UEFA Stadium Lighting Guide 2023

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UEFA Stadium Lighting Guide 2023

Contents

1 — Introduction

The UEFA Lighting Guide 2023 provides detailed technical information and guidance on floodlighting for football stadiums. It replaces the previous version from 2016. While only minor changes have been made to the lighting requirements, additional design guidance and information has been included on the use of LED as the light source.

When designing a new pitch illuminance system, note that the illuminance values given here are the recommended minimum values to be applied to each relevant stadium category. It is recommended that, wherever possible, illuminance values should exceed UEFA's minimum requirements for the various competitions as stated in the UEFA Stadium Infrastructure Regulations taking account of further stipulations in the individual competition regulations and manuals. Staging agreements for finals or final tournaments may include specific clauses on floodlighting.

The UEFA Lighting Guide 2023 is intended for UEFA member associations and suppliers to provide appropriate illuminance at stadiums in the UEFA region. It takes account of recent technological developments and will guide stadium owners wanting to install a high-quality system tailored to the current and anticipated future broadcasting environment and UEFA's competition requirements.

When designing a pitch illuminance system, the lighting efficiency should be evaluated, and the most environmentally friendly solution should always be chosen.

2 — Design guide

These are guidelines for artificial illuminance systems at football pitches. The way you apply these principles to the design elements and combine them in one design will determine how successful your design is.

The following important points should be considered and applied when designing a new pitch illuminance system or making alterations to an existing system.

Main points

1. It is essential that players' comfort and performance are not hindered by the pitch illuminance system.
2. The ability of match officials to perform effectively should not be hindered by the pitch illuminance system.
3. A spectator should be able to watch and enjoy the match without suffering any discomfort caused by the pitch illuminance system.
4. The pitch illuminance system should provide a level of illuminance that enables television broadcasters to operate effectively, in line with the requirements set out for the relevant UEFA illuminance level.
5. The relevant level of UEFA competition must be considered when assessing a stadium's needs to determine the appropriate UEFA illuminance level.
6. A successful pitch illuminance system will produce illuminance levels and uniformity that comply with the requirements of the relevant UEFA illuminance level requirements, with soft shadows where possible.
7. The pitch illuminance system must be reliable and effective for the given stadium location. The specific conditions that are relevant for the stadium location should be carefully assessed.
8. The pitch illuminance system should provide a long-term solution that is both efficient and cost-effective.
9. The environmental impact of a pitch illuminance design solution should be carefully assessed. The design team should be committed to achieving an environmentally responsible solution. The light source for all new stadiums in the UEFA Level A and B should be provided by LED luminaires. It is recommended that LED luminaires are also used in UEFA level C and D stadiums and only for specific reasons should HID luminaires be used for new installations.
10. Every sports stadium is unique. Consequently, each stadium will require a design solution that is appropriate for the relevant stadium and illuminance level.
11. The stadium's infrastructure and design will have a significant impact on the type of pitch illuminance system that can be applied. A four-corner tower/column system will not generally meet UEFA's requirements for level A stadiums.
12. Modern artificial lighting systems are able to provide high-quality illuminance on the pitch and may potentially be integrated into the architectural design of the stadium.
13. The artificial lighting system may also be used to create lighting effects for stadium events and for pre/post-match lighting effects.
14. The lighting design should always take account of the latest technological requirements for broadcast television.
15. The designers should always assess the existing lighting equipment and consider the technology currently available and whether it is appropriate for the desired lighting solution.

3 — UEFA illuminance levels

It is essential to ascertain the level of UEFA competition that the stadium is intended to be used for. The pitch illuminance system should be designed to meet the requirements of the relevant UEFA illuminance level. An illuminance system that operates to a higher specification than is necessary may be unduly expensive to install and operate. In some situations, it may even be considered inappropriate given the stadium's size and location. However, it is also important that the design process gives due consideration to long-term aspirations in terms of the intended use of the stadium. In some cases, it may be preferable to comply with the requirements of a higher UEFA illuminance level to allow for future development.

Guidance in selecting the relevant UEFA illuminance level is provided in Overview of illuminance levels for UEFA competitions.

New stadiums

When designing a new stadium, this guide should be used to determine the level of illuminance required. Once the illuminance system (i.e. floodlights) has been installed, a UEFA illuminance test report should be submitted to UEFA for analysis. A test report template can be found in UEFA Illuminance test report template.

Note that UEFA encourages the use of energy efficient LED lighting and recommends it for pitch illuminance systems. However, it is important for the correct high-quality LED light source to be used.

