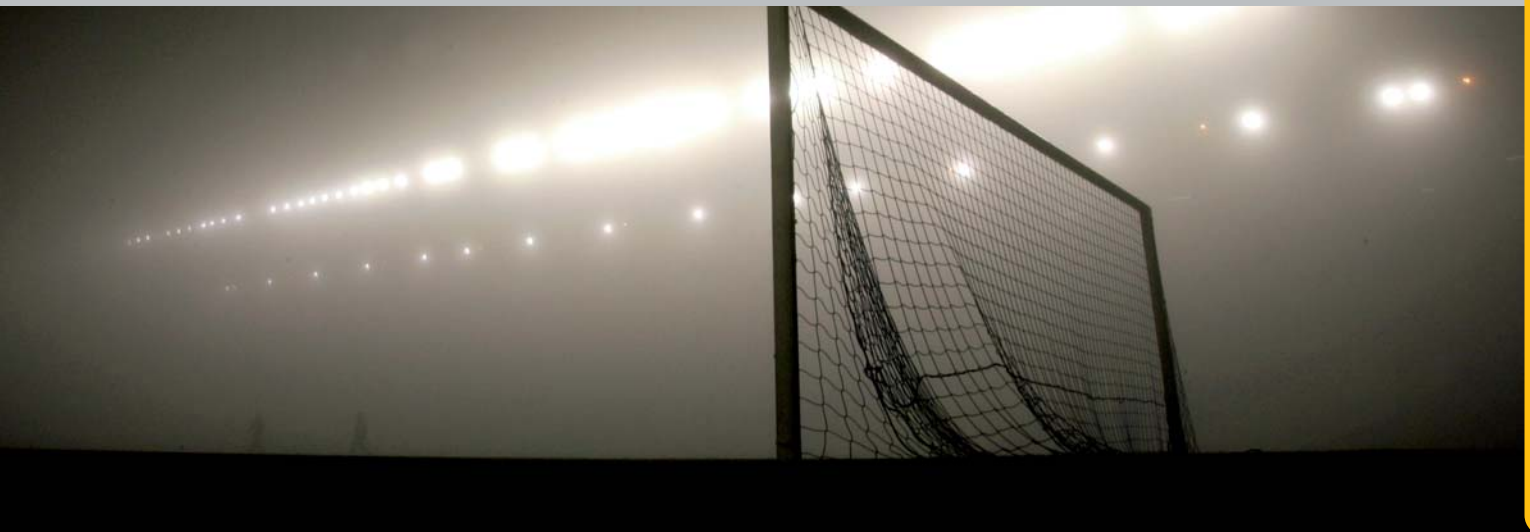


# 9 →

## Lighting and power supply

A lighting system must be installed which meets the needs of broadcasters, spectators, players and officials without spilling light into the environment and without creating a nuisance for the local community.



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## 9.1 → Power supply

The delaying or cancellation of an event due to the loss of electrical mains is unacceptable. A careful evaluation of the available utility service is crucial, but redundant services are necessary as are back-up and ride-through power sources. Redundant mains from the utility should be fully sized to carry the facility during event conditions.

The intake mains may be tied in a preferred/alternate arrangement (diagram 9a) or as in-use “hot” sources (diagram 9b) handling separate facility loads with manual or automatic tie switches. On loss of the intake mains, on-site back-up power should start immediately but there will be a time lag. Consequently, this back-up must include some ride-through capacity while the on-site source(s) start up since field lighting, which is typically high-intensity discharge (HID), will extinguish and require several minutes to re-start and the broadcasting of the event will be interrupted. This ride-through can be provided in several manners, including special generators and uninterruptible power supply (UPS) systems. Back-up power should have the capacity to operate for a minimum of three hours during an outage.

Delineation and separation of the essential event loads from the life safety system loads is necessary as the ride-through capacity is primarily needed for continuation of the event, not for exiting the facility in emergency conditions. Additional planning is necessary for space allocation of the equipment for intake and back-up sources. Maintaining separation and providing multiple points of distribution with some overlap and redundancy is recommended.

## 9.2 → Facility requirements

### Overview

The primary goal of the event lighting system is to illuminate the event to digital video quality for the media without creating nuisance glare for the players/officials and adding spill light/glare to the spectators and surrounding environment. Permanent lighting, temporary lighting and a combination of both systems should be considered.

#### – Environmental

Special care should be taken to limit the spill light and glare off the field, both inside and outside the stadium.

#### – Players and officials

The players and officials must be able to perform to their fullest ability within an illuminated environment that enhances play.

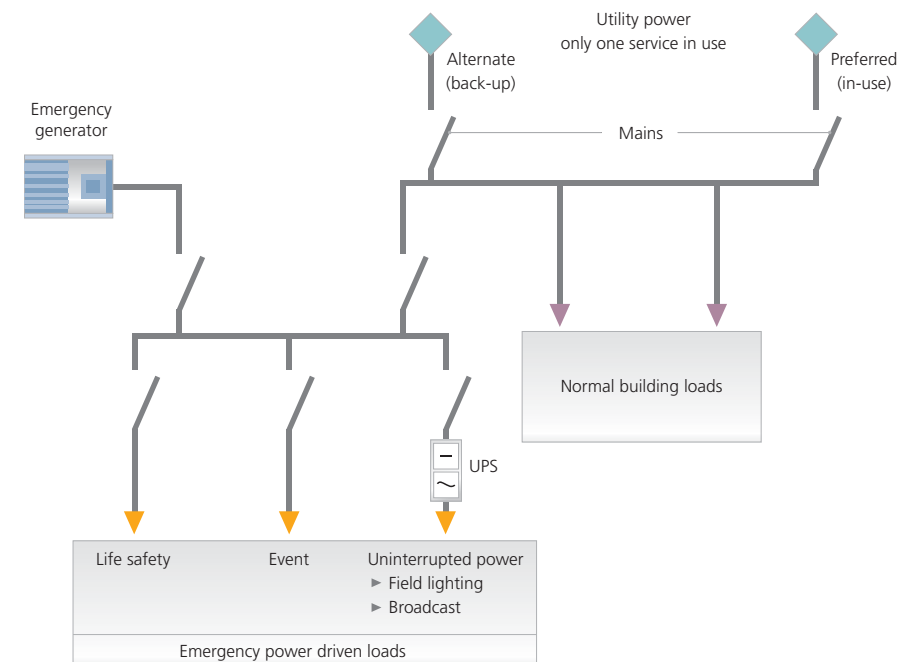


Diagram 9a:  
Power option 1

Two utility services are designed and installed – both fully sized – only one is used at a time. The loss of in-use mains would result in a time delay in closing the alternate source.

