SPORT ENGLAND

Design
Guidance Note

Creating a sporting habit for life

Artificial Sports Lighting

Updated guidance for 2012

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Artificial Sports Lighting

Design Guidance Note

Foreword

Sport England believes that good facilities are fundamental to the development of sporting opportunities for everyone, from the youngest beginner to the international class athlete. The buildings, whether large or small, can encourage civic pride and assist the process of revitalising deprived neighbourhoods. Facilities that are well designed, built to last and well maintained are a pleasure to use and give an ample return on the time and money invested in their construction.

Good design needs to be based on a sound understanding of issues such as current trends and practices within individual sports, developments in the sport and leisure industry, technical developments in architecture and construction and the lessons to be learnt from previously built schemes.

Good design needs to be embraced within the earliest vision statement for any project and enshrined in the initial briefing stage through to the final detailed specifications and operational arrangements.

Sport England's Design Guidance Notes aim to:

- ***Increase awareness of good design in sports facilities***
- ***Help key building professions, clients, user representatives and other stakeholders to follow best practice***
- ***Encourage well designed sports facilities that meet the needs of sports and are a pleasure to use.***

Sport England Design Guidance Notes are provided to help promote a greater understanding and appreciation of overall design concepts, of technical issues and of the critical factors that need to be considered in reaching appropriate solutions for a particular project. They also advise where further information, advice and expertise may be found and point to benchmark examples.

Artificial Sports Lighting

Design Guidance Note

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1.0 Introduction

The creation of an appropriate visual environment is a fundamental requirement in sports design and the effective integration of the artificial lighting system should be considered as a standard part of a modern sports facility.

This Design Guidance Note considers artificial sports lighting for both internal and external sports activities and identifies those that have special requirements. Its aims are:

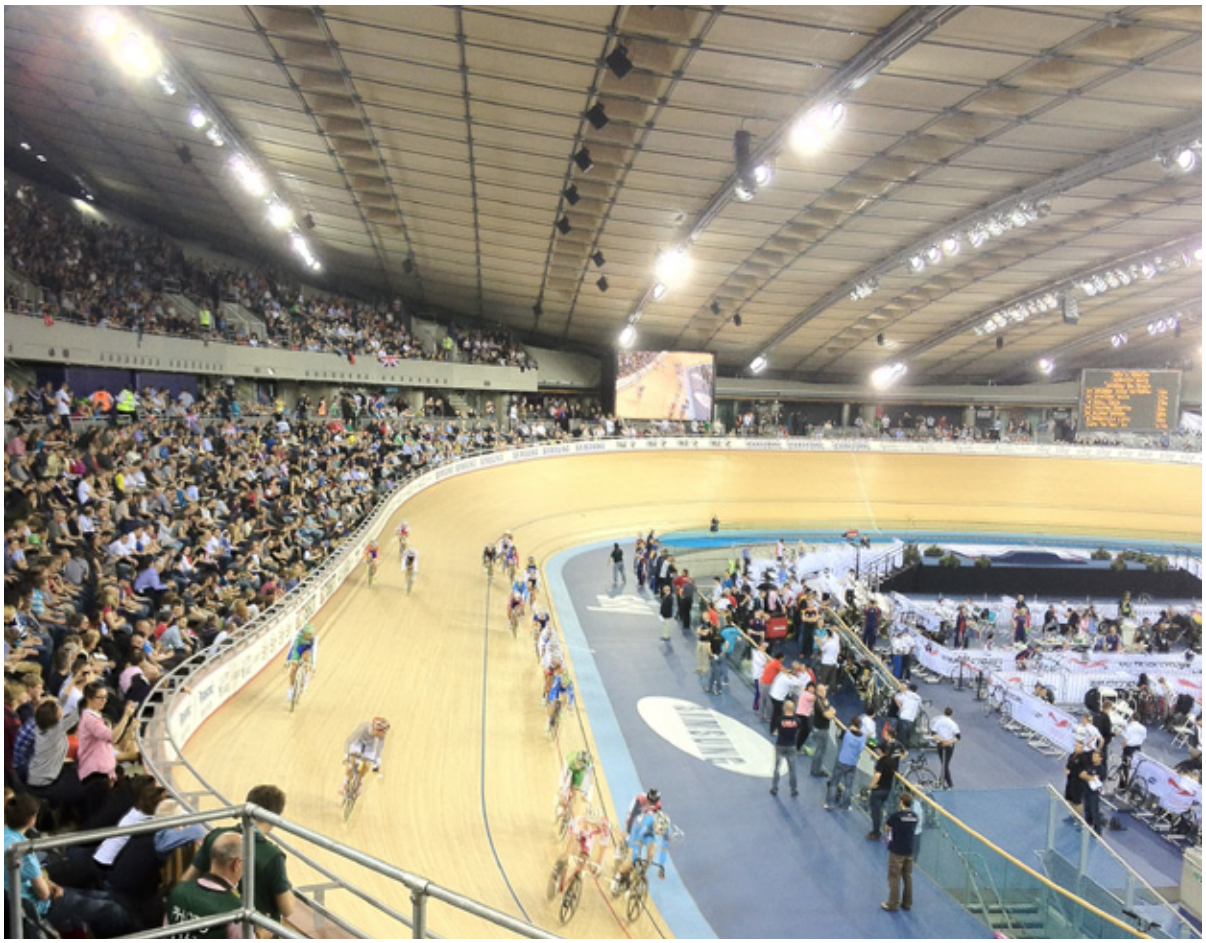
- To give a basic explanation of a complex subject
- Updating basic industry guidance on the types and levels of lighting needed for different sports – See Appendices 3 and 4
- To cross-reference to other sources of information.

The principles of lighting design are illustrated by a few descriptive outlines referring to specific sports and activities. Similar methods and principles can be used in the procurement of lighting for any sport or mixture of sports.

General benefits

The general benefits of good artificial lighting can be readily understood:

- Indoors, artificial lighting helps designers to provide consistent, uniform, adequate lighting levels, sometimes using artificial lighting alone and sometimes with supplementation by daylight
- In facilities such as swimming pools, artificial lighting is essential for the maintenance of safe conditions
- Outdoors, providing artificial lighting on a sports facility greatly extends the hours of play, particularly in winter
- The high, uniform levels of light necessary for many televised sports events can only be ensured through artificial lighting.



Technical complexities

Lighting is a subject area with a high degree of technical complexity that can be difficult to understand.

The complicating factors which need to be taken into account in developing a lighting design may include:

- The varying and conflicting requirements of individual sports in a multi-sports context
- A lack of appreciation of the needs of some individual sports that are particularly sensitive to poorly designed lighting
- Complex inter-relationships with other elements of the building such as:
  - Reflectance and colour of surfaces
  - Variation in background surfaces
  - Configuration of walls and roof
  - Location of structural supports
- Wider inter-relationships with issues such as:
  - User satisfaction
  - Overall sustainability
  - Energy usage
  - Environmental factors
  - Availability of a suitable electrical supply
- Health and safety issues, for example in swimming pools or in fast moving ball games such as cricket or hockey, where the maintenance of a good lighting system is a fundamental requirement.

Professional advice

This Design Guidance Note is not intended to be a substitute for appointing the appropriate professionally qualified organisations, who will be required to develop the:

- Sports lighting performance requirements into acceptable design solutions and specifications
- Other environmental lighting that will be required for support areas in and around the building or outdoor pitch
- Related systems such as electrical supply, wiring and controls.

For information on the selection of specialist lighting consultants and contractors, consult:

- ***The Society of Light and Lighting (CIBSE)***
- ***Sports and Play Constructors Association (SAPCA)***
- ***Sport England's framework list of lighting contractors.***

2.0 Design Issues

General requirements

It is important that the lighting requirements of each sport are fully understood at the outset of a project. This requires an understanding of the nature of the sporting activity and key characteristics. Many sports involve swift player actions and reactions and involve relatively small objects such as shuttlecocks and balls travelling within three dimensions at very high speed.

Design Considerations

Lighting installations for sport should balance the following issues within an integrated design:

- ***Levels of illuminance***
- ***Uniformity of illuminance***
- ***Contrast***
- ***Glare control***
- ***Colour rendering***
- ***Compliance with statutory regulations.***

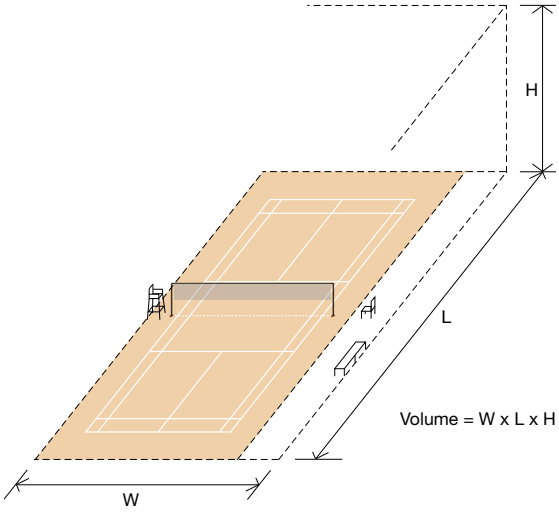
Volume of the field of play

The whole of the three-dimensional volume above and including the field of play should be considered, rather than just the two-dimensional surface of the playing area.

This can include:

- Safety zones around the playing area
- Space reserved for officials and team benches
- The underwater volume in the case of a swimming pool
- Spectator facilities.

Where events are televised, or for sports which involve great use of the height above the playing area - for instance badminton, athletics throwing events, cricket, rugby - consideration of the full volume is especially important. In lighting engineering terms, this means considering both horizontal and vertical planes for the full volume of the field of play.



Consider the full volume of the sports space to be illuminated

For example, a lighting scheme for badminton should not be based solely on illuminance on the floor, when the path of the shuttlecock can be anywhere in a playing volume 7 - 9 m high.

As well as the area bounded by the pitch or court perimeter line (the '*Principal Area*'), additional safety or run off zones (making up the '*Total Area*') will need to be lit. Consideration must be given to the lighting levels both on the surfaces of and in the volume above each of these zones.

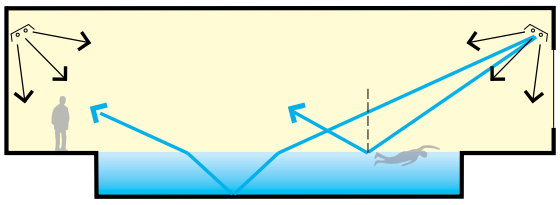


Fig.1 Visibility issues need to be considered throughout the volume of the field of play

For up-to-date information on sports dimensions, see the Sport England 'Sports Data Sheets' and the Sport England Guidance Note 'Comparative Sizes of Sports Pitches and Courts'.

Even illumination

Generally, the full volume of the field of play should be illuminated evenly to create equal playing conditions for all players and to create a consistent level of visibility. Changes in illuminance levels can create difficulties in judging the speed and the trajectory of the playing object.

Sports areas should be lit so that those taking part and those watching can see clearly all that is going on. This calls for suitable brightness and contrast over the playing area, sufficient light at all points, correct distribution of light and adequate control of glare. Playing objects will be seen because they contrast with their background in brightness, colour or both. The more marked the contrast, the more clearly objects are perceived in general. For instance, for Badminton a reduction in illumination behind the court is preferred to achieve an acceptable background contrast. (See section on Badminton, page 16.)

Contrast in illumination levels and shadows should be avoided in the field of play

Lamp types

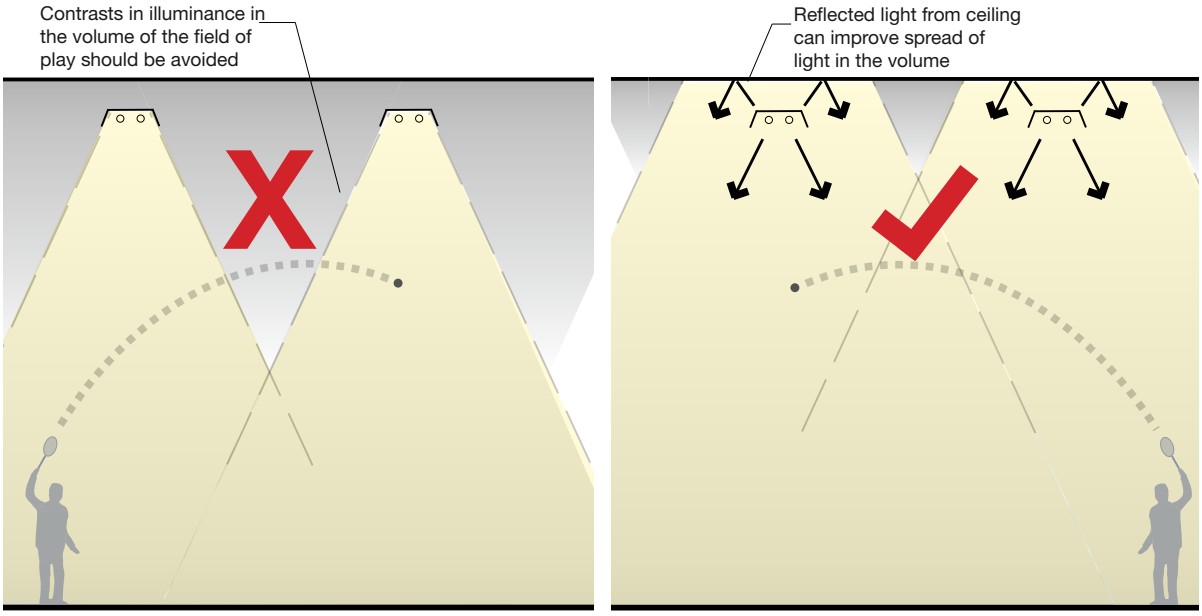
There is a variety of different lamp types used for sports lighting, as shown in the table below. Their characteristics differ and manufacturers are continually developing improved products. Selection is often made on the basis of colour of light emitted, energy consumption and life expectancy.

Types of lamps	
Indoors	Tubular fluorescent
	Compact fluorescent
	Metal halide
	High pressure sodium
	Light emitting diode (LED)
Outdoor	Metal halide
	High pressure sodium
	Tungsten halogen

For both indoor and outdoor sports, sodium lighting will only be acceptable where its relatively poor colour rendering can be tolerated. Tungsten halogen lights are inexpensive, but inefficient. Metal halide lamps are efficient and give good colour rendering. They are specifically recommended by some National Governing Bodies for Sport (NGBs). For indoor use, fluorescent lamps offer a good balance between cost and efficiency.

Light emitting diode (LED) lights are starting to be offered for sports lighting purposes. A decision as to whether or not to use LED lights is complex, because there are many variables to consider and because LED technology is advancing rapidly.

For further information on LED lighting for indoor and outdoor sports, see Appendix 2.



Even illumination is required in the full volume of the field of play

Levels of illumination

The level of illumination that is appropriate for a particular sport should be checked with the requirements of the National Governing Body (NGB) or the organisation that is promoting a particular event. This can vary with the level of play and competition. Verification that minimum standards are being achieved can be a requirement for each individual event, as in the case of hockey.

The *CIBSE Lighting Guide 4 2006* and *BS EN 12193:2007* give general recommendations for the range of lighting standards. However, it should be noted that in some cases, these differ from the requirements of the NGBs requirements as noted in Appendices 3 and 4.

Glare

The complete elimination of glare in sport is difficult to achieve due to the ever-changing directions of view of participants. Nevertheless, measures should be taken to minimise glare that may affect the visual performance of participants.

When attempting to minimise the likelihood of glare, the factors over which a designer has control are;

- Selection of luminaires designed with attention to the avoidance of glare.

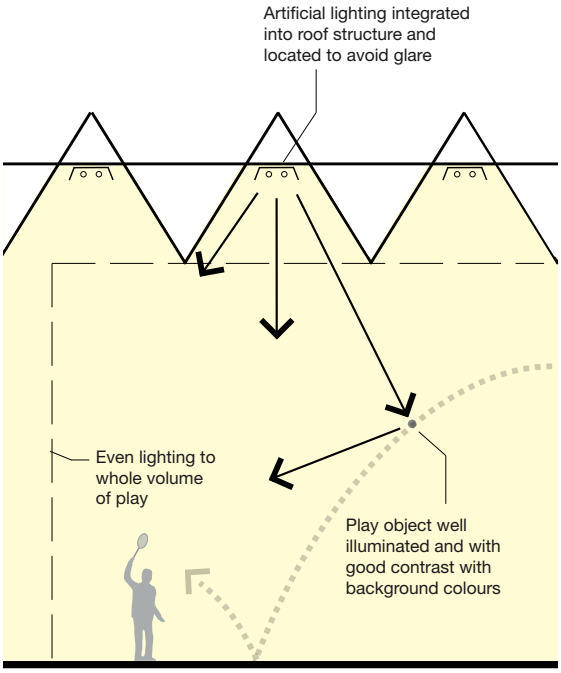
  In designing a luminaire, there are two main methods of avoiding causing glare, which are;

  - to make any direct view of the light source impossible by placing it deep within the luminaire, behind baffles
  - to use low-intensity light sources, such as fluorescent tubes.