Existing stadiums

Existing stadiums may wish to evaluate their current illuminance system to ascertain any changes necessary to meet the required standards for the relevant level of competition.

Again, a UEFA illuminance test report should be completed and submitted to UEFA for analysis. UEFA may provide information about the current illuminance conditions and any modifications that may be required. A test report template can be found in UEFA Illuminance test report template.

It is important for all five reference planes to be tested during the illuminance test and the results provided in the UEFA illuminance test report. The five reference planes consist of one horizontal plane and four vertical planes.

Illuminance levels

The requirements in terms of the artificial illuminance of a football pitch are split into five illuminance levels. The UEFA illuminance level for each competition round can be found in the following table. If there is any uncertainty as to which level applies, you should contact UEFA for further guidance.

Stadiums and football grounds that are not intended to be used for TV broadcasts are not required to meet the higher lighting requirements of levels A, B, C and D. However, the lighting conditions should still meet the relevant sporting requirements for players, officials and spectators. The non-broadcast specification constitutes the minimum requirements.

Overview of illuminance levels for UEFA competitions

UEFA competition levels		
UEFA competition	UEFA illuminance level	Floodlight power supply level (FPSL)
UEFA EURO final tournament	Elite level A	FPSL A for HID FPSL A for LED
UEFA European Football Championship: qualifying matches	Level B	FPSL B for HID FPSL B for LED
UEFA Nations League finals	Level B	FPSL A for HID FPSL A for LED
UEFA Nations League: league phase	Level B	FPSL B for HID FPSL B for LED
UEFA Women's EURO final tournament	Level B	FPSL B for HID FPSL B for LED
UEFA Women's EURO qualifying rounds	Level D	FPSL B for HID FPSL B for LED
FIFA Women's World Cup: qualifying rounds	Level D	FPSL B for HID FPSL B for LED
UEFA European Under-21 Championship: final tournament	Level B	FPSL B for HID FPSL B for LED
UEFA European Under-21 Championship: qualifying matches	Level D	FPSL B for HID FPSL B for LED
UEFA Super Cup	Level A	FPSL A for HID FPSL A for LED
UEFA Champions League final	Elite level A	FPSL A for HID FPSL A for LED
UEFA Champions League: group stage to semi-finals	Level A	FPSL B for HID FPSL B for LED
UEFA Champions League: play-offs	Level B	FPSL B for HID FPSL B for LED
UEFA Champions League: third qualifying round	Level C	FPSL B for HID FPSL B for LED
UEFA Champions League: first and second qualifying rounds	Level D	FPSL B for HID FPSL B for LED
UEFA Europa League final	Elite level A	FPSL A for HID FPSL A for LED
UEFA Europa League: group stage to semi-finals	Level B	FPSL B for HID FPSL B for LED

UEFA competition levels		
UEFA Europa League: third qualifying round and play-offs	Level C	FPSL B for HID FPSL B for LED
UEFA Europa League: First and second qualifying rounds	Level D	FPSL B for HID FPSL B for LED
UEFA Europa Conference League final	Elite level A	FPSL A for HID FPSL A for LED
UEFA Europa Conference League: group stage to semi-finals	Level B	FPSL B for HID FPSL B for LED
UEFA Europa Conference League: third qualifying round and play-offs	Level C	FPSL B for HID FPSL B for LED
UEFA Europa Conference League: first and second qualifying rounds	Level D	FPSL B for HID FPSL B for LED
UEFA Women's Champions League final	Level B	FPSL B for HID FPSL B for LED
UEFA Women's Champions League: group stage to semi-finals	Level D	FPSL B for HID FPSL B for LED
UEFA Women's Champions League: Preliminary round, round 1 & round 2	Eh ≥350 lux	FPSL C
UEFA Youth League: qualifying rounds and finals	Eh ≥350 lux (non-broadcast matches)	FPSL C
	Level D (broadcast matches)	FPSL B for HID FPSL B for LED
Men's and women's youth competitions: final tournament	Level D	FPSL B for HID FPSL B for LED
Men's and women's youth competitions: qualifying rounds	Eh ≥350 lux	FPSL C
UEFA Regions' Cup: preliminary round to final	Eh ≥350 lux (non-broadcast matches)	FPSL C
	Level D (broadcast matches)	FPSL B for HID FPSL B for LED
Non-broadcast matches	Eh ≥350 lux	FPSL C