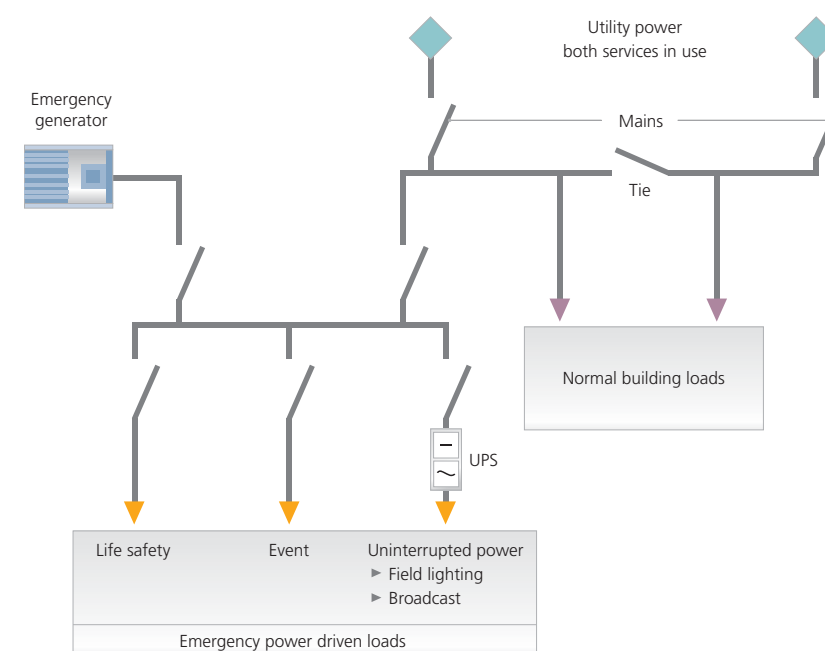


Diagram 9b:  
Power option 2

Two utility services are designed and installed and both are used – loss of either one gives only partial outage until tie is closed.

## Lighting and power supply

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## – Spectators

The spectators must be able to view the event, scoreboard, video and all activities on the field in comfort, free from glare and excessive spill light.

## – The media

The media video and broadcasts produced during an event shall be of digital quality, with balanced illumination and free from hard-line shadows and glare.

## Competition categories

Five classes of lighting systems have been developed (I to V). There are two categories that need televised-quality lighting and three classes for non-televised events.

Class V	International televised	Event pitch shall be shadow free/glare free.
Class IV	National televised	Event pitch shall be shadow free/glare free.
Class III	National game non-televised	Event pitch shall be glare free with a minimum of eight poles (recommended).
Class II	Leagues and clubs non-televised	Event pitch shall be glare free with a minimum of six poles (recommended).
Class I	Training and recreation non-televised	Event pitch shall be glare free with a minimum of four poles (recommended).

## Mounting height of light fittings

The mounting height of the light fittings is critical to the success of the sports lighting system. The mounting height geometry for sideline head frames and poles is 25 degrees above the horizon, starting from the middle of the pitch and looking back towards the stadium seating bowl. The head frame and light structure may exceed this 25-degree minimum guideline but it may not exceed 45 degrees.

## Camera views to be considered

There are many possible camera positions which can be used to create the televised experience. The camera positions illustrated are some of those which are popular. A lighting specification should take account of the actual camera positions to be used in order to ensure that each camera receives sufficient light, from which good-quality video can be created. Where required, the additional advice of an appropriate television broadcaster or a regional television consortium can be sought.

For more on the needs of the media, see Chapter 8.

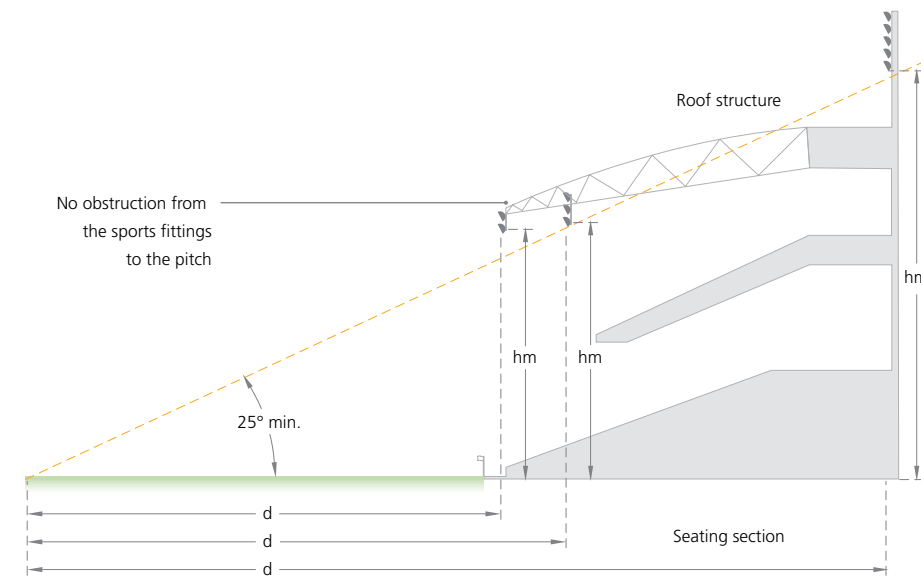


Diagram 9c:  
Mounting height of  
light fittings

Mounting height  $\geq 25^\circ$   
 $hm = d \cdot \tan(25^\circ)$

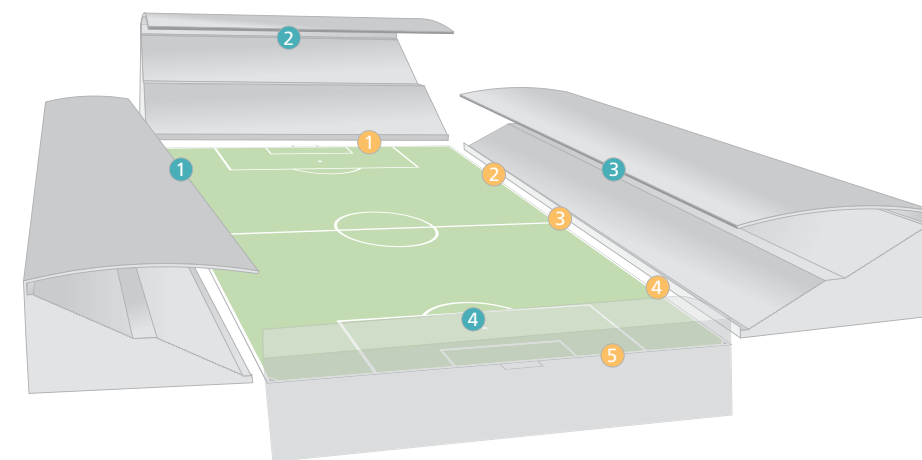


Diagram 9d:  
Standard camera views

- Fixed camera
- Field camera



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The principal goal of the lighting system is to ensure symmetrical lighting for both touch line and goal line conditions. Both fixed and field cameras can be added without affecting the digital video quality.

Player and broadcast view angles

Providing a glare-free environment for the players, officials and media is the most important design requirement. The following two areas are defined as “no floodlight zones” for all five categories of competition:

- Corner goal-line area:  
In order to maintain good visual conditions for the goalkeeper and attacking players in the corners, lighting equipment shall not be placed within an area of 15 degrees on either side of the goal line.
- Behind the goal line:  
In order to maintain good visual conditions for the attacking players in front of the goal and the goalkeeper, as well as for video media at the opposite end of the pitch, lighting equipment shall not be placed within 20 degrees behind the goal line and 45 degrees above the horizon from the goal line.

Shadow control (multi-zone aiming)

Limiting hard-line shadowing on the pitch is becoming one of the biggest problems facing high-definition, digital video quality media. Multi-zone aiming is the repetitive aiming from different head frame locations at similar locations on the pitch. This repetitive aiming from separate locations limits hard-line shadows created by the players.