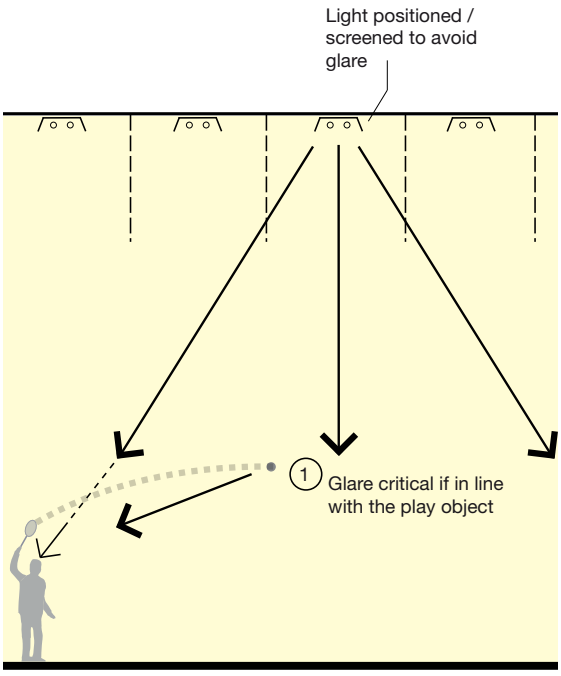
- The locations of the luminaires.

  Where possible, luminaires should be located in positions which mean that players will not need to look towards them or in their general direction in the course of a game, for example behind the badminton baseline.

Inappropriately located lights can cause discomfort glare



Natural and artificial lighting sources integrated with building structure



Lighting should not be located in direct line of sight of the player

Indoors, generally down-lighter type luminaires should be used that incorporate some glare control with some degree of back lighting to avoid high levels of contrast.

Outdoors, the use of high-intensity discharge lamps because of their high light output and efficiency means that any view of a light source will cause glare. Use of baffles might prevent direct sight of the light source, but is avoided by most manufacturers because it reduces the efficiency of the luminaire.

The locations of luminaires relative to directions of view should be considered carefully. Some NGBs have very specific requirements relating to the positioning of luminaires in relationship to the court markings and field of play. Examples are badminton, where fittings must not be over the actual courts, and basketball and netball, where there are minimum distances from the goals. Both the International Hockey Federation (FIH) and FIFA stipulate a minimum angle of 25º above the horizontal from the pitch centreline to the lowest luminaire and FIFA guidance states that the columns should not be within 10º of the goal line, measured from the centre of the goal. Always consult the NGB rules and *BS EN 12193:2007.*

In sporting environments, similarly to indoor working conditions, glare should be calculated using the unified glare rating (UGR) method and limiting values used shall be those specified in *prEN 12464.*

Colours of surfaces

The colours of the surfaces in a sports hall - walls, ceiling, dividing nets - are often important because the play object will be seen against them. Choosing the right colours can help make the play object more visible. For example, a mid-range reflective surface helps badminton players see a white shuttlecock and a surface of higher reflectance helps players see the flight of a red cricket ball.

The brightness of a surface depends on its colour and its reflectance or LRV.

Levels of play

The general levels of play for sports activity are defined in the *CIBSE Lighting Guide 4* and similar definitions are used in the more recent *BS EN 12193:2007.* However, they can be very difficult to interpret in that they use general, overlapping terms that might not correspond exactly with the types of use that are to be accommodated.

Sport England use a more descriptive approach although some NGBs have their own methods, different again, of classifying the levels of play in their particular areas of expertise. Lighting levels should be compared with the requirements of individual NGBs and / or the promoter of a particular event.

The table below provides guidance on the new level of play categories for each sport as agreed by the NGBs and Sport England.

	Basketball	Netball	Badminton	Volleyball	Cricket
International This category relates to the lowest level of International play [1].	International	International and Super League	International High Performance Centres	International	N/A
Premier This category relates to a Premier / National League Club competing in regional or Inter county competitions	Senior EBL Men Division 1 and 2, Women Division 1	Regional and Premier League	Inter-County Championships BADMINTON England Tournament Circuits Premier Club in a Performance Centre	National League Club	N/A
Club This category relates to a local club competing in District and County League competitions.	Senior EBL Men Division 3 and 4, Women Division 2 EBL Youth Leagues	Local club and inter county competition	Premier Club in a Community Badminton Network	Club	Club
Community This category relates to school and community use where there is no formal competitive structure / no specific need for space for officials or spectator accommodation.	Recreational	School and recreational use	Recreational Club	Practice and school sport	Educational

[1] For higher levels of international competition, such as major championships, the relevant NGB should be consulted at a very early stage as the requirements vary considerably.

Visual impairment

The term 'visual impairment' refers to a permanent loss or reduction of the visual function.

The illuminance values typically quoted in lighting references are those relevant to individuals of forty years of age. These take no account of the effects of the ageing eye, the changes in which can be sub-divided into physical and perceptual changes.

The most common age-related changes in vision and their effects on everyday activities can include the following:

- Decreased ability to focus close up
- Increased lighting requirements
- Increased sensitivity to glare
- Reduced contrast sensitivity
- Decreased colour sensitivity
- Increased time required to adjust to bright light and / or darkness
- Decreased ability to judge depth.

Such changes can, either individually or in combination, typically give rise to a requirement for increased illuminance levels when older people are carrying out similar visual tasks (refer to *CIBSE LG4* for further information). Estimates vary but typically, a 60 year old needs twice as much light to do the same task as a 20 year old.

Increased lighting levels may remedy some of the problems experienced by older individuals but this can also sometimes cause further problems by increasing the risk to others who may be more easily affected by sources of glare.

The ability to control the light output from an installation using selective switching may provide some improvement in playing conditions but it has to be appreciated that this will only be of benefit to those players who suffer from the same or similar types of visual impairment.

See separate Sport England Design Guidance Note 'Accessible Sports Facilities' for advice on creating a 'confusion free' visual environment within sports buildings that includes:

- ***Careful location and control of natural and artificial lighting***
- ***Accentuation of contrast and texture to help people with visual impairments***
- ***Gradual changes in lighting levels from area to area***
- ***Avoidance of shadowing at key areas such as reception desks***
- ***Control of glare and shinny and reflecting surfaces***
- ***Avoidance of spot lights and up lighters set in the floor.***

General emergency and safety lighting

Emergency lighting, which is covered by *BS 5266*, is required in the event that the main lighting system might fail. Part 7 of *BS 5266* includes the total requirements of the *European Emergency Lighting Standard – EN 1838.*

The classification of buildings and the areas within that require emergency lighting are defined in the Building Regulations *Approved Document B – Fire Safety.* See *CIBSE Technical Memorandum 12: Emergency Lighting* which includes the design aspects of conventional emergency lighting.

There are two major subdivisions of emergency lighting i.e. 'escape lighting' and 'standby lighting'. Escape lighting is provided for safety reasons to ensure safe and effective evacuation of a building in an emergency, while standby lighting may be provided to enable normal activities to continue despite an emergency.

Sport specific safety issues

For sports applications, standby lighting can be further subdivided into 'safety lighting' and 'continuation of an event'. The degree of standby lighting provided will be influenced by the nature of the activities being undertaken, the duration of the activities and the level of associated risks involved.

BS EN 12193:2007 provides guidance on 'safety lighting', the purpose of which is to ensure that in the event of a power failure a sporting activity can be safely stopped without causing injury to participants.

Provision of standby lighting with the purpose of allowing events to continue to their conclusion in the event of failure of the main lighting system is not usually economical. Exceptions will be provision of alternative cover for major events, where loss of lighting would cause unacceptable cancellation.

The lighting level for the safe stopping of an event is a percentage of the level for that class. This applies to the following sports and percentages listed below:	
Sport	**% for minimum period (seconds)**
Swimming	5% for 30s
Indoor gymnastics	5% for 30s
Indoor and outdoor equestrian	5% for 120s
Speed skating	5% for 30s
Bobsleigh and toboggans	10% for 120s
Ski jump and landing	10% for 30s
Ski slopes	10% for 30s
Cycle racing	10% for 60s
The safety lighting shall come on the instant the general lighting fails and last for at least the period specified.	

***BS EN 12193:2007* safety lighting levels and minimum periods**

See also the following publications:

- *The Good Practice Safety Guide for small and sporting events taking place on the highway, roads and public places*: Home Office

  http://www.runbritain.com/static/pdfs/rdp/event-safety-guide.pdf

- *Guide to Safety at Sports Grounds - fifth edition*: Department For Culture, Media and Sport publication available from *The Sports Grounds Safety Authority* web site.

  http://safetyatsportsgrounds.org.uk/pubs/sgsa/greengde.php

3.0 Indoor Sports Lighting

General

A good sports lighting system should provide adequate illuminance, suitable brightness, contrast, uniformity of light distribution and satisfactory control of glare for the activities in question.

The lighting schemes will have a major influence on the overall ambience of the playing space.

Many indoor sports facilities cater for a range of activities. Some of these different activities can take place simultaneously, for example in a sports hall divided into sections. There may also be a need to achieve adequate visual conditions for spectators. Non-sporting use such as school examinations and community events may also need to be accommodated.

Where substantial variations in illuminance are required, additional switching of supplementary lighting could be considered.

Developing a design strategy

The table below summarises the key steps in developing a lighting design strategy.

Design Strategy	
Confirm the layout(s) of sports areas	Analyse and prioritise in terms of programme and building operation
Define the volume(s) of the field(s) of play	
Identify adjacent areas with visual links	
Establish the general lighting requirements	See *BS EN 12193:2007* for general illumination
Establish the NGBs detailed requirements and the pattern of lights to be switched around individual courts (in a multi sports situation)	See Sport England / NGB requirements and establish / resolve any conflicts with industry references

Sports lighting should be:

- ***Considered early in the building design process***
- ***Well integrated into the design of the facility***
- ***Not treated as a separate specialist fit-out issue.***

Balancing priorities

It is generally recommended that the lighting design is based on the requirements of the priority activities i.e. the sports that are played most often or have the most stringent requirements. However, all other potential activities should be catered for in terms of basic visual safety and functionality.

For example, in many multi-sports halls in England, a lighting design that caters well for badminton with courts running across the hall will give adequate conditions for the sports that are played along the length of the hall.

However, a common enhancement is to provide additional switchable lighting systems for sports such as cricket or other sports played down the length of the hall that have specific competition requirements. In some cases, or where there are priority activities with widely different or conflicting requirements, this can mean the provision of separate lighting systems - see Sport England's *'Affordable Sports Halls' Appendix 9.*

Standards of illuminance for indoor sports

BS EN 12193:2007 provides guidance on the levels of illuminance for different sports, indoor and outdoor. However, this guidance conflicts in some cases with NGB requirements. Levels of illuminance vary with levels of play. International or Premier level of play will require higher lighting levels than Club or Community level of play.

See Appendices 3 and 4 for a summary table with highlights of key design considerations.

BS EN 12193:2007 also gives the dimensions for the 'principal area' and 'total area' of the field of play. Together with the required heights, these areas define the volume in which illumination is required and which the lighting design must address.

Any other adjacent volumes such as those of any circulation, spectator and storage areas that are visually linked with the field of play should also be considered.

In the case of a multi-sports facility, the requirement of each individual sport must be identified and prioritised.

Other Sport England Design Guidance

There are several Sport England Design Guidance Notes in which relevant information is provided:

- *Accessible Sports Facilities*
- *Affordable Sports Halls*
- *Badminton*
- *Comparative Sizes Check List*
- *Design for Sport on School Sites*
- *Fitness and Exercise*
- *Indoor Bowls*
- *Sports Data Sheets*
- *Sports Halls Design and Layouts*
- *Swimming Pools*
- *Swimming Pools Audit Check List*
- *Village and Community Halls.*

The use of daylight

The use of natural light in indoor sports spaces to augment the artificial lighting system that would normally be required is an issue that often generates conflicting interests.

For some NGBs, natural lighting of indoor spaces is completely unacceptable. The sun or areas of bright sky seen either directly through windows or by reflection from bright surfaces within the sports hall can lead to a level of disability or discomfort glare that will be unacceptable or even dangerous. Any proposal to use natural light requires very careful consideration of how glare can be controlled and how reasonably stable and uniform levels of lighting can be ensured.

Consider the health and safety risk of a flash of sunlight causing badminton players to lose sight of a shuttlecock flying towards them at 200 mph.

Some of the issues can be ameliorated within the design of the rooflights themselves but generally this will incur additional capital costs. These should be carefully considered against the possible energy savings and other benefits that might be accrued across the life of the building.

For example, rooflights can be designed with screening layers to diffuse the incoming daylight and help distribute light evenly over the field of play. Automatic black out blinds can also be incorporated to eliminate the risk of glare at times when critical sports such as Badminton are played. The light output of the artificial lighting system can also be controlled through an automatic dimming system to achieve a consistent level of lighting.

Some of the advantages and disadvantages of using natural daylight to illuminate all or part of a sports hall are covered in the table below.

Advantages	Disadvantages
Maintains a link with the outside world.	Can contribute to an unacceptably high levels of direct and / or reflected glare that can be a health and safety risk for sports such as Badminton.
Engenders a feeling of well-being among the occupants of the space.	
Can contribute energy savings by reducing the hours that the artificial lighting is switched on.	Sudden fluctuations in the intensity of sunlight penetrating into a sports hall through windows can lead to problems in maintaining uniformity of illuminance over the field of play. This can lead to reduction in the ability of participants to accurately judge velocity of sports balls etc.
	Requires north facing fenestration in order to minimise the effects of direct sunlight.
	Can increase energy costs through increase levels of heat loss.

Advantages and disadvantages of using daylight for illuminating sports halls

Multi-sports halls

Introduction

Lighting for sporting applications involves particular characteristics, the sensitivity to which is likely to differ between individuals. Opinions may therefore vary as to the level of acceptability of a lighting installation. Nevertheless, the principal aims and objectives in lighting a sports hall include:

- The provision of a safe, enjoyable environment for players
- The illumination of court markings and key features such as nets and goals for the player and match officials
- The provision of suitable and sufficient lighting for spectators
- The provision of lighting for television broadcasting, where applicable.

The geometry and layout of a sports hall area together with the material, colour and surface finish of internal fabrics used all have an influence on the quality of the final lighting produced. For this reason, it is important that lighting installations for sports halls are considered as an integral part of the initial architectural design with all other necessary building services. Because of their reflectance and colour, the walls, floor and ceiling of the sports hall all influence lighting levels and quality and thus also affect the design and the operating cost of the hall lighting system.

Playing surfaces in sport should, theoretically, appear to have a constant brightness when viewed from all appropriate directions. In practice, however, the extent to which this can be achieved depends largely upon the qualities of the playing surface, including its spectral reflectance and any surface texture, as well as the manner in which it is illuminated.

Illuminance requirements

It is a requirement that every lighting installation complies with current statutory regulations including *BS 5266 Code of Practice for the Emergency Lighting of Premises* and the Building Regulations.

NGBs recommended values of illuminance and uniformity ratio for different levels of activity in some sports frequently undertaken in sports halls are given below. Appendix 3 includes a more complete list of sports, with the recommendations given in *BS EN 12193:2007* and with notes indicating where these recommendations differ from the requirements of NGBs.

Multi-sports facilities

Design of the lighting installation for multi-sports halls is a complex matter in which the conflicts between the requirements of different sports need to be resolved. This matter is considered in some detail in Sport England's *'Affordable Sports Halls'*.

Many sports halls stage several differing sports and in an attempt to maximise the time and space allocation within a sports hall, some of these differing sports may take place at the same time. This has the potential to produce a conflict of interests in respect of simultaneous lighting requirements. There must, however, be flexibility within a lighting installation that will allow selective switching and / or other methods of control to

Lighting requirements for current *'levels of play'* definitions from Sport England's *Sports Data Sheets

	International		Premier		Club		Community	
	Average Lux	Min Uniformity	Average Lux	Min Uniformity	Average Lux	Min Uniformity	Average Lux	Min Uniformity
Badminton	1000	0.7	500	0.7	500	0.7	500	0.7
Basketball	750	0.7	500	0.7	500	0.7	500	0.7
Netball **	1500	0.7	750	0.7	750	0.7	750	0.7
Volleyball	1000 - 1500	0.7	500	0.7	500	0.7	500	0.7
Cricket (indoor) ***	-	-	-	-	750	0.8	750	0.8

Notes:

* See '*Developing The Right Sports Hall'* and '*Sports Data Sheets'* available from the Sport England web site. (These supersede the definitions for levels of play in *BS EN 12193:2007* and *CIBSE LG4 2006*).

** See the *'Affordable Sports Halls'* (ASH) document for indicative designs based on 500 lux with switching down to 300 lux for school / training and other enhancements for higher levels of play.

*** Recommended lighting levels, taken from the ECB's *'TS3 - Indoor Sports Halls with Cricket Provision'* and Sport England's *'Sports Data Sheets'*.

satisfy the demands of differing sports that may be played at varying levels of competition.

