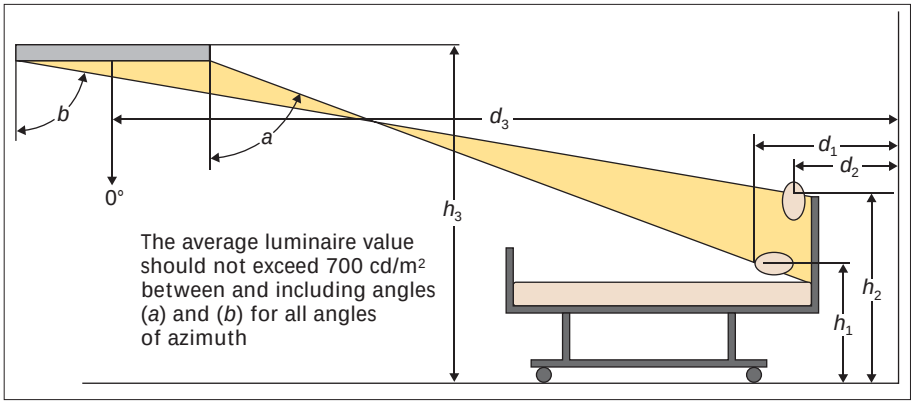
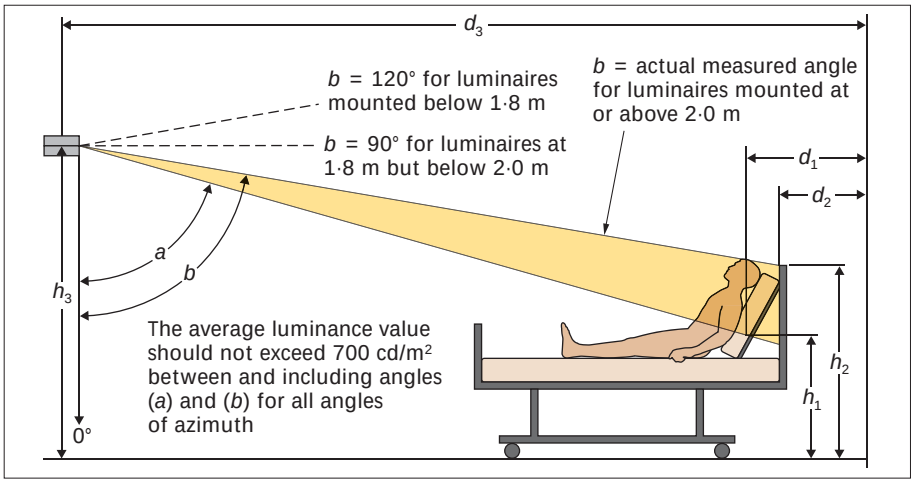


Figure 4 Elevation angles for wall mounted luminaires



— h_3 = 2.7 m (ceiling mounted), 2.0 m (rail mounted), 1.8 m (wall mounted)
— d_1 = 900 mm
— d_2 = 450 mm
— d_3 = 4.0 m (ceiling mounted), 5.0 m (rail mounted), 8.0 m (wall mounted)

Note: for wall mounted luminaires fixed at a height ⩾2.0 m, angle *b* shall be the actual measured value; at mounting heights ⩾1.8 m but < 2.0 m from finished floor level, angle *b* shall always be 90°; for mounting heights < 1.8 m, angle *b* shall always be 120° degrees from the downward vertical. The average luminance value must not exceed 700 cd/m^2 at any angle of azimuth between and including the angles of assessment detailed in Figure 4 above. See Figure 1 (section 3.10.5) for further details.

3.11.2 Ward areas: maximum (room) surface luminance assessment

Luminaires must not cause excessive luminance spots (bright patches), to the room surfaces when viewed by the patients. In addition the average luminance of all the room's major reflecting surfaces should not exceed 600 cd/m^2 and that the maximum measured spot level should not exceed 1500 cd/m^2, retaining a ratio between maximum and average of less than 3:1. In addition, there should be no sudden change in the values of luminance on any of the major reflecting surfaces, i.e. they should change gradually.

The maximum spot luminance value of any surface directly illuminated by the luminaire must not exceed 1500 cd/m^2. To demonstrate this, the lighting design must include an initial set of luminance calculations for the ceiling and walls based on at a grid spacing not exceeding 1 m. The results should then be used to determine the point at which the maximum luminance occurs on both the ceiling and the walls. A further calculation of luminance must then be undertaken using a fine grid, centred at the maximum point of the 1 m grid. The new calculation grid should be extended to 2 m $\times$ 2 m with grid spacing of 0.2 m. At no point within the calculation area should the maximum luminance value exceed 1500 cd/m^2.

If the actual room's surface reflectance factors are not known, the following reflectance factors should be used and a recalculation made once the actual values are known:

— ceiling: 0.7
— walls: 0.5
— floors: 0.2

3.11.3 Reading lights (general)

The patient's reading light is required to give a minimum of 300 lux on and around the pillow area. As most people will rest with their head or back against the pillows the actual task area requiring illumination will be further down the bed, probably around the region of the patient's torso. For this reason, and to allow for the various positions adopted by the patient at rest, the 300 lux value should be an average value measurable over a horizontal area of 1 m $\times$ 1 m (i.e. 1.0 m^2) centred at the bed head and directed towards the bottom of the bed at a working height of 1.0 m above floor level (see Figure 5). It is a common practice within hospital wards that during periods of rest the indirect or room lighting component will be switched off to aid sleep; any patient wishing to read during these periods will make use of their personal reading light. It is therefore imperative that the designer ensures that any luminaire intended to be used as a patient reading light fully meets the performance requirements of this section independently of any indirect or room lighting component. Any calculation or demonstration should also show that it has taken into account the possible shielding effect of the bed head or the patient's head and shoulders. The reading

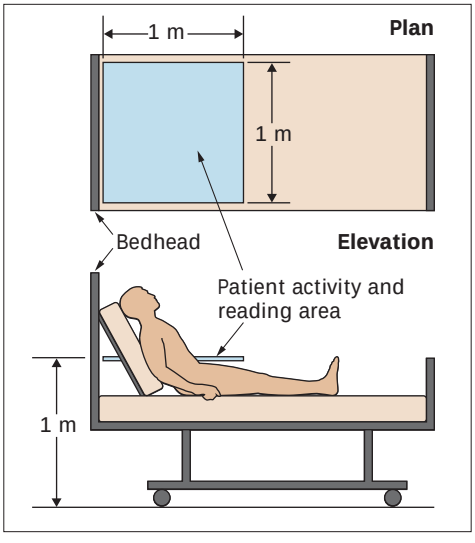


Figure 5 Patient's activity/reading area (indicated by blue shading)

light switch should be conveniently positioned within reach of the patient; it is usually provided as part of the patient's nurse call/entertainment system handset. Suitable reading lights, especially if they are articulated, may also be used for general nursing activities at the bed positions. If treatment requiring an illuminance exceeding 300 lux is given at the bedside then a mobile examination luminaire must be provided.

If the reading light is adjustable to suit the patient's position in bed, its range of movement should be limited to avoid causing glare to others.

Reading lights are usually provided to all hospital beds, but it may be undesirable to have them within easy reach of children and mentally ill patients. In such circumstances, high-level wall or ceiling mounted luminaires should be used and the switches placed out of the patient's reach or supplemented by key switch control. All reading lights, regardless of type, should be cool to the touch and easy to clean, reading lights should also be constructed with smooth 'wipe clean' surfaces.

3.11.4 Wall mounted reading lights (fixed and adjustable)

Reading lights that are task specific, i.e. of the articulate arm type, may be mounted at a height less than 1.8 m. Common practice is that reading lights are also used for supplementary local illumination by nursing staff for clinical assessment and general medical procedures. Therefore the required illuminance should be 300 lux on a theoretical horizontal pillow position. Occasionally patients may rest in a chair adjacent to their bed, articulated reading lights can have an advantage in providing direct illumination at these positions. However, any reading light so employed should aim to provide a reasonable level of illumination adjacent to the bed sides specifically for this purpose.

As stated previously, wall mounted fixed or trunking integral luminaires intended to be used as patient reading luminaires should be installed in a manner that minimises the shielding effect of the patient's body; the designer must ensure that the performance requirements of section 3.11.3 are fully achieved independently of any room lighting component. Any calculation or demonstration should also take into account the possible shielding effect of the bed head or the patient's head and shoulders.

There is an increasing usage of electric beds in ward areas which offer a greater range of movement and patient-specific adaptation. These beds are fundamentally different from the traditional 'Kings Fund' bed design and the choice of reading lights should take this in to consideration.

3.11.5 Ceiling mounted reading lights (fixed)

In some situations, ceiling mounted reading lights are required to provide a higher degree of safety and to leave the space above the bed head unobstructed. This is particularly appropriate in wards for children and mentally ill patients. It is also a solution that provides a great deal of flexibility.

Two luminaires, or a luminaire with twin lamp heads, when installed over the bed area can either be switched individually to cater for the reading requirements or switched on together for clinical examination. In both instances local switching would be required.

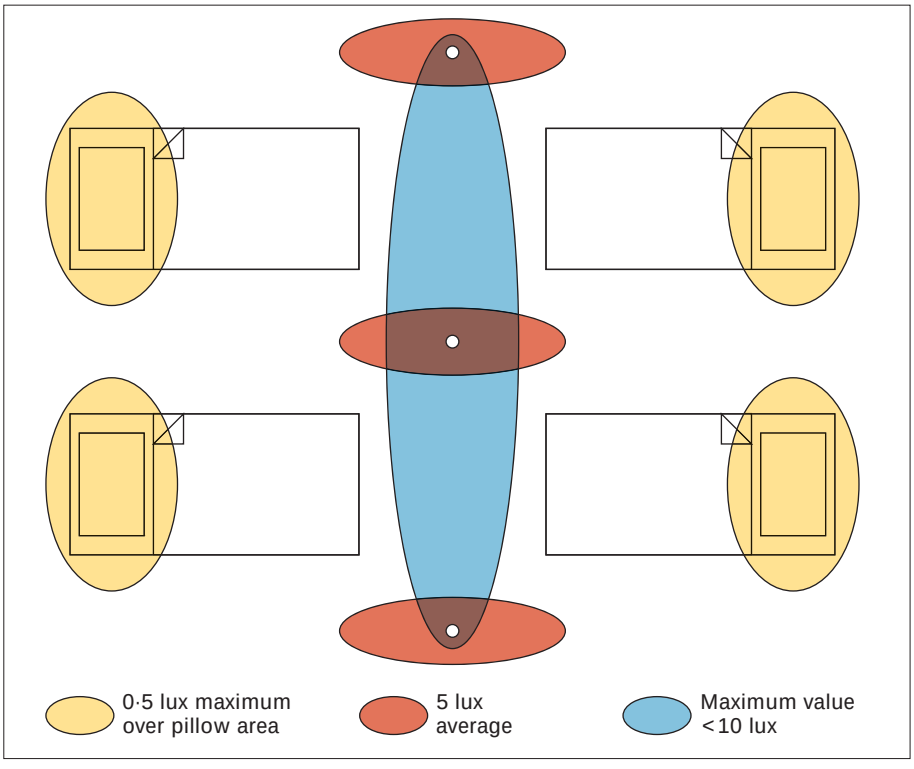
The angle of view for patients in the adjacent and opposite beds should be considered and a suitable luminaire selected having a cut-off that prevents a direct view of the lamp or its mirror image in the reflector. Any louvre or internal surface visible within these angles should not exceed an average luminance of 700 cd/m^2. As an approximate guide, the spread of light should extend only as far as the mid-point between bed spaces. Luminaires of this type must be sited with care or be equipped with a suitable louvre system that ensures supine patients do not suffer visual disturbance as a result of looking into the reflector.

3.11.6 Night lighting

Night lighting needs to achieve two things; first to provide enough light for the safe movement around the general ward area and, secondly, to allow the nursing staff the ability to discern facial features and a patient's general condition. A

patient in discomfort will generally convey this through facial or arm gestures. It is important therefore that the lighting level is sufficient to allow nursing staff on nightly rounds to see the patient's face but not high enough to destroy a good sleeping environment. The illuminance for the central ward circulation space should therefore be no more than 5 lux average at 0.85 m working plane. In addition the maximum permissible level measured anywhere on the pillow should be 0.5 lux. To help with visual acuity the maximum level measured anywhere in the ward should not exceed 10 lux at a working plane of 0.85 m. At this level, visual acuity is very low but it is still possible to discern the movement of patients. The general requirements for night lighting are diagrammatically shown in Figure 6.

Figure 6 Night lighting requirements



In the provision of night lighting the designer should also be aware that current medical opinion believes that slightly or partially illuminated ceilings can cause nightmares or phantasmagoria in certain patients. Therefore it is not advisable to provide night lighting by any indirect means.

To avoid disturbing glare, the luminance of any luminaire left on during the night within the ward area should not exceed 30 cd/m^2 above and including a luminance limiting angle of 35° from the luminaire's downward vertical at all angles of azimuth. This level must not be exceeded particularly for any part of the luminaire that can be viewed by a patient from his/her bed. In addition, any luminaire positioned at the bed head or within the bedded area described by the screening curtains should not exceed 30 cd/m^2 above and including a luminance limiting angle of 20° from the luminaire's downward vertical at all angles of azimuth. This level must not be exceeded, particularly for any part of the luminaire that is in direct view of the recumbent patient.

The main problem when considering night lighting will be the brightness of the lamp(s) or luminaire(s). The use of a single source to illuminate the whole room will not achieve the performance criteria and should be avoided; the use of multi-lamp or localised sources should be considered. Low output devices such as light-emitting diodes (LEDs) would better suit the application rather than dimmed or low wattage fluorescent lamps.

Night lighting needs to be considered as part of the whole design and not as an afterthought or a totally separate provision.

Moving shadows cast by car headlamps, trees or from nearby road lighting can be particularly disturbing to patients. It is recommended therefore that blinds or curtains be drawn over the windows at night where external sources may cause such effects.

3.11.7 Bed head observation lighting (watch lighting)

As the name suggests, bed head observation lighting or watch lighting is a prescribed lighting level that must be maintained at and around the bed head position. It allows the staff to continuously monitor and observe a patient's progress during crucial periods such as post-operative care or during critical illness. Bed head or observational lighting is not required in all bedded areas but only in designated wards such as high dependency or critical care wards. The lighting level should be provided at all times, especially during the night or when the general lighting has been switched off to aid rest or sleep. It should therefore be separately switched and controlled from the general lighting. It should be designed to avoid producing any direct visual disturbance to the patient or patients in adjoining beds. It should also avoid producing disability glare for staff that may have to monitor and operate screen-based diagnostic equipment. It is therefore unlikely that the general use of a patient's reading light, which has not been designed for this purpose, will be successful. An illuminance of 15–20 lux at the bed head position is considered adequate for observational tasks, provided the supplementary night lighting is of the recommended level.

If compact source fluorescent lamps are used in bed head or recessed luminaires, observation lighting may be provided by various means, e.g. selective switching in a multi-lamp luminaire, dimming or by a dedicated low wattage lamp. Suitably housed and positioned low output devices, such as LEDs would also be a suitable choice in the provision of observation lighting.

If closed circuit television (CCTV) is to be employed for night observation then consultation with the CCTV specialist is imperative to ensure that the visual performance requirements are met.

3.12 Examination lighting

Wall or ceiling mounted examination lamps are usually limited to examination rooms/bays or consulting rooms and are not provided in medical or surgical wards. In general it has not been practical to combine the functions of an examination light and reading light in one luminaire; however future developments may provide this opportunity.

Plate 15 Doncaster Royal Infirmary, Doncaster

3.13 Deep plan wards

The term 'deep plan' usually refers to wards in which the bedded areas are on the periphery and service rooms, corridors and possibly the nurses station are sited deeper within the building. The constant movement by staff from the central core area to periphery areas with a higher level of daylight could cause problems with visual adaptation. Problems such as adaptation must be considered when designing the electric lighting.