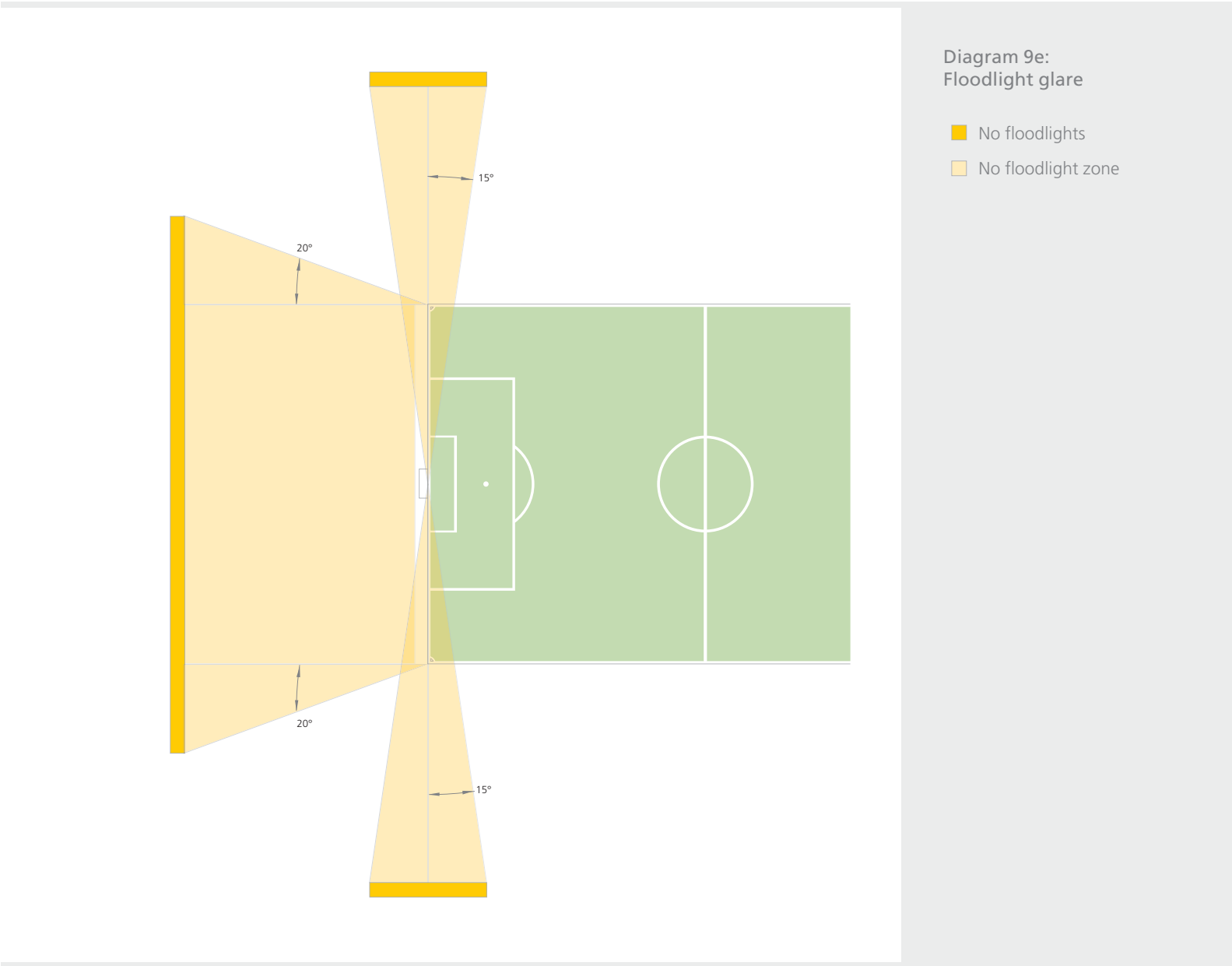
Diagrams 9f and 9g divide the pitch into three zones, with Zone 1 representing both end zones and Zone 2 representing the middle of the pitch. The aiming for each zone shall have a minimum of four overlapping lighting arrays per side for international events and three overlapping lighting arrays per side for national televised events.

Modelling is achieved when an event player is surrounded by illumination from different locations, creating a balanced illuminated environment. A shadow-free environment is achieved when hard-line shadows on the pitch do not exist.

Installation planning (non-televised)

For international and national televised events, the lighting head frames are positioned on the stadium for digital video quality lighting. Multi-zone aiming is not required for a non-televised pitch. For national, league and training non-televised events, the following standard lighting design guidelines apply (see diagram 9h, page 173):

Hard-line shadow on the pitch is one of the biggest problems facing high-definition digital broadcasting.



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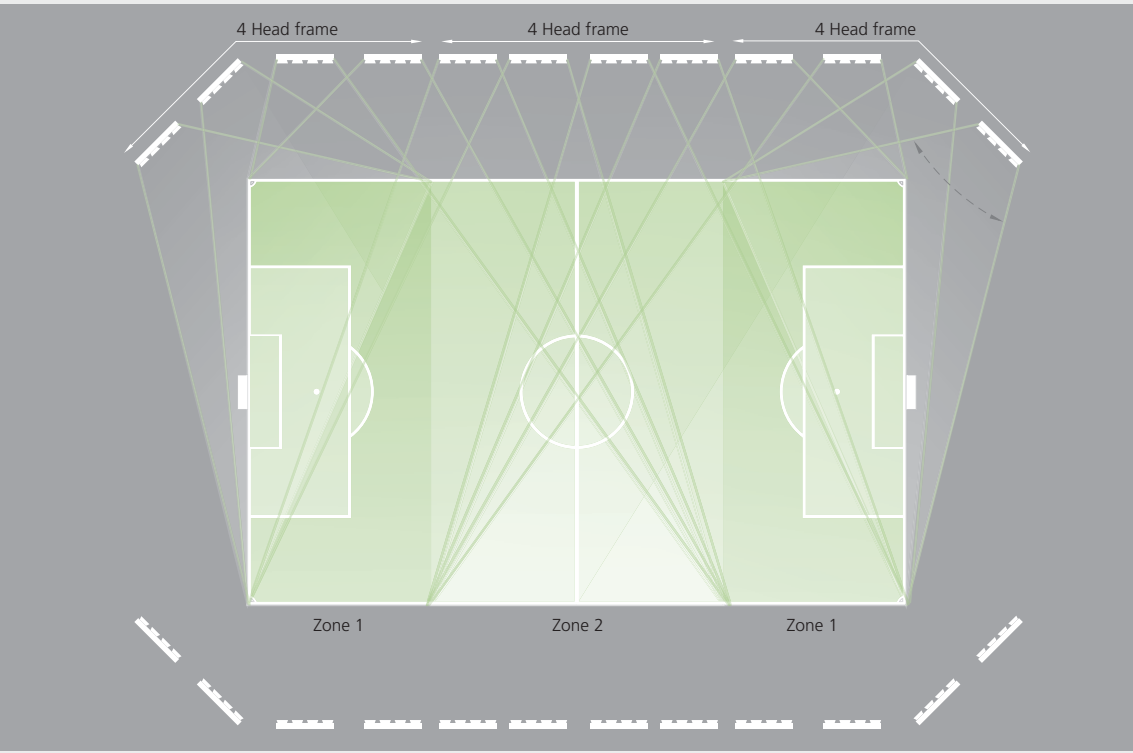