As a consequence of the often significant diversity of lighting requirements within sports halls, it is usually recommended that the activity with the most stringent lighting requirements be used as the basis for lighting design. The demands of other sports should, however, be met wherever practical. Where there is limited information on the likely usage of a sports hall, it is generally recommended that a scheme is designed to suit the most common use, usually badminton courts.

It is important to be aware that a sport's lighting requirements may involve luminaire placement, both vertically and in the horizontal plane, as well as lighting levels. The requirements of different sports may well be incompatible and this can lead to a need for, effectively, multiple lighting installations in one hall. Switching arrangements for simultaneous use of a sports hall for different sports are likely to be complex and need to be considered carefully.

Horizontal and vertical illuminance

Lighting references, best practice case studies and design guides generally specify 'horizontal illuminance' i.e. illuminance on the horizontal plane. There is, however, a requirement for suitable and sufficient vertical illuminance e.g. on the bodies of participants and on the equipment required for the playing of sports.

Calculations are therefore based upon the reasoning that when the values of horizontal illuminance specified are attained, the corresponding values of vertical illuminance required for the safe and efficient playing of a sport are usually simultaneously achieved. Values of vertical illuminance should not be less than 30% of the corresponding simultaneous horizontal values, measured at the same locations. Vertical illuminance values are measured 1 m above court level; horizontal illuminance is measured on the court surface. When vertical illuminance is critical, for instance for televised activities, it is separately specified, calculated and measured.

Illuminance gradient

Initial design considerations typically include satisfying horizontal illuminance and uniformity ratio values. Additionally, with some sports illuminance gradients are specified so that rates of change of illuminance are restricted, thereby preventing sharp changes in illuminance over short distances on the playing area. Among other things, this avoids the appearance of 'banding' on the playing surface.

Specialist sports halls

Badminton

Sport England's Design Guidance Note *'Badminton'* and the *Badminton Sports Data Sheets* provide information on the design of dedicated badminton facilities and on the integration of badminton into multi-sports halls.

Badminton requires very carefully designed lighting to enable the game to be played to a good level. When designing the lighting for badminton halls, it is essential to appreciate how the game is played. The shuttlecock can move at very high speeds over the net, requiring maximum light reflectance from its white feathers. The white shuttlecock can best be seen when illuminated against a darker background. The path of the shuttlecock is often high above the net and sufficient vertical illuminance within the overall volume of the field of play must therefore be provided.

Players must be able to follow the flight of the shuttlecock against the background without being troubled by glare or having their attention distracted by bright light sources.

Luminaires must not be directly positioned over the court. Doors and windows to other lit areas are all a potential distraction and arrangements should be made for such light sources to be temporarily screened or switched off.

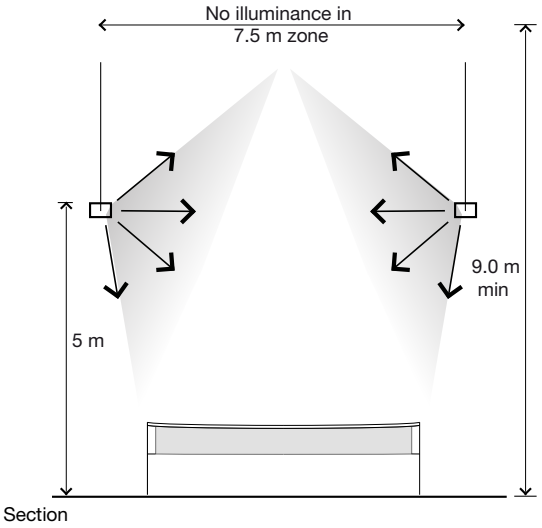
It is often thought that badminton requires very high Illuminance levels but this is not necessarily the case.

Badminton requires lighting throughout the full volume of the field of play and for the luminares to be grouped centrally around the net. Any luminaires towards the rear of the court should ideally be turned off (or controlled) in order to darken the background to give a contrast with the white shuttlecock.

It is essential to consider lighting early in the design process so that the lamp type and locations can be co-ordinated with the court layout and background colours. Lighting and colours should be considered as an entity.

Badminton England recommends 1000 lux for international levels of play and 500 lux for all other levels of play.

Field of play for lighting = 18 x 10.5 x 9.0 m



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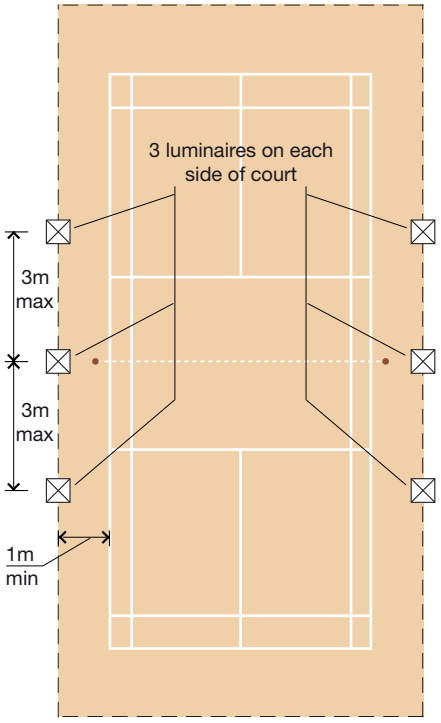
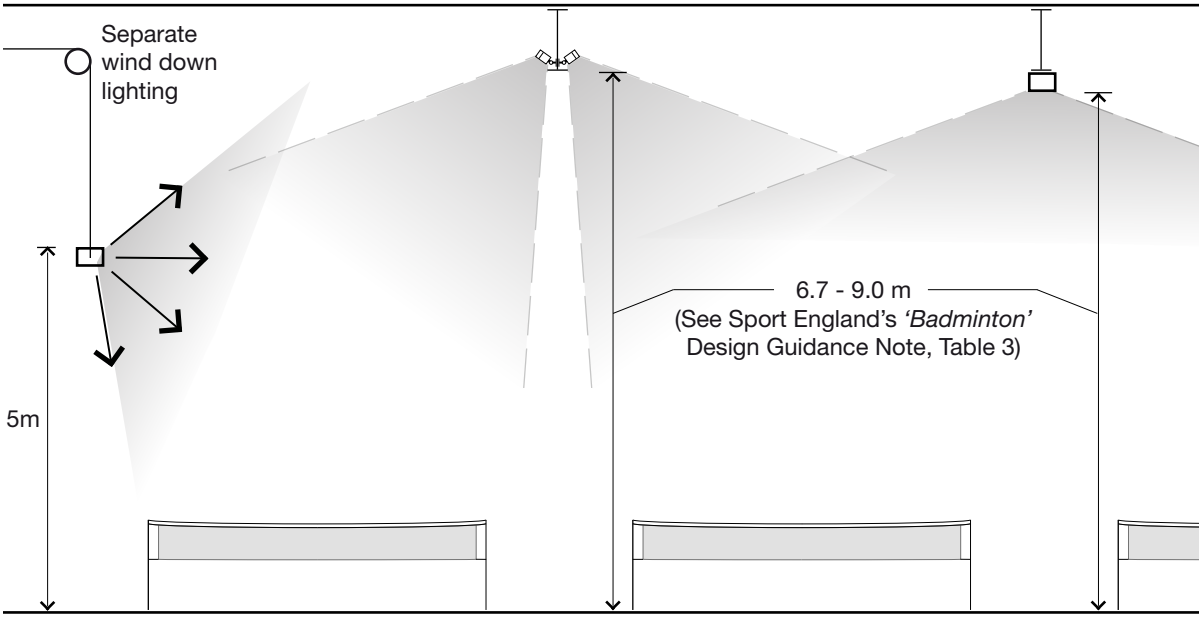


Plan

Badminton England preferred lighting for a *High Performance Centre*



Section

Wind-down lighting units and split or single high level lighting between badminton courts in a multi-sports hall

Badminton England's requirements are based on their experience of creating the optimum lighting conditions for the sport. This advice does not fully conform with the recommendations of *BS EN 12193:2007* and is based on:

- A preferred height above the floor of 5 m for the luminaires
- Illumination levels with the following values:

Average	At least 500 lux
Uniformity U_1	At least 0.5
Uniformity U_2	At least 0.7

- 3 luminaires located symmetrically on each side of the net
- Luminaires being > 1 m from the side lines of the court for high performance centres and 0.75 m for other centres (with 1.5 m between courts)
- Luminaires having glare control
- Maximum illumination at the net area of the court
- Background colours having reflectance of 30-50%
- Ceiling reflectance being 70-90%.

In a multi-sports environment, luminaires mounted at 5 m above floor level are likely to cause a conflict for sports such as volleyball, trampolining and basketball that require a greater clear height. This can be achieved by using wind-down fittings or carefully controlling the location and light spread of high-level luminaires. A switching arrangement whereby the fittings at the back of each court, if any, can be turned off will also be preferable.

See separate Sport England Design Guidance Note *'Badminton'*.

Sport England Design Guidance Notes 'Badminton' and 'Sports Halls: Design and Layouts' recommend the following paint colours:

Colour	*Code*
Blue	*86 BG 43/321*
Green	*30 GG 40/290*
Blue green	*53 GG 50/360*
	87 GG 51/291
	10 GG 48/366

Indoor bowls

Sport England's Design Guidance Note *'Indoor Bowls'* provides information on the design of indoor bowls facilities.

Artificial lighting in indoor bowls centres can fundamentally affect the enjoyment and quality of play. As well as being critical during a game, the quality of the lighting system can have a major impact on the overall ambience.

Artificial lighting must be considered as an integral element of the overall design and planning of all areas in the centre. The colours and types of surface must be carefully selected in conjunction with the lighting scheme to achieve the optimum overall visual quality for activities and to provide an attractive environment.

Visual requirements are for players to clearly see the jack and the locations of the woods around it together with being able to follow the run of the live wood from the far end of the rink.

Because of the large, open playing area, the uniformity of the brightness of the green is very important. The material of the green itself may influence the apparent uniformity, because of its 'nap' which can give different impressions of brightness when viewed from different directions. An illuminance gradient of no more than 5% per metre is recommended.

Care should be taken in the layout and selection of luminaires to ensure that the green is uniformly illuminated with no discomfort glare for the players. Arranging the lines of luminaires parallel with the rinks allows operational economies, through lighting only rinks which are in use, and may help achieve the required lighting uniformity. The underside of luminaires should generally be between 4.5 m and 6.0 m above the green.

Glare can also be controlled by reducing the contrast between the luminaires and the hall surfaces. Ensuring that the ceiling and end walls have the high levels of reflectance recommended by Sport England will help with this.

Example of high reflectance from ceiling and end walls as recommended by English Indoor Bowls Associations

There are differences between the advice from the English Indoor Bowls Association (EIBA) and *BS EN 12193:2007* as shown in the table below.

Natural lighting can be used to support artificial lighting and give a less oppressive feel to the playing area. If natural light does penetrate the interior of the green it must do so from above. Vertical or V-profile baffles should be fitted to prevent glare. Natural lighting can improve the hall's atmosphere but suitable systems are expensive.

Sunlight must not fall directly onto the bowls playing surface.

Minimum illumination standards		
	Sport England Design Guidance Note *'Indoor Bowls'* and EIBA	***CIBSE Lighting Guide 4 / BS EN 12193:2007***
Uniformity ratio	≥ 0.9	≥ 0.8
Maintained average illuminance on the playing surface	≥ 500 lux	≥ 500 lux Illuminance gradient should be less than 5% per metre to avoid a banding effect which can occur with low luminaire mounting heights, because of reflectance from the mat.
Surface reflectance		
End walls	70 %	40 % min
Side walls	70 %	40 % min
Ceiling	90 %	60 % min
Bowls carpet	30 %	30 % min

Indoor cricket

The Sport England *Sports Data Sheets* on *'Indoor Cricket'* give information on the integration of cricket into the facilities in a multi-purpose sports hall.

Cricket can take place indoors as both an indoor game and as a training activity within a netted area. Both require high levels of lighting so that players, coaches and spectators can safely follow the players' actions and the rapid movement of the ball.

The cricket ball can reach very high speeds and requires quick player reactions at close quarters. All phases of play need to be seen clearly: the run up, the movement of the bowler's arm and the delivery of the ball need to be seen by the batsman; the bowler and fielders need a clear view of the wicket, batsman and the flight of the ball.

CIBSE LG4 and *BS EN 12193:2007* recommend different levels of lighting for indoor cricket and for cricket nets but the *England and Wales Cricket Board* (ECB) makes no distinction between lighting requirements for practice nets and play[2]. This reflects the potential for indoor sports spaces to be used flexibly for a range of training and game activities in addition to the more traditional cricket net format. The *CIBSE Guide* and the *BS EN* recommend levels of lighting for Class II and III indoor cricket which the ECB considers unacceptable.

The ECB requirements are related to the levels of play in the table below. These differ from the 'Classes' defined in the *CIBSE LG4 Guide* and the *BS EN*.

There is also a strong preference for the use of natural daylight in sports halls used for cricket and with this approach, careful shading and coordination with the playing areas is required to ensure an even distribution of light and the avoidance of all direct sunlight.

The artificial lighting should also reproduce daylight conditions as far as possible. This is often achieved with multiple fluorescent light fittings mounted at high level. The light fittings can either run parallel on either side of the wicket and in line with the direction of play, or be mounted transversely with screening to avoid the batsman's line of sight. Glare can be controlled with the use of lamps with diffusers that give a low glare rating and by the use of a light coloured ceiling that reduces the contrast.

Careful coordination of the locations of the lighting, heating system, net tracks and the wicket will be necessary to avoid shadows and achieve uniformity of light distribution.

The recommended reflectance of the walls and ceiling is 70%.

	Design illumination	Design uniformity
Low-level Club / Local Club	750 lux average	E_{min} / E_{ave} = 0.8
Mid-Level Competition / Regional Club level	1000 lux average	E_{min} / E_{ave} = 0.8
Top-Level Competition / International / National level	1500 lux average	E_{min} / E_{ave} = 0.8

Examples of cricket schools with even levels of lighting with minimum glare and no shadows

[2] See ECB Facility Briefs and Guidance Notes, TS2 *'Cricket Specific Indoor Centres'* and TS3 *'Indoor Sports Halls with Cricket Provision'*.

Fitness centres

The Sport England Design Guidance Note *'Fitness and Exercise Spaces'* provides information on the overall design and layout of fitness centres. Advice on the use and control of natural lighting is included.

Fitness centre users must be able to concentrate on their training in safety without distraction from the lighting installation.

The ambient lighting level should be adequate for the safety of the users. Good artificial lighting design can also enhance the visual appearance and appeal of the space and create an attractive environment.

The recommended illuminance is between 200 - 300 lux with a recommended uniformity ratio of 0.8. The Sport England Design Guidance Note *'Fitness and Exercise Spaces'* discusses the different requirements for the various types of spaces within fitness centres.

BS EN 12193:2007 includes recommendations for Gymnastics (see Appendix 3):

- Light fittings should be carefully located to avoid direct glare, particularly when the exercise requires the use of equipment in a horizontal position. Many attractive fitness spaces make good use of natural lighting and external views.
- Exercise areas should be brightly lit with no harsh direct lights such as spot lamps shining in users' faces. Lighting design should take account of any mirrored surfaces.
- Dimmer switches may be useful for yoga, antenatal and relaxation classes. Some clubs may require more sophisticated lighting systems (e.g. colours or strobes linked to music) for certain classes, demonstrations, competitions and social events. The use of selective controls or dimming can be effective in helping to create the desired ambience and can also help to reduce running costs when daylight is available.
- Lighting controls should be accessible to staff only. Basement spaces, where no natural light is available and where ceilings are often low, can require particularly careful lighting design.

Lighting should help to create an attractive ambience

Indoor Tennis

Artificial lighting is an important element in the creation of indoor tennis facilities that are attractive to users of all ages and abilities.

A good level of illumination and contrasting background colours are required so players, coaches and spectators can follow the flight of the ball. The reflectance values of the floor and wall finishes should be fully co-ordinated into the design and the selection of the lighting system.

Luminaires should be arranged so that they are not within the clear height zone of the court, above the field of play or within players' normal sight-lines. This also applies to any natural lighting and usually involves placing the luminaires and rooflights above the spaces on each side of or between courts. Care should be taken to avoid glare caused by the location of fittings and / or the contrast between light sources and the surfaces of the hall. Protection of the fittings from damage must be provided by the application of permanent proprietary guards or louvres in accordance with the manufacturer's recommendations. In addition to satisfying the fundamental requirements of function, safety and economy, the design must minimise future maintenance needs and running costs – (see Section 5 *Lighting Cost of Ownership*).

A good level of illumination and contrasting background colours are required so players, coaches and spectators can follow the flight of the ball.

For further information, refer to the LTA web site: www.lta.org.uk/

The operating switches for the lights should be located centrally, at the Centre's reception for instance, so that the lights on each court can be switched on and off as required.