Experiments have shown that it is possible to view a patient in bed under night lighting conditions having just left an internal room lit to a level between

150 and 200 lux. However, care must be taken where the access doors to core rooms are opposite or near bedded areas as spill light and the brightness of the luminaires in the core rooms could cause discomfort to the patients.

A simple method of controlling this light is by the utilisation of locally controlled dimming facilities in general circulation areas. Sufficient light will be provided to enable simple tasks to be performed, such as storage or retrieval of items from cupboards. Where this is insufficient to perform specific tasks, such as drug dispensing or reading labels, local task lighting must be employed.

3.14 Specialised wards

There are a number of types of specialised wards in which the nursing procedures may require modifications or additions to the standard ward lighting as described in sections 3.10.1 to 3.11.7. In general, the recommended illuminances for bedded areas given in the table in section 3.10.2 are applicable but the following additional requirements should be noted.

3.14.1 Adult acute wards

These wards usually only require lighting in the manner described in section 3.10.2.

Plate 16 Royal Berkshire Hospital, Reading

3.14.2 Units for elderly patients

Many elderly patients have poor eyesight and have particular difficulty in focusing and judging distances. Whilst no increase in the recommended illuminances given in section 3.10.2 is necessary in the bedded area, the lighting may be increased in the corridors to define routes and changes in level. This should also be co-ordinated with colour schemes that fulfil the same purpose. High contrast or dramatic lighting can cause harsh shadowing and should be avoided within these areas as this can produce fear, paranoia or confusion in certain vulnerable patients. It can also influence a patient's ability to rest or sleep by creating problems of phantasmagoria. It should also be remembered that elderly people will probably need to visit the toilet during the night and that the electric lighting in corridors and toilets should allow for this likelihood.

3.14.3 Mental illness units

Location	Maintained illuminance (lux)	Notes
Bedrooms	50 to 100	Use switching or dimming to achieve the lighting levels required to suit the various tasks. Decorative (but robust) luminaires should be used to create a domestic atmosphere.
Special/secure rooms	100 to 150	Use vandal resistant luminaires switched from outside the room
Circulation (night)	5	Avoid the use of a few high brightness luminaires, aim for a minimum uniformity of 0.2 using low output or dimmed luminaires.

Generally, the areas in a mental illness ward can be classified into three groups and the luminaires chosen accordingly. In all cases it is advisable to seek information from the clinical team to ensure a full understanding of the risk assessment before specifying luminaires of a particular design. Particular attention should also be paid to the positioning of the selected luminaires. Luminaires should not be positioned directly above a patient's bed or above a treatment couch or table. The selection and installation of luminaires should also be planned to avoid ligature points (i.e. possible anchor points for improvised ligatures that could be employed by patients seeking to harm themselves by hanging). Also some toilet areas or toilet cubicles may be required to be lit by 'blue' lighting; this is achieved by using either a special fluorescent lamp or lamp filter. This type of lighting is usually installed when patients are likely to inject themselves with drugs without medical supervision. The use of this blue light makes it very difficult for the patient to identify the appropriate vein. The blue light should be produced at a particular wavelength if it is to be effective, so specialist advice should be sought from either the lamp or filter manufacturer if this provision is required.

The three areas of consideration within these special wards are:

(*a*) Bedrooms: decorative luminaires may be considered more appropriate to help create a domestic atmosphere.

(*b*) Special or secure rooms: vandal-resistant luminaires should be used and these should be ceiling mounted and switched from outside the room.

(*c*) Areas other than bedded areas such as circulation or activity spaces: general purpose linear and compact fluorescent luminaires are suitable for these areas of mental illness units. The night time lighting in the circulation space should not be greater than 5 lux.

3.14.4 Intensive care wards for the mentally ill

Location	Maintained illuminance (lux)	Notes
Care wards/units	300	Create a reassuring and low glare atmosphere by lighting techniques rather than by luminaire aesthetics. Ensure the suitability of the luminaire to the environment.
Bed head (night/watch)	5–20	Use the recommendations given in sections 3.11.6 and 3.11.7.

These units are intended to contain patients having disturbed behavioural patterns. The lighting should provide a reassuring effect and the luminaires should be suitable for an environment with potentially dangerous patients. The designer should aim to provide a lit environment that has some variation in light and shade with a soft transition between the two. Specifying luminaires with no ligature points has to be a serious consideration when evaluating their suitability. The reassuring effect should not be achieved by the use of domestic type luminaires. Luminaires should be selected so as to be safe for the patients but certain industrial types, e.g. bulkhead fittings etc., are not considered suitable and should be avoided. The design and construction of the luminaires should be such that metal or plastic parts cannot be easily broken off or removed and used as weapons or tools. The luminaires should not contain any glass components other than the lamps.

Some light is required at all times within patient areas for staff security. This can be achieved by the use of sustained emergency luminaires which prevent lamp outage in the event of a failure to the normal mains lighting. Standby supplies should provide lighting to Grade B standard, see section 1.2.6.

Some of the luminaires in areas such as corridors, bathrooms and toilets need to remain switched on at all times, except for maintenance. Such luminaires should be controlled by a key or concealed switch to ensure that they cannot be switched off by the patients.

Control of the lighting for the whole unit, including external lighting, must be provided for staff use. Patients may be permitted to use switches controlling some of the bathroom/toilet luminaires and their own bedroom lighting. However, a master overriding switch control should be provided in a lockable compartment outside the bathroom/toilet or bedroom. Alternatively, the central control system should be located in the 'staff only' section of the unit.

3.14.5 Children's bedded areas

Location	Maintained illuminance (lux)	Notes
Bed head (night)	5	Local switching (auto/manual)
Bed head	30–50	General ward lighting techniques to be used see sections 3.10.1 to 3.11.7.

Lighting to children's wards and communal areas should take the designer beyond the usual provision of task requirements. Children within these areas will probably feel vulnerable and frightened by the experience, so the designer should try and model the area to be interesting and therapeutic. Vibrant colours will almost certainly be used throughout so the lighting designer should be careful when selecting the light sources so that they do not inadvertently destroy the ambiance the interior designer is trying to create. Working together with the interior designer will pay dividends towards the creation of an interesting, happy and colourful final solution.

In addition, it is imperative that the lighting designer understands that young children, especially newborn or premature babies, are particularly susceptible to bright light, which can not only cause stress within the child but can also cause retinal damage. They do, however, still require a recognisable pattern of night and day to help them develop diurnal rhythms and normal sleep patterns[16,17]. Observation windows may be situated above the beds or cots of very small children for this reason and, to avoid damage to the lamp or patient, ceiling mounted reading lights are recommended within these areas.

3.14.6 Orthopaedic bedded areas

Although it is unlikely that any different or additional lighting would be required, the design of the lighting equipment will have to take account of the considerable amount of apparatus that may be present around and above some beds. The choice and installation of luminaires should be co-ordinated with this apparatus at the design stage.

3.14.7 Intensive therapy, high dependency and coronary units

Location	Maintained illuminance (lux)	Notes
Bed head observation	10 to 20	Use the recommendations given in sections 3.11.6 and 3.11.7
Bed head	30 to 50	General ward lighting techniques to be used (see sections 3.10.1 to 3.11.7); greater attention should be given to co-ordination due to the intensity of equipment used.
Bed, clinical	400	General lighting to be supplemented by either additional luminaires or by switchable means to achieve the observation level.
Bed, examination	1000	Mobile or local examination luminaires to be used.

The lighting should endeavour to satisfy the conflicting requirements of minimising the disturbance to patients while providing sufficiently high illuminance for close observation and treatment by the staff. Luminaires should be closely co-ordinated with the intensity of equipment typically provided in these areas.

The general lighting at the bed heads should conform to the recommendations given in sections 3.10.1 to 3.11.7 and supplemented to provide the recommended illuminance of 400 lux. These luminaires should be individually controlled.

Bed head observation lighting or watch lighting is required for the observation of a patient usually after the general lighting has been switched off. It should be designed to avoid producing any direct visual disturbance to the patient or patients in adjoining beds. It should also avoid producing disability glare for staff that may have to monitor and operate screen based diagnostic equipment. It is therefore unlikely that the general use of a patient's reading light which has not been designed for this purpose will be successful. An illuminance of 15–20 lux at the bed head position is considered adequate for observational tasks, provided the supplementary night lighting is of the recommended level. Recommendations for the provision of watch or bed head observation light can be found in section 3.11.7.

Night lighting should comply with the recommendations given in section 3.11.6. Patient reading luminaires will not be required.

Although nursing procedures and the monitoring regime in a high dependency unit (HDU) or coronary care unit (CCU) are not as rigorous as in an intensive therapy unit and the lighting requirements will be totally satisfied by adopting similar solutions to those used in HDUs and CCUs. To aid the observation process the nurses' station/staff base lighting should conform to the recommendations given in section 3.14.8.

3.14.8 Nurse stations (staff bases)

Location	Maintained illuminance (lux)	Notes
Desk (day and evening)	300	Low glare luminaires suitable for use with visual display terminals should be used to provide operator comfort and avoid any visual distraction to patients.
Night-time	30–200	This can be provided by selected switching or dimming of the main luminaires, or by the use of a suitable desk luminaire.

Nurses' stations, or staff bases as they are more commonly known, are usually located where staff can oversee the bedded areas; only rarely do they receive daylight. In addition, these work stations nearly always have display terminals in regular use by hospital staff, any luminaire selected for use within this, and the immediate surrounding area, should be designed in accordance with the requirements for visual display terminal (VDT) areas and the Display Screen Equipment Regulations[18].

On the desk, the maintained illuminance should be 300 lux during the day, morning and evening, and controllable to between 30 and 200 lux at night, the higher value being recommended for any exacting visual tasks, such as dispensing medicines. The provision of dimming to control the night levels will allow the staff to individually adjust the amount of light to suit the particular night time tasks. In addition very well shielded lighting close to the floor should be provided to the front of the base station for night-time use when the normal lighting has been switched off. This will allow the leading edge of the base station to be seen by patients and staff moving around during the night. All light

Plate 17 King's College Hospital, London

sources should be shielded to prevent any distraction or glare to patients trying to sleep. At night, the luminance of any part of the station visible to recumbent patients should not exceed 150 cd/m^2. Local lighting which illuminates the nurse at the station can be reassuring to patients but care should be taken to ensure that no distorted shadows are caused.

3.15 Ward corridors

The principles of lighting should be as in section 3.6. Alternatively, luminaires to the same specification as those for the bedded areas may be used see section 3.10.2.

Special requirements for night-time lighting are given in section 3.11.6. The locations of the luminaires should be chosen to avoid objectionable glare to recumbent patients through glazed partitions or open doors.

3.15.1 Ward corridors screened from bed-bays

Location	Maintained illuminance (lux)	Notes
Floor level illumination (day)	200	Uniform illumination levels should be achieved using low glare luminaires; see section 3.6.2.
Night-time	5–10	Achievable by selected switching of low wattage luminaires or by the dimming of the main corridor luminaires.

During the day, the combination of natural and electric light should maintain at least 200 lux in the corridor area. At night, the floor illuminance should be similar to that in the circulation area, i.e. 3 to 5 lux. The luminance of the luminaires should comply with the limitations given in sections 3.11.1 and 3.11.2.

3.15.2 Ward corridors partly open to bed-bays

Location	Maintained illuminance (lux)	Notes
Floor level (day)	200	Uniform illumination levels using low glare luminaires; see also section 3.6.2.
Wall illumination (early morning and evening)	150	Special attention should be given to illuminating the walls so as not to make the ward feel isolated.
Night-time	5–10	The locations of the luminaires should be carefully chosen to avoid glare and high illumination levels in adjacent patient areas.

During the day maintained illuminance should be not less than 200 lux at floor level. During the evening and early morning periods the appearance of the corridor wall as seen from the bed position is of some importance and should be bright enough to give the impression that the ward is not isolated, the recommended wall illumination level is between 100 and 150 lux. During the night 5 to 10 lux at floor level is satisfactory.

3.15.3 Dayrooms, play areas, ward dining areas and staff rooms

Location	Maintained illuminance (lux)	Notes
Working plane	200	The lighting method together with the luminaire type should be selected to produce a comfortable but non-clinical feel to the areas.

Plate 18 Sir Michael Sobell Hospice, Oxford (photo courtesy of Charlotte Wood Photography)

The principal aim within these areas is to provide a non clinical appearance, particularly in small rooms and areas used by long-stay patients. The co-ordination of interior design and lighting can create areas suitable for relaxation. A combination of direct and indirect lighting techniques can be used to achieve variety. The lighting should be well-diffused and free from distracting glare or harsh contrasts.

Some day spaces are part of bedded areas and the introduction of domestic lighting will contrast with the functional lighting in the rest of the area. This contrast should be designed with care to co-ordinate with the furnishings and to provide a pleasing overall atmosphere. Decorative luminaires can be used, provided their design and construction allow for easy maintenance and cleaning. If possible the electric lighting should be combined with the architectural design so an integrated solution can be found. For more information on dining rooms, see section 3.7.

4 Clinical areas and operating departments (general)

The following sections provide recommendations for the design and installation of electric lighting for general and specific purposes and for the choice of surface finishes and colours in operating theatres and ancillary areas. Clinical areas defined within this section refer to areas or rooms in which surgical, clinical or medical procedures are carried out, usually by a surgeon or doctor. Clinical areas referred to in section 3 relate, in very general terms, to rooms or areas in which general nursing care or minor clinical procedures are carried out.

The chief requirement of luminaires is that they provide sufficient light for the critical examination of patients, for operative procedures and for the use of life support apparatus. It is essential that the general lighting should have clinical colour rendering characteristics i.e. CRI $\geqslant$ 90 and should provide an even distribution of illuminance throughout the department.

Surface colours and finishes must not distort the colour rendering of the light sources. The use of strong colours for wall surfaces, particularly strong blues and greens and any dark colours, should be avoided because they may affect the appearance of patients' skin and tissue due to coloration of the reflected light.

Ceilings and walls should have a semi-gloss or eggshell finish. The walls should not produce reflections of the luminaires, especially where they might occur at the eye-height of theatre staff.

The ceiling reflectance should be 0.7 to 0.9, which can be achieved by the use of off-white or a pale shade, other than blue or green. This will assist in controlling the luminance contrast between the ceiling and the general lighting luminaires. The walls should have a tinted finish, rather than white, with a reflectance of 0.5 to 0.8. The floor should have a light-tone finish with a reflectance of at least 0.3 to maintain an adequate inter-reflected light component, especially within the actual operating theatre.

Plate 19 General surgery at a London teaching hospital

During the day maintained illuminance should be not less than 200 lux at floor level. During the evening and early morning periods the appearance of the corridor wall as seen from the bed position is of some importance and should be bright enough to give the impression that the ward is not isolated, the recommended wall illumination level is between 100 and 150 lux. During the night 5 to 10 lux at floor level is satisfactory.

3.15.3 Dayrooms, play areas, ward dining areas and staff rooms

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Working plane	200	The lighting method together with the luminaire type should be selected to produce a comfortable but non-clinical feel to the areas.

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4 Clinical areas and operating departments (general)

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Surface colours and finishes must not distort the colour rendering of the light sources. The use of strong colours for wall surfaces, particularly strong blues and greens and any dark colours, should be avoided because they may affect the appearance of patients' skin and tissue due to coloration of the reflected light.

Ceilings and walls should have a semi-gloss or eggshell finish. The walls should not produce reflections of the luminaires, especially where they might occur at the eye-height of theatre staff.

The ceiling reflectance should be 0.7 to 0.9, which can be achieved by the use of off-white or a pale shade, other than blue or green. This will assist in controlling the luminance contrast between the ceiling and the general lighting luminaires. The walls should have a tinted finish, rather than white, with a reflectance of 0.5 to 0.8. The floor should have a light-tone finish with a reflectance of at least 0.3 to maintain an adequate inter-reflected light component, especially within the actual operating theatre.

Plate 19 General surgery at a London teaching hospital

The specification for fluorescent lamps used throughout the theatre complex should ensure clinical quality colour rendering, i.e. CRI $\geqslant 90$, particularly of the patients' skin, tissue, eyes and nails. The luminaires used should be constructed in accordance with the general recommendations given in section 10 and the specific information provided in section 4.1. All luminaires used within the theatre complex should have a degree of ingress protection of not less than IP54. In addition all luminaires must be constructed to allow for easy cleaning.