Diagram 9f:  
Class V  
Field aiming international

▬ Fitting head frame  
---- Aiming zone

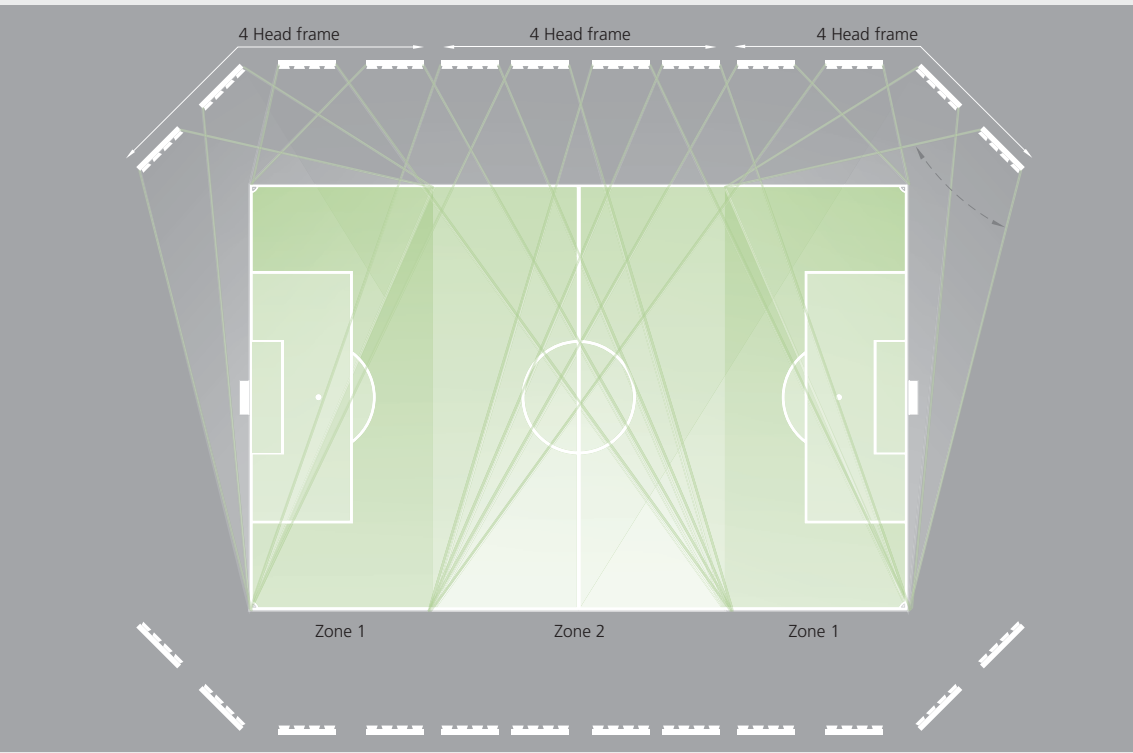


Diagram 9g:  
Class IV  
Field aiming national

▬ Fitting head frame  
---- Aiming zone

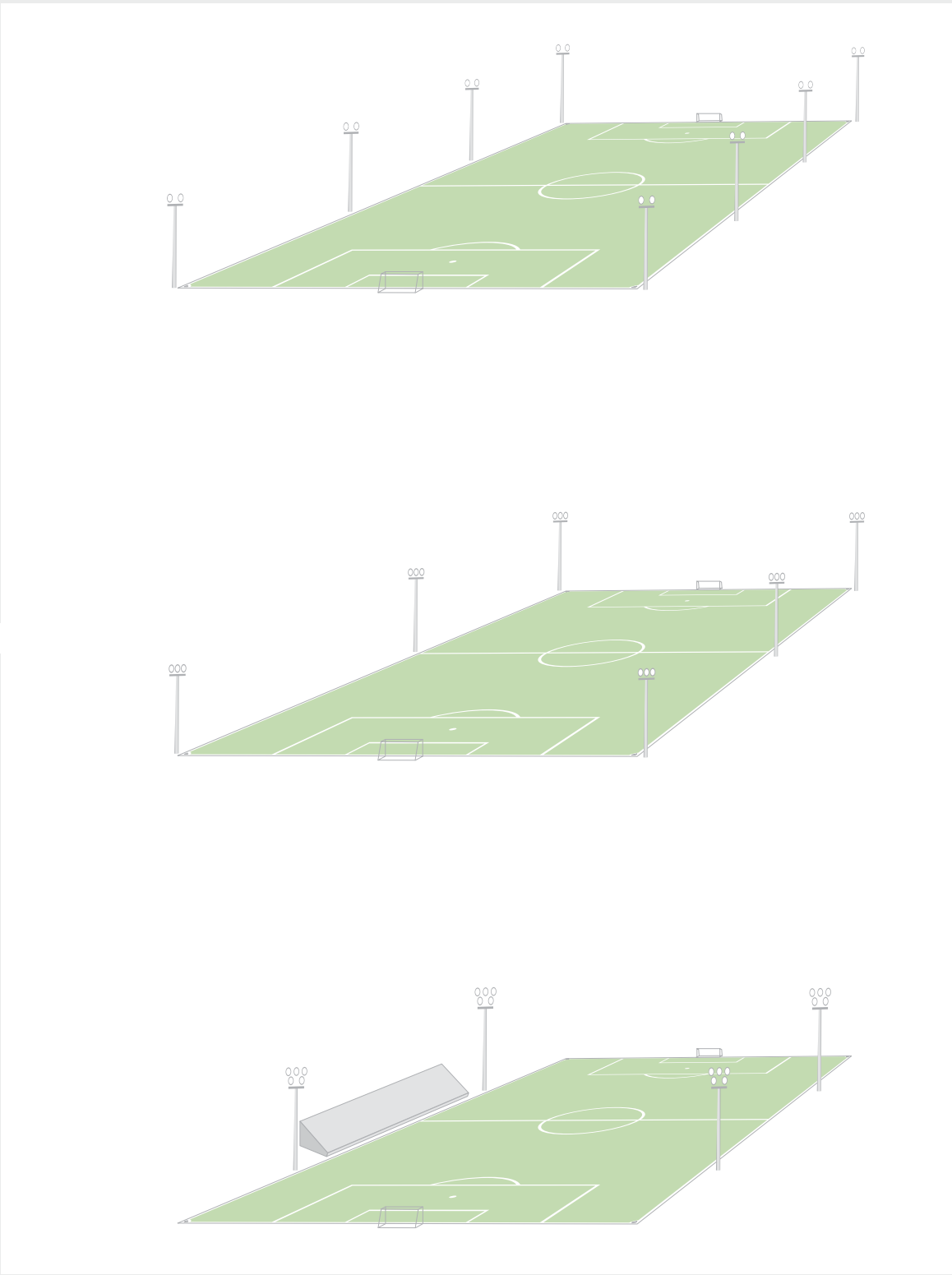


Diagram 9h:  
Installation planning  
(non-televised)

Class III  
National game

Class II  
League and club

Class I  
Training and recreation

Exact pole location and details will vary with each installation; seating areas should be free from poles obstructing the view of spectators.