The figures below provide the performance standards that are required. These are set court by court and are measured when the courts are individually lit.

Minimum illumination standards		
Maintained average illuminance within the PPA [3]	Lux	600
	Uniformity of illuminance (E_{min} / E_{ave})	0.7
Maintained average illuminance within the TPA [3]	Lux	500
	Uniformity of illuminance (E_{min} / E_{ave})	0.6
Minimum colour temperature [3]	min 3,600 k	
Minimum height of luminaires	6.5 m located outside the PPA	

Lighting levels for indoor tennis

[3] See Appendix 1 for definitions.

Swimming pools

Introduction

The Sport England Design Guidance Note *'Swimming Pools'* gives details on all aspects of swimming pool design.

The recommended levels of illuminance for swimming pools are 300 lux for most activities and 500 lux for competition. For international events, FINA require 600 lux at the start and turn ends of the pool, while for Olympic swimming events the requirement is for 1500 lux over the entire pool.

Design aspects

There are a number of specific design aspects to be considered for pools including:

- Reflectance and glare
- Luminaire types
- Access for maintenance
- Direct lighting
- Indirect lighting.

Lighting, whether artificial or natural, must minimise glare and reflections from the surface of the pool. *HSG 179* guidance stresses the importance of lifeguards having good visibility beneath the water and suggests minimum numbers of lifeguards being on duty for programmed and un-programmed swimming sessions.

Light from directly above the pool surround should cause no problems if the angle of incidence to the water surface is high and there are high levels of light reflectance from the internal walls and floor surfaces of the pool basin [4]. Problems generally occur when the luminaires or windows are located in the side walls, such that the angle of incidence causes problems for attendants and spectators. When the angle of incidence is low and combined with wave action on the water, the reflection patterns on the water surface can make it impossible for lifeguards to see swimmers below the water surface who might be in difficulty. This will depend upon the geometry of the pool hall and the location of glazing and should be considered at an early design stage. See Sport England Design Guidance Note *'Swimming Pools'* for options for controlling specular glare.

Light fittings

Light fittings must be located and angled to avoid glare or reflection, from the points of view both of bathers in the water and of staff on the pool surrounds.

The selection of the type of luminaire is important. Indirect lighting is preferable, to avoid specular reflection.

Lights require regular maintenance and ensuring an easy and safe means of access to fittings should be a priority, particularly if they are located over the pool (see *Construction Design & Management Regulations 1994*).

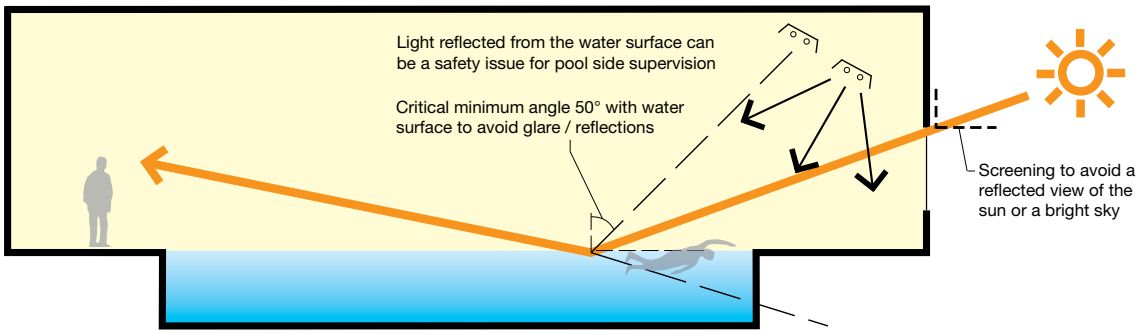
Consider the position of light fittings in relation to the routing of air-handling ductwork and other services so that light distribution is not adversely affected.

The emergency lighting system should ideally be a maintained system. This is a battery-operated system capable of maintaining safe levels of illumination in the event of failure of the main electricity supply.

Underwater lighting

Underwater lighting can reduce the effect of veiling reflections on the pool surface and improve the general evenness of illumination below the surface of the water. This can increase pool safety and help coaches to study the technique of swimmers.

There are two basic types of underwater lighting; 'dry niche' and 'wet niche'. Dry niches contain luminaires behind watertight portholes and wet niches are recessed into the walls of the pool.



For a swimming pool, the field of play should include lighting to the underwater volume

[4] International Commission of Lighting (CIE) 62: 1984 Technical Report: *'Lighting for Swimming Pools'*

Materials and corrosion

Corrosion of materials can be a major problem when they are located in the humid atmosphere of a swimming pool hall.

Experience has shown that all metals, including stainless steel and aluminium, need high quality protection and effective maintenance to avoid corrosion. This can be provided by the application of a paint system, or in the case of aluminium, the provision of deep anodising. A great deal of attention should be paid to all parts of the installation including cable trays, trunking, conduit, bracketing and fixings. Contact between dissimilar metals in a humid atmosphere can lead to very rapid corrosion.

It is recommended that luminaires should be constructed to a minimum standard of IP54.

Uplighter type luminaires positioned over the pool surround and reflecting from the roof soffit to give an even level of lighting across the pool hall and the underwater volume. A raised lifeguard chair is provided to give an enhanced view over the water area.

4.0 Outdoor Sports Lighting

Floodlighting

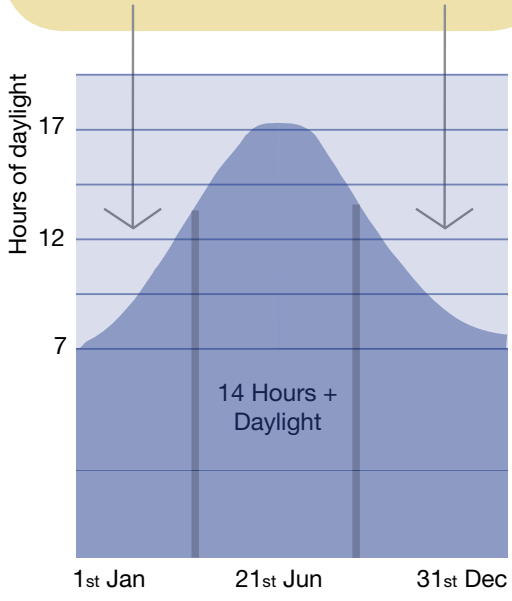
Floodlighting used to be considered a specialist feature that was provided only for prestigious sporting events, but suitably scaled-down installations are now common in local community facilities giving extended hours of play to a much wider range of users.

Recent years have seen a rapid growth in the number of floodlit outdoor sports facilities. Outdoor sports lighting is now regularly seen at:

- Artificial grass pitches
- Natural turf pitches
- Multi use games areas (MUGAs)
- Tennis courts
- Athletics tracks
- Golf driving ranges
- Dry ski slopes.

The potential for an additional 1000 - 1500 hours of use every year with floodlighting.

See CIBSE Lighting Guide LG4.



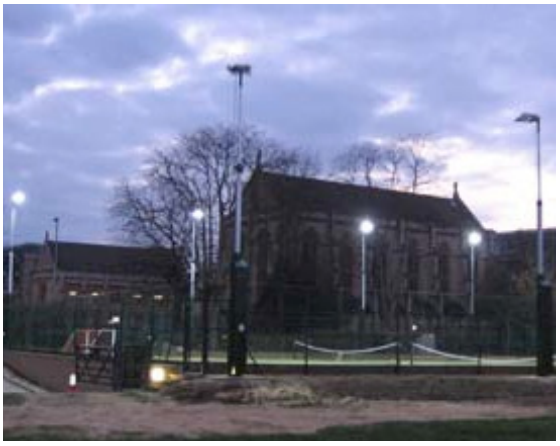
Outdoor sports lighting provides an important way of extending the use and the overall value of outdoor sports facilities. In the summer period, England enjoys long hours of daylight that give the opportunity to take part in sports and leisure activities during the long summer evenings. In contrast, the winter daylight can be as short as 7 hours a day and can restrict opportunities for outdoor sports to short periods during the weekends. In numerical terms, outdoor sports lighting can extend the playing hours by some 1000 -1500 additional hours per annum and this can allow people to train or play evening matches 7 days a week, all year round.

Feasibility

Before deciding to install floodlights, it is important that the cost benefits of the lighting are considered. The increased use, flexibility and additional income should be balanced against the initial capital cost and thereafter, the on-going energy costs, costs of maintenance and the additional management costs necessary to maximise these benefits.

The formulation of profiles of a typical week's use during the playing seasons, before and after the installation of floodlights, can help in this assessment. Such profiles should include:

- Club matches, training and coaching sessions for all adult and junior teams
- The likely casual use of the facility by other clubs, teams and individuals - the sports or leisure department of the Local Authority should be able to help in this respect
- Use by local educational establishments.



Comparing the 'before' and 'after' profiles can help to predict the likely levels of additional income and expenditure that providing floodlights will generate and will help clarify whether such provision is likely to be financially viable.

It will also make clear whether there is a realistic probability that additional sporting opportunities will be created. Such opportunities may arise from:

- Enabling the use of outdoor facilities all year round by members of the local community currently precluded e.g. those in full-time employment
- Enabling the use of outdoor facilities all year round for activities currently taking place indoors, thus freeing up this space for other activities and user groups.

It may also be helpful to consult the Local Authority's *Sport and Recreation Strategy* or the *Regional Recreation Strategy* and Sport England's *Facility Planning Model* to ascertain whether a need for floodlit sports facilities has been identified for the area.

Design Principles

The benefits of sports lighting include:

- Increased use of facilities

  Facilities with floodlighting can be used on winter evenings, giving substantially higher usage rates than equivalent non-floodlit facilities and increasing choice and flexibility of playing times for users.

- Programming flexibility

  Longer operating hours give facility managers and users more freedom in programming and in initiating sports development programmes.

- Additional income

  Increased use means greater potential to generate additional income – essential with the high capital cost of providing a MUGA or STP, although there will be increased wear and tear on the playing surface, reducing its service life.

- Usage options

  A floodlit MUGA adjoining a sports hall can accommodate activities such as football, netball and tennis, releasing more expensive indoor space for other activities.

On the other side of the balance, there are several disadvantages which are predominantly cost-related. These include:

- Capital cost

  Outdoor sports lighting schemes are generally expensive and require a high level of use to justify initial expenditure. Higher levels of use can mean other additional expenditure on such things as increased car parking provision and other infrastructure improvements, the costs of which also need to be built in to any assessment of financial viability.

- Energy costs

  The on-going revenue costs of floodlights can be a substantial financial burden, particularly for small sports clubs with limited financial resources, and adequate provision must be made to meet these (see Section 5).

- Maintenance

  All floodlights require regular cleaning and servicing to maintain illumination levels. This work must be carefully planned and can be expensive and time consuming. Maintenance considerations can be a determining factor in the initial choice of a floodlight system (see Section 5).

- Management and supervision

  The pressure to maximise a facility's use to offset some of the costs above can have significant additional management and supervision implications. These can be particularly onerous for small sports clubs with no full time employees who rely on volunteers and club members to manage and maintain a facility.

- Nuisance to neighbours

  Floodlighting proposals are seldom welcomed by a sports club's neighbours. There are

usually concerns over the potential night-time nuisance of light spillage and the visual impact in the daytime of the lighting structures. However, with careful design and proper presentation of the proposals, opposition can often be mitigated.

Although planning authorities may have a general preference for short columns as opposed to taller ones, there are good reasons for them to be correctly proportioned to the size of the pitch to be floodlit. For example, from a user point of view, the lighting is likely to be more uniform and there will be fewer problems with glare.

From the point of view of neighbours, the main disadvantage is the possibly increased daytime visibility of the lighting columns. However, using tall columns usually reduces the night-time visibility of light sources and greatly reduces glare. All other things being equal, increasing column height can often reduce overspill as well, though not greatly.

Skate park floodlighting installation using tall columns

The design of outdoor sports lighting can range from relatively simple lighting columns around outdoor pitches to more complex integrated designs for major sporting venues. The design of floodlighting is complex and best undertaken by a specialist consultant or lighting manufacturer. Before briefing either, however, there are issues that should be addressed by any potential client if abortive effort, time and fees are to be avoided.

A good floodlighting installation should be expected to have only minimal overspill outside the pitch which is being lit. The intensity of the illumination from each floodlighting column should also be limited. The calculated source intensity of the 'worst case' floodlighting column from a particular viewpoint, such as the window of the nearest neighbouring house, should also be checked to ensure that guideline limits are not exceeded.

See the Institution of Lighting Professionals (ILP) *Guidance Notes for the Reduction of Obtrusive Light GN01:2011* which can be downloaded from the ILP website. ILP was formerly known as the Institution of Lighting Engineers (ILE):

http://www.theilp.org.uk/

https://www.theilp.org.uk/documents/obtrusive-light/

Careful detailed design can alleviate most problems and should be based on the following principles:

- ***Understanding the characteristics of the areas around the site***
- ***Use of appropriate levels of illumination for a particular sport(s)***
- ***Energy efficient design and operation / maintenance***
- ***Controlling spillage onto surrounding areas***
- ***Considering the wider visibility from surrounding areas***
- ***Limiting the hours of usage***
- ***Good commissioning and future maintenance.***

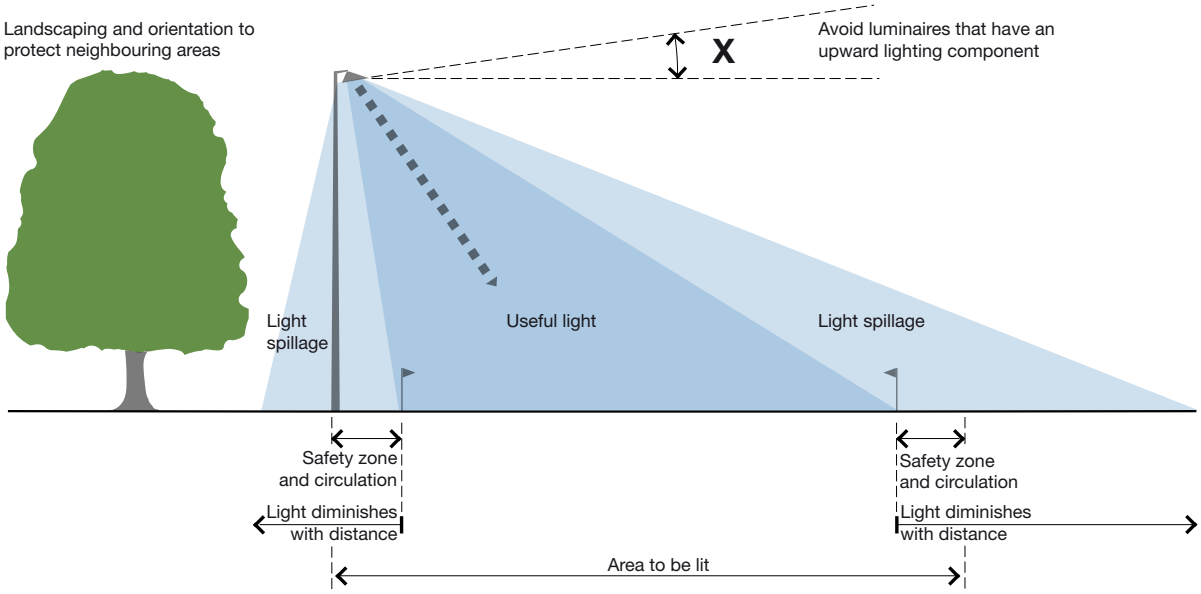


Diagram 1: Sectional view of light from an individual column

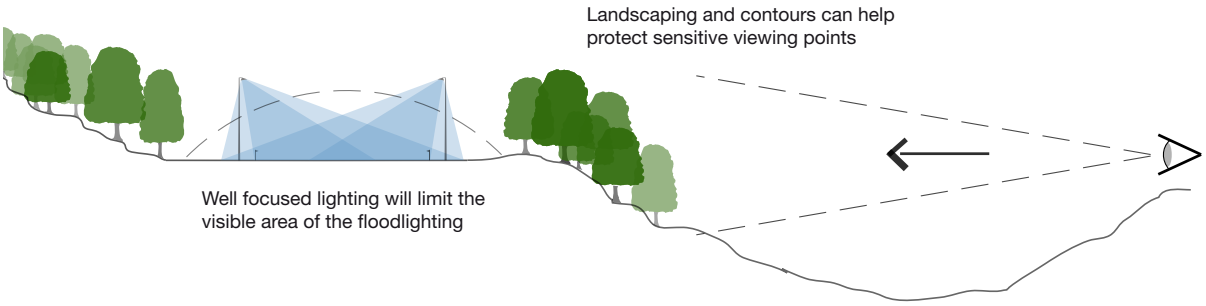


Diagram 2: Sectional view of lighting viewed from a distance [5]

The use of luminaries with double asymmetric beams designed so that the front glazing is kept at or near parallel to the surface being lit should, if correctly aimed, help to keep obtrusive light to a minimum.