4.1 Operating theatres

Location	Maintained illuminance (lux)	Notes
Operating table (directed locally)	10000 to 160000	Local switching (auto/manual).
Operating theatre (general lighting)	1000	Dimming (regulated high frequency gear) (auto/manual).
All other places where work is carried out.	$\geqslant 500$ but $\leqslant 1000$	Dimming (regulated high frequency gear) (auto/manual).

BS EN 60601-2-41: 2000: *Particular requirements for the safety of surgical luminaires and luminaires for diagnosis*[19] provides detailed information on the requirements of 'luminaires for diagnosis', 'minor (treatment) surgical luminaires' and 'major and system surgical luminaires', as follows:

— *Major surgical luminaire*: a single luminaire in the patient environment which is fail-safe, i.e. fed from an uninterruptible supply source, and provides the illumination requirements to 'locally' illuminate the body of the patient. It is intended to be used in operating rooms to support the treatment and diagnosis of patients.

— *Minor surgical luminaire (treatment luminaire)*: a single luminaire in the patient environment which is fail-safe, i.e. fed from an uninterruptible supply source, and provides the illumination requirements to 'locally' illuminate the body of the patient. It is intended to be used in operating rooms for diagnosis and treatment both of which could be interrupted without any danger to the patient in cases of a mains failure or a failure of the luminaire.

— *Luminaire for diagnosis*: luminaire to illuminate the body of the patient locally in order to support diagnosis and treatment, both of which could be interrupted without any danger to the patient in cases of a mains failure or a failure of the luminaire. It is not intended to be used in operating rooms.

— *Surgical luminaire system*: a combination of several surgical luminaires to illuminate the body of the patient locally. The system must be fail-safe, i.e. fed from an uninterruptible supply source, and provide adequate central illuminance. It is intended to be used in operating rooms to support the treatment and diagnosis of patients.

The level of illumination in the surgical field will be determined by the type of surgical procedure, the depth of the body cavity to be illuminated and the angle of illumination. Consequently different surgical procedures will require operating luminaires of varying luminous intensities and illuminated field sizes. In a large theatre suite each theatre may be equipped with an operating luminaire specifically suited to the type of surgery to be undertaken

in each theatre. In smaller suites where various types of surgical procedures will be undertaken in the same theatre, then it will be necessary to select an operating luminaire that will provide the best all-round solution.

Plate 20 Operating theatre luminaire, Blackburn Hospital, Blackburn

The general lighting requirement of 1000 lux is usually adequate for performance of ancillary tasks by theatre staff. The luminaires should be ⩾ IP65/54 and sealed onto or into the ceiling fabric to an equal standard.

The general lighting is required to provide both horizontal and vertical components of illuminance, vertical being required for good visibility of swab count racks, wall-mounted equipment, life support equipment etc., the surfaces of which should not be glossy. Compliance with the requirements of the other parts of this section will normally ensure that the vertical illuminance is adequate.

For ophthalmic, ear, nose and throat (ENT), and micro-surgery much lower levels of general illuminance will be required. A value of 10 to 50 lux is recommended, which can be provided by the use of dimming, which will provide the flexibility that is often required in theatres to permit multi-functional use

When planning for general lighting, some or all of the following items of equipment may also be included in the ceiling layout: fixed X-ray machine, track mounted X-ray machine, fixed operating table luminaire, track mounted operating table luminaire, air conditioning grilles, medical gas pendant and electrical supply outlets, ceiling mounted operating microscopes, image intensifiers and closed circuit television.

Surface mounted or, in some instances, wall mounted luminaires may be required where theatre ceilings are not suitable for recessed luminaires. If wall mounted luminaires are used care should be taken to ensure that the minimum horizontal light requirement is achieved without high levels of vertical intensity producing visual discomfort to theatre staff.

Practice has shown that glare should not be a problem in the comparatively small areas of modern operating theatres provided that the recommended illuminances, colours and reflectances are used, and linear recessed or surface fluorescent luminaires having a downward light output ratio (DLOR) of approximately 0.6 are specified.

Failure of the lighting during an operation may have serious consequences and it is essential to provide sufficient and reliable standby lighting.

Instantaneous changeover to the standby supply is required for the major surgical luminaire or surgical luminaire system. Reference should be made to section 8 and the specific information provided in section 8.2.

4.2 Operating theatre table luminaire

The purpose of an operating luminaire is to illuminate the surgical site for optimal visualisation of small, low contrast objects at varying depths in incisions and body cavities. It must do this with minimal shadows, heat transmission and colour distortion. The luminaire must be capable of working for extended periods of time without radiating excessive heat that would cause discomfort and dry tissues in the surgical site.

4.2.1 Operating table lamps

4.2.2 General theatre table luminaire considerations

The selection of an operating theatre table luminaire for major surgery should conform to BS EN 60601-2-41: 2000[19], but the final selection should also take into account the preferences of the surgeons who will be working within the theatres.

The designer should also be aware of the following considerations, which may affect the luminaire selection:

- The theatre ceiling height should provide sufficient clearance for the mounting of the specified luminaire, including any satellite luminaire, in relation to the operation table and the theatre staff. The luminaire head should be capable of being raised to provide at least 2 metres clearance from the floor.
- The position of the luminaire should be co-ordinated with other fixed equipment to ensure minimal interference with its function.
- Quick, positive lamp replacement should be possible.
- The luminaire should be of robust construction, easy to clean and proofed against the ingress of dust and water to a minimum of IP55.
- The head of the luminaire should be fully adjustable, both horizontally and vertically, and be able to rotate through 350°; it should automatically remain in any set position.
- Proprietary suspended ceiling systems are not suitable to support operating theatre table luminaires. Substantial structural steelwork capable of carrying the weights and in particular, the turning moments, of the selected luminaire must be considered at the design stage.
- Counterbalance mechanisms should be constructed such that they do not cause an obstruction to surrounding equipment and persons.
- The luminaire should have a variable diameter of illuminance fields, either by internal adjustment or by variation of the height. The intensity should also be variable, preferably by a stepped switching or continuously variable method, incorporated in the luminaire controls.

Full details of construction constraints together with electrical safety requirements are contained in BS EN 60601-2-41: 2000[19]. Photometric requirements for operating theatre table luminaires are also contained in BS EN 60601-2-41: 2000.

4.2.3 Light intensity

The intensity of light required by the surgeons will vary according to the type of surgical procedures being undertaken. In some circumstances surgery may be performed on more than one part of the body simultaneously, in which case a satellite lamp will be required. For example, major reconstructive surgery of the head and neck will require a main and satellite lamp system with an ability to provide a combined total illumination level in excess of 200 000 lux measured one metre from the lamps. In practice this will require a general surgery main

lamp having an intensity of approximately 145 000 cd together with a satellite lamp having an approximate intensity of 100 000 cd together these will provide the required illumination.

It is recommended in BS EN 60601-2-41: 2000[19] that the maximum luminous intensity of any single operating lamp does not exceed 160 000 cd.

4.2.4 Importance of colour rendering

Colour perception is very important in an operating lamp. Because the surgeon is looking mainly at red and yellow tissue, the operating lamp must have a good mixture of light in the red and yellow frequency range if the surgeon is to see these objects clearly. Most modern operating luminaires are generally fitted with lamps that have a strong yellow and red content, and colour rendering values in excess of RA90.

4.2.5 Heating effect of operating table luminaires

Infrared radiation, invisible to the human eye, is the main cause of heating, as it is absorbed into tissue. Good operating lamps must remove the infrared part of the spectrum without removing the visible red and yellow components, which the surgeon needs for good visualisation (see section 4.2.4). BS EN 60601-2-41: 2000[19] specifies that the total irradiance shall not exceed 1000 W/m^2.

4.2.6 Colour temperature

BS EN 60601-2-41: 2000[19] for surgical luminaires states that the colour temperature or correlated colour temperature (CCT) of the lamp type should be between 4000 and 6500 K.

4.2.7 Ultraviolet light

Ultraviolet light is damaging to humans as it causes burning of the skin, most commonly noticed as sunburn. It is also potentially damaging to the eyes. Tungsten halogen and metal halide light sources emit appreciable levels of ultraviolet radiation that must be filtered out. Like infrared, ultraviolet light is invisible to the human eye and so does not aid visualisation. BS EN 60601-2-41: 2000[19] states 'the UV irradiance for wavelengths below 400 nm shall not exceed 10 W/m^2'.

4.2.8 Operating lamp supporting structures

Operating lamps can be very heavy and, because of the length of the radius arms, the lamps will exert large forces on the mounting structure when full extended. The need to provide a solid fixing for the operating lamp system is often overlooked.

Where the building structure has a solid slab obtaining a good fixing for the lamp stem is quite straightforward. However, many modern hospital buildings have lightweight structural steel frames with long spans and large ceiling voids.

When mounting an operating lamp to a steel frame the steel frame should be well braced with the absolute minimum of deflection. The effect of deflection in the supporting structure is that the operating lamp will be unstable and movement of the main lamp can result in the unexpected movement of satellite lamps and vice versa.

4.3 Viewing facilities

Most theatre viewing facilities are now provided for by the use of closed circuit television systems (CCTV). However, although no longer commonly provided in operating departments, any viewing facilities still being used may be treated as follows. It should be noted that the provision of a viewing room above the theatre may affect the location of the general theatre lighting luminaire in the theatre itself.

Conventional viewing facilities take the form of an observation room above or to one side of the theatre. Theatres with side viewing rooms can be lit by the specific methods for general lighting already described in section 4.1; however note should be taken of the need for the combination of smaller luminaires and dimming to achieve the lower levels required. This may be avoided by inclining the window, the head being set further into the theatre than the base.

Lighting in the viewing room is necessary for safe movement of students and staff. The luminaires should be so sited that they are not visible to the principal operating theatre staff at their working positions. An illuminance of 30 lux is recommended but higher values, up to 300 lux, may be required for note-taking during lectures or demonstrations.

The use of dimmers should be considered to enable higher levels of illumination to be used when required.

Closed circuit television in operating theatres is outside the scope of this Lighting Guide but the illuminances recommended given in section 4.1 should be adequate for the use of both monochrome and colour cameras. Any colour correction filters on the camera should be suitable for the principal light source. Details of any requirements for CCTV within operating theatres will need to be carefully resolved with the CCTV specialist.

4.4 Ultra-clean air ventilation enclosures (UCV)

Where operating theatres are fitted with ultra-clean ventilation systems careful consideration should be given to the choice of operating lamp to be used inside the UCV canopy.

Operating lights should be toroidal, cruciform or small multiple dome-shaped luminaires when vertical air flows are employed as they provide good aerodynamic properties. The larger (typically 1 metre diameter) saucer-shaped luminaires supported from a central pillar will occlude the airflow in the critical central zone and are not recommended for vertical flow systems but may be used for horizontal systems where the luminaire shape has little influence on the air flow. The illuminance levels referred to in section 5.1 should be maintained.

The enclosure is usually formed by fixed clear partial walls terminating about 2.0 m above floor level, to which exterior panels, terminating at about 1 m above floor level, may be attached. To maintain the general illumination within the enclosure, it may be necessary to provide permanent lighting in addition to the normal general lighting of the theatre; such supplementary luminaires should be located so as to avoid shadows.

Where the enclosure has a final diffuser fabricated from translucent material it has been found practicable to install luminaires above this diffuser with little loss of light transmission.

Care must be taken to ensure that the luminaires do not interfere with the air supply. They should be constructed so as to permit normal disinfection of all surfaces. It is preferable to use operating table luminaires with an open frame design, since these offer minimum disturbance to the air flow.

Plate 21 Ultra-clean ventilation air enclosure, Blackburn Hospital, Blackburn

Some types of enclosure have perforated metal plates that hinge downwards. This may preclude the mounting of general lighting within the enclosure, in which case the luminaires should be mounted on the ventilation module.

Plate 22 Ultra-clean air enclosure with integrated luminaires

The general lighting illuminance should be maintained under the canopy, this can be achieved by using asymmetric distribution or other suitable low glare luminaires.

The above describes two particular types of enclosure. It is expected that other types will become available and the general philosophy described in section 4.1 should be applied to the lighting design requirements. The main criteria for such areas are:

- sufficient ceiling height to enable the operating theatre table luminaire to be positioned appropriately for the particular surgical procedures to be undertaken
- construction of the operating theatre table luminaire should offer minimum disturbance to air flow
- illuminance provided by the general lighting should be as even as possible over the whole area including that within the enclosure
- suspended ceilings will need to be strengthened (see section 4.2.2).

4.5 Ancillary areas within operating departments

It is essential that clinical quality colour rendering should be maintained throughout the theatre complex, including any lifts that serve the clinical areas. Luminaires used in these areas should comply with the appropriate requirements given in section 10 and the specific information provided in section 4.1. The following areas may require special attention.

4.5.1 Scrub-up areas

Location	Maintained illuminance (lux)	Notes
Working plane (sink top)	500	Lamps and luminaires all to be IP ⩾ 65/54 similar to those used within the theatre itself.

The luminaires and lamps should be of the same specification as those used in the theatre to minimise the possibility of bacterial transmission; that is IP65 room-to-void with the front frame on, and IP54 when the frame is off for lamp replacement. See also section 10.1.

4.5.2 Preparation rooms

Location	Maintained illuminance (lux)	Notes
Bench	500	Lamps and luminaires to be IP ⩾ 65/54, similar to those used within the theatre itself.

Not all operating theatres have preparation rooms but, where provided, the luminaires and light sources should be of the same specification as those used in the theatre. The luminaires should be IP ⩾ 65/54, sealed onto or into the ceiling fabric to an equal standard. See also section 10.1.

4.5.3 Anaesthesia rooms

Location	Maintained illuminance (lux)	Notes
Working plane	500	Lamps and luminaires to be as those used within the theatre itself, i.e. IP ⩾ 65/54. Luminaires to be co-ordinated with the room's medical equipment.
Head of trolley (local)	1000	To be provided by a wall or ceiling mounted examination luminaire.

The general lighting luminaires should not be located on the ceiling above areas where patients on trolleys are likely to be left for any length of time; a ceiling or wall mounted examination luminaire should be provided.

Ventilation grilles and medical gas pendants may also be included in the ceiling layout and these must be taken into account when the lighting installation is designed.

The luminaires should be of the same type as those used in the theatre, i.e. IP ⩾ 65/54, sealed onto or into the ceiling fabric to an equal standard. See also section 10.1.

Selective switching or dimming may be required to permit optimum viewing conditions for the observation of both the patient and the controls. The wall and ceiling reflectance should be similar to those in the operating department, see section 4.

4.5.4 Post-anaesthesia recovery rooms

Location	Maintained illuminance (lux)	Notes
Trolley (at any point)	500	Selective luminaire positioning is required to avoid patients looking directly at the luminaires.
Circulation space (floor)	300	Applicable only to areas well away from the beds or trolley.

The lighting in the post-anaesthesia recovery room has to satisfy the conflicting requirements of high illuminance for observation of the patient, at all points of the body on the trolley or bed, with minimum visual discomfort to the patient, often just recovering consciousness. A point worth noting is that because the patients that use these areas are usually unconscious, the design group often decide that windows are not necessary. However, windows are appreciated by the staff so this fact should be taken into consideration at an early stage and, if possible, windows or clearstory windows fitted.

The patient is usually in a supine position with their field of vision directed mostly at the ceiling directly above his/her head. However, this is not always the case so other rest positions should also be considered when designing the lighting. The recommended lighting arrangement is to have a recessed or

semi-recessed luminaire above the foot of each trolley/bed space, with its longest length at right angles to the trolley's or bed's length.

If such an arrangement is impracticable, e.g. where there is a solid slab concrete ceiling, luminaires may be located at the ceiling/wall junction behind the head of each trolley/bed space and adjacent to the length of the bed. These luminaires require an asymmetric distribution directed towards the middle of the patient or at the wall to allow the reflected light to illuminate the patient; possibly supplemented by additional luminaires along the bed sides.