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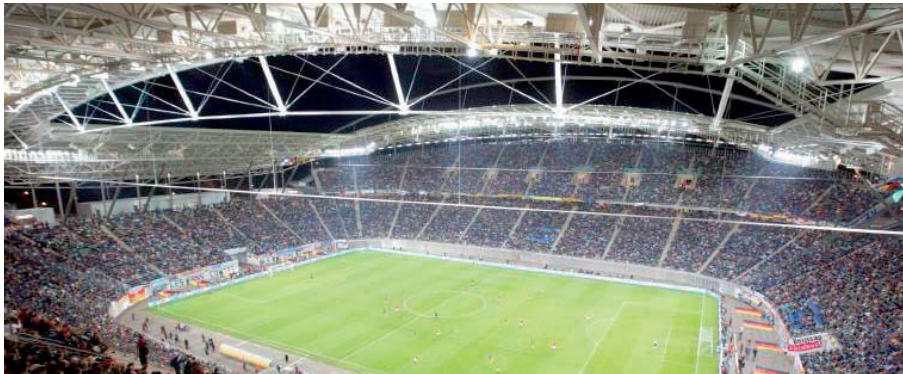


9.3 → Lighting design specifications and technology

Horizontal uniformity

Horizontal

Horizontal illuminance is a measure of light reaching a horizontal plane, one metre above the playing surface. A 10m x 10m grid across the playing field is used as a basis for collecting these measurements and calculating maximum/minimum/average illumination on the playing field.



Variation

Football is a high-speed sport and maintaining a uniform illumination across the playing field will enhance player performance and create excellent high-definition video. The methods for calculating uniformity are expressed below. Either method, CV or UG, can be used to calculate uniformity.

	Televised events	Non-televised events
Co-efficient of variation (CV)	CV ≤ 0.13 - 0.15	CV ≤ 0.3 - 0.4
Uniformity gradient (UG)	UG = 1.5 - 2	UG = 2 - 2.5

Vertical illumination

Field camera vertical

Vertical lighting at field level is the amount of illumination reaching the vertical surface of the players. This illumination helps to show close-up details of players, particularly their faces, at critical moments during the match. These images are captured by (both hand-held and motorised) field camera positions. Variations in vertical illumination will create poor digital video. The designer must consider balancing the illumination to reduce over-/under-illuminated areas during field camera operations.



Fixed camera vertical

Vertical light above the pitch captured by the upper touch-line and goal-line cameras is referred to as fixed camera vertical illumination. These cameras panning the pitch must capture the entire play during the event. Variation in illumination will create poor digital video. The designer must consider balancing the illumination to reduce these over-/under-illuminated areas during fixed camera operations.

The lighting system must illuminate the football match to digital video quality.



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Colour temperature

Colour temperature describes the feeling or appearance of how warm (red) or cool (blue), a certain type of illumination appears to be. It is measured in kelvins (Tk). Current digital camera technology allows the video-produced media to be altered to ‘gain’ colour and contrast, as needed to produce the desired colour quality. Acceptable colour temperature for outdoor stadiums for all classes of competition is Tk ≥ 4,000.

Colour rendering

Colour rendering is the ability of an artificial illumination source to reproduce natural lighting. The colour rendering practical scale is Ra20 to Ra100, where the higher the rating, the better the colour quality. Good colour produced by the artificial illumination system shall be Ra ≥ 65 for both televised and non-televised events.

Summary of lighting specifications for televised events

The following table is a summary of the criteria to be considered for televised events. It sets out the recommendations for vertical and horizontal illuminance, uniformity and the colour properties of lamps, for each class of activity.

Lighting specifications for televised events

		Vertical illuminance			Horizontal illuminance			Properties of lamps	
		Ev cam ave	Uniformity		Eh ave	Uniformity		Colour temperature	Colour rendering
Class	Calculation towards	Lux	U1	U2	Lux	U1	U2	Tk	Ra
Class V International	Fixed camera	2,400	0.5	0.7	3,500	0.6	0.8	> 4,000	≥ 65
	Field camera (at pitch level)	1,800	0.4	0.65					
Class IV National	Fixed camera	2,000	0.5	0.65	2,500	0.6	0.8	> 4,000	≥ 65
	Field camera (at pitch level)	1,400	0.35	0.6					

Notes:

- Vertical illuminance refers to illuminance towards a fixed or field camera position.
- Vertical illuminance uniformity for field cameras can be evaluated on a camera-by-camera basis and variation from this standard will be considered.
- All illuminance values indicated are maintained values. A maintenance factor of 0.7 is recommended; therefore initial values will be approximately 1.4 times those indicated above.
- In all classes, the glare rating is GR ≤ 50 for players on the pitch within the player primary view angle. This glare rating is satisfied when the player view angles are satisfied.
- Constant Illumination Lamp technology is acceptable and encouraged.

Summary of lighting specifications for non-televised events

The following table is a summary of the criteria to be considered for non-televised events. It sets out the recommendations for horizontal illuminance, uniformity and the properties of lamps, for each level of activity.

Lighting specifications for non-televised events

Activity level	Horizontal illuminance	Uniformity	Lamp colour temperature	Lamp colour rendering
Class	Eh ave (lux)	U2	Tk	Ra
Class III National games	750	0.7	> 4,000	≥ 65
Class II Leagues and clubs	500	0.6	> 4,000	≥ 65
Class I Training and recreation	200	0.5	> 4,000	≥ 65

Notes:

- All illuminance values indicated are maintained values.
- A maintenance factor of 0.70 is recommended. Initial values will therefore be approximately 1.4 times those indicated above.
- Illuminance uniformity shall not exceed than 30% every 10 metres.
- Primary player view angles must be free of direct glare. This glare rating is satisfied when the player view angles are satisfied.



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9.4 → Environmental impact

Light pollution and unwanted light trespass fall into two categories: spill illumination, which is light leaving the perimeter of the stadium that is measurable; and glare, which is excessive brightness in the normal field of view for pedestrians and motorists outside the stadium. This impact on local communities is critical to the safety, dark sky experience and well-being of the countries and cities they serve. Every effort needs to be made to limit both spill and glare inside and outside the stadium. New design specifications should include sharp cut-off reflectors and high efficiency reflectors for televised events.

Spill illumination leaving the stadium can be calculated and measured. These values are expressed in horizontal illumination values and maximum vertical illumination. In the absence of local guidelines, the following schedule should be considered:

Angle of illumination	Distance from stadium perimeter	
Horizontal spill	50m from stadium perimeter	25 lux
Horizontal spill	200m further	10 lux
Maximum vertical	50m from stadium perimeter	40 lux
Maximum vertical	200m from stadium perimeter	20 lux

For more on environmental compatibility, see Chapter 1.

Every effort needs to be made to limit the overspill of stadium light onto the surrounding community.

9.5 → Installation commissioning

Inspection and equipment

Measuring the actual illumination prior to play is required to ensure system performance. The following specifications are suggested standard guidelines:

Specifications	Symbol
Average horizontal illumination	Eh ave
Average fixed camera illumination	Ev ave (fixed camera)
Average field camera illumination	Ev ave (field camera)
Uniformity (min./max. illumination)	U1
Uniformity (min./average illumination)	U2

Both digital and analogue light meters are acceptable. Calibration of the instrument should be carried out yearly. The calibration date and the meter serial number must be noted on the worksheets submitted. Care should be taken while recording readings to limit the shadow created by the testing personnel. The light meter shall be attached to a tripod, level with the pitch and one metre above the pitch.