4 — UEFA illuminance requirements

Elite level A floodlight illuminance

Elite level A floodlight illuminance	
Eh ave (average horizontal illuminance)	>2,000 lux
Uniformity U1h	>0.50
Uniformity U2h	>0.70
Ev ave-0° (vertical illuminance on 0° reference plane)	average >1,500 lux minimum >1,000 lux
Uniformity U1v-0°	>0.50 *(see Pitch illuminance system design)
Uniformity U2v-0°	>0.60 *(see Pitch illuminance system design)
Ev ave-90° (vertical illuminance on 90° reference plane)	average >1,500 lux minimum >1,000 lux
Uniformity U1v-90°	>0.50 *(see Pitch illuminance system design)
Uniformity U2v-90°	>0.60 *(see Pitch illuminance system design)
Ev ave-180° (vertical illuminance on 180° reference plane)	average >1,500 lux minimum >1,000 lux
Uniformity U1v-180°	>0.50 *(see Pitch illuminance system design)
Uniformity U2v-180°	>0.60 *(see Pitch illuminance system design)
Ev ave-270° (vertical illuminance on 270° reference plane)	average >1,500 lux minimum >1,000 lux
Uniformity U1v-270°	>0.50 *(see Pitch illuminance system design)
Uniformity U2v-270°	>0.60 *(see Pitch illuminance system design)
Match continuity mode (MCM) * This applies to LED. No disruption permitted for HID	See FPSL A
Flicker factor (FF)	average <3% maximum <3%
Minimum adjacent uniformity ratio (MAUR)	>0.60 ≤10 failures
Colour temperature (Tc)	5,000–6,200K
Colour rendering (Ra)	≥80 Ra
Glare rating (R_G)	<50
Maintenance factor (MF)	0.90 LED 0.80 HID

Level A floodlight illuminance

Level A floodlight illuminance	
Eh ave (average horizontal illuminance)	>1,500 lux
Uniformity U1h	>0.50
Uniformity U2h	>0.70
Ev ave-0° (vertical illuminance on 0° reference plane)	average >1,250 lux minimum >700 lux
Uniformity U1v-0°	>0.40
Uniformity U2v-0°	>0.50
Ev ave-90° (vertical illuminance on 90° reference plane)	average >1,250 lux minimum >700 lux
Uniformity U1v-90°	>0.40
Uniformity U2v-90°	>0.50
Ev ave-180° (vertical illuminance on 180° reference plane)	average >1,250 lux minimum >700 lux
Uniformity U1v-180°	>0.40
Uniformity U2v-180°	>0.50
Ev ave-270° (vertical illuminance on 270° reference plane)	average >1,250 lux minimum >700 lux
Uniformity U1v-270°	>0.40
Uniformity U2v-270°	>0.50
Match continuity mode (MCM) Within 15 minutes of power disruption	see relevant FPSL
Flicker factor (FF)	average <12% maximum <15%
Minimum adjacent uniformity ratio (MAUR)	>0.60 ≤20 failures
Colour temperature (Tc)	5,000–6,200K
Colour rendering (Ra)	≥80 Ra
Glare rating (R_G)	<50
Maintenance factor (MF)	0.90 LED 0.80 HID

Level B floodlight illuminance

Level B floodlight illuminance	
Eh ave (average horizontal illuminance)	>1,400 lux
Uniformity U1h	>0.50
Uniformity U2h	>0.70
Ev ave-0° (vertical illuminance on 0° reference plane)	average >1,000 lux minimum >600 lux
Uniformity U1v-0°	>0.40
Uniformity U2v-0°	>0.50
Ev ave-90° (vertical illuminance on 90° reference plane)	average >1,000 lux minimum >600 lux
Uniformity U1v-90°	>0.40
Uniformity U2v-90°	>0.50
Ev ave-180° (vertical illuminance on 180° reference plane)	average >1,000 lux minimum >600 lux
Uniformity U1v-180°	>0.40
Uniformity U2v-180°	>0.50
Ev ave-270° (vertical illuminance on 270° reference plane)	average >1,000 lux minimum >600 lux
Uniformity U1v-270°	>0.40
Uniformity U2v-270°	>0.50
Match continuity mode (MCM) Within 15 minutes of power disruption	see relevant FPSL
Flicker factor (FF)	average <12% maximum <15%
Minimum adjacent uniformity ratio (MAUR)	>0.60 ≤30 failures
Colour temperature (Tc)	5,000–6,200K
Colour rendering (Ra)	≥80 Ra
Glare rating (R_G)	<50
Maintenance factor (MF)	0.90 LED 0.80 HID