Plate 23 Recovery room, Blackburn Hospital, Blackburn

The recommended illuminance should not be less than 500 lux at any point on the trolley or 500 lux average at floor level around the bed and in the circulation space beyond the foot of the bed. Illuminances and luminance limits should be carefully observed. Each luminaire should be individually switched.

In post-anaesthesia recovery rooms more than 6.5 m wide, central surface mounted luminaires, complying with the luminance limits given in section 3.11.1 may also be required to maintain the recommended average illuminance over the whole area, particularly with the arrangement described above.

4.5.5 Plaster rooms/minor operating theatres

Location	Maintained illuminance (lux)	Notes
Working plane (general illumination)	500	To be provided by ceiling fixed luminaires spaced to give good uniformity and low levels of glare.
Operating plaster table	15 000 to 30 000	To be provided by a minor operating theatre luminaire only if the room is to be classified as dual purpose.

Occasionally, plaster rooms can be classified as dual purpose, i.e. a plaster room and minor operating theatre. If this is the case then the lighting requirements will be the same as those for operating theatres, described in section 4.1. In addition a minor operating theatre table luminaire may be provided. Should the room not be classified as a minor operating theatre then the provision of 500 lux by surface or recessed ceiling luminaires should be adopted. The luminaires should provide good uniformity with minimal glare.

4.5.6 Endoscopy rooms

Location	Maintained illuminance (lux)	Notes
Working plane	300	Care should be taken in the positioning of luminaires to avoid discomfort glare to patients under local anaesthetic.

This room may form part of the operating department, the out-patients or the adult acute department. If part of the operating department it should be classed as a minor operating theatre and the lighting design should comply with the principles indicated in section 4.1; in addition, a minor operating luminaire may be required. The fibre-optic light source may be provided from an endoscope trolley or from a satellite luminaire (as part of the minor operating theatre luminaire) with an endoscope attachment.

If the endoscopy room is part of the out-patients or adult acute department the patients will be under local rather than general anaesthetic so the general lighting should be towards the lower level of the scale and designed to avoid glare and discomfort to the patients. Generally, the fibre optic light source will be provided from an endoscope trolley, and a wall-mounted adjustable examination luminaire should be provided above the appropriate work bench.

4.5.7 Day surgery

Location	Maintained illuminance (lux)	Notes
Working plane (general illumination)	500	To be provided by ceiling fixed luminaires spaced to give good uniformity and low levels of glare.
Operating table	15 000 to 30 000	To be provided by a minor operating theatre luminaire.

Day surgeries can be an integral part of a hospital complex or a stand alone building. They usually have an area or room in which minor operations can be performed. The lighting provision should be similar to a minor operating theatre (see section 4.5.5). Patients will however generally recover in an area similar to a bedded area until fit enough to be released (see section 3.10). Watch and night lighting will not be required.

It should also be remembered that during some part of their stay the patients will generally be under some form of aesthetic, usually local, so the lighting design should try and avoid discomforting glare or the use of bright light patterns to help reduce any possible confusion or stress felt by patients in a semi-comatose state.

5 Specialised areas

This section reviews those areas which, by the nature of the tasks undertaken within them, require special lighting techniques to be applied. Not all the specialised areas likely to be found in a hospital or health care building will be considered in detail. Information on the areas not covered is given within the general lighting schedule contained in Part A.

5.1 Accident and emergency (A&E) units

It should be noted that operating theatres in accident and emergency departments are not as complex as the theatres described in section 4 but the lighting should still comply with the principles given within that section.

Plate 24 Accident and emergency area, Bradford Hospital, Bradford

This room may form part of the operating department, the out-patients or the adult acute department. If part of the operating department it should be classed as a minor operating theatre and the lighting design should comply with the principles indicated in section 4.1; in addition, a minor operating luminaire may be required. The fibre-optic light source may be provided from an endoscope trolley or from a satellite luminaire (as part of the minor operating theatre luminaire) with an endoscope attachment.

If the endoscopy room is part of the out-patients or adult acute department the patients will be under local rather than general anaesthetic so the general lighting should be towards the lower level of the scale and designed to avoid glare and discomfort to the patients. Generally, the fibre optic light source will be provided from an endoscope trolley, and a wall-mounted adjustable examination luminaire should be provided above the appropriate work bench.

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Plate 24 Accident and emergency area, Bradford Hospital, Bradford

5.1.1 Resuscitation area

Location	Maintained illuminance (lux)	Notes
Working plane	500	Uniformity to be in excess of 80% over the whole working plane, i.e. no room boundaries are to used during calculation.
Head of trolley (local)	30 000 to 60 000	To be provided by an examination or minor operating theatre luminaire.

In the resuscitation area, initial treatment of the patient may involve several persons carrying out tasks simultaneously, such as the administration of drugs and minor surgery. Therefore, the recommended general illuminance should be provided over the whole area at trolley height. A minor operating theatre table luminaire or examination luminaire and an X-ray viewing screen are also normally required.

5.1.2 Minor treatment rooms and cubicles

Location	Maintained illuminance (lux)	Notes
Working plane	500	Care should be taken in the positioning of luminaires to avoid discomfort glare to patients.
Couch (local)	15 000 to 30 000	To be provided by a local examination luminaire.

All practicable precautions should be taken to reduce glare to patients by correctly locating the luminaires and by limiting their luminance at normal viewing angles.

Plate 25 Minor surgery luminaire

The general lighting should be supplemented by adjustable wall or ceiling mounted examination luminaires, to provide flexible coverage of all those areas where critical examinations are to be undertaken. X-ray viewing screens may be required for groups of treatment rooms or cubicles.

5.1.3 Major treatment rooms

Location	Maintained illuminance (lux)	Notes
Working plane	1000	Principles of section 5.1 to be used.
Couch (local)	50 000 to 90 000	To be provided by an examination or minor operating theatre luminaire.

These rooms are generally smaller than main operating theatres and the ceiling mounted equipment will not be as complex. However, the general lighting should comply with the principles given in section 4.1. A minor operating

theatre table luminaire or examination luminaire to BS EN 60598-2-25[20] will be required.

Plate 26 Major treatment room, Doncaster Royal Infirmary, Doncaster

5.2 Audiology

The lighting should be well diffused and free from distracting glare or harsh contrasts. Noise which might interfere with the free field audio examination of the patient is to be avoided by the use of appropriate luminaires and controls which should also be free from electrical interference with sensitive monitoring apparatus.

5.2.1 Audiology consulting rooms

Location	Maintained illuminance (lux)	Notes
Consulting rooms	300	Low glare with good vertical illumination to assist with non verbal communication is required.

The lighting should contribute to the presentation of a reassuring environment so that the patient is at ease during the consultation and tests. It is also necessary to take consideration of the need to enhance non-verbal communication with good quality lighting design that produces good facial modelling essential for the process of lip reading.

5.2.2 Audiology test rooms

Location	Maintained illuminance (lux)	Notes
Working plane	150 to 300	The different levels should be obtained by dimming rather than selective switching in order to maintain uniformity levels.

Reduced levels of the general lighting may be required. This should be obtained by the use of dimming luminaires rather than switching. Additionally, wall or ceiling mounted special luminaires are usually required for visual stimulus tests. These should be selected and positioned in consultation with medical staff and the controls should be conveniently located.

Care needs to be taken in the selection of luminaires in order to maintain ambient noise levels below the design standards for clinical areas. These levels should be determined prior to the design being carried out through consultation with clinical advisors; special consideration should be given to the potential noise problems with certain dimmer types.

All windows in rooms that are used for examination purposes should be equipped with complete black-out facilities this will aid concentration for certain tests. Rooms used exclusively for children under five could find a dark atmosphere frightening and therefore should not be fitted with black-out facilities; daylight is preferable to electric light.

Some test rooms have an adjoining observation room; the visual link between the two rooms should be either dark glass or a semi-transparent mirror. The observation room should be lit to not more than 100 lux with the luminaires well screened from the test room and controlled by selective switching or dimming.

If a semi-transparent mirror is used, the governing factor is the relation between the illuminance levels of the lighting on the two sides of the glass, the direction of vision always being from the darker side towards the lighter. Therefore, the lighting and decorations must always be darker on the observer's side of the glazing. Any lighting provided in the observer's area must be well screened from the area to be observed and should be localised where possible. Precautions should be taken to ensure that the one-way vision effect is not reversed in the transition from daytime to night-time conditions. This may mean that windows will require blinds or some form of screening.

5.2.3 Vestibular/Snoezelen (audio and multi-sensory) function rooms

Location	Maintained illuminance (lux)	Notes
Couch head and instruments	100	To be provided by local task light shielded away from the patient.

The couch will be located so that the test equipment can be connected to the patient's ears. Lighting from an adjustable wall or ceiling mounted luminaire is required to enable the consultant to apply the equipment. To avoid reflections and stray light, the room should be painted matt black and any windows should be equipped with complete black-out facilities.

While undergoing tests, patients are recumbent with the head supported at an angle of 30° to the horizontal and are in complete darkness except for ceiling mounted fixation lights. The type and exact location of these fixation lights takes precedence over all other services and should be chosen in consultation with the medical staff.

During the tests, the consultant will be monitoring responses on apparatus either in a curtained-off area of the same room or in an adjacent room. A well shielded adjustable luminaire, either bench, wall or ceiling mounted, should be provided for the monitoring apparatus.

5.3 Clean areas (sterile units)

The manufacture of fluids or drugs for injection requires clean environmental conditions. These areas must be aseptic and all fixed surfaces must be protected against the ingress of dirt and dust. These areas are usually within departments such as sterile fluids manufacturing, pharmacies, aseptic suites etc., and are designated 'clean areas'. The luminaires should have a degree of protection not less than IP54 and the luminaires should be sealed onto or into the ceiling or building fabric to an equivalent standard. It should be noted that only parts of the areas designated 'clean' will require this level of cleanliness.

If the sterile supply unit is producing fluids, an illuminated fluid viewer may be required. Where fluids are bottled, this area also will need to be of 'clean area' standard.

Reference should also be made to BS EN 14644[21] with regard to general requirements for clean rooms.

5.4 Dentistry

Location	Maintained illuminance (lux)	Notes
Couch or place of work	500	Luminaire positions to be co-ordinated with the position of the couch.
Mouth (directional)	8000 to 20 000	To be provided by an examination or dental operating luminaire.
Work surface (general)	500	To be provided by the general lighting installation.
Working surface (critical tasks)	1000	To be provided by local task lighting.

Plate 27 Dental treatment room, Doncaster Royal Infirmary

The general lighting luminaires should be located in relation to the couch so that the patient's face is not obscured by shadows caused by the dentist or dental assistant. Good colour rendering lamps, i.e. $\geqslant$ RA80 should be used.

The other luminaires, parallel to the couch, provide general lighting to balance the high illuminance given by the operating luminaire. Local light of up to 1000 lux may be required on the work surfaces for critical tasks such as fine work on dentures. This can be provided by a local luminaire with good colour rendering lamps, i.e. $\geqslant$ RA90.

The dental operating luminaire needs to have a sharp cut-off, giving high illuminance in the patient's mouth but low intensity towards the eyes to avoid distracting glare to the patient. It may be mounted from the ceiling, wall, floor or couch. The dental operating luminaire should have a low voltage supply or be electrically protected to ensure the safety of both staff and patients.

5.5 Diagnostic (electro-medical) equipment rooms

Location	Maintained illuminance (lux)	Notes
Trolley and equipment	500	Luminaire selection and positioning is important to avoid visual discomfort to patients.

In rooms used for electro-cardiography, electro-encephalography, electro-myography and similar techniques, care is needed in the selection and positioning of the luminaires to avoid glare and discomfort to patients. Additionally, the immunity and resistance to radiation interference needs of Medical Devices Directive 90/385/EEC[22] and the avoidance or limitation of electromagnetic interference so as to not adversely affect equipment should also be addressed. Tungsten lighting may still find a use in this respect. For some equipment, the illumination of vertical surfaces may also be important; consultation with the medical staff should be sought.

5.6 Examination rooms

Location	Maintained illuminance (lux)	Notes
Working plane	500	Luminaire selection and positioning is important to avoid visual discomfort to patients.
Couch or chair (local)	15 000 to 30 000	To be provided by a local examination luminaire.

Precautions should be taken to reduce glare to patients by the correct location of luminaires and by restriction of their luminance.

The general lighting should be supplemented by an adjustable ceiling or wall mounted examination luminaire to provide flexible coverage of all areas where critical examinations are to be undertaken.

5.7 Hydrotherapy pools

Location	Maintained illuminance (lux)	Notes
Water level	300	Luminaires to be suitably IP rated and accessible for maintenance.

Luminaires must have a degree of protection not less than IP54. Suitably resistant luminaires, conforming to BS EN 60598-2-18[23] should be used if there is any likelihood of corrosion by chlorine products. The ambient temperature near the ceiling may be 30 °C or higher, therefore luminaires should be selected with this in mind.

The luminaires should be ceiling mounted in a suitable position to permit safe maintenance. The presence of beams for patient hoists must be taken into account.

The luminaires should be located so as to avoid veiling reflections on the surface of still water. Daylighting can also cause veiling reflections and the orientation and design of the windows should be considered at a very early stage in the design process.

5.8 Maternity and neonatal units

Location	Maintained illuminance (lux)	Notes
Working plane	150/300/500	The different illumination levels should be provided by a simple push button scene select system (pre-set dimming levels).
Couch (local)	1000 (minimum)	To be provided by a local examination luminaire.

5.8.1 Labour, delivery, recovery and postpartum (LDRP)

The lighting fulfils two main functions: (*a*) to provide a comfortable lighting environment for the mother whilst in labour and during delivery and (*b*) to provide sufficient light for the midwifery staff. The lighting should be well-diffused and free from distracting glare or harsh contrasts.

The previously applied practice of having separate areas within a labour ward for first and second stage delivery has now mostly disappeared. It is more common for en-suite single-bed rooms to be provided with a domestic appearance. Some of these may also incorporate birthing pools. The choice of luminaires is therefore particularly important in order to fulfil the functions above. A dedicated luminaire or even mobile examination lamp may be required for some clinical needs as determined in conjunction with clinical staff.

Delivery rooms will generally take the form of a treatment room. The direct lighting scheme should provide an illuminance of 500 lux. The luminaires should be located on either side of the delivery couch and parallel to its length, rather than directly above it, to avoid direct glare to the patient. If a third luminaire is required, it should be beyond the foot of the couch and at right angles to it. A telescopic or adjustable luminaire should be mounted on the ceiling, near the foot of the couch, to provide a minimum of 15 000 to 30 000 lux. The lamp head should be adjustable to within 1 metre of the floor. Alternatively, a mobile portable examination luminaire may be provided.

5.8.2 Neonatal units

Location	Maintained illuminance (lux)	Notes
Cot (night)	5	Use the recommendations given in section 3.11.6.
Cot (day and evening)	50 to 100	Luminaires to be positioned as far away from the cots as possible.
Cot incubator area (local)	15 000 to 30 000	To be provided by a local examination luminaire.
Circulation space between cots (day)	100	To be provided by the general installation.

The accommodation within a neonatal unit is generally divided into two categories: cot areas, where premature babies receive special care, and incubator areas, where the babies receive intensive care. It is imperative the lighting designer understands that newborn, especially premature, babies are particularly susceptible to bright light, which can cause stress and retinal damage[16,17]. It will be necessary therefore to consult the clinical specialist on a project-by-project basis for the precise needs of any one unit. However, the principles below will provide an initial guide.

In cot areas, the lighting and luminaires should be positioned as far away from the cots as practicable to avoid direct glare into the cots. However, additional luminaires, separately switched, may be required over or near the cots to provide a higher illuminance for certain medical procedures to be carried out. Final luminaire positions should be agreed after consultation with the medical staff.

Blinds should be provided in areas where daylighting from side windows or roof lights could cause glare.

In incubator areas, higher levels of illuminance are required for the examination and care of babies and this should be provided by low glare luminaires. In such areas, babies are surrounded by complex equipment, some of which may have high luminance luminaires attached to or integral with the equipment. Further medical treatment lamps are frequently located over the babies to aid recovery.