Televised measurements shall include three categories of readings: horizontal, fixed camera and field camera.

- Horizontal:** positioning the measuring cell one metre above the pitch at 90°, perpendicular to the pitch (worksheet 1, page 182).
- Fixed camera:** positioning the measuring cell one metre above the pitch, 30° above the horizon (worksheet 2, page 183).
- Field camera:** positioning the measuring cell one metre above the pitch and parallel to the pitch (worksheet 3, page 184).

Non-televised measurements shall include one category of readings: horizontal.

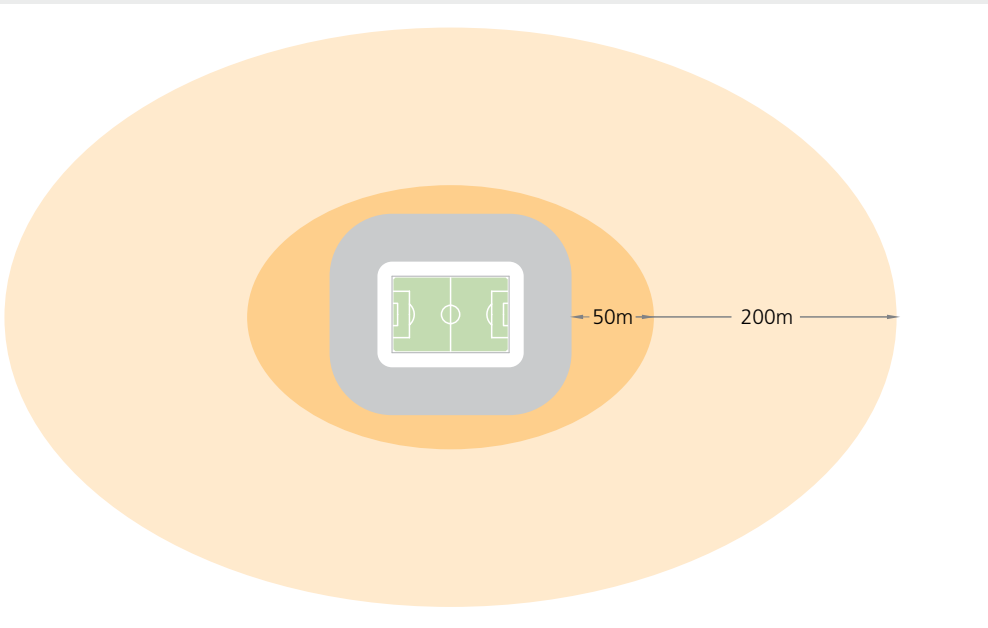


Diagram 9i:  
Environmental impact

- 25 lux horizontal  
40 lux max vertical
- 10 lux horizontal  
20 lux max vertical



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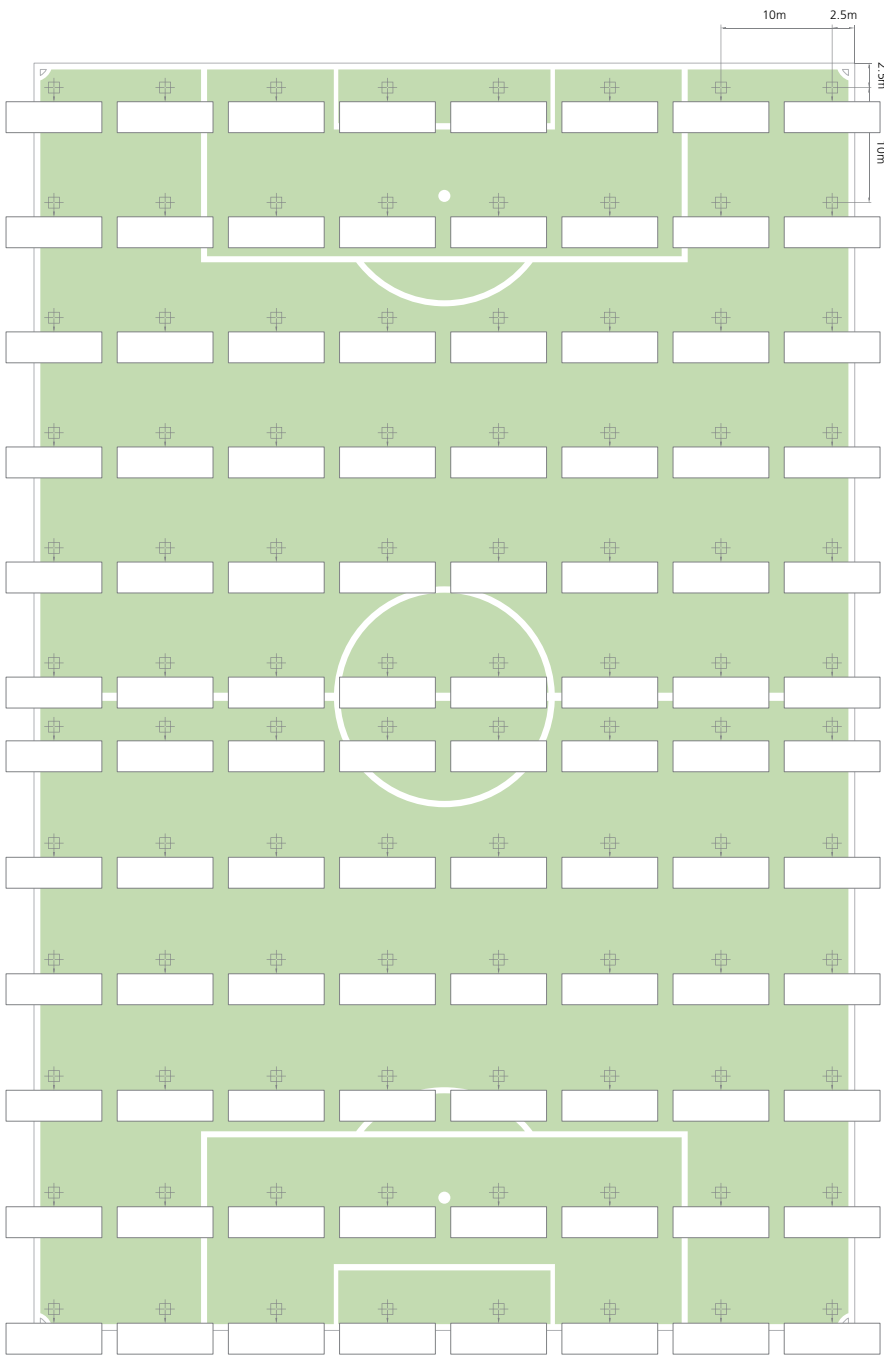
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Worksheet 1: Horizontal measurements and calculations