Level C floodlight illuminance

Level C floodlight illuminance	
Eh ave (average horizontal illuminance)	>1,200 lux
Uniformity U1h	>0.40
Uniformity U2h	>0.60
Ev ave-0° (vertical illuminance on 0° reference plane)	average >700 lux minimum >350 lux
Uniformity U1v-0°	>0.35
Uniformity U2v-0°	>0.45
Ev ave-90° (vertical illuminance on 90° reference plane)	average >700 lux minimum >350 lux
Uniformity U1v-90°	>0.35
Uniformity U2v-90°	>0.45
Ev ave-180° (vertical illuminance on 180° reference plane)	average >700 lux minimum >350 lux
Uniformity U1v-180°	>0.35
Uniformity U2v-180°	>0.45
Ev ave-270° (vertical illuminance on 270° reference plane)	average >700 lux minimum >350 lux
Uniformity U1v-270°	>0.35
Uniformity U2v-270°	>0.45
Match continuity mode (MCM) Within 15 minutes of power disruption	see relevant FPSL
Flicker factor (FF)	average <20% maximum <30%
Minimum adjacent uniformity ratio (MAUR)	>0.50 ≤ 30 failures
Colour temperature (Tc)	4,200–6,200K
Colour rendering (Ra)	≥70 Ra
Glare rating (R_G)	<50
Maintenance factor (MF)	0.90 LED 0.70 HID

Level D floodlight illuminance

Level D floodlight illuminance	
Eh ave (average horizontal illuminance)	>800 lux
Uniformity U1h	>0.40
Uniformity U2h	>0.60
Ev ave-0° (vertical illuminance on 0° reference plane)	average >350 lux minimum >200 lux
Uniformity U1v-0°	-
Uniformity U2v-0°	-
Ev ave-90° (vertical illuminance on 90° reference plane)	average >350 lux minimum >200 lux
Uniformity U1v-90°	-
Uniformity U2v-90°	-
Ev ave-180° (vertical illuminance on 180° reference plane)	average >350 lux minimum >200 lux
Uniformity U1v-180°	-
Uniformity U2v-180°	-
Ev ave-270° (vertical illuminance on 270° reference plane)	average >350 lux minimum >200 lux
Uniformity U1v-270°	-
Uniformity U2v-270°	-
Match continuity mode (MCM)	-
Flicker factor (FF)	-
Minimum adjacent uniformity ratio (MAUR)	-
Colour temperature (Tc)	4,200–6,200K
Colour rendering (Ra)	≥65 Ra
Glare rating (R_G)	<50
Maintenance factor (MF)	0.90 LED 0.70 HID

5 — Illuminance design guidelines

The pitch illuminance system should provide the optimum illuminance level to ensure that the match is played without hindrance for players, officials, spectators and broadcasters.

The guidelines below should be used to design a high-quality pitch illuminance system that satisfies the requirements of the relevant UEFA illuminance level.

Players and officials

The primary concern should be to give players and officials the optimum conditions in which to perform. The illuminance system should not distract or hinder players or officials during the match.

Spectators

The illuminance system should provide spectators with an environment that is comfortable and free from glare and allows them to see the match clearly.

Broadcasters and media

Television broadcasters require certain illuminance conditions to enable high-quality pictures to be produced. The minimum illuminance levels required for specific competitions are set out in UEFA illuminance requirements.

Pitch illuminance system design

When designing new pitch illuminance systems for stadiums at UEFA elite level A, the recommended vertical illuminance uniformity is U1 >0.5 and U2 >0.6. From 2022 this is the new requirement of illuminance uniformity at elite level A. All existing pitch illuminance systems installed prior to 2019 must perform above the current requirements of U1 >0.4 and U2 >0.5.

The positioning of floodlight luminaires has a huge impact on the pitch illuminance conditions, so it is one of the primary concerns in the design process. The luminaire mounting positions will have a direct impact on the pitch illuminance level and uniformity for all planes and also on the creation of player shadows and the visual comfort experienced by players, officials and spectators.

The architectural requirements and design aesthetics of recent years have challenged previous illuminance design guidelines. New stadiums are often built in ways that require the pitch illuminance system to perform to the required standard while remaining true to the architectural design.

UEFA recommends that all new pitch illuminance designs focus primarily on ensuring player comfort. Designs should ensure the comfort of players, officials and spectators, while providing optimal operating conditions for television broadcasters. Any new pitch illuminance design/concept that achieves this while also fulfilling UEFA's other pitch illuminance requirements will be welcomed.