The whole area of a neonatal unit will have air supply grilles in the ceiling and care is needed in the positioning of luminaires to avoid directing or deflecting the air stream onto the babies or their cots. For example, it may be necessary to use recessed luminaires to avoid downdraft.

At night the lighting for cot areas should conform to the standards given in section 3.11.6, i.e. 5 lux with a 0.3 uniformity level for observation lighting. The luminance from the night lighting luminaires should not exceed 30 cd/m^2 above and including an angle of 45° from the luminaire's downward vertical, at all angles of azimuth[17].

Neonatal units typically require a constant temperature of 24 °C and a relative humidity of 45% (winter and summer); also, the temperature of specified areas may need to be varied between 21 °C and 30 °C. On a psychrometric chart, this corresponds to a range of relative humidity of 55 to 32%. The luminaires and control gear chosen should be able to function satisfactorily under these conditions.

5.8.3 Mother and baby rooms

Location	Maintained illuminance (lux)	Notes
General (day)	300	Luminaires to use lamps with a colour rendering capability of CRI ⩾ 80.
Reading	300	To be selectable by the patient and to be provided at the bed head position only.
Watch	5–10	Use the recommendations given in section 3.11.7

The cot is placed alongside the mother's bed. The lighting should be as prescribed for bedded areas. Watch lighting should allow observation of the baby in the cot. It is important to remember that some babies can become jaundiced so the lamp colour and rendition is important. Sight lines from light sources within the baby's view should be plotted at the design stage.

5.9 Medical records

Location	Maintained illuminance (lux)	Notes
Desk	300	Good vertical illumination required controlled by local switching (auto/manual).
Floor	200	Local switching (auto/manual).

Whilst there is an increasing transition to the provision of electronic data storage for medical records, requiring the technical provisions of display screen lighting to be met, there will still be many instances of traditional Medical Record Departments or areas to be lit with the following requirements being applicable.

The labels on record files, particularly those stored at lower levels should be adequately lit. With fixed storage racks, it is usual to locate the luminaires over the aisles, parallel to the racks. However, for sliding racks, the luminaires should be in continuous rows at right angles to the racks, so that the light reaches the lower vertical surfaces.

The reflectance of the floor and the storage boxes or files should be high and diffuse, to maintain a good inter-reflection of light.

Plate 28 Medical records and library area

5.10 Mortuaries

Location	Maintained illuminance (lux)	Notes
Working plane	500	Luminaires to be positioned around the tables to provide a very high level of uniformity over the whole table surface.
Post-mortem table	5000	To be provided by a local examination luminaire.
Dissecting bench (local)	5000	To be provided by a local examination luminaire.
Examination	15 000 to 30 000	For forensic work the illuminance level may need to be increased.

5.10.1 Postmortem and viewing rooms

The general lighting should be arranged around the postmortem table with the objective of providing even illuminance over the whole area of the table. Additional luminaires will be required above dissecting tables which are positioned by the wall opposite or near to the end of the postmortem table.

The postmortem table will require a ceiling mounted examination luminaire to provide local lighting. The position of this luminaire and the general lighting will need to be coordinated with the ventilation arrangements. Wall mounted examination luminaires conforming to BS EN 60601-2-41[19] may be required to provide local lighting on the dissecting table. The lower arm of the examination luminaire must be of sufficient length to enable the lamp head to traverse all parts of the table. Note that the examination luminaire is required to be of the 'safety extra-low voltage' (SELV) type.

Examination luminaires are not splash-proof and therefore should be capable of being folded toward the ceiling during washing down.

5.10.2 Body stores

Location	Maintained illuminance (lux)	Notes
Working plane	200	Usually provided as part of the storage facility.

The lighting in body storage units is usually provided by the manufacturer and takes the form of bulkhead luminaires. The general lighting in the area adjacent to the units should be 200 lux at the working plane.

It is worth noting that the temperature around the body storage units is generally kept at a lower level than other general areas within the mortuary. This helps with the storage of human remains by lowering the thermal gradient between the units and surrounding area. Because of this, any luminaire for use within these areas should be chosen on the basis that their operational capabilities will not be adversely affected by the lower temperatures.

5.10.3 Relatives' waiting rooms and bier rooms

Location	Maintained illuminance (lux)	Notes
Waiting/viewing room	30–150	Lighting to be provided by dimmable tungsten lamped luminaires with soft light attachments.

The bier room requires indirect or softly diffused lighting to give a pleasant appearance to the body. The relatives waiting/viewing room should have domestic type lighting, e.g. wall mounted luminaires. Dimming facilities should also be provided to reduce the illuminance to a lower level than that in the bier room to ensure satisfactory viewing. The setting up and adjustment of illuminance is normally carried out by mortuary staff prior to arrival of the relatives.

5.11 Occupational and physiotherapy units

Location	Maintained illuminance (lux)	Notes
Floor	300	Careful co-ordination of luminaires is required around ceiling mounted equipment.

Occupational therapy units comprise a multitude of rooms or areas for various types of activities, all of which require a good level of general lighting. Further guidance is given in the SLL *Code for lighting*[11]. In planning the lighting for these areas, care must be taken to ensure the positions of the luminaires are co-ordinated with ceiling mounted equipment, such as exercise frames. In workshops where rotating machinery is used, the luminaires must have high frequency ballasts to minimise stroboscopic effects. Extra-low voltage local lighting may be required on some machines.

Many physiotherapy units include a gymnasium with a high ceiling height of 6–8 m and clerestory windows or roof lights. The walls support various items of equipment including wall bars. Therefore, ceiling mounted high output sources are recommended. A few wall mounted fluorescent luminaires may be required to cater for access and cleaning purposes.

High level luminaires should be provided with louvres to control glare and protective screens or cages to retain broken glass. Maintenance of high level luminaires must be considered at the design stage and the height and width of the doors must be sufficient to allow access by maintenance towers. Note that if discharge luminaires are used then there may be a need to provide fluorescent or other suitable lighting to cover for re-strike periods.

5.12 Ophthalmology

Location	Maintained illuminance (lux)	Notes
Test room (working plane)	50 and 300	This is usually provided by luminaires with dimming. Control is usually provided locally around the chair position.
Consulting room (working plane)	300	Illuminated as a general office with consideration given to any computer or screen activity.
Chair (local)	1000	To be provided by a minor treatment lamp (mobile or ceiling mounted).
Bjerrum screen	100 (maximum)	Dimming required between 100 lux and lamp extinction (tungsten luminaires should be used).

These departments usually comprise two types of room: a general consulting room and a specialised eye test room. Consulting rooms take the form of a general office and there are no special lighting requirements. However, when colour deficiency tests are undertaken, e.g. using Ishihara charts, it is recommended that the correlated colour temperature (CCT) of lamps used should approximate to that of north light, i.e. 6500 K, and their colour rendering ability be in excess of RA90. It is usual to equip one room with such a source to enable these tests to be performed.

The specialised eye test rooms may require blackout facilities. Modern test screens/charts usually incorporate an integral light source so dimming of the general lighting will be required. Snellen charts are used for checking visual acuity. According to BS 4274-1: 2003: *Visual acuity test types. Test charts for clinical determination of distance visual acuity. Specification*[24], the luminance of the presentation on the test chart shall be uniform and not less than 120 cd/m^2. Any

variation across the chart should not exceed 20%. The luminance contrast of the chart should be not less than 0.9 where luminance contrast is given by:

$$\text{Luminance contrast} = \frac{(\text{luminance of background}) - (\text{luminance of letters})}{\text{luminance of background}}$$

The measurement of a patient's distance visual acuity is carried out with the general consulting room lighting switched on and adjusted to an illuminance level commensurate with the conditions likely to be experienced in domestic and/or workplace environments. This is to ensure that the results achieved represent the patient's visual acuity in the 'real world' and not in artificially created environments.

Historically such charts were externally illuminated but these have been almost totally superseded by internally illuminated charts, projection charts or computerised systems where letters of the appropriate font size are displayed on display screen equipment at a predetermined distance from the patient. However, if a chart does require externally illuminating, then 300 lux on the chart's surface is the recommended level; an important consideration is to ensure the chart is evenly illuminated with no veiling reflections.

One of the consulting rooms may contain a wall mounted Bjerrum screen, which consists of a panel of dark grey material, about 2 m square, with faint pale grey concentric circles. This screen needs to be evenly lit across its complete surface. The lamps and luminaires providing this illuminance should be capable of providing approximately 100 lux evenly over the screen with facilities for dimming to extinction to allow staff to perform eye tests. In general, if the screen viewed by the patient is enclosed then the background illuminance, and hence luminance, will not affect the test results. Other models of visual field analyser, where the screen is not totally enclosed, continually monitor the background luminance and maintain it at a level appropriate for the test being carried out. Some models have a 'cut-out' facility whereby the equipment will effectively close down if the ambient luminance is too high.

Other tests carried out during a routine eye examination may include the measurement of a patient's visual field and intraocular pressure (IOP). Such tests may be carried out in areas adjacent to the consulting room. The checking of IOP is not dependent upon any specific illumination requirements whereas the illumination requirements associated with the assessment of a patient's visual field is dependent upon the type and *modus operandi* of the equipment used.

A minor treatment lamp (mobile or ceiling mounted), capable of adjustment for close proximity to the examination chair, may be required for fitting contact lenses and/or minor operations.

5.13 Pathology laboratories

Location	Maintained illuminance (lux)	Notes
Bench top	500	Ceiling recessed luminaires with low glare optical control attachments should be used.
Localised on bench	1000	Preferably supplied from the general lighting installation separately switched.

The control of glare within these areas is difficult due to the different positions of benches, the high brightness of equipment and their increasing use of visual display units. High gloss and highly reflecting surfaces should be avoided as a minimum measure against glare.

The general lighting requirement will normally be met by the use of fluorescent lamps installed in ceiling mounted surface or recessed luminaires with low brightness louvres and good optical reflectors. The lighting should be well diffused and free from distracting glare or harsh contrasts. Luminaire positions should relate to the layout of the benches to help minimise the need for additional local lighting. The final choice of luminaires should also take into consideration the need for glare control if any display screen equipment is to be used.

Some areas may require high air change rates and surface luminaires should be positioned to minimise disturbance to air distribution in these areas.

Sometimes short wavelength ultraviolet light is used for germicidal control; ultraviolet sources should not be in use when staff are working in the area. Advice should be obtained from the manufacturers and users. Door switches may be required to ensure that such sources are switched off when people enter the space.

Lighting requirements for clean rooms or areas are given in section 5.3.

5.14 Radiotherapy

Location	Maintained illuminance (lux)	Notes
Couch	100	This level should be achieved through dimming localised luminaires.
Equipment	300	Luminaires to be co-ordinated around the equipment to provide good uniformity.

The main treatment rooms contain equipment such as linear accelerators etc., which produce gamma radiation.

Variable control of the illuminance is required because light beams are used to align the patient and the machine. Ceiling mounted luminaires should be positioned in relation to the machine through its range of movement and to the arrangements provided for observing the patient (either by closed circuit television or viewing window).

The control should incorporate two-way switches linked with the control desk, which is usually situated in a separate room.

Approach doors to radiotherapy areas should carry radiation warning signs.

5.15 Sterilising and disinfecting units

Location	Maintained illuminance (lux)	Notes
Medical equipment	300	'Easy clean' luminaires sealed to IP65 (minimum).
Washing area	300	'Easy clean' luminaires sealed to IP65 (minimum).
Autoclaves	300	'Easy clean' luminaires sealed to IP65 (minimum).
Loading area	300	'Easy clean' luminaires sealed to IP65 (minimum).
Maintenance area	200	'Easy clean' luminaires sealed to IP65 (minimum) unless the area is remote to the cleaning unit where IP20 luminaires can be used
Storage area	150	'Easy clean' luminaires sealed to IP65 (minimum).

Sterilising and disinfecting units vary in size from very large units serving a group of hospitals to small support units attached to the operating department of a single hospital.

The autoclave maintenance area and the store rooms require enclosed, easily cleaned luminaires. The autoclave area, the washing rooms and the packing areas are regularly disinfected and require luminaires to have an IP65 minimum ingress protection rating; in addition the luminaires near the autoclaves should be steam-resistant.

5.16 X-ray and imaging departments

Location	Maintained illuminance (lux)	Notes
General lighting (1 m above floor)	300	To be provided by ceiling fixed or recessed luminaires co-ordinated around any equipment. Two-way switching and control required.

5.16.1 Diagnostic X-ray rooms

The general lighting is for entry to the area and transferring the patient to the couch, for the initial setting-up of equipment and for equipment maintenance. Ceiling mounted fluorescent luminaires are suitable, with two-way switching at the door and the control desk. In some fluoroscopy rooms, dimmable lighting may be required, controlled from the desk.

Plate 29 X-ray department, Blackburn Hospital, Blackburn

Ceiling mounted luminaires should be located so as not to interfere with movement of the apparatus. If this is not possible, separately switched wall mounted luminaires should be provided. In many cases the general lighting is provided as part of the specialist supplier's package for the ceiling as a fully coordinated design with the equipment supports and ventilation equipment.

Plate 30 X-ray department, Blackburn Hospital, Blackburn

Radiation warning lights are required outside both staff and trolley entrances to the diagnostic room, preferably near eye-level. These may be lit from behind to display appropriate messages e.g. 'MACHINE ON' or 'DO NOT ENTER' or 'X-RAY IN USE'. The latter should be coupled to the X-ray pre-exposure circuit and supplied from the X-ray isolator. All other warning lights should be coupled to the X-ray machine control switch. All internally illuminated signs should not exceed the ratio of 1.5:1.

Table 4 gives the maximum limit recommendations for luminance according to the actual size of the sign as detailed within ILE Technical Report TR05[14].

Table 4 Maximum recommended luminance for illuminated signs

Illuminated area (m^2)	Maximum luminance (cd/m^2)
Up to 0.49	2000
0.5 to 1.99	1600
2.0 to 4.99	1200
5.0 to 10.0	1000
Over 10	800

5.16.2 X-ray or image processing dark rooms

Location	Maintained illuminance (lux)	Notes
X-ray processing room (bench top)	50	Tungsten bulkhead fittings that can accept colour filters should be used, all luminaires to be dimmable.
Digital processing room (general lighting) (1 m above floor)	300	To be provided by ceiling mounted luminaires with a luminance limiting angle of 65°.

With the growing provision for electronic X-ray imaging it is unlikely that such processing rooms are likely to be encountered, but if such a room is encountered then the following principles should apply.

For automatic processing units, safe lighting over the feed trays should be controlled by integral switching in the machine. The lids of film hoppers should be linked with the change-over switches to ensure that, if the lids opened during developing, the general lighting is automatically changed to safe lighting.

For manual processing, a splash-proof translucent screen, lit from behind, will be required for viewing films. If daylight film processing equipment is installed, safe lighting is usually not necessary.

6 Health centres and standalone facilities

The information contained in Parts A and B of this Guide, together with that contained in other CIBSE/SLL publications, e.g. the *Code for lighting*[11], is sufficient to carry out the lighting design on the majority of departments within the health care system, i.e. medical centres, doctors' surgeries or other types of clinics. However, some differences in the approach to the lighting design may be necessary and must be considered at an early stage of planning.

Health centres are usually separate units, sited either remotely from a hospital or as part of a much smaller group of like facilities. The structures vary considerably since they are generally designed to suit local conditions and site restrictions. For this reason there is no standard form of construction or standard ceiling heights used so each building will have to be dealt with individually.

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The lighting should, of course, be designed to blend with the style of interior in addition to providing a low maintenance, energy efficient installation. The design should also follow the general philosophy and technical recommendations contained in this Lighting Guide, whilst retaining scope for design freedom. The requirement for low maintenance is of particular important since both maintenance staff and spares are often remote from the facility, resulting in delay in replacement or repair.

Generally health centres are considered as day units. However some areas are used during the evenings for lectures, so emergency lighting for escape purposes must be provided in such areas. Since health centres are usually remote from the hospital building standby generators may not always be available so non-maintained battery operated emergency lighting system will be necessary. Such systems may be self contained, with integral batteries, or supplied from a central battery.