Mounting the luminaires high i.e. on tall columns, will help to direct the lighting down onto the pitch, although this must be balanced against the increased daytime visibility of the installation.

Sports requirements

The sports catered for, along with the anticipated level of play, will determine the floodlighting requirements.

It should be noted that conflicting guidance might sometimes be given by different organisations or publications regarding the recommended standards of lighting for different sports. In such instances, reference should be made to the appropriate NGB for the sport(s) concerned.

Where a facility is to be used for activities for which different lighting levels are needed, the lighting must be installed to cater for the most

[5] *Limits of Floodlight Source Intensity* (*ILP Guidance Notes for the Reduction of Obtrusive Light GN01: 2011 : Table 1*).

demanding set of lighting requirements. Often it will be possible to provide a reduced level of lighting for the activities with lower lighting requirements, by selective switching of the lights. Note that dimming of discharge lights i.e. in this context, metal halide and high-pressure sodium lights, is not possible; the lights are either on or off.

The overall system

Procurement of a sports lighting system will involve the cooperation of a number of separate sub-disciplines to ensure that many different factors are taken into account:

- Planning, landscaping, orientation and layout

  The location of the pitch to give optimum use of available space and avoid sensitive planning issues.

- Lighting

  Choice of luminaire mounting height, location and configurations to achieve the required illumination on the playing area and avoid light pollution.

- Column

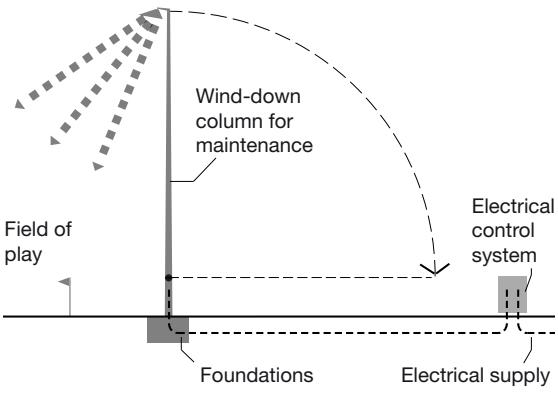
  Structural stability of columns and foundations to suit site conditions.

- Electrical

  Design of the electrical installation; cabling, power distribution, control and safety systems.

- Maintenance

  Selection of all components and the arrangement of the whole to allow cost effective maintenance and the replacement of components at the end of their life.



Main elements in an outdoor sports lighting system

Site configuration

It is important that appropriate analysis and feasibility work is undertaken to establish the optimum configuration of the site. The aim should be to identify all the issues that might influence the overall project. Issues must be identified and considered at an early stage in the process. The Planning Authority will require evidence that the possible effects of the proposed lighting on the neighbours and the surrounding landscape, whether rural or urban, have been considered and are acceptable. For example:

- Neighbouring housing may raise concerns about light shining into bedrooms or gardens
- Nearby highways and roads can be affected by lights
- Visibility of floodlighting columns from surrounding areas during the daytime.

Well-designed and properly installed floodlighting should minimise light spillage, whilst landscaping and careful orientation and positioning of the pitch within the site can reduce the daytime visibility of columns.

Specialist help may well be appropriate to consider such matters as:

- A survey of the ambient night time lighting level at key points around the site

  If ambient lighting levels around the site are already high, disturbance from the proposed sports lighting will be less significant.

However, the ILP Guidelines are for total obtrusive light levels – i.e. the sports lighting and other sources of light taken together.

- The optimum orientation of the playing areas

  Changes to the alignment or orientation of the floodlights with respect to roads can have an effect on road safety.

- Critical distances from the pitch to the site boundary

  Selecting the right location and orientation of the pitch within the site can help to minimise any overspill or obtrusive effects of the lights on neighbours and surroundings.

- The adequacy of the existing electricity supply

  Clearly, the electrical supply must have the capacity to power the proposed lights, as well as the existing loading on the site (the lighting, possibly heating, refrigeration, cooking, air conditioning etc.). To know whether the supply has the capacity, the existing supply will need to be inspected; the existing loads will need to be assessed and the requirements of the proposed lighting system added. If the supply capacity is less than the total (with a margin for safety and future expansion), an upgrade to the power supply will be needed.

  It is important to know this at an early stage in the project as power supply upgrades can be very expensive, and an appropriate financial provision will need to be in the project costs.

- Subsoil conditions and foundations for columns

  The design and dimensions of the concrete foundations for the lighting columns will need to be based on the soils and wind exposure characteristics of the particular site. The chemical properties of the soils are also important, since they can affect the type of cement needed in the concrete. The mechanical properties of the soils are important, since they will determine the dimensions of the foundation.

Consultation

The provision of floodlighting can be contentious, particularly if the sports area is adjacent to residential areas or within a particularly sensitive location. Local consultation should be undertaken. Neighbours should be informed of the lighting proposals at an early stage in the project, before it is too late to make changes to address any concerns neighbours may have. Depending on the scale of the lighting proposals, a public exhibition may sometimes be appropriate. In due course, the Planning Authority will circulate the proposals to the neighbours, as part of the process of considering the application. It is preferable for the neighbours already to have had a chance to have some input in the preparation of the proposals, rather than hearing of them for the first time when the Planning Authority asks for their views.

The sports catered for may, rightly or wrongly, lead to assumptions regarding the user profile at the facility.

There is a perceived association between particular sports, particular age groups and human behaviour. This leads to assumptions regarding the noise and nuisance generated by outdoor sports and the additional noise and nuisance likely to be generated, therefore, through increased use enabled by the provision of floodlights.

For the latter reason in particular, it is vital in a residential area to involve local residents when considering floodlighting provision. Through consultation and their involvement at an early stage, addressing any concerns they might have, the planning process can be simplified.

Even when housing is quite close to a floodlighting installation, with careful design and accurate aiming of the luminaires, nuisance through light spill and glare can be minimised

Visual impact

Many Local Authorities have published classifications for the night-time environment and lighting levels for particular sites. Some have set limits on acceptable levels of obtrusive light, while others may refer to the ILP Guidance. Highway Authorities may also set limits on lighting spillage onto roads, or on the source intensity of the lights, seen from the road. There are strict limits on lighting in aerodrome and airport runway approach corridors as well.

The wider visibility of the pitch from the surrounding areas should also be considered and screening with tree planting can help to protect particularly sensitive view points.

The photograph below shows an example of well-controlled lighting that is directed onto the pitch and avoids light pollution into surrounding areas and into the night sky. However the effect caused by a combination of reflection from the surface and the illuminated space may be visible from some distance.

Well directed lighting onto the pitch avoids light pollution into surrounding areas and into the night sky.

Specialist consultants or design / installation companies can produce environmental impact studies that include contour plans and sections to show the extent of the area around the pitch which would be affected by light spillage. These are helpful for initial feasibility studies and decisions about the optimum location of a pitch on the site and are likely to be required to support applications for statutory consents.

Since the *Wildlife & Countryside Act (1981)* makes it illegal to kill, injure, capture or disturb bats, some authorities will require a study of the likely effects of the proposed lighting on bats. This may require monitoring the site for the presence of bats over a period of several evenings. Opinions vary as to the degree of the effect of artificial lighting on bats, but most authorities agree that they are detrimental. Care must be taken to minimise the effects, by avoiding lighting the corridors - usually hedgerows or lines of trees - along which bats 'commute' in their search for food.

Obtrusive light

The *ILP Guidance Note GN01* deals with the problem of obtrusive light at length.

The avoidance of obtrusive light from poorly designed or badly maintained outdoor sports lighting is important for a number of reasons.

- It represents wasted energy that will effect overall sustainability

  Remember that every lumen emitted by the lights must be paid for. It is in the pitch owner's interests to make sure that as much of the light as possible falls on the area where it is wanted.

- It has the potential to cause a nuisance to surrounding areas

  Unwanted light can be an intrusion into the neighbours' properties and lives. None of us welcome uninvited disturbance.

- It can damage the night environment through glare, sky luminance and site aura

  Introducing floodlighting into the darkness of the night can lead to spillage of misdirected light into areas or volumes other than those where it is needed, changing the natural state of the night-time environment. This can be a nuisance to people and can seriously impact on nocturnal wildlife. Glare can be minimised by careful design of the lighting installation. When properly aimed, modern double-asymmetric floodlights should not emit any light above the horizontal plane.

  Sky 'aura', meaning the glow which appears above a lit pitch when it is viewed from a distance at night, results from a combination of the reflectance of the pitch surface and light scattering by dust or moisture in the air above the pitch. As such, it is a consequence of factors other than the lighting itself and is largely unavoidable.

I.L.P. Guidance Note GN.01 – Reduction of Obtrusive Light (2011): Table 1 - Environmental Zones			
Zone	Surrounding	Lighting Environment	Examples
E0	Protected	Dark	UNESCO Starlight Reserves, IDA Dark Sky Parks
E1	Natural	Intrinsically dark	National Parks, Areas of Outstanding Natural Beauty etc.
E2	Rural	Low district brightness	Village or relatively dark outer suburban locations
E3	Suburban	Medium district brightness	Small town centres or suburban locations
E4	Urban	High district brightness	Town / city centres with high levels of night-time activity

I.L.P. Guidance Note GN.01 – Reduction of Obtrusive Light (2011)						
Environmental zone	Sky Glow ULR (Max %) [1]	Light Intrusion (into windows) Ev (lux) [2]		Luminaire Intensity I (candelas) [3]		Building Luminance Pre-curfew [4]
		Pre-curfew	Post-curfew	Pre-curfew	Post-curfew	Average, L (cd/m^2)
E0	0	0	0	0	0	0
E1	0	2	0 (1*)	0	0	0
E2	2.5	5	1	2,500	500	5
E3	5.0	10	2	7,500	1000	10
E4	15.0	25	5	25,000	2,500	25

Key / Notes:

ULR	**Upward Light Ratio of the Installation** is the maximum permitted percentage of luminaire flux that goes directly into the sky.
Ev	**Vertical Illuminance in Lux** - measured flat on the glazing at the centre of the window.
I	**Light Intensity in Candelas (cd)**
L	**Luminance in Candelas per square metre (cd/m^2)**
Curfew	**The time after which stricter requirements (for the control of obtrusive light) will apply**; often a condition of use of lighting applied by the local planning authority. If not otherwise stated - 23:00hrs is suggested.
*	**Permitted only from** Public road lighting installations
1	**Upward Light Ratio** – Some lighting schemes will require the deliberate and careful use of upward light, e.g. ground recessed luminaires, ground mounted floodlights, festive lighting, to which these limits cannot apply. However, care should always be taken to minimise any upward waste light by the proper application of suitably directional luminaires and light controlling attachments.
2	**Light Intrusion (into windows)** – These values are suggested maxima and need to take account of existing light intrusion at the point of measurement. In the case of road lighting on public highways where building facades are adjacent to the lit highway, these levels may not be obtainable. In such cases where a specific complaint has been received, the Highway Authority should endeavour to reduce the light intrusion into the window down to the post curfew value by fitting a shield, replacing the luminaire, or by varying the lighting level.
3	**Luminaire Intensity –** This applies to each luminaire in the potentially obtrusive direction, outside of the area being lit. The figures given are for general guidance only and for some sports lighting applications with limited mounting heights, may be difficult to achieve.
4	**Building Luminance –** This should be limited to avoid over lighting, and related to the general district brightness. In this reference building luminance is applicable to buildings directly illuminated as a night-time feature as against the illumination of a building caused by spill light from adjacent luminaires or luminaires fixed to the building but used to light an adjacent area.

Local site issues

Local issues need to be factored into the overall design and are likely to be important in the planning application. Early liaison should take place with the Local Planning Authority to understand their policies and strategies relating to the night-time environment. These may include:

- Use of recognised standards
- A lighting designation for the particular site [6]
- Sustainability
- Existing ambient luminance in the area
- Control of light spillage
- Promoting a standard design method [7].

Planning Authorities are likely to refer to the Institution of Lighting Professionals (ILP) Guidance Notes when deciding on the standards that are appropriate for the limitation of obtrusive lighting.

Planning Authorities need to be satisfied that any proposed sports lighting installation has been designed with all possible steps taken to protect the interests and amenity of users and neighbours. Lighting overspill diagrams, showing the spread of light around the pitch are likely to be required - see diagram below. These can include OS mapping data, to relate the proposed lights to surrounding buildings and roads.

The brief for a floodlighting project should be carefully considered and the design, installation and commissioning should involve appropriately skilled professionals. Each site will have its own characteristics and sensitivities and early surveys should be undertaken to establish:

- The surrounding night time environment
- Critical viewpoints.

Example of a lighting overspill diagram likely to be required by planning authorities showing the spread of light around the pitch

[6] *BS EN 12193:2007* gives maximum permitted levels of obtrusive light for various environmental zones (ranging from E1 = National Parks and protected area to E4 = town centres and commercial areas).

[7] See table for standard design method based on *CIE 150.*

Tennis

Benefits of outdoor sports lighting for tennis

As with many other outdoor sports, lighting gives the opportunity to play tennis for an increased amount of time through the year and encourage and support participation, coaching and development for all levels of play. See page 25 for '*Design principles'* section.

Playing time available

Taking bad weather into account, an all-weather court in the South East of England is available for about 2,500 hours of daylight playing time per year. Lighting increases playing time by about 40%, or 1000 hours. Clubs with lighting have an enormous advantage over those without lighting, attracting coaches, more players, extending playing times and providing increased revenue from court fees during the winter months.

These same benefits will also accrue to floodlit court providers in all other sectors e.g. schools, colleges and Local Authority sports centres. The problem is that, of the estimated 30,000 courts available to tennis players in Great Britain, less than 1.5% are floodlit.

Tennis venues with court floodlighting are able to attract and retain coaches of the highest standard since they are able to carry out their work for a greater proportion of the year, enabling them to earn a decent living and giving them an incentive to develop their professional skills. As a result, all their players will benefit, but there are even greater benefits for talented players with their sights on competition and success.

Full time coaches based at centres with floodlit courts are also able to promote and to carry out development activities in order to introduce newcomers to tennis, particularly women and those from social groups who might not previously have been attracted to the game.

Lighting requirements

The following lighting levels for artificial lighting within the prescribed areas are recommended by the *Lawn Tennis Association* (LTA) for different standards of play. Illuminance is measured at the playing surface. The standards apply on a court-by-court basis, irrespective of the control switching arrangements. However, it must be stressed that the lighting levels are recommended figures and that individual requirements may vary.

Standard	Minimum	Recommended
Maintained average illuminance on PPA	400 lux	500 lux
Maintained average illuminance on TPA	300 lux	400 lux
Uniformity of illuminance on PPA (E_{min} / E_{ave})	0.7	0.7
Uniformity within TPA E_{min} / E_{ave}	0.6	0.6

Lighting levels for tennis

The uniformity of the lighting across the field of play is an important factor and should be identified in the design brief. Greater uniformity will generally be achieved by systems using taller columns and / or a larger number of light sources.

Athletics

In considering lighting for athletics, events can be divided into two groups. These are:

- Those events which take place essentially at ground level – track events, horizontal jumps and shot putt
- Those events which involve the space significantly above ground level - throwing events (except shot) and vertical jumps.

For events in the first group, it is sufficient to consider horizontal illuminance at ground level.

For events in the second group, the full volume within which the event takes place must be considered – for instance, the maximum height of the flight of the javelin or hammer and the maximum height of the pole vault bar.

In most cases the stadium or indoor arena will be lit to a standard where the requirements of both groups of events are met simultaneously. (See sections 5.0 & 6.0 of *CIBSE Lighting Guide 4*).

Proper lighting of the full volume required for events in the second group is a very important safety consideration. It is essential for the hammer and javelin and discus to be visible throughout their flight. High jumpers and pole vaulters must be able to see the bar. Note that it can be very expensive to light the volume above an athletics track. For an outdoor track which is not enclosed by a stadium, lighting this volume without producing overspill light and without creating glare for distant observers may be very difficult. If, for whatever reason, it is not practicable to light the entire volume for a given event, that event should not take place under lights.

The Table below gives a partial summary of the recommendations of the *International Association of Athletics Federations* (IAAF), as published in the *Track and Field Facilities Manual 2008 Edition*. For televised events, different standards will apply.