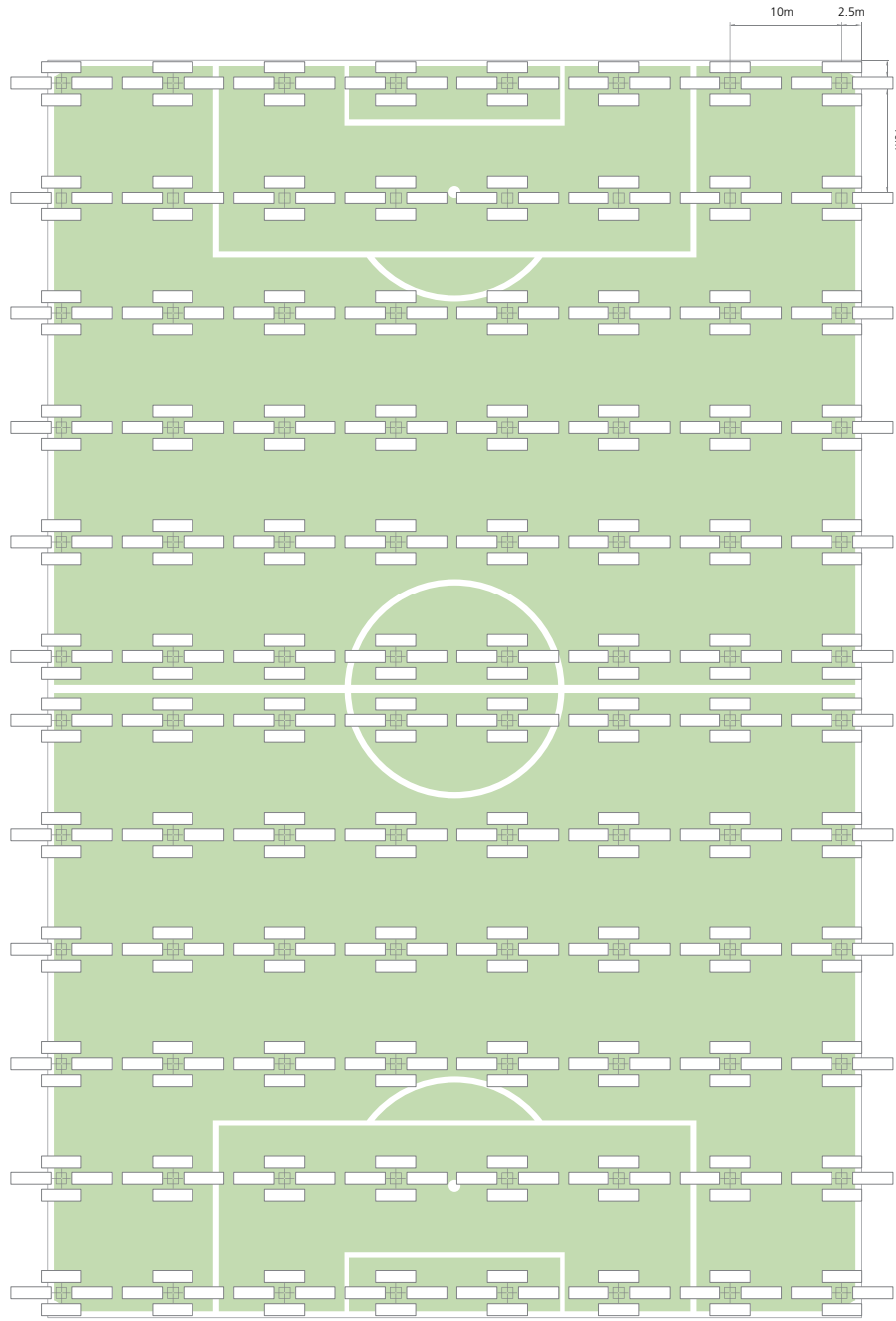
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Conditions:

Date:

Venue:

Worksheet 2: Field vertical measurements and calculations



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Conditions:

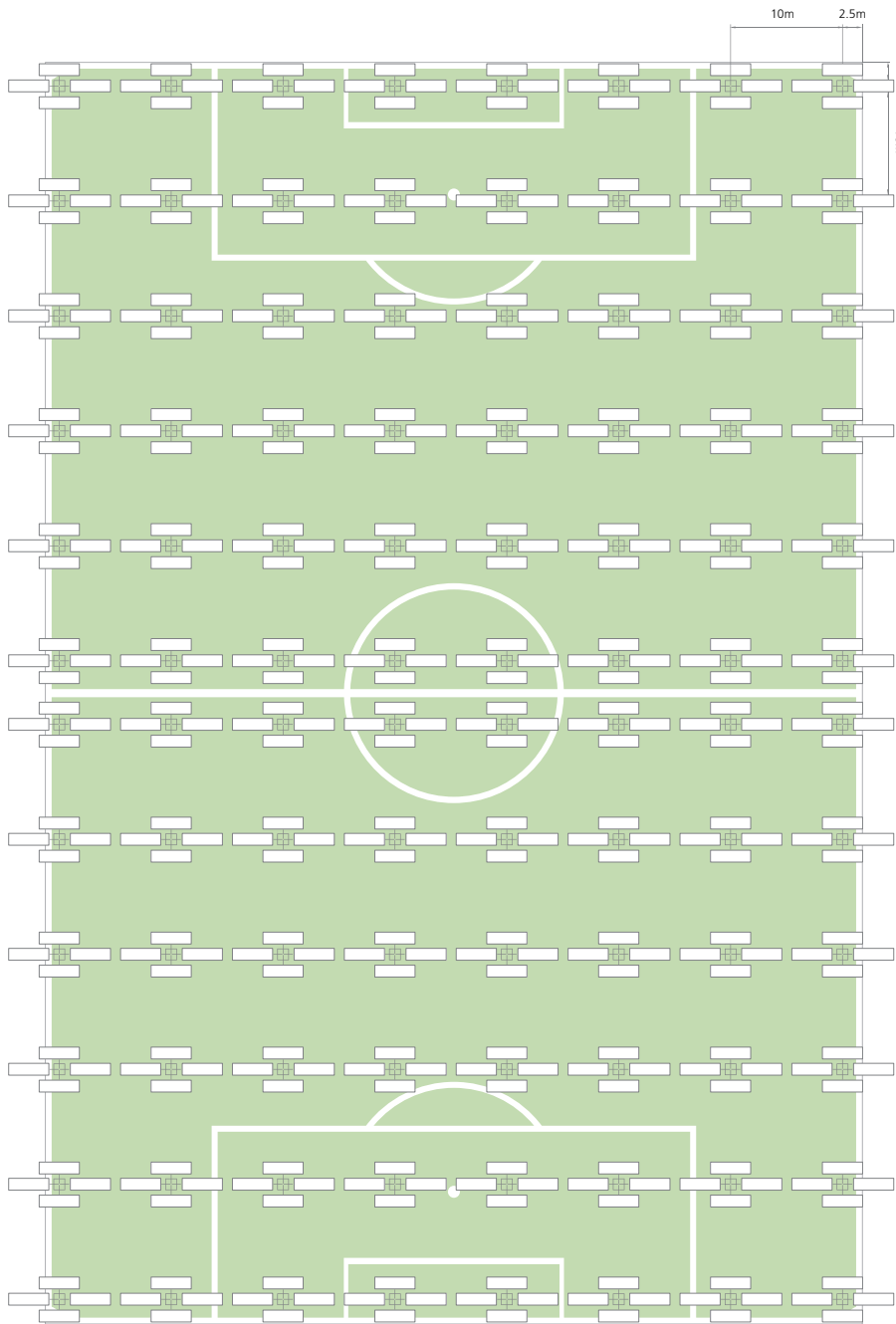
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Venue:



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Worksheet 3: Fixed vertical measurements and calculations

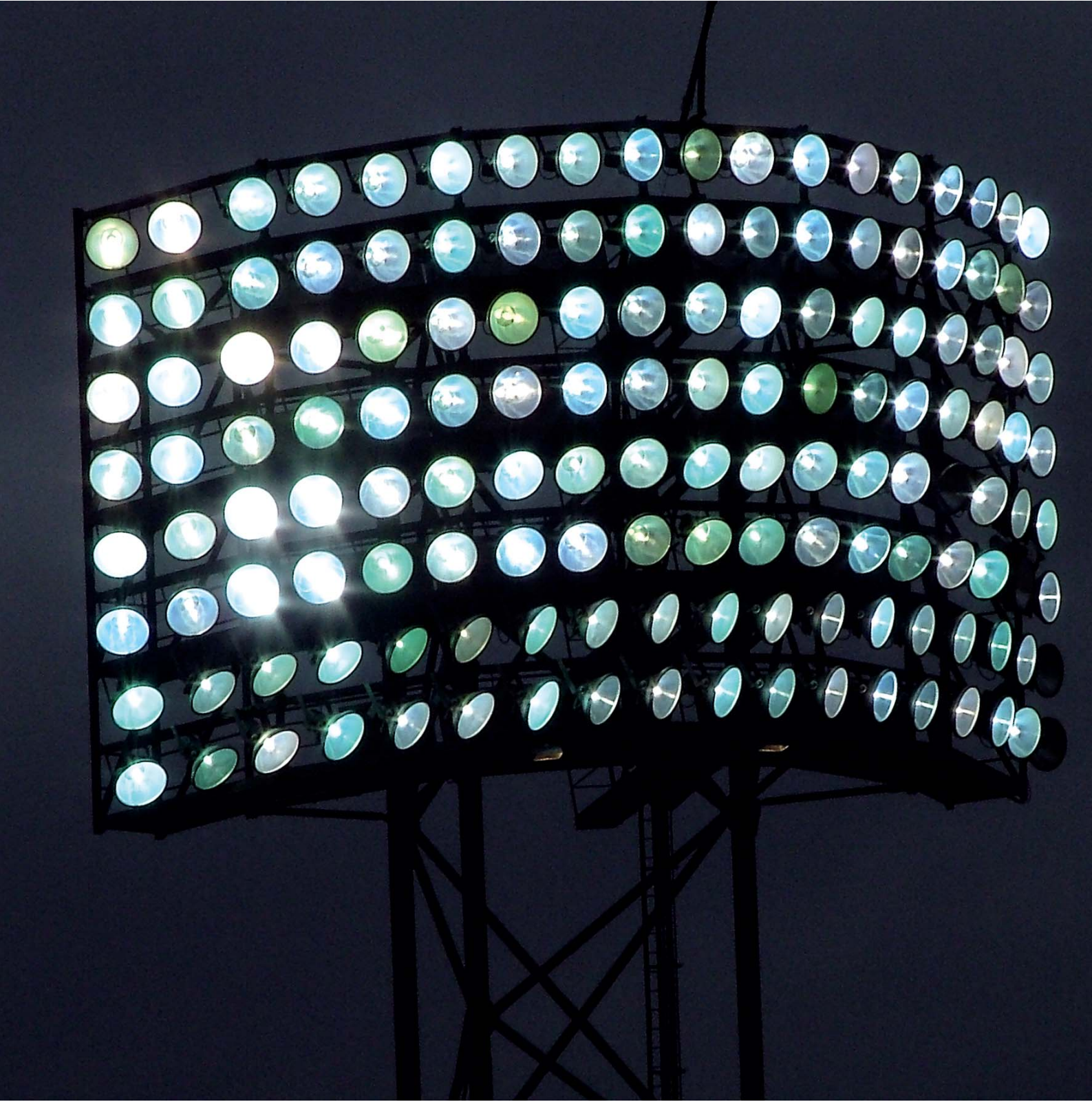


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9.6 → Glossary of lighting terms

**Colour rendering index: Ra** → The degree to which a specific light source reproduces a set of reference colours compared with the same colours under daylight conditions. This index is measured on a scale of Ra0 to Ra100.

**Colour temperature: Tk** → The colour appearance of the light emitted by a light source, in kelvins.

**Eye sensitivity curve: V(a)** → The human eye is more sensitive to some colours than to others, e.g. it is 20 times more sensitive to green and yellow light than to either red or blue light.

**Field camera vertical: Efieldv** → Illuminance on a plane 1m above the pitch and parallel with the pitch aimed towards the sideline.

**Fixed camera vertical: Efv** → Illuminance on a plane 1m above the pitch and 20° above the horizon aimed towards the camera positions.

**Glare rating** → The degree to which a lighting installation is disturbing to a person on or near the pitch. GR is defined by the Commission Internationale de l'Eclairage in publication 112, 1994, *Glare Evaluation System for use within Outdoor Sports and Area Lighting*.

**Horizontal illuminance: Eh/Eh ave** → Light incident (falling) on a horizontal plane 1m above the pitch.

**Illuminance: E** → The quantity of light falling (incident) on a surface at a specific point, expressed in lux.

**Illumination: E ave** → Average horizontal illuminance as a result of either calculation or measurement.

**Illuminance gradient %** → The difference in illuminance between two adjacent points on the pitch.

**Illuminance towards camera: E cam** → Illuminance on a plane 1m above the pitch and perpendicular to the camera position.

**Illuminance uniformity** → Describes how evenly light is distributed over the pitch surface and is expressed by the ratios of U1 and U2.

**Initial illuminance: E init** → The illuminance after the first 100 hours of use.

**Initial lumens** → The output of a light source (lamp) after the first 100 hours of use.

**Intake mains** → The incoming utility service, which would be the metered feeders.

**Light trespass** → The amount of light spill and glare leaving the premises

**Lumens: Lm** → The spectral power distribution of a lamp weighted by the eye sensitivity curve.

**Lux** → The unit of illuminance in lumen/m², incident on a pitch surface.  
1 lux = 1 lumen/m².

**Maintained illuminance: E maint/E ave maint** → The (average) illuminance below which the installation should not fall; below which the lamps should be replaced and or the installation cleaned.

**Maintenance factor** → A factor less than 1. Initial illuminance x maintenance factor = the maintained illuminance. This compensates for the depreciation in lamp output and light fitting surfaces.

**Maximum vertical** → Illuminance recorded on a light meter aimed at the brightest light source.

**Mounting heights: Hm** → The mounting height of the light fittings with respect to a point on the pitch. Hm = distance “d” x tan d.

**Primary player view angle: PPVA** → Normal players’ view angle in relationship to the playing field and the spill light fittings.

**Ride-through** → The ability of a power system to maintain continuous uninterruptible stable power during an outage, or during bumps/spikes, while waiting for a generator to start.

**Temporary lighting** → Light fitting poles and structures support event head frames that are removable after an event.

**Vertical illuminance: Ev** → Light incident on a vertical plane 1m above the pitch. Orientation to be specified.