It should also be remembered that day centres can be used to carry out minor surgical procedures, if these facilities are to be incorporated within the centre then the requirements of section 4.5.7 should apply.

7 Exterior lighting

When considering the external lighting the designer has, and should take, the opportunity to consider not only the functional requirements of external lighting but also the amenity aspects and the benefits that good exterior lighting can bring. A similar approach should be taken to the way in which parklands, hotels and outdoor leisure areas would be lit. Advantage should be taken to provide landscape illumination wherever possible and to add a sense of visual enhancement to interesting architecture, sculptures or building structures. Entrances should be treated in the same way as entrances to leisure centres or retail outlets. The designer should ensure they provide an attractive, comforting appearance to all the entrances, grounds and surrounding areas for patients, staff and visitors alike to appreciate and enjoy. Environmental planning will also require the lighting designer to be mindful of the light pollution that may be caused. Although difficult to alleviate totally, it can be reduced considerably by careful consideration of the positioning of luminaires and the technical quality of the products used.

Exterior lighting should at the very least provide both pedestrians and vehicular traffic with good visual guidance around hospital and health care sites. In addition to the visual tasks it should also be designed to provide pedestrians with a ‘psychologically safe’ environment and as far as possible provide a pleasing display to both buildings and landscaped areas. Due to the large size of modern hospital complexes, several different types of lighting are likely to be required. Colour rendering, installation efficacies and maintenance issues must all be considered as well as the luminaire positioning relative to each building. CCTV is also common in all areas and camera positions must also be considered, in relation to the lighting equipment.

Hospital sites frequently have older buildings eclipsed by newer adjacent buildings; these often provide narrow pathways used by staff, patients or visitors. Due to the concealed nature of these areas, the lighting design must ensure that adequate illumination, either directly or by way of spill light, is provided to these walkways.

The choice of product for exterior lighting must also consider obtrusive light from outdoor lighting installations. CIE Technical Report 150: *Guide on the limitation of the obtrusive light from outdoor lighting installations refers*[25].

7.1 Roadway lighting

Road lighting requirements are currently detailed in BS 5489-1[26] and BS EN 13201: Parts 1 to 3[27].

Hospital entrance and exit points will often connect with major traffic routes and the lighting should be graded, in order to avoid sharp contrast with the external roadway lighting. In the majority of cases, categories ME 2, ME 3b and ME 3c would be considered satisfactory for most hospital roads (BS EN

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13201[27] classes CE 3, CE 4 and CE 5 and classes S1, S2 and S3 should also be referred to).

7.2 Sign lighting

Due to the complex nature of hospital sites, direction signs are very important by day and even more important during the hours of darkness. Unless the signs are self illuminated, road lighting should be positioned in such a manner as to illuminate them adequately. If this proves impracticable, then self-illuminated signs should be used. The uniformity of luminance should be determined by the ratio of the maximum luminance to the minimum luminance which must not exceed 10:1 for external coloured signs if they exceed 1.5 m^2. If the signs are less than 1.5 m^2 the ratio should be reduced to 6:1. All internally illuminated signs should not exceed the ratio of 1.5:1.

Table 4, see page 61, gives the maximum limit recommendations for luminance according to the actual size of the sign as detailed within the ILE Technical Report TR05[14].

7.3 Car parking

Guidance for all types of exterior lighting, including recommended illuminance levels, can be found in detail in BS 5489-1[26] and summarised in the general lighting schedule (Table 2). On new installations it is advisable to seek the advice of the police to ensure a that a 'safe by design' policy is initiated early in the project. This should include advice on CCTV together with the positioning and type of lighting required. Luminaires should be positioned adjacent or close to any pay-and-display machines; the minimum levels indicated in Table 2 should be revised to provide the enhanced level. The external lighting should include all entrance and exit points, including all pathways that link with buildings. All exterior luminaires should use high output, good colour quality, low energy lamps. Care should always be taken to avoid or minimise any spill light into buildings that may include wards and to adjacent residential areas. Where possible, all floodlights should be of an asymmetric type with zero or minimal upward light distribution, i.e. above the 90° elevation.

For smaller car parking areas, it may be possible to provide illumination from the periphery and also from buildings in the immediate vicinity. Larger areas will require columns to be located either centrally or on the boundaries of the car parking area. The location of the columns should take into consideration the parking bays. Where columns are used, their height and position relative to adjacent access roads must be taken into account. Access for maintenance purpose should also be considered, and wherever possible, the column height should be such as to allow on-site maintenance to be carried out without the need for specialist access equipment.

7.4 Pedestrian ways

Footways that are not well illuminated from road lighting or floodlighting must be provided with adequate illumination to ensure people's safety. Wall mounted luminaires from adjacent buildings or low-level luminaires can be provided in the absence of street lighting. If low-level luminaires are utilised, these must be of the vandal resistant type and incorporate long life, low energy lamps. If CCTV is operational, the minimum illuminance for the CCTV equipment must be taken into account, as well as care in the positioning of the luminaires.

Particular attention should be given to routes that allow passage to plant rooms where maintenance staff may require night access. These access points which may be at roof level must also be adequately illuminated. Similar special consideration must be provided for routes to staff on-site residential areas, which may be in regular night-time use.

7.5 Spill lighting

As mentioned in sections 7 and 7.3, care must be taken to avoid spill and stray light. The problem can be significant on sites of this type so it will require greater attention at the design stage. Roadways and pathways will in most cases run adjacent to buildings, so any spill light into wards should be minimised. Consideration should also be given to the local environment, which will often

include landscaped areas with trees and bushes. Stray lighting through trees into wards can create disturbing effects and must be minimised.

Spill lighting onto external properties must also be limited. Calculations should be carried out to determine the extent and amount of stray light, particularly on the vertical faces of surrounding property, to ensure compliance with the requirements of CIE Technical Report 150: *Guide on the limitation of the obtrusive light from outdoor lighting installations*[25].

7.6 Security lighting

There are many areas that pose security risks around hospital sites, particularly pharmaceutical storage areas (including industrial gases), staff on-site accommodation and also switchgear/plant rooms that house emergency generators. Particular attention should be given to these areas to ensure that there is no areas of darkness that may encourage unauthorised persons to gain access or linger in the area.

7.7 Helicopter landing pads

Helicopter ambulances are available over most of the UK to deliver care to patients rapidly and to transport them to hospital if appropriate. Their usage is likely to increase, both with public expectations and with the increasing need to transfer patients from general to specialist hospitals. As a result, hospital helipads are becoming an integral part of the pre-hospital care service and an important facility at many hospitals.

The three principal options for positioning a helipad are at ground level, at rooftop level, or on a low structure or mound above ground level. In addition to the standard visual aids that all three options will require they will also have to be individually assessed to take into account all the environmental aspects of the helipad's location, together with the helicopter's approach and take off corridors, to determine all the lighting equipment and its positional requirements. These considerations are outside the scope of this document but full details can be found in Department of Health's Health Note 15-03: *Hospital helipads*[28].

8 Emergency lighting

An emergency lighting system may be a complete, but separate, lighting installation supplied from a standby power source. The installation may use dedicated emergency luminaires or normal mains luminaires converted to operate from the standby power supply. The standby power supply may consist of either locally mounted rechargeable batteries, central battery systems or a standby generator.

The final decision regarding the actual need, including the suitability and adequacy of the emergency lighting, will rest with building control, the fire authority and the health care organisation. It is therefore essential to enter into early discussions and consultation with all interested parties.

Escape route lighting should be provided for the safe movement of occupants from the areas of risk to safe areas, whereas standby lighting is provided for the continuation of essential activity.

Escape route lighting should be provided within five seconds of a power failure. Therefore it should be powered from either self-contained or remote batteries to cover the period before the standby generator is in a position to accept any load. It is however unlikely that the higher lighting levels required for standby lighting could be provided by batteries, in this instance static converters could be used again until the standby generator could accept the load.

Escape route lighting circuits supplied from central batteries or generator should be separated from all other wiring and where possible routed to avoid passing through areas of high fire risk, in addition to being wired using fire-rated cable.

As statutory requirements vary, the relevant authorities together with the health care organisation should be consulted at a very early stage. However, recent guidance such as parts of BS 5588[29] and DD 9999[30] now shift the onus of responsibility onto the designers of the building systems to implement safety

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systems in accordance with legislation and good industry practice. The design should be in line with the requirements of BS 5266[6]. Design guidance is also provided in SLL Lighting Guide LG12: *Emergency lighting design guide*[13].

8.1 Escape route lighting

Safety and escape route lighting is required for the movement of patients, staff and visitors to a safe location in an emergency as well as for the full evacuation of the building. It is worth noting that any recessed emergency luminaires used on an escape route will have to retain the fire integrity and the rate of fire spread of the surrounding ceiling system. In practice this means that any attachment used will have to withstand the 850 °C glow wire test and be manufactured from a self-extinguishing material such as polycarbonate or a tPA-based polymer.

Some of the people using these premises will be physically incapacitated to a greater or lesser extent and/or may be mentally impaired. Because of this, and because those undergoing treatment as in-patients (as well as visitors) will be unfamiliar with the overall layout, hospitals and health care buildings require special consideration. When dealing with such premises, it is essential to give due regard to all of these factors and look carefully at problems that may arise because of the physical requirements of some residents/patients.

The following circumstances will have to be catered for: (*a*) patients who are confined to bed and would need considerable evacuation time and (*b)* patients such as blind or deaf patients and wheelchair users, who may need staff assistance.

Because of the likely condition of patients, hospitals do not normally fully evacuate. Patients are generally moved in a process called ‘progressive horizontal evacuation’ from the high risk areas to areas of low risk while the fire is brought under control. The levels of illumination therefore should be sufficient to allow the process of progressive horizontal evacuation to be made easy, particularly in those areas where elderly patients may be present.

Escape route lighting is particularly required at the following locations:

— corridor intersections
— changes of direction and level
— stairways and lift halls
— exit doors
— fire alarm call points
— firefighting equipment
— outside final exits.

In addition to the above, emergency lighting provision must be made for areas over 60 m^2, toilets over 8 m^2 or with no external windows, escalators and plant rooms.

Having determined the essential locations for luminaires along the routes for movement and escape to the exterior at ground level, intermediate lighting points will be required to provide adequate illuminance along the selected routes. This should be in line with the requirements of BS 5266[6], which calls for a minimum of 1 lux on the centre line of a 2 m wide escape route. Within the UK, BS 5266 allows for a centre line illumination of 0.2 lux if the escape route can be guaranteed to be unobstructed, otherwise the more onerous 1 lux will have to be provided. Elsewhere a minimum of 0.5 lux should be provided to all non-designated escape route areas requiring emergency lighting. The lighting designer should be aware that the majority of users within these premises are likely to be suffering from some physical defect and that in addition some of the users may be elderly and suffering from defective vision. Consequently the emergency lighting may need to be at a higher level than would be necessary in other types of premises; refer to BS 5266 for further guidance.

Lift cars should also be included in the coverage. Lifts that have orthopaedic bed capacity should be connected directly to the essential services

supply and, in addition, they should also be provided with emergency lighting to 100% of the normal service level for a minimum of 1 hour to cover the possibility that there may be a delay before the generator can restore normal supply service. In all other lifts, emergency lighting should be provided to at least a 50% normal service level for a minimum of one hour in order to alleviate any distress to the passengers.

Fire muster points and dedicated refuge areas must be given special consideration to ensure they are illuminated to a minimum of 5 lux and are visible or stand-out from the surrounding area.

Illuminated signs on the movement and escape routes should comply fully with BS 5499[31]: Parts 1 and 4 and BS EN 50172[32], in addition to the requirements of the Signs Directive[33].

The electrical supply for escape route lighting can be maintained by one of the following methods.

(*a*) A mains-sensing, automatic start-up generator, with battery back-up to cover not only the generator's start-up period but also cater for the maintenance period required in the event that the generator fails to start.

(*b*) A central battery system, which provides immediate electrical supply to the emergency lighting luminaries for a minimum of three hours. Large hospitals may require many separate units to suit the layout of the buildings.

(*c*) Self-contained emergency luminaires that provide a minimum of three hours capacity to power the lamp(s).

8.2 Standby lighting

Standby lighting is classified as Grade A or Grade B in line with the requirements of Health Technical Memorandum HTM 2011[34]. It is required in certain parts of the hospital to enable essentials activities to be carried out in the event of a mains failure. Hospitals normally work to two standards of illuminance. In critical areas such as operating theatres, delivery rooms and high dependency units, the quality of standby lighting should equal, or near equal (90+%), to the normal mains lighting level; this is classified as Grade A. Non-critical but important areas will require lighting to a reduced level, generally 50% of the normal mains level; this is classified as Grade B.

The two standards of standby lighting recommended are:

— *Grade A*: lighting that is of a quality that equals, or nearly equals (i.e. 90+%), that provided by the normal mains lighting. In addition certain Grade A classified areas, such as operating theatres, must have sustained lighting so that no outage is experienced.

— *Grade B*: lighting that is at a reduced level, i.e. between 30% and 50% of the normal mains level. The exact level should be determined by the task activity and its ability to be carried out properly.

Note: in hospitals and nursing homes, selective switching or dimming of lamps will reduce the overall light output below that of its 'installed' level. At such times, this lower lighting level describes the task requirement. Therefore the standby lighting, if activated during this period (whether Grade A or Grade B as defined above), should relate to the lower level condition.

Because of the high ratio of infirm occupants who may require assistance during evacuation, a minimum level of 1 lux is recommended on the centre line of all escape routes. An important issue to remember is that in hospitals during

mains failure conditions, the safety lighting will probably be supplied by a standby generator. However, this method of standby supply will always create a break in the supply while the engine is run up to speed prior to accepting the load. Therefore, in addition, battery back-up to power the lamp(s), with a minimum of three hours capacity, should be provided to cover the start-up period and cater for the possibility that the generator fails to start.

Where critical tasks are being carried out, for example in operating theatres, the system must provide immediate and full level lighting by means of an independent battery supply. This is required to cover not only the generator start-up period but also to cater for a possible maintenance period in the event that the generator fails to start.

Operating theatre lights are of special importance as their construction can cause particular problems in the provision of emergency lighting. Here it is of the highest importance that the theatre suffers no interruption of supply and that the operating lights provide the same level as when in normal mains condition; this is normally achieved by using a maintained central system.

8.3 Associated mains lighting

With the need to keep the building's fire risk to a minimum, the housings of all mains luminaires, mains converted, and emergency luminaires are required to be manufactured from a self-extinguishing material. Also these luminaires should be designed for low maintenance and long operational life, therefore a combination of robust materials and strong construction is essential.

8.4 Type of luminaire and mounting height

Cleanliness is obviously very important so luminaires should be constructed without exposed clips, dust traps or ledges, making them easy to wipe clean. If luminaires are to be used within the line of sight of a patient's bed head, care must be taken to reduce the glare to within acceptable limits. Indeed, the mounting height and position of all luminaires should be carefully selected to avoid glare to both patients and staff.

8.5 Testing

Escape route and safety lighting installations require regular planned maintenance and testing programmes. The requirement for regular testing, together with verification of the system's operational capability, may prove to be very labour intensive, therefore the use of stand-alone or central-testing systems must be considered.

It should also be noted that when generators are used for the provision of standby power, the monthly testing requirement is for an operating period of one hour on full load.

9 Light sources

9.1 Daylight and Daylighting

Daylight is an important factor in our normal lives so its importance within a hospital environment should never be underestimated. It should be incorporated within the building design at every opportunity to create a feeling of wellbeing, which in health care buildings has been shown to aid the recovery process. Light can alleviate the symptoms of seasonal and non-seasonal depression. It regulates the secretion of the hormone melatonin which plays a major part in our wellbeing. In addition it can help increase the length and quality of sleep and has a direct effect on cortical activity of the brain. Continual low light exposure levels have long been associated with negative emotional states; it is clear that the body's immune and other physiological systems are affected by light. Significantly, the quantity and character of light required to influence the circadian system differs from that which is required for vision, so every opportunity to provide daylight into all areas must be explored.