Level of play	Horizontal Illuminance		Colour rendering index	Glare rating
	Outdoor Athletics			
	Eave lux	Emin / Eave		
International / Premier	500	0.7	≥ 80	≥ 50
Club	200	0.7	≥ 65	≥ 50
Community	100	0.5	≥ 20	≥ 50

Notes

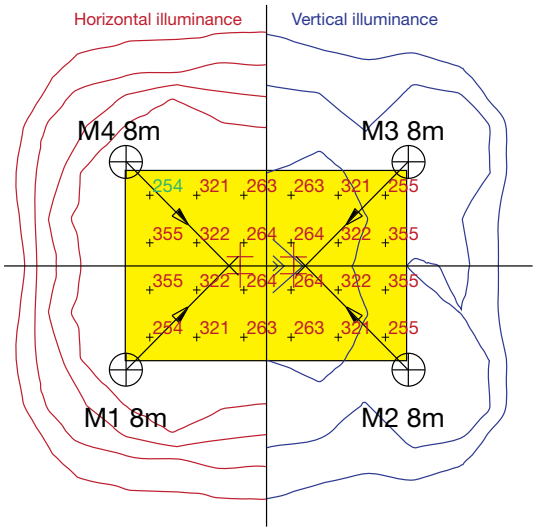
- Glare should be controlled by careful positioning of luminaries, e.g. over the pole vault area.
- The vertical illuminance at the finishing line should be at least 1000 lux for photo finish equipment.
- For outdoor tracks (community level of play), the level of horizontal illuminance can be reduced to 50 lux for jogging (see Section 5.0 of *CIBSE LG4*, *Stadia - large and small*).

Multi use games areas (MUGAs)

A community MUGA may well stand unused for much of the day, when children are at school and the employed are at work, and be used predominantly in the evenings and at weekends. Without lighting, the use which is possible in winter is severely restricted.

Lighting on a MUGA must always cater for the activity which has the most demanding requirements. For instance, a MUGA which is marked out for both Netball and Football will need to be lit to the 400 lux required for Netball. Depending on the type and number of luminaires employed, it may be possible to provide a lower lighting level for football or for low-level training by having some of the lights switched off. However, discharge lights i.e. metal halide and sodium lights, cannot be dimmed.

MUGAs will not normally host International or Premier events. The lighting required will be to Club or Community levels of play.



Typical lighting plot for MUGA

Club and Community lighting for tennis, netball, 5-a-side, basketball, rush hockey					
		Club		Community	
		Horizontal Illuminance (Lux)	Uniformity (Emin / Eave)	Horizontal Illuminance (Lux)	Uniformity (Emin / Eave)
Netball		400	0.7	400	0.7
Tennis (recommended)	PPA	500	0.7	500	0.7
	TPA	400	0.6	400	0.6
5-a-side football		120	0.6	120	0.6
Basketball		200	0.6	75	0.5
Rush hockey		350	0.7	200	0.7

5.0 Lighting Cost of Ownership

General

The initial purchase cost of a sports lighting system may seem high, but the on-going costs associated with running the system are also significant and must not be underestimated. When design proposals and alternative systems are being assessed, running and replacement costs as well as maintenance costs must be identified and included alongside the initial capital costs in any financial assessment.

It is of course important to make sure that, when choosing lighting levels, they are matched to requirements, taking into account NGB recommendations, funding body requirements and technical body recommendations. Selection of higher than necessary lighting levels inevitably means higher than necessary energy costs, as well as increasing the costs of procurement, installation, maintenance and replacement.

The on-going cost of ownership is the total of the cost of operating the lights and keeping them in good working condition and is made up of:

- Energy costs

  The cost of the electricity needed to run the lights.

- Maintenance costs

  The cost of the labour, materials and plant needed to keep the lights in good condition, replacing limited-life components as required.

- Sinking Fund

  A fund established to ensure that when there is a need for replacement of major components of the system, or of the complete system, sufficient finance is available.

Maintenance factor

The light output of an installation, irrespective of regular maintenance, will fall with time as lamps age. Lamp life and the rate of light output depreciation will vary according to lamp type and manufacturer.

Three things are essential to keep the fall in light output within acceptable limits:

- Equipment must be well designed, constructed, installed and commissioned
- Lamps must be changed and luminaires cleaned regularly
- The maintenance factor used in an installation's design calculations must be related to the facility's location and proposed maintenance regime.

The 'Maintenance Factor', also sometimes called 'Depreciation Factor', is a statement of the amount by which the lighting performance of the system will fall, compared to its performance after 100 hours use. For instance, if the Maintenance Factor is 0.8, the lighting levels will never fall below 80% of the values after 100 hours use – provided the system is properly looked after.

When designing the lighting, the as-new performance of the system must be high enough to ensure that lighting levels will still be adequate when all degrading factors have taken effect.

Maintenance factors, including the necessary allowances for depreciation caused by dirt and lamp deterioration, should be understood and agreed by all parties before an order is placed. These factors should be included in any design calculations to establish the minimum initial illuminance values required to achieve the recommended maintained lighting values (illumination, uniformity etc.).

There are two components in the maintenance factor; loss of light due to deterioration of the luminaire; and loss of light due to lamp depreciation. Luminaire maintenance factor depends on the quality of the sealing of the lamp compartment, which is related to the luminaire IP rating, local pollution and the frequency and effectiveness of cleaning. Lamp maintenance factor depends on design and manufacture. Lamp maintenance factor data must be obtained from the lamp manufacturer and must be examined carefully. Even lamps which are physically and electrically interchangeable may have widely differing light output depreciation characteristics. In some cases, the light output of a 2 kW metal halide lamp can be as high as 90% after 2000 hours, while a different manufacturers' lamp may retain only 60% of its output after the same time. Clearly, lamps with rapid depreciation characteristics will need to be replaced more often if illuminance is to be maintained at the specified levels. This can significantly increase the lifetime cost of ownership.

Depending on local conditions and maintenance cleaning intervals, Maintenance Factors can range from 0.5 to 0.9 (See CIBSE Lighting Guides LG4 and LG6). The minimum initial illuminance on a new installation will be equal to the specified maintained illuminance divided by the maintenance factor. For instance, if the specified illuminance on a netball court is 400 Lux and the maintenance factor is 0.8, the illuminance when the lights are new should be no less than 500 Lux. 'New' normally means after no more than 100 hours use.

Clearly, it is in the supplier's interests to carry out his designs and calculations with the highest possible maintenance factor. For outdoor lighting installations, maintenance factor is normally in the range 0.75 to 0.8, but may be lower in a polluted environment. Suppliers should be asked to justify a suspiciously high maintenance factor.

Illuminance measurement and monitoring

Regular measurements of illumination levels and lighting uniformity are an important part of maintenance procedures. They can give early warning of a need for bulk lamp replacement and will help to demonstrate that maintenance has been carried out properly and effectively.

In sports halls where there are typically several marked out playing areas within a much larger area, it is possible to take illuminance readings over the whole area. It is, however, suggested that monitoring surveys should be undertaken for each separate playing area using the recommendations provided for that sport, especially where there are different switching arrangements for different sports or where the system has been specified to give defined performance levels for each playing area. In some cases, there may even be separate lighting installations for different sports; clearly, under these circumstances, each installation must be assessed separately.

The approach adopted for outdoor installations will vary, depending on the type of facility. At a tennis club with several courts each having individual switching, the specified lighting level will be the same on every court. On a pitch, two or three different lighting levels may be specified for hockey, football and training. Each lighting level should be checked separately, but a single measurement grid can normally be used over the whole pitch.

Selection of the grid on which the calculations and measurements of lighting levels are carried out is important and can have a significant effect on the outcome. Unless the grid extends to the edges and corners of the field of play, these areas can sometimes be poorly lit even though an objective assessment of the lighting performance indicates compliance. If predictive plots of lighting performance appear to show low lighting levels in these areas, the prospective supplier should be asked to justify the grid location and spacing. For some sports, the measurement grid is specified.

It is usual for horizontal illuminance values to be measured at ground level, while vertical illuminance values are normally measured one metre above ground level. Care is needed to avoid producing inaccurate readings as a consequence of the observer casting shadows over the detecting head of the measuring instrument. This can be achieved by using a 'two-part' instrument whereby the remote sensing head can be affixed to an extension rod and is connected to the display unit by means of an interconnecting cable. Shadows will, of course, result in inaccurately low readings. Sometimes reflections from the observer's clothing can cause inaccurately high readings. This is equally undesirable.

To ensure accurate measurements, the light meter used must be periodically calibrated in accordance with the manufacturer's recommendations. Orientation of the detecting head of the instrument should be checked, using a spirit level (or similar) as measurement errors will be introduced if the detector head is not correctly aligned with the horizontal or vertical plane.

Energy costs

The benefits of minimising energy use and costs are obvious - overall operating costs are reduced and environmental impact can be minimised.

The careful selection of lamps and luminaires at the design stage is the first step to ensuring good energy efficiency. They must match requirements and be inherently energy efficient.

The next step is to ensure that switching and control arrangements are such that only the necessary illuminance levels are provided over relevant areas and only during the periods required. If there will be times when only one third of a football pitch is being used, for cross-pitch 5-a-side, for example, it is wasteful to light the other two-thirds of the pitch. Similarly, if a pitch is being used for a game of football needing only 120 lux, it is wasteful to light it to 350 lux. Switching and control arrangements must make these different lighting combinations possible. The energy cost of this wasted light should not be underestimated. At 15p per kWh, the energy cost alone of operating a single 2 kW luminaire can approach £500 for a normal year's use.

Agreement with the electricity supply company of the most appropriate electricity tariff is a further step.

Energy tariffs

Energy charges are normally made up of any *standing charge* made by the energy supplier, plus a per-unit charge for each kilowatt hour (kWh) of electrical energy used. Calculation of energy costs should be considered a fundamental part of the project design process. The illumination level, the lamp type, the type of lighting equipment, and the layout will all have an impact on the overall

efficiency of the system. In some cases a more sophisticated lighting scheme will have benefits in terms of economy of operation.

Electricity tariffs are usually categorised by payment interval, which can be quarterly or monthly.

Quarterly tariffs normally apply to relatively small consumers and are comparatively straightforward in format. They often comprise two components; a standing charge and a unit (kWh) charge based upon energy usage. Monthly tariffs may be more involved and often apply to larger supplies. Use of *Comparison Websites* may be helpful in selecting a supplier and tariff.

It has to be appreciated when calculating the expected electrical energy costs for a lighting installation, that the energy consumption of discharge lamps can be significantly higher than the 'nominal' power of the lamp, because of power absorbed in the lamp control gear. Different electricity suppliers have different ways of dealing with this, depending on how poor the power factor is and on how large the connected load is.

Having taken all possible steps to minimise energy use and costs, the realisation of the benefits to be accrued becomes the responsibility of the facility operator. Careful control and management are essential, to ensure that floodlights are only at the lighting level required, are only on when needed and are only on in the areas being used.

Maintenance costs

Maintenance costs are those associated with:

- Cleaning
- Repairing and re-lamping
- System testing and certification.

The importance of a regular maintenance regime cannot be overestimated. Failure to carry out routine and regular maintenance will inevitably lead to declining performance of the system, increasing instances of "failed lamp" units, and ultimately to a system which is unsafe. It will also fall below the expectations of players, who will migrate to other facilities where better playing conditions are available.

Again, maintenance issues must be considered throughout the project design stages. Accessibility is a requirement for the contractor, and poor access will push up maintenance costs. Equally, the choice of lighting equipment will impact on operational costs.

In many cases, a maintenance regime can be designed to take in multiple operations per contractor visit. Such a regime will minimise costs, as manpower and site access equipment can be used more efficiently.

General

All lighting schemes, both indoor and outdoor, should be operated under a cyclic maintenance programme. An effective cleaning and maintenance regime will ensure that the installation continues to operate at maximum possible efficiency throughout its life cycle.

An effective maintenance programme will include:

- Cleaning of luminaires at intervals appropriate for the frequency of use of the lighting system and the ambient pollution levels. Luminaires on a busy 5-a-side football centre in an industrial or coastal environment will need to be cleaned more frequently than those at a rural tennis club with a 9.30 pm curfew.
- Replacement of lamps in accordance with a 'Lighting Design Maintenance Plan' based on manufacturers' data relating to lamp light output depreciation and bulk lamp replacement intervals. The manufacturer's data will show the number of hours for which a lamp can operate before it should be replaced. Note that it will be necessary to keep a record of the lighting system operating hours.
- Keeping records of all maintenance performed. These records can help show the development of problems or faults before they become catastrophic.

Access to lamps should only be undertaken by appropriately trained and qualified caretaking staff in accordance with a location-specific Risk Assessment and Method Statement. Alternatively, an appropriately qualified electrical / lighting maintenance company with the required access equipment can be employed.

A regular check of illumination levels and lighting uniformity should be included in the maintenance procedures. This will help to demonstrate that maintenance has been carried out properly and effectively and will give early warning of the need for bulk lamp replacement.

Cleaning

Apart from replacing lamps, the glass and reflector of each fitting have to be kept clean.

Luminaires are designed to produce beams using highly polished reflectors as in car headlamps. The reflecting surfaces of luminaires are easily damaged. It is advisable to not wipe reflectors

unless absolutely necessary. If cleaning is essential then only chemically neutral detergents should be used, rinsed thoroughly with clean water and allowed to dry before placing back into use.

It is important to keep the interior moisture-free to minimise corrosion. Moisture can cause the creation of a milky film over parts of the reflector and the front glass of the luminaire, or can cause corrosion and failure of the lamp connectors, or pitting of the reflector.

Most floodlights have a sealed front glass which may be opened to clean the reflector and replace the lamp (though in many cases lamps are replaced from the back of the luminaire rather than via the front glass). The condition of the seals should be checked whenever a lamp is replaced or the luminaire is cleaned. When closing the luminaire after cleaning, it is important to make sure than it is dry and that no moisture is left inside.

Whilst luminaires should be cleaned more frequently than lamps should be changed, it is clearly financially beneficial to arrange for luminaire cleaning to coincide with lamp changing. Most lighting contractors will clean the luminaires as a matter of course when re-lamping.

Lamp replacement

The failure of an individual lamp may not always trigger a requirement to carry out an immediate replacement, particularly in outdoor installations with fixed columns or indoor installations where access is difficult. In such cases lamp replacement can require scaffolds and / or raised platforms, which may not be considered financially justifiable for the replacement of a single lamp. Nevertheless it has to be appreciated that even a single lamp failure can create a dark area, or a dark space in the illuminated volume, which may give players difficulty in following the trajectory of a ball or shuttle. On an outdoor pitch or court, where there are often relatively few lights per playing area (there may be only 4 lights on a tennis court), failure of a single lamp can cause lighting levels and uniformity to fall well outside the specified limits.

The average life of a lamp is different for each type. It should also be borne in mind that lamps start to deteriorate in their effectiveness from the moment they are first switched on. The temptation is to wait for a lamp to fail before replacing it, but they should be replaced at the end of their performance life, which is usually well before the end of their ultimate life. To maintain lighting uniformity, lamps should be replaced as a complete set per court or pitch. However, sometimes, where there are two different switching levels in regular use, the 'high' and 'low' level lamps may possibly be on different replacement cycles.

It used to be suggested that annual replacement of a small proportion of the lamps in an installation was an acceptable alternative to less frequent bulk replacement, but this is no longer regarded as a desirable way of proceeding, because of the deleterious effects on the uniformity of the lighting.

The cost of re-lamping an entire installation should not be under-estimated. The sums can be large and must be budgeted for.

Lamp life is not guaranteed. It can occasionally happen that a lamp will fail well before its rated life. Some manufacturers may replace lamps that fail within a few weeks of installation, even though they offer no guarantee.

Luminaire aiming

Luminaire aiming may need to be adjusted from time to time. When a system is installed, each luminaire is aimed to direct light to a particular area of the pitch, or of a particular court, in accordance with the lighting design. After a long period, the aim may be shifted by vibration or high winds.

Types of maintenance

Minor Service:

- Periodic inspection to keep the front glass of the luminaire clean
- All equipment exposed to the elements checked to ensure the integrity of the weather sealing
- An inspection to ensure the tightness of ALL electrical connections.

Interim service:

- All work listed under the minor service schedule, plus a test to monitor the degradation in performance of the lamps and hence the overall lighting installation. This test should be identical to that carried out prior to handover. For a tennis club or a multi-sports installation, it would thus be on a court-by-court or pitch-by-pitch basis, with measurements carried out at each of the designed operating levels.

Major service:

- Re-lamping of each court where it has been previously established that performance has dropped from the original installation level (initial value) to the 'maintained level' specified in the original design
- All work listed under the 'minor service' section should also be carried out, together with a full document test.

Health and safety requirements should be taken into account when servicing floodlighting. If a high-level maintenance vehicle or working platform is used, adequate protection of the court surface must be provided.

Sinking fund - Life cycle costs

A typical floodlighting system is likely to have a life expectancy of some 20 - 25 years before it requires full replacement, but within this period individual components will have shorter lifespans. Adequate budget allowance should be made for all such costs. This is often referred to as a 'sinking fund'.

Items such as lamps have a life expectancy related to actual hours of use, but the life expectancy of other components will depend on a range of factors:

- Wear and tear in normal use
- Environmental conditions
- Misuse
- Adequacy of maintenance.

The sinking fund, which should be set up when the lighting systems are first installed, must be sufficient to meet these predictable replacement costs as they arise. Contributions to the sinking fund must be regular and realistic. The size of the contributions can be worked out from the tendered costs of the lighting system, or from a quotation obtained for the purpose, either of which will need to be sufficiently detailed to allow the elements of the system to be costed separately - see table below.

Note that the life expectancies quoted above are minimum figures and that many suppliers would quote significantly longer average life expectancies.

Control and protection system include many different components with different life expectancies. Failures of ignitors are expected, but it is unusual for ballasts to fail. Capacitors can have very long lives, but should be checked regularly.

Luminaire life is affected by quality of the materials and the manufacturing process, by the quality of the seals, by location and pollution levels, but most of all by design. The life of some luminaires can be as short as 10 years, though others may last much longer. In selecting a luminaire, reports from owners of similar systems can be useful. In coastal locations, life is likely to be shorter than elsewhere.

Column life is determined mainly by the quality of the galvanizing. BS galvanizing is expected to last 25 years, so column life should normally be no less than this. Again, coastal location will affect life. Column condition can be checked, both visually and instrumentally for the condition of the galvanizing, and mechanically for the mechanical strength of the column and the stability of the foundation.

Value for money

Consideration of the total life-cycle cost of a proposed floodlighting installation should lead to the selection of a system giving the best value for money. This may not necessarily be the system having the lowest initial capital cost.

Warranties must be examined and assessed carefully. An attractively long warranty is of little use if its conditions mean that no replacement will be carried out until long after the performance of the lighting system has fallen below acceptable levels.

Lamp life is another critical factor. There are different ways of assessing lamp life. The figure which must be used when assessing life-cycle cost is the time when the light output from the lamps, combined with any depreciation due to the luminaires, falls to the level specified for the facility. At that stage, lamp replacement will be necessary.

Elements to be replaced	Minimum life expectancy	Costs
Control and protection systems	5 years	Approx 20% of the capital cost should be included four times in a 20 year life cycle budget.
Luminaires	10 years	The full capital cost of the luminaires should be included twice in a 20 year life cycle budget.
Cabling	20 years (or more if the cables are not disturbed when columns are replaced or other work is carried out)	Full capital cost of the cabling should be included once in a 20 year life cycle budget.
Columns	20 years	Full capital cost of the columns should be included once in a 20 year life cycle budget.

Appendix 1

Simplified definitions

The terminology used by lighting engineers can be confusing if one is not familiar with their sometimes specialised meanings.

For a comprehensive glossary of lighting terminology and definitions please refer to *CIBSE LG4* and *BS EN 12193:2007*.

Colour rendering	The ability of a lamp to make the colours of a lit surface appear the same as they do under natural light. The colour rendering of a lamp is indicated by its colour rendering index Ra. Ra has a maximum value of 100, which is equivalent to daylight. The higher the value, the better the colour rendering and visual appearance of colours. A low-pressure sodium lamp (the old yellow streetlight) has Ra = 0 – it is not possible to distinguish colours under that sort of lighting. High-pressure sodium lights still have a 'golden' colouring, but have much better colour rendering, with Ra~~ 25. Metal halide lights generally have Ra between 65 and 90.
Colour temperature	Very hot objects emit light of a colour which varies with temperature - think of 'red hot' and 'white hot'. The colour temperature of a light source is the temperature of a standard object (a 'black body') which emits light of a hue similar to that of the light source.
Disability glare	Glare that impairs the vision of an observer without necessarily causing discomfort. Disability glare may be produced directly or by reflection.
Discomfort glare	Glare that causes discomfort without necessarily impairing the vision of objects. Discomfort glare may be produced directly or by reflection.
Diversity (Electrical)	In an electrical system, the ratio of the sum of the individual maximum demands to maximum total demand. The maximum electrical load on an electrical system will be less than the total of the demands of the individual components of the system, because not all items of equipment will be in use at the same time. See also 'Uniformity'.
Emergency lighting	Lighting provided for use when the supply to the normal lighting fails.
Escape lighting	A specific part of the emergency lighting, provided to ensure that the escape route is illuminated at all material times.
Field of play	General term for the defined space in which the sports activity takes place. (Also see terms used in *BS EN 12193:2007* for 'principal area' and 'total area'.)
Glare	Excessive brightness in the visual field. A glare rating value (GR) can be assessed for the field of play and other key areas. See *LG4 / BSE 12193:2007* and *CIE publication TC 5.04*.
Illuminance	The amount of light falling on a surface. Expressed as 'lux' (lumens per square metre).
Illuminance gradient	The rate at which illuminance on a surface varies with position. Expressed as % per metre. For instance, for Indoor Bowls, the difference in illuminance at two points 1 metre apart on a rink must not be more than 5% (*CIBSE Guide*).
Isolux diagram	A plan, usually of the Playing Area, with lines linking points of equal illuminance — similar to the contour lines on a map that link points of equal height above sea level. When extended to include the Total Playing Area and beyond these diagrams can be used to show the extent and intensity of light spillage.
Lamp	A light source or electrically powered device which produces light.
LRV	LRV, *Light Reflectance Value*, is the amount of light reflected from a surface, expressed as a percentage of the amount of light falling on it. LRV is measured using the method described in BS 8493.
Lumen	The unit of luminous flux – i.e. the rate at which a source produces light.
Luminaire	A general term for a light fitting.

Lux	The unit of measurement of illuminance. One lux equals one lumen per square metre.
Maintenance Factor (MF)	A factor used to predict the worst-case performance of a lighting system at any point in its life, provided it is properly looked after. A detailed definition of MF is included in the County Surveyors' report on the topic (concerned mainly with road lighting), available for download from the ILP website.
Minimum maintained (average) illuminance (E_{ave})	The value below which the (average) illuminance in the specified area should not fall at any time during the life of a (properly-maintained) lighting installation. It is the illuminance level at which maintenance should be carried out. The method for determining average illuminance, based on readings over a prescribed grid, is dealt with in *CIBSE Lighting Guide LG4: Sports*
Principal Area (PA)	The playing area needed for a sport – typically the area bounded by the outer line of the pitch or court markings, though sometimes additional space outside the lines is needed as well, for instance for tennis, volleyball, women's lacrosse. In tennis, the term *Principal Play Area* (PPA) is used.
Reference area	The area over which lighting performance is specified or measured.
Reflectance / Reflection factor	The proportion of light falling onto a surface which is reflected back off that surface. See *LRV.*
Safety lighting	That part of the emergency lighting that provides illumination for the safety of people involved in a potentially dangerous process or situation and to enable proper shut down procedures for the safety of the operator and other occupants of the premises (known as 'high-risk task area lighting' in *BS 5266-7 / EN 1838*).
Standby lighting	That part of the emergency lighting which may be provided to enable normal activities to continue.
Threshold Increment (TI)	The measure of disability glare expressed as the percentage increase in contrast required between an object and its background for it to be seen equally well with the source of glare present.
Total Area (TA)	The area encompassing the playing area plus a specified area around it, normally to provide safety margins or run-offs. In tennis, the term *Total Play Area* (TPA) is used and TA is the area of the whole of the courts' enclosure.
Total Light Output Ratio (TLOR)	The fraction of the light produced by the lamp which leaves the luminaire in any direction. TLOR is, in effect, the efficiency of the luminaire.
ULOR (or ULR)	Upward Light Output Ratio: The fraction of the light produced by the lamps which leaves the luminaires above the horizontal. ULOR, sometimes called ULR, should always be zero for a properly-installed, well-designed sports lighting installation
Uniformity	The evenness of the distribution of light over the court surface. There are two definitions of Uniformity, known as U_1 and U_2. U_1 is defined as the ratio of the minimum illuminance in the area to the maximum illuminance in the area (E_{min} / E_{ave}). U_1 is also sometimes known as Diversity - but see the definition of diversity above. U_2 is defined as the ratio of the minimum illuminance in the area to the average illuminance over the area (E_{min} / E_{ave}). The uniformity of light is as important as the level of illumination. Light should be spread evenly over the whole area, including behind the baselines, outside the sidelines, and above the playing area.

Appendix 2

Light emitting diode (LED) lighting

LEDs for indoor sports lighting

For indoor purposes, the development of LED lights has reached a point at which their use is starting to be worth considering. Manufacturers are making rapid progress in the development and improvement of LED lighting and new products arrive on the market frequently.

However, there is no simple answer to the question of whether or not to use LED lights.

The factors to be taken into account when considering whether to install LED lights or conventional ones – typically fluorescent tubes – include the following;

- **Initial cost**

  The installed cost of an LED-based lighting system is approximately twice that of a conventional fluorescent system, for the same light output.

- **Running cost**

  The luminous efficacy of an LED luminaire is significantly higher than that of a fluorescent tube luminaire, so, for the same lighting level, the energy costs of operating the lighting installation will be lower. LEDs can be dimmed which can further help to reduce energy costs.

- **Maintenance costs**

  The replacement cost of LED 'lamps' is much higher than that of fluorescent tubes, but their life is significantly longer. Depending on the type of LED lamp and the degradation of light output considered acceptable, the life of an LED lamp is said by manufacturers to be from 40,000 to 100,000 hours. Conventional fluorescent tube lifetime is also variable, depending on type of tube and the operating pattern i.e. whether the tube is switched on and off frequently, but is normally quoted as 7,000 to 8,000 hours. The balance between the replacement costs of LED and fluorescent lamps will depend on the overhead costs of replacement, to do with access costs, labour costs, whether external contractors carry out the replacement and whether the space needs to be closed down for the replacement etc.

If there is uncertainty over whether installation of LED lights is likely to be beneficial, the decision can be deferred. LED replacements for some sizes of fluorescent tube are available and can be installed in the same fittings, with a relatively simple modification to the wiring of the fitting.

The Institution of Lighting Professionals (ILP) have prepared *'Guidelines for Specification of LED Lighting Products 2011'* available to download from the ILP website. This includes helpful information on LED lighting for all applications.

LED's for outdoor sports lighting

For outdoor sports, the light output of LED units remains too low, so far, for their use to be practicable for any but the smallest MUGA, although development continues to be rapid.

To illustrate this, at the time of writing the highest output available from a standard LED 'lamp' – which is a panel consisting of a metal plate with a large number of individual LEDs mounted on it – is 14,000 lumens. This compares with approximately 100 000 lumens for a 1 kW metal halide lamp and approximately 200,000 lumens for a 2 kW metal halide lamp. To light a small MUGA for football requires, typically, 4 kW of metal halide lighting. To light a single tennis court requires, typically, 8 kW of metal halide lighting. This means that with current products, between 50 and 60 LED luminaires would be needed to light a tennis court to the recommended levels

Appendix 3

Indoor Sports - Summary of the recommendations of *BS EN 12193* with additional notes on key design issues

Note: Where not otherwise stated in the Table, the 'Classes' used in *BS EN 12193:2007* correspond approximately with Sport England '*Level of play*' categories as follows:

- Class 1 - International / Premier
- Class II - Club
- Class III - Community.

Sport / Class	Horizontal illuminance		Vertical illuminance		Ra	Reference / Sport England updates
	Eave (lux)	Emin /Eave	Eave (lux)	Emin/Eave		
Aerobics						Table A.3 *BS EN 12193:2007*
I	500	0.7			60	
II	300	0.7			60	
III	200	0.7			20	
Archery						Table A.5 *BS EN 12193:2007* See requirements for vertical illuminances at distances from the target *CIBSE Lighting Guide 4*
I	200	0.5	1000 - 2000	0.8	60	
II	200	0.5	1000 - 2000	0.8	60	
III	200	0.5	1000 - 2000	0.8	20	
Athletics						Table A.3 *BS EN 12193:2007* Glare from luminaires above pole vault shall be avoided Vertical illuminance of 1000 lux at finish line for photo recording equipment
I	500	0.7			60	
II	300	0.7			60	
III	200	0.7			20	
Badminton						Table A.1 *BS EN 12193:2007* No luminaires should be above the court See NGB recommendations 30% vertical illumination. *CIBSE Lighting Guide 4* Badminton World Federation (BWF) recommend 1000 lux for international competition Badminton England recommend 500 lux for all other levels of play
I	750	0.7			60	
II	500	0.7			60	
III	300	0.7			20	

Sport / Class	Horizontal illuminance		Vertical illuminance		Ra	Reference / Sport England updates
	Eave (lux)	Emin /Eave	Eave (lux)	Emin/Eave		
Basketball						Table A.2 *BS EN 12193:2007* No luminaires should be above the 4.0 m diameter circle around the basket
I	750	0.7			60	
II	500	0.7			60	
III	300	0.7			20	
Billiards						Table A11 *BS EN 12193:2007* The ratio of Eave (TA) to Eave (PA) can be relaxed to 0.5
I	750	0.8			80	
II	500	0.8			80	
III	500	0.8			80	
Boccia						Table A.8 *BS EN 12193:2007*
Boules						Table A.8 *BS EN 12193:2007*
Bowling (10 pin)						Table A.5 *BS EN 12193:2007* See requirements for illuminances at distances from the pins
I	200	0.5	500	0.8	60	
II	200	0.5	500	0.8	60	
III	200	0.5	500	0.8	20	
Bowls (Flat and short mat)						Table A.9 *BS EN 12193:2007* Illuminance gradient should not be more than 5% per metre to avoid a banding effect that can occur with low mounting heights of fittings and reflectance from the mat See page 18 for conflicting advice between *CIBSE Lighting Guide 4* and the Indoor Bowls Sports Governing Bodies
I	500	0.8			60	
II	500	0.8			60	
III	300	0.5			60	
Boxing						Table A10 *BS EN 12193:2007* Ev.ave should be at least 50% of Eh.ave
I	2000	0.8	1000		80	
II	1000	0.8	500		80	
III	500	0.5	250		60	

Sport / Class	Horizontal illuminance		Vertical illuminance		Ra	Reference / Sport England updates
	Eave (lux)	Emin /Eave	Eave (lux)	Emin/Eave		
Cricket						Table A.1 *BS EN 12193:2007* See ECB recommendations
I	750	0.7	500	0.8	60	
II	500	0.7	300	0.8	60	These levels are regarded as unacceptable by ECB
III	300	0.7	200	0.8	20	These levels are regarded as unacceptable by ECB
Cricket nets						Table A.1 *BS EN 12193:2007* See ECB recommendations
I	1500	0.8	500	0.8	60	
II	1000	0.8	300	0.8	60	
III	750	0.8	200	0.8	20	
Cycle racing						Table A.2 *BS EN 12193:2007* Illuminance is taken on the surface of the track The vertical illuminance at the finish should be 1000 lux for photo-finish equipment and officials
I	750	0.7			60	
II	500	0.7			60	
III	300	0.7			20	
Curling						Table A12 *BS EN 12193:2007*
Dancing						Table A.3 *BS EN 12193:2007*
I	500	0.7			60	
II	300	0.7			60	
III	200	0.7			20	
Darts						Table A.7 *BS EN 12193:2007*
I	200		750		60	
II	100		500		60	
III	50		300		20	
Equestrian						Table A.3 *BS EN 12193:2007*
I	500	0.7			60	
II	300	0.7			60	
III	200	0.7			20	
Fencing						Table A.1 *BS EN 12193:2007*
I	750	0.7	500	0.7	60	
II	500	0.7	300	0.7	60	
III	300	0.7	200	0.7	20	

Sport / Class	Horizontal illuminance		Vertical illuminance		Ra	Reference / Sport England updates
	Eave (lux)	Emin /Eave	Eave (lux)	Emin/Eave		
Fistball						Table A.2 *BS EN 12193:2007*
Floorball						Table A.2 *BS EN 12193:2007*
Football 5 / 6-a-side						Table A.2 *BS EN 12193:2007*
I	750	0.7			60	
II	500	0.7			60	
III	300	0.7			20	
Go Karting						
I	750	0.7			60	
II	500	0.7			60	
III	300	0.7			20	
Gymnastics						Table A.3 *BS EN 12193:2007*
I	500	0.7			60	
II	300	0.7			60	
III	200	0.7			20	
Handball						Table A.2 *BS EN 12193:2007*
I	750	0.7			60	
II	500	0.7			60	
III	300	0.7			20	
Hockey						Table A.1 *BS EN 12193:2007* Note that England Hockey recommends a minimum of 350 lux for competition www.englandhockey.co.uk/
I	750	0.7			60	
II	500	0.7			60	
III	300	0.7			20	
Ice Hockey						Table A.1 *BS EN 12193:2007* For mounting heights below 8.0 m, Emin/ Emax should be greater than 0.5, for Class 3 the uniformity can be relaxed to 0.5
I	750	0.7			60	
II	500	0.7			60	
III	300	0.7			20	
Ice sports (artistic)						For mounting heights below 8.0 m, Emin /Emax should be greater than 0.5, for Class 3 the uniformity can be relaxed to 0.5
Judo						Table A.2 *BS EN 12193:2007*
I	750	0.7			60	
II	500	0.7			60	
III	300	0.7			20	