All new buildings should be designed so that the maximum number of internal surfaces receives direct sunlight. Window blinds can always be used to moderate the flow of sunlight into a ward. Traditionally, the architect has been responsible for designing for the ingress of daylight, but in the complex areas of a hospital or health care environment the much wider requirements for solar control, energy efficiency etc. require the services and skills of an experienced

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lighting or building services engineer. The lighting designer should be employed as early as possible so that their skills in daylight techniques, computation and resolving the problems associated with the methods available, can all contribute to the final solution and be fully integrated with the architectural concept.

The recommendation for daylight in hospitals, especially the ward areas, is to achieve an average daylight factor between 2% and 5%. Most hospital areas should aim to achieve at least 3%. However, the daylight factor cannot be taken in isolation as a high daylight factor with a low uniformity value will make the spaces adjacent to large windows look gloomy and supplementary lighting may be required to instill a visual balance. Uniformity levels of between 30% and 50% should be achieved. In this way an area with a 2% daylight factor and a uniformity of 40% will look more attractive than a space with a daylight factor of 5% and a uniformity level of 10%[2].

In some areas daylight may provide sufficient and suitable illumination for normal tasks to be carried out in the middle part of the day; full use of this daylight will help maximise the energy savings. The extent of daylight penetration will vary with the location, orientation and window design. It may also be possible, with good design or equipment such as reflective daylight tubes, to 'pipe' the light deep into buildings that would otherwise receive no daylight.

The transition between daylight and electric light should also be carefully considered at an early stage, as additional levels of electric lighting may be required to visually integrate the daylight.

9.2 Types of light source

The main types of light sources are:

— tungsten filament (GLS)
— tungsten–halogen (mains)
— low voltage tungsten–halogen
— low pressure mercury (fluorescent)
— high pressure mercury (metal halide)
— high pressure sodium discharge
— light emitting diodes (LEDs)
— induction lamps.

Within each of the above groups there are further sub-categories of lamp types, differing in wattage, luminous efficacy, colour properties, life, start-up and restart times, construction and, of course, cost.

In view of the wide variety of lamp types available, the International Electrotechnical Committee (IEC) has devised an International Lamp Coding System (ILCOS)[35], which helps provide a common communication point between manufactures, suppliers and customers. A general selection of those codes together with a description of lamp types is given in Table 5.

Because of the wide range of lamp types within each code, manufacturers should always be consulted for specific application and technical data.

For information regarding malignant melanoma and fluorescent lighting refer to CIE publication 106[36].

Table 5 represents only a small selection of the typical lamps used within hospitals and health care buildings. However, manufacturers are currently developing a number of innovative light sources that should be considered alongside the more familiar types. Lamp types such as cold cathode, light emitting diodes (LEDs) and electroluminescent panels can all be considered for use in display, signage and emergency lighting. The characteristics of LEDs in particular could provide an innovative solution to the night lighting of wards. The use of fibre optics with an appropriate light source is also becoming commonplace, providing practical solutions for display lighting, way guidance, and lighting for corrosive environments and areas where access is difficult.

Table 5 Lamp types and ILCOS codes

ILCOS code	Description
FD	Low pressure mercury discharge lamp with fluorescent coating; this includes all types, i.e. high output, high efficiency T5, tri-phosphor, and halo-phosphor T8 and T5 circular
FSS	Low pressure mercury discharge 2D lamp with fluorescent coating
FSQ	Single ended low pressure mercury discharge twin and quad-limbed lamp with fluorescent coating
FSM	Single ended low pressure mercury discharge multi-limbed lamp with fluorescent coating
FSD	Single ended low pressure mercury discharge high wattage twin-limbed lamp with fluorescent coating
HSG	Low voltage tungsten halogen capsule lamp
HRG	Low voltage tungsten halogen dichroic lamp
HRGI	Mains voltage single ended tungsten halogen PAR lamp
HAG	Mains voltage linear tungsten halogen lamp
ME	High pressure mercury discharge lamp with metal halide additives; this code includes all types and wattages, including ceramic arc tube types
SE	High pressure single ended sodium discharge lamp with an arc tube placed within an elliptical outer envelope, including standard, high output and deluxe types
ST	High pressure single ended sodium discharge lamp with an arc tube placed within a tubular clear outer envelope, including standard, high output and deluxe types
GE	High pressure single ended mercury discharge lamp; the lamp consists of an inner arc tube placed within an elliptical outer envelope internally coated with a fluorescent layer

9.3 Lamp life and lumen maintenance

The term ‘lamp life’ simply defines the time period after which the lamp ceases to operate it is sometimes referred to as its ‘mortality rate’.

Lumen maintenance, often confused with lamp life, is the time after which the light output of a lamp is reduced to such an extent that it is more economical to replace it. Lamp manufacturers produce data for each lamp type, usually in the form of a graph to show its expected lumen loss over time. Confusingly, this curve is sometimes know as a ‘lumen depreciation curve’ or ‘lumen mortality curve’.

The term ‘lumen maintenance’ generally relates to discharge lamps as filament lamps show very little depreciation over their life. The definition of average lamp life is straightforward for filament lamps but it is less easy to define for discharge sources. With filament lamps the life is expressed as the time after which 50% of a large sample of lamps will have failed. This is also used to express the rated life of most discharge lamps however other factors will need to be considered such as lamp lumen output which, for economic or design reasons, may lead to a reduced period before the lamps are changed.

To assess the period for lamp replacement, reference should be made to the actual lamp manufacturer’s data since lamp development continues to produce lamps with longer lives and lower lumen depreciation, which will have a direct bearing on the maintenance cycle of a building.

9.4 Lamp control gear

The control gear for a discharge lamp will have three distinct functions: (*a*) to start the lamp, (*b*) to control the lamp current after ignition, and (*c*) to correct the power factor.

The efficacy of the lamp is dependent on the total power required to operate the lamp.

There are principally two types of control gear: copper–iron ballasts used with a separate starting device and separate power factor correction capacitor, and electronic ballasts, often referred to as ‘high frequency’ ballasts. Current developments in control gear are leading towards an ever-increasing use of electronic ballasts, which provide many advantages over copper–iron types.

The main advantages of electronic ballasts are a reduction in power consumption, softer lamp ignition that improves lamp life, and lamp failure sensing to shut the circuit down in the event lamp failure. Electronic ballasts also offer the advantage of incorporating both the starting device and the power factor correction within the same housing, thereby helping to reduce the amount and complexity of the luminaire's internal wiring. Electronic control gear is available in a number of different types, some of which allow the lamps to be dimmed. This not only helps provide solutions to meet specific lighting requirements but also helps reduce the total energy consumed.

The operational efficiency of each ballast type is governed by EU Directive 2000/55/EC[37], which came into force in November 2005. This states that only CELMA Energy classes A1, A2, A3, B1, and B2 can be used. It is the responsibility of the manufacturer or importer to seek compliance before the product can be CE-marked for compliance with all the trading directives currently in force.

While the directive advocates the use of energy efficient solutions the onus is still with the lighting designer to ensure that the most energy efficient products are used. Indeed, it would be difficult to justify the use of the less efficient class B products within the health environment so the obvious and first choice should be to use class A2 or A3. However, given the increasing requirement for variable lighting levels and the drive to energy efficiency through building management systems (BMS), class A1 (dimmable), could be considered essential for a large number of applications within a health establishment.

10 Construction and operation of luminaires

All luminaires used should comply with BS EN 60598-2-25[20] in respect of electrical safety and mechanical construction. They should all be CE -marked with the manufacturer's declaration of conformity to all directives designated under the Harmonized European Standards, and certified to be in full compliance with the EMC Directive[38]. In addition, all luminaires intended for use within clinical areas of healthcare buildings should specifically comply with the requirements of BS EN 60598-2-25[20].

It is worth noting that any recessed emergency luminaires used on an escape route will have to retain the fire integrity and the rate of fire spread of the surrounding ceiling system. In practice this means that any attachment used will have to withstand the 850 °C glow wire test and be manufactured from a self-extinguishing material such as polycarbonate or a tPA-based polymer.

The degree of protection against the ingress of moisture or dust is covered by performance tests described in BS EN 60598-1[39]. The relevant classifications are given in Table 6.

Table 6 Degrees of protection from moisture and dust

Classification	Description
IP22	Drip proof
IP23	Rain proof
IP34	Splash proof
IP54	Dust proof and splash proof
IP55	Jet proof and dust proof
IP65	Jet proof and dust tight

The term 'proof' does not mean that the luminaire is fully sealed against the particular hazard but that the amount of moisture or dust able to enter the luminaire in normal use is unlikely to be sufficient to interfere with its normal operation.

Luminaires used in hospitals and health care buildings are required to meet high standards of safety and hygiene, the following points should be considered.

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Luminaires used in hospitals and health care buildings are required to meet high standards of safety and hygiene, the following points should be considered.

10.1 Dust-borne infection

It is possible for airborne dust particles as small as 0.5 µm to transport harmful bacteria. Luminaires in common with other items of equipment can cause the transfer of infection by surface contact or by the dust particles they may harbour. Therefore luminaires for use in hospitals and health care buildings should have the minimum area of horizontal or near horizontal surfaces on which dust may settle, and such dust should be easily removable by simple cleaning methods. In high risk areas it is advisable to use luminaires with no horizontal ledges, only downward and vertical faces. It is also advisable in operating theatres to use luminaires that have glass diffusers since the close cell structure of glass cannot be penetrated by bacteria and is unaffected by sterilising materials and ultraviolet light. A further measure in preventing the transmission of infections is to ensure that any luminaire requiring ingress protection between the void and the room uses luminaires that have mechanical measures to ensure that the seal between the ceiling and the luminaire frame is securely made. It should not rely on being manually held while being fixed into place.

10.2 Noise

The 'hum', which naturally occurs in wire wound (mains) ballasts, particularly with fluorescent lamps, should not be amplified by resonance in the luminaire or in the enclosures of remote control units. This is particularly important when fluorescent lamps are being considered for ward lighting. At night when ambient noise levels are low, particularly in rural areas, even a barely perceptible hum can become irritating to patients. The effects of noise within luminaires should diminish in future thanks in part to the requirements of EU Directive 2000/55/EC[37], see section 10.5, and to the increasing quality standards applied to the manufacturers of mains and high frequency ballasts.

No part of any luminaire should rattle, either due to normal building vibrations or draughts.

10.3 Electrical safety

Electrical safety should be considered a top priority within all electrical apparatus used within the health environment, especially in bed head luminaires that are accessible to patients. Such luminaires should be either be of Class II construction or supplied from a safe extra-low voltage (SELV) supply, as defined in BS EN 60598-1[39]. The construction should be robust and the luminaires should be capable of being securely mounted.

Provision should be made for easy cleaning of the interior of enclosed luminaires without the risk of electrical shock.

Hand-held switches at mains voltage can be dangerous to patients so an extra-low voltage relay-actuated switch, at a maximum of 24 volts, should be incorporated into any patient's nurse call apparatus. Electrical connections should be accessible only with the use of tools.

10.4 Electromagnetic compatibility (EMC)

Many items of electrical equipment installed in the hospital can cause interference, either by radiation or by transients through the mains voltage supply. The prime nuisance factor from fluorescent luminaires is from radio interference. Suppressors, if fitted to the ballasts within the luminaires, should reduce the interference to below the limit required by BS 5394[40].

The use of high frequency electronic control gear within the patient environment requires careful consideration with regard to electromagnetic emissions and immunity. The testing and certification of a ballast by a manufacturer as an independent component is not sufficient for an 'original equipment manufacturer' (OEM) to state that its use within another housing or product will meet the overall technical requirements.

When electronic components are mounted into equipment or products with other electronic equipment, such as a light fitting or bed head services trunking system (BSTS), the emission characteristics of the individual component, as well as the overall equipment, change. Consequently, tests need to be performed by manufacturer on the complete assembly as it would be installed to include all elements such as nurse call lighting, mains power etc.

BS EN 60601-2-41[19] defines the EMC test requirements for electrical medical equipment within the patient environment and the EMC elements of ISO 11197[40] should be observed for BSTS products which include lighting components. However, this is further complicated with the variances of nurse call and data equipment but manufacturers should be able to demonstrate compliance with product standards.

10.5 Luminaire installation and maintenance

The effective operation and efficiency of any installed system can only be maintained if serious consideration is given to the long term maintenance of the installation. A maintenance policy that pursues and expects the good upkeep of equipment by regular inspection and overhaul is a sign of good housekeeping. Maintenance and safety are two closely related subjects. Generally safety is largely dependent upon good standards of maintenance.

The frequency of maintenance will be influenced by several operating factors, for example:

— the overall quality of the equipment
— the frequency of use of the equipment
— the environmental conditions
— operator use/good housekeeping
— the nature and reliance of the system, e.g. is the installation critical?

These factors together with others will influence the maintenance procedure as will the maintenance budget. The philosophy of planned preventative maintenance or maintenance at regular intervals must be balanced against the consequences of a breakdown and allowing such to happen before any action is taken (so called 'breakdown maintenance'). The best approach is often a mixture of both.

Whatever the final approach or regime adopted, using either in-house or 'contracted out' staff, the maintenance procedure should at the very minimum follow the guidelines given in Appendix A2. Also it may help with future lamp replacement if during the installation procedure luminaires are fitted (either at the factory or on site) with highly visible stickers that indicated the lamp type installed in each luminaire. This would help in planning lamp replacement and the ordering of replacements by maintenance staff. One of the most important issues to consider at the design stage is the provision of safe and easy access to all the lighting equipment, including windows. This is essential to ensure effective, low cost maintenance throughout the life of the equipment.

A schedule for the installation and maintenance of luminaires is provided in Appendix A2.

11 Lighting controls

11.1 Function of control systems

Effective lighting controls enable the users of the building to ensure that the electric lighting is used only when required. This can contribute to user comfort and improved energy efficiency. However, while the designer can ensure that the appropriate controls are provided, it is the building occupants who are ultimately responsible for their use. It is therefore important that the building occupants fully understand the controls strategy, how the controls work, and how they can interact with them.

Electric lighting is not generally needed when a space is unoccupied or when there is adequate daylight. The lighting control system should therefore enable the lighting to be controlled in zones related to the level of daylight received. For example, luminaires in a well day-lit perimeter area, close to windows, should be controlled separately from luminaires deeper in the room.

The control zones should also be related to the use of the space. Lighting of circulation areas, for example, should be controlled separately from the general lighting.

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Lighting controls can either switch lighting on or off, or vary the light output of the lamps by dimming or 'regulating' its output. Fluorescent lamps controlled by regulating high frequency ballasts can be dimmed to provide a wide range of light outputs, typically between 1% and 100% of the lamp's maximum output. The use of these ballasts in a lighting design, allows for the unobtrusive and flexible control of lighting by either manual or automatic means.

Manual control by the occupant can be accomplished either directly using a dimmable wall switch or remotely by means of, for example, a hand-held infrared transmitter. Automatic control can be achieved by a simple time switch or by sensors responding to available daylight or to the occupation of the space.

Daylight levels can be measured using photocells. Occupation of the space can be sensed by detecting movement, noise or body heat. Control signals can be transmitted either by the use of a low voltage bus or as high frequency pulses on the mains supply wiring.

The main factors that influence the specification of controls include occupancy patterns, the amount of available daylight, the type of luminaire (e.g. can it be dimmed?), the desired level of control sophistication and, of course, costs.

Control systems for use in hospital or health care buildings must be fully considered before being included in the design. By their nature, such systems can involve conflicts with nursing and clinical procedures. Occupancy-sensing devices should not be used in any clinical or ward areas.

11.2 Energy efficiency and good design practice

Due to the operational nature of hospitals and health care buildings, their overall energy consumption can be, and usually is, extremely large. The lighting represents a substantial proportion of the overall energy consumption. It is essential therefore to ensure that energy efficiency is central to the lighting design and reflects current good practice. All new installations should try to better the current minimum efficacy value of 45 luminaire-lumens per circuit watt (*note*: this value is likely to increase during the life of this Lighting Guide). With careful design this efficacy can be increased to 60 luminaire-lumens per circuit watt. Careful design at an early stage will provide long term energy savings.