Sport / Class	Horizontal illuminance		Vertical illuminance		Ra	Reference / Sport England updates
	Eave (lux)	Emin /Eave	Eave (lux)	Emin/Eave		
Korfball						Table A.2 *BS EN 12193:2007* No luminaires should be above the 4.0 m diameter circle around the basket
I	750	0.7			60	
II	500	0.7			60	
III	300	0.7			20	
Martial arts (Kendo, Karate)						Table A.2 *BS EN 12193:2007*
I	750	0.7			60	
II	500	0.7			60	
III	300	0.7			20	
Netball						Table A.2 *BS EN 12193:2007* No luminaires should be above the 4.0 m diameter circle around the basket
I	750	0.7			60	
II	500	0.7			60	
III	300	0.7			20	
Petanque						
Racketball						Table A.1 *BS EN 12193:2007* No luminaires within 1.0 m of wall
	50	0.5			20	
I	750	0.7			60	
II	500	0.7			60	
III	300	0.7			20	
Rollerskating						Table A.3 *BS EN 12193:2007*
I	500	0.7			60	
II	300	0.7			60	
III	200	0.7			20	
Rhythmic gymnastics						Table A.3 *BS EN 12193:2007*
I	500	0.7			60	
II	300	0.7			60	
III	200	0.7			20	
Shooting						Table A.5 *BS EN 12193:2007* See requirements for illuminances at distances from the target
I	200	0.5	500	0.8	60	
II	200	0.5	500	0.8	60	
III	200	0.5	500	0.8	20	

Sport / Class	Horizontal illuminance		Vertical illuminance		Ra	Reference / Sport England updates
	Eave (lux)	Emin /Eave	Eave (lux)	Emin/Eave		
Snooker						Table A11 *BS EN 12193:2007* The ratio of Eave (TA) to Eave (PA) can be relaxed to 0.5
I	750	0.8			80	
II	500	0.8			80	
III	500	0.8			80	
Speed skating						Table A.3 *BS EN 12193:2007*
I	500	0.7			60	
II	300	0.7			60	
III	200	0.7			20	
Squash						Table A.1 *BS EN 12193:2007* No luminaires within 1.0 m of wall
I	750	0.7			60	
II	500	0.7			60	
III	300	0.7			20	
Swimming						Table A.6 *BS EN 12193:2007* Additional requirements for diving, racing and polo in individual pools *BS EN 12193:2007* advises against underwater lighting for racing and polo
I	500	0.7			60	
II	300	0.7			60	
III	200	0.5			20	
Table tennis						Table A.1 *BS EN 12193:2007*
I	750	0.7	500	0.7	60	
II	500	0.7	300	0.7	60	
III	300	0.7	200	0.7	20	
Tennis (indoor)						Table A.4 *BS EN 12193:2007* No luminaires above the court and within 3.0 m from the base line, or in the players' line of sight
I	750	0.7			60	LTA specify minimum maintained average illuminance of 750 lux (0.7 uniformity value) within the PPA and 600 lux (0.6 uniformity value) within the TPA
II	500	0.7			60	LTA specify minimum maintained average illuminance of 600 lux within the PPA and 500 lux within the TPA (see page 21)
III	300	0.5			20	Below LTA specified standard (see page 21)

Sport / Class	Horizontal illuminance		Vertical illuminance		Ra	Reference / Sport England updates
	Eave (lux)	Emin /Eave	Eave (lux)	Emin/Eave		
Tug of War						Table A.2 *BS EN 12193:2007*
I	750	0.7			60	
II	500	0.7			60	
III	300	0.7			20	
Volleyball						Table A.2 *BS EN 12193:2007* No luminaires above the net area
I	750	0.7			60	
II	500	0.7			60	
III	300	0.7			20	
Wall climbing						Table A.3 *BS EN 12193:2007*
I	500	0.7			60	
II	300	0.7			60	
III	200	0.7			20	
Weight lifting						Table A.2 *BS EN 12193:2007*
I	750	0.7			60	
II	500	0.7			60	
III	300	0.7			20	
Wrestling						Table A.2 *BS EN 12193:2007*
I	750	0.7			60	
II	500	0.7			60	
III	300	0.7			20	

Appendix 4

Outdoor Sports - Summary of the recommendations of *BS EN 12193* with additional notes on key design issues

Note: Where not otherwise stated in the Table, the 'Classes' used in *BS EN 12193:2007* correspond approximately with Sport England '*Level of play*' categories as follows:

- Class 1 - International / Premier
- Class II - Club
- Class III - Community.

Sport / Class	Horizontal illuminance		Vertical illuminance		Ra	Reference / Sport England updates
	Eave (lux)	Emin /Eave	Eave (lux)	Emin/Eave		
American football						Table A.21 *BS EN 12193:2007*
I	500	0.7			60	
II	200	0.6			60	
III	75	0.5			20	
Archery						Table A.15 *BS EN 12193:2007*
I	250	0.5	750	0.8	60	
II	200	0.5	750	0.8	60	
III	200	0.5	750	0.8	60	
Athletics						Table A.13 *BS EN 12193:2007*
I	500	0.7			60	For discus, javelin and hammer, special precautions should be taken since the object may travel above the line of light and hence be invisible during part of the flight The vertical illumination at the finish line should be 1000 lux for photo-finish equipment and officials
II	200	0.5			60	For Class 2 the colour rendering index limit can be reduced to 20
III	100	0.5			20	Horizontal illuminance can be reduced to 50 lux for running events
Bandy						Table A.19 *BS EN 12193:2007*
Basketball						Table A.21 *BS EN 12193:2007*
I	500	0.7			60	
II	200	0.6			60	
III	75	0.5			20	
Baseball						Table A.14 *BS EN 12193:2007*
I	750	0.7	500	0.5	60	
II	500	0.7	300	0.5	60	
III	300	0.5	300	0.5	20	
Beach Volleyball						Table A.21 *BS EN 12193:2007*
I	500	0.7			60	
II	200	0.6			60	
III	75	0.5			20	

Sport / Class	Horizontal illuminance		Vertical illuminance		Ra	Reference / Sport England updates
	Eave (lux)	Emin /Eave	Eave (lux)	Emin/Eave		
Bobsleigh, Luge and Tobogganing						Table A.28 *BS EN 12193:2007*
Boccia						Table A.20 *BS EN 12193:2007*
Boules						Table A.20 *BS EN 12193:2007*
I	200	0.7			50	
II	100	0.7			50	
III	**50**	0.5			20	
Cricket						Table A.14 *BS EN 12193:2007*
I	750	0.7	500	0.5	60	
II	500	0.7	300	0.5	60	
III	300	0.5	300	0.5	20	
Curling						Table A.12 *BS EN 12193:2007*
Cycle racing						Table A.18 *BS EN 12193:2007*
I	500	0.7			60	The vertical illumination at the finish line should be 1000 lux for photo-finish equipment and officials
II	300	0.7			60	
III	100	0.5			20	
Equestrian						Table A.13 *BS EN 12193:2007*
Fistball						Table A.21 *BS EN 12193:2007*
I	500	0.7			60	
II	200	0.6			60	
III	75	0.5			20	
Football						Table A.21 *BS EN 12193:2007*
I	500	0.7			60	
II	200	0.6			60	
III	75	0.5			20	FA recommend minimum 120 Lux for Class III Football Refer to www.TheFA.com
Go Karting						Table A.18 *BS EN 12193:2007*
I	500	0.7			60	The vertical illumination at the finish line should be 1000 lux for photo-finish equipment and officials
II	300	0.7			60	
III	100	0.5			20	
Golf driving range						Table A.26 *BS EN 12193:2007*
I						
II						
III	100	0.8			50	

Sport / Class	Horizontal illuminance		Vertical illuminance		Ra	Reference / Sport England updates
	Eave (lux)	Emin /Eave	Eave (lux)	Emin/Eave		
Handball						Table A.21 *BS EN 12193:2007*
I	500	0.7			60	
II	200	0.6			60	
III	75	0.5			20	
Hockey						Table A.22 *BS EN 12193:2007* Engand Hockey recommends a minimum of 350 lux for competition and the following levels for particular pitches Class 1 = 750 lux Class 2 = 500 lux Class 3 = 300 lux See 'Guide to the Artificial Lighting of Hockey Pitches' download at: www.englandhockey.co.uk
I	500	0.7			60	
II	200	0.7			60	
III	200	0.7			20	
Horse racing						Table A.24 *BS EN 12193:2007*
Ice Hockey						Table A.19 *BS EN 12193:2007*
I	750	0.7				
II	500	0.7				
III	200	0.5				
Netball						Table A.21 *BS EN 12193:2007* AENA recommend 400 lux minimum maintained average for competitive play and 200 lux minimum maintained average for training Go to: http://www.englandnetball.co.uk Under *'The Game'*, select *'Facility and Court Information'* Lamps / columns in line with the player's sight of the net should be avoided
I	500	0.7			60	
II	200	0.6			60	
III	75	0.5			20	
Petanque						Table A.20 *BS EN 12193:2007*
I	200	0.7			50	
II	100	0.7			50	
III	50	0.5			20	

Sport / Class	Horizontal illuminance		Vertical illuminance		Ra	Reference / Sport England updates
	Eave (lux)	Emin /Eave	Eave (lux)	Emin/Eave		
Rugby						Table A.21 *BS EN 12193:2007* RFU lighting requirements are: Premiership: Eh 800 Lux, U2 = 0.7 Ev 500 Lux RFU Levels 2 to 5 / National Leagues: 200 Lux RFU Levels 6 and below, and training / Regional Leagues and lower levels of competition: 100 Lux The illuminance on a 5.0 m margin around the playing area is to be at least 25% of the illuminance on the playing area
I	500	0.7			60	
II	200	0.6			60	
III	75	0.5			20	
Cross country / street						Table A.17 *BS EN 12193:2007*
I	20	0.3			20	
II	10	0.3			20	
III	3	0.1				
Shooting						Table A.15 *BS EN 12193:2007*
I	250	0.5	750	0.8	60	
II	200	0.5	750	0.8	60	
III	200	0.5	750	0.8	60	
Skiing						Table A.17 *BS EN 12193:2007*
Skiing alpine / freestyle / jumps						Table A.23 *BS EN 12193:2007*
Softball						Table A.25 *BS EN 12193:2007*
Speed skating (400m)						Table A.13 *BS EN 12193:2007*
I	500	0.7			60	
II	200	0.5			60	
III	100	0.5			20	
Swimming						Table A.27 *BS EN 12193:2007*
I	500	0.7			60	
II	300	0.7			60	
III	200	0.5			20	

Sport / Class	Horizontal illuminance		Vertical illuminance		Ra	Reference / Sport England updates
	Eave (lux)	Emin /Eave	Eave (lux)	Emin/Eave		
Tennis						Table A.16 *BS EN 12193:2007* LTA recommend maintained average illuminance of 500 lux on the PPA and 400 lux on the TPA LTA specify minimum maintained average illuminance of 400 lux on the PPA and 300 lux on the TPA To maintain safety margins and to ensure that there are no luminaires in an unacceptable location, there must be no lighting columns within the TPA
I	500	0.7			60	
II	300	0.7			60	
III	200	0.6			20	LTA does not fund recreational level lighting
Tug of War						Table A.21 *BS EN 12193:2007*
I	500	0.7			60	
II	200	0.6			60	
III	75	0.5			20	
Volleyball						Table A.21 *BS EN 12193:2007*
I	500	0.7			60	
II	200	0.6			60	
III	75	0.5			20	

Appendix 5

Lighting codes, standards and guides

General publications:

The Outdoor Lighting Guide (2005)	Includes a short section on sports lighting	Written by the Institution of Lighting Professionals	Published by Taylor and Francis
Guidance Notes for the Reduction of Light Pollution	Free website download	Institution of Lighting Professionals	www.theilp.org.uk
Sports Lighting	CIBSE Lighting Guide 4 : Sports lighting	Society of Light & Lighting, link from CIBSE website	www.cibse.org
Good Practice Guide		Department of the Environment	
Guidance Notes for Floodlighting		Sport England	www.sportengland.org
Floodlighting of Outdoor Sports Facilities		Fields in Trust (formerly known as National Playing Field Association)	www.fieldsintrust.org
Light & Lighting - Sports Lighting	BS EN 12193:2007 -The "European Norm" standard - contains specific lighting guidance on a wide variety of sports	British Standards Institute	www.bsigroup.com

Publications on specific sports:

Tennis	Go to LTA website, click on 'Clubs' tab, then 'Resources'. Under 'Facility Advice and Guidance' category, download *'Floodlighting Outdoor courts Guidance'* pdf	Lawn Tennis Association Total Tennis	www.lta.org.uk/ www.totaltennisuk.net/
Hockey	*'Guide to the Artificial Lighting of Hockey Pitches'* - available as website download England Hockey recommendations refer to the previous version of the FIH guidelines and are unchanged	International Hockey Federation (FIH) England Hockey	www.fihockey.org www.englandhockey.co.uk

Rugby Union	*'RFU Facilities Guidance Note No. 4 - Floodlighting'* (It is understood that a separate guide on match floodighting may be in preparation)	Rugby Football Union	www.rfu.com
International Football	FIFA publish a very specific document, available as a website download: *'Guide to the artificial lighting of football pitches'*.	FIFA	www.fifa.com
	UEFA provide a document specifically dealing with competitions under their control - 'Guidelines and recommendations for floodlighting for all UEFA Competitions'. Other UEFA documents deal, for instance, with stadia and with specific competitions such as the Champions' League and include guidance on lighting.	UEFA	www.uefa.com
Football - domestic leagues	The FA publish a very wide range of publications dealing with the different requirements of the many leagues operating in the UK.	FA	www.thefa.com

Appendix 6

Design check list

Step	Action	Requirements	Comments
	Key: ● = required ❍ = recommended		
1	Statement of client needs / operational statement	●	
2	Site survey	●	Check with Local Planning Authority. Check the planning designation of the area. Check the ambient lighting levels in location and undertake an Environmental Impact Assessment.
3	Critical viewpoints	●	Check the proximity of sensitive viewpoints such as: • Housing • Highways. Protected areas such as Sites of Special Scientific Interests / parks. Consider landscape screening and the orientation or alternative locations.
4	Existing lighting conditions	❍	
5	Baseline conditions	❍	
6	Task analysis	●	Consider the lowest level of illumination compatible with the proposed usage.
7	Establishment of environmental setting	●	
8	Lighting design objectives	●	The greater the number of floodlights, the lower the intensity of illumination required from each floodlight. Highways: Must not present a night time visual nuisance towards traffic. • Disability glare prevented by a threshold Increment ≤15% (*ILP Guidance Notes for the Reduction of Obtrusive Light: Table 2: 2005*) • Highway Authorities may also impose a particular overspill restriction but no mandatory limits are currently set. Residential: For properties, the overspill limitation is restricted by: • *'Light Trespass into Windows'* (ILP Guidance Notes for the Reduction of Obtrusive Light: Table 1: 2005). The restricting maxima are inclusive of all existing lighting contribution, expressed as pre-curfew & post-curfew. Curfew limits of vertical illuminance measured normally to the centre of window glazing. Horizontal illuminance overspill should be reasonably controlled, but no specific limitations are currently set.

9	Lighting design methodology	❍	
10	Calculated predictions	●	
11	Obtrusive light calculation	●	The greater the column height, the greater the ability to focus downwards, but this may also result in greater visual impact due to the height of the total 'volume' that is illuminated. Ensure the scheme is designed to minimise spillage by use of lamps with 'efficient optics' (e.g. flat glass etc.)
12	Comparing design with baseline values	●	
13	Designer's critique	❍	
14	Viewpoint visualisation	❍	
15	Virtual walkthrough	❍	
16	Surface colour schedule	❍	
17	Luminaire schedule	●	
18	Energy usage	❍	
19	Schedule of luminaire profiles	●	
20	Layout plan	●	

Alternative Languages And Formats:

This document can be provided in alternative languages, or alternative formats such as large print, Braille, tape and on disk upon request. Call the Sport England switchboard on 08458 508 508 for more details

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Acknowledgements:

Sport England thank the following individuals and organisations for their contribution:

Badminton England (BE)
England Basketball (EB)
England and Wales Cricket Board (ECB)
England Hockey Board (EHB)
England Netball (EN)
Lawn Tennis Association (LTA)
Rugby Football League (RFL)
Rugby Football Union (RFU)
The Football Association (FA)
Volleyball England (VE)

Abacus
Exclusive Leisure Ltd.
CUPhosco
Fielden Clegg Bradley Studios
Highlights Floodlighting Ltd
Institution of Lighting Professionals (ILP)
London Legacy Development Corporation
Olympic Delivery Authority (ODA)
Philips Lighting
Quincey Mason Practices (QMP)
Sports Lighting UK
The Sports and Play Construction Association (SAPCA)

David Bosher
K J Austin
Wieslaw Dziedzina
M D Simpson
Charlotte Woods

User Guide

Before using this guidance for any specific projects all users should refer to the User Guide to understand when and how to use the guidance as well as understanding the limitations of use.

Click here for **'User Guide'**

Click here for current **'Design and Cost Guidance'**

Issue Tracker

002 – Updated and Amended Combined Publication: November 2012
001 – Initial Publications:

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Bloomsbury Square
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Tel : +44 (0)8458 508 508

Awarding funds from The National Lottery®

ISBN 978-1-86078-183-4

Further Information:

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