In an effort to increase the installed efficiency of any lighting design proposals this Lighting Guide introduces a design energy efficiency rating (DEER) system aimed at encouraging responsible lighting design. In line with the requirements of Building Regulations Approved Documents L2[1] in England and Wales, and Section 6 of the 2007 Technical Handbook[41] in Scotland, the DEER system uses the target values published within these documents as a base level or 'statutory minimum'. It then extends the scheme by introducing two higher levels of efficiency called 'best practice' and 'exemplary'.

Therefore the three levels and corresponding energy target values are as follows:

- DEER level C = statutory minimum = 45–59 luminaire-lumens per circuit watt (inclusive)
- DEER level B = best practice = 60–65 luminaire-lumens per circuit watt (inclusive)
- DEER level A = exemplary = 66 and above luminaire-lumens per circuit watt

For more information on the DEER system, together with an explanation of how to calculate the level for a project, see section 1.2.2 and Appendix A1 where a sample work sheet is provided.

Greater use of control products and automated luminaire control strategies within the design will provide far better efficiency returns than relying on good housekeeping practices alone. It will also help encourage good

energy management if the lighting design stipulates the use of sub-metering the lighting supply to various areas of the hospital (see CIBSE TM39: *Building energy metering*[42]). This will help the facilities manager to understand and better regulate the use of energy within the various departments of the building.

11.3 Types of control

Manual switching is the most common method of control but can lead to wastage. Careful consideration should be given to zoning, especially in deep plan areas. Labelling of switches assists in the correct use of zoned lighting.

11.3.1 Switching

Local switching at workstations is required where local or localised lighting has been adopted. Presence detection units such as passive infrared (PIR) or microwave devices can be useful for saving energy in storerooms, cupboards or any areas that may be occupied for short periods.

11.3.2 Selective switching

Manual selective switching may be applied to one or more lamps in a multi-lamp luminaire or to one or more luminaires in an installation. Single switching or two-way switching may be used.

Time switches can be set to switch on or off at the desired times. It is recommended that digital-type time switches be used in series with photocells. The most common application for this type of switch is external lighting but there may be internal corridors where natural daylight may be exploited.

11.3.3 Daylight linking

One or more of the luminaires adjacent to windows may be linked to internal photocells to monitor daylight and adjust the electric lighting accordingly by dimming or increasing the lamp output. One practice that should be actively discouraged is the use of daylight sensors which switch out certain lamps or luminaire rows adjacent to windows without first dimming the lamps to their lowest level. The practice of switching off luminaires when the lamps are at full output is not only distractive, while the occupants visually adapt, it also lowers the quality of the lit space by creating a visual imbalance at various times of the day.

11.3.4 Constant illuminance

Designing for maintained illuminance means that initially, when the lamps are new and both the luminaires and room surfaces are clean, the illuminance will be substantially higher that the design level.

The actual level achieved will depend on the characteristics of the installation and the maintenance programme the end user intends to follow. The use of regulating high frequency ballasts allows the luminaires to be linked to photocells which monitor the characteristics of the installation and 'maintain' the lighting at the designed illuminance value. The reduction in the energy consumed is returned to the end user as an energy saving. As the system ages the controls will automatically increase the power to the lamp. Eventually, the system will operate at full load in order to produce the maintained illuminance, at which time maintenance is required.

The same control system can also cover change of use. If the function of an area changes then the control system or photocell can be re-programmed to provide the light level required for the new function.

11.3.5 Occupancy control

Lighting linked to occupancy or, more appropriately, occupancy pattern, can show considerable savings in energy usage. Another example of occupancy detection saving is where a detector sensing the approach of a building user switches the lighting between a 'non-occupied' illumination level and a higher 'occupied' level.

A predetermined time delay should be built into the control system to avoid excessive switching, which can shorten lamp life.

11.3.6 Automatic control

In its simplest form a timer control system may switch the lighting installation on and off at predetermined times, or it may be programmed to send signals at certain times during the day to switch off selected luminaires.

If daylight is sufficient, or lights are switched off in unoccupied areas, it is unlikely that these will be switched on again until needed. This type of system can be used in selected areas for providing reduced lighting levels early in the morning or evening to cover cleaning and security operations. Local manual override switching is essential when automatic controls are used. Security requirements may also demand general override control to cover any emergency conditions at night.

Occupancy detectors are used to detect the presence of people and to control the lighting accordingly. These can rely upon acoustic, infrared, microwave or other methods of detection. A time lag must normally be built into the system to prevent premature switch-off or excessive switching cycles.

Automatic control is generally undertaken by using one of two methods. The first is the use of stand-alone devices within certain areas where there is a specific control requirement. This method can be expanded to cover larger areas or even complete buildings. This is done by using a larger number of stand-alone devices linked together to provide communication between the devices, thereby increasing the functionality of the system.

The second method of automatic control uses control systems intended to be linked together to cover the whole building, and receive information from one or more sensing devices. This type of control system can be further divided into two types: those specifically designed to control the lighting only and those intended to control a number of systems. Multiple system control types are usually referred to as building management systems (BMS). What generally differentiates a BMS from a dedicated lighting control system is that a BMS will usually control all the building services, such as the heating, ventilation and boiler control functions, as well as the lighting.

Building management systems are usually complex and expensive, using high levels of communication and software control for operational and reporting purposes. Because of this complexity, BMSs can usually address every luminaire in order to programme the appropriate lighting within individual areas. Therefore alterations can be made to the lighting by adjustments made on the computer. This, combined with local override control, means that changes can be made without the need for expensive relocation of luminaires and alteration to switching arrangements. This facility was regarded as one of the main advantages offered by a BMS over other systems. However, dedicated lighting control systems are now available that can equal or exceed the functionality offered by BMS at a much reduced cost.

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Introduction

Hospitals and health care buildings are among the most complex and varied that a lighting designer will meet. In undertaking such a role, the lighting designer will have to satisfy two very important considerations.

The obvious and most important will be to meet the many and diverse task requirements demanded of each area within the building. Some of the tasks to be carried out will require specific and exacting levels of visual performance. The very safety of its occupants depend on it: not only must the performance be met, but it must also be maintained throughout a series of possible supply interruptions. Achieving performance standards for visual tasks will be the very least that is required of the designer to ensure the safety of patients, staff and visitors.

The second and almost equally important consideration will be to create an environment that is visually satisfying, wholly appropriate and 'emotionally compatible'. Understandably, publications aimed at advising lighting designers within the healthcare establishment generally focus most of their attention on the issue of technical excellence; but lighting has always been more than just providing for the visual task, it has to be about the illumination of spaces, enhancing and describing the architecture and, more importantly, it can be a producer of emotion and a sense of well-being. Good lighting will also help promote an air of quality and competence within the hospital, providing a welcome reassurance for patients and help a great number of patients and visitors feel more positive about their experiences there.

One of the major challenges facing the National Health Service (NHS) today is finding ways to reduce their energy consumption. Hospitals have seen a large increase in their energy usage in recent years and this, together with increasing energy costs, are starting to soak up a significant part of the NHS's annual budget. In response to requests from the Department of Health to look at ways to help reduce their energy needs, this publication introduces a 'design energy efficiency rating system (DEER). The system is aimed at rewarding greater levels of design responsibility with increased installed efficacies. The DEER rating system is based on Building Regulations Approved Document L2[1] requirements for conservation of fuel and power, packaged in such a way as to encourage a greater awareness of energy efficiency in design. Full details of the proposals are given in section 1.2.2.

The section on colour and architecture further exploits the influence that total appreciation and coordination of design philosophies can have on the finished building. Projects have increasingly used the technical and task requirements as a 'minimum achievable' benchmark. They should all now aim to produce creative elements in all areas where it is essential to craft a quality feel to the space. Quality lighting has to be viewed as crucial in its contribution to the through-life costs and performance of the building, and not just as an unnecessary erosion of profit. Furthermore, while it is understood that no project, irrespective of its size, is without its budgets, the lighting designer must, in addition to the initial capital costs, take into consideration the ongoing energy and maintenance costs together with its eventual disposal cost, i.e. its 'whole life cost'. Whole life cost, however, must also take into account the quality and effectiveness of the visual environment; if it enhances the performance of the staff or the recovery of the patients then it will be money well spent. It would also only represent a tiny part of the overall cost of the hospital.

Mindful of the fact that many 'non-technical' people may be involved within the design team, and within the project as a whole, this publication requires certain deliverables to assist all interested parties in visualising the finished results, prior to installation. This helps avoid interested members being daunted by incomprehensible jargon, and will encourage them to contribute

earlier in the discussions. Lighting designers should utilise the power of modern lighting design software, now widely available, which renders images to ‘photo-realistic’ standards.

If daylight is sufficient, or lights are switched off in unoccupied areas, it is unlikely that these will be switched on again until needed. This type of system can be used in selected areas for providing reduced lighting levels early in the morning or evening to cover cleaning and security operations. Local manual override switching is essential when automatic controls are used. Security requirements may also demand general override control to cover any emergency conditions at night.

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Appendix A1: Sample work sheet (DEER)

Design Energy Efficiency Rating (DEER): sample worksheet										
(a) Area	(b) Area description	(c) Luminaires used	(d) Quantity	(e) Total circuit watts per luminaire	(f) Total lamp lumens (total lamp lumen output x (d) x luminaire LOR)	(g) Total lamp lumens per area (sum of (f) for each area)	(h) Luminaire control factor per area	(i) Corrected luminaire output ((g) ÷ (h))	(j) Total area circuit watts (sum of (d) x (e) for each area)	(k) Area luminaire-lumens per circuit watt (i) ÷ (j)
1	12 m section of corridor ≤ 2 m wide	2 x 18 W downlights with glass attachments	6	38	10080	10080	0.9	11200.0	228	49
2	12 m section of corridor ≥ 2 m wide	3 x 28 W T5 modular recessed luminaire with low glare	5	95	34710	34710	0.9	38566.7	475	81
3	Single bedded ward	2 x 18 W downlight	1	38	1440	4248	1	4248.0	92	46
		2 x 26 W Bed head	1	54	2808					
4	4-bedded ward	2 x 18 W downlight	2	38	2880	16650	1	16650.0	325	51
		2 x 26 W Bed head	4	54	11544					
		1 x 28 W 2D circular	1	33	2226					
5	Reception area	2 x 18 W downlight	8	38	11520	15840	1	15840.0	418	38
		2 x 18 W downlights with glass attachments	3	38	4320					
6	General admin office	1 x 55 W PLL modular recessed luminaire with low glare attachment	40	57	168940	168940	0.85	198752.9	2280	87
7	Doctor's consulting room	2 x 28 W T5 surface prismatic controlled luminaire	2	66	9152	9152	0.9	10168.9	132	77
8	Recovery room	1 x 55 W PLL modular recessed luminaire with very low glare attachment	12	57	41904	54696	1	54696.0	882	62
		2 x 28 W T5 modular recessed luminaire with very low glare attachment	3	66	12792					
9	Minor operating theatre	3 x 28 W T5 recessed IP65/65 luminaires with prismatic controllers	2	95	10140	10140	1	10140.0	190	53
10	Major operating theatre	4 x 28 W T5 recessed IP65/65 luminaires with prismatic controllers	6	124	40560	40560	1	40560.0	744	55
									Total gross area luminaire-lumens per circuit watt	600
									Design Energy Efficiency Rating = total gross area lumens per circuit watt ÷ number of areas considered (i.e. 600 ÷ 10)	60
Project Design Energy Efficiency Rating = 60 luminaire-lumens per circuit watt (average) = Level B = 'Best Practice'										

Appendix A2: Luminaire installation/maintenance schedule

Luminaires					
Item	**Description of work**	**Monthly**	**3-monthly**	**6-monthly**	**12-monthly**
Cleanliness	Clean fittings where necessary				✓
All lamps within all areas	Check for failed lamps or signs of deterioration Spot replacement should be performed on a regular basis within all areas	Each area should be assessed to determine an economical period for a complete lamp replacement or obtain the information from the lighting O&M manuals			
Re-lamping	Contract should be specific with regard to responsibility of replacing lamps				✓
Security of fitting	Check security of fixings and suspensions				✓
Cable connections	Check externally for security and signs of arcing or overheating				✓
Flexible down leads and connectors	Check for deterioration, renew if necessary				✓
Diffusers and reflectors	Clean and correctly adjust before re-assembly				✓
Lamp control gear	Check operation and compatibility with lamp				✓
External luminaires including signs					
Item	**Description of work**	**Monthly**	**3-monthly**	**6-monthly**	**12-monthly**
General condition	Clean and check for physical damage, signs of water ingress or condensation, if present check seals and report to client			✓	
Electrical wiring	Check integrity and report to client if renewal necessary				✓
Earth continuity	Check and remedy if necessary			✓	
Lamps or tubes	Check for failed or blackened tubes or lamps Replace as necessary				✓
Cold cathode tubes	Check for faulty tubes or low brightness Replace or re-process as necessary				✓
Control gear	Check for correct operation				✓
Security of fittings	Check condition and security				

Self-contained emergency lighting					
Item	**Description of work**	**Monthly**	**3-monthly**	**6-monthly**	**12-monthly**
Testing	To be carried out monthly in accordance with BS 5266: Part 1: 1988 All tests shall be logged as per Appendix C of BS 5266	✓			
	Test for one hour			✓ (optional)	
	Test for three hours				✓
Operation	Check operation, if failure is suspected replace lamp	✓			
Battery	Check condition and date of expected life Renew if necessary				✓
Central battery emergency lighting					
Item	**Description of work**	**Monthly**	**3-monthly**	**6-monthly**	**12-monthly**
Testing	To be carried out monthly in accordance with BS 5266: Part 1: 1988. All tests shall be logged as per Appendix C of BS 5266	✓			
	Energise from battery for period of one hour			✓	
	Test for three hours under full load conditions				✓
Operation	Check operation, if failure is suspected replace lamp				✓
Battery or batteries	Ensure terminals are clean and check electrolyte level Check condition of battery case(s).			✓	
Battery charger	Check operation and proper functioning			✓	
Hazardous area emergency luminaires					
Item	**Description of work**	**Monthly**	**3-monthly**	**6-monthly**	**12-monthly**
Condition	Check for mechanical damage or signs of corrosion			✓	
Self-contained emergency luminaires	Testing regime as detailed under ‘Self-contained emergency lighting’ section above				
Central battery controlled emergency luminaires	Testing regime as detailed under ‘Central battery emergency lighting’ section above				

Category continues

Hazardous area emergency luminaires (continued)					
Item	**Description of work**	**Monthly**	**3-monthly**	**6-monthly**	**12-monthly**
Seals	Check condition and replace as necessary			✓	
Cable and conduit entries	Check condition of seals				✓
RCDs (if fitted)	Test the tripping operation Test with approved RCD tester		✓		
Earth fault loop impedance	Check			✓	
Labels and notices	Check for presence, clean and check security of fixing			✓	
Integrity	Check installation for mechanical damage			✓	
Fitting and cover	Clean and check condition. Examine for incipient cracks in glass or retaining cement			✓	
Lamp	Replace on a planned basis as appropriate			✓	
Cable and conduit entries	Check condition of sealing rings etc.			✓	
Return to service	Ensure that any seals are correctly in place and the correct number and type of cover bolts are used			✓	
Lifts					
Item	**Description of work**	**Monthly**	**3-monthly**	**6-monthly**	**12-monthly**
Lift car interior	All indicator lamps, car illumination and emergency lighting (if fitted) shall be functionally checked and replacement lamps and tubes fitted as required		✓		
	Lighting diffusers to be cleaned and if damaged repaired or replaced		✓		
	Emergency lighting shall be operationally checked on each visit for a minimum of 1 hour duration and recorded on the sheet as to its condition All electrical switches shall be cleaned and checked for operation		✓		

33 Council Directive 92/58/EEC of 24 June 1992 on the minimum requirements for the provision of safety and/or health signs at work (ninth individual Directive within the meaning of Article 16 (1) of Directive 89/391/EEC) *Official J. of the European Union* **L245** 23–42 (26.8.1992) (Brussels: Commission of the European Union) (1992)

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