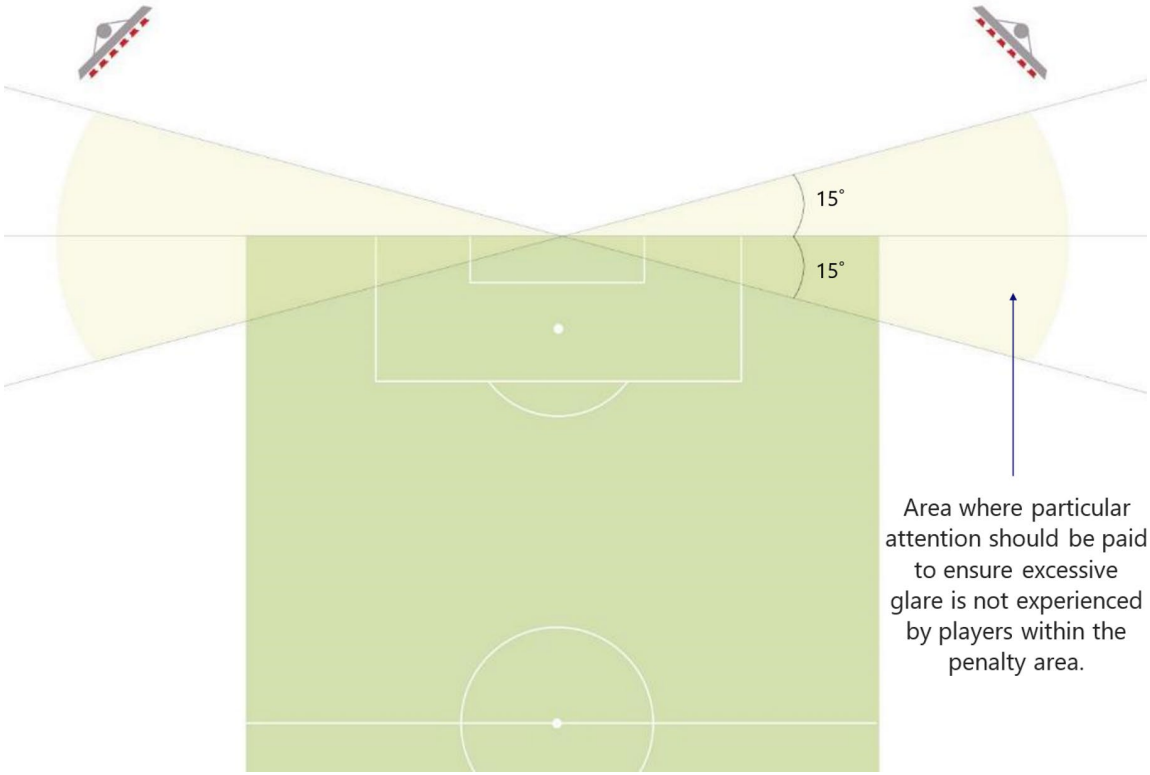
Pitch illuminance system design guide diagrams

Design guide diagrams	
Position	Guidance
Corners – column/tower floodlight array	Particular attention should be paid to the zone within 15° of either side of the goal line to avoid excessive glare around the goal line. Multiple luminaires, as used in column or tower installations, should not be placed in this zone.
Linear — roof rim lighting	When pitch illuminance is provided by means of a linear run of luminaires around the stadium roof rim structure, the luminaires should be positioned at a sufficient lateral distance from the pitch perimeter.
Player face modelling	The luminous flux must reach players at the correct angle to provide the required face modelling. Dark shadows across player faces should always be avoided irrespective of the direction they are facing.
Column positions	Corner columns should be positioned so that they provide optimal illuminance conditions. Generally corner columns should not be used for UEFA lighting level A stadiums unless additional luminaires are installed around the pitch perimeter.
Corners – column/tower floodlight array	If the installation design requires luminaires to be positioned within 15° either of the goal line, the luminaires' focal point should be outside the penalty area. Luminaires positioned outside the 15° zone may be focused on the penalty area. This is only suitable for linear floodlight arrays.
Pitch perimeter – lateral distance to luminaire position	There should be adequate lateral distance between the luminaire mounting positions and the goal lines and side lines to achieve the required vertical illuminance level around the perimeter of the pitch.
Pitch perimeter – luminaire mounting zone	The luminaires should be mounted at an angle of no less than 25° and no more than 45° above the centre of the pitch.
Pitch perimeter – second linear row	The luminaires should be mounted at an angle of no less than 25° and no more than 45° above the centre of the pitch. To improve vertical illuminance around the perimeter of the pitch, it may be necessary to install an additional linear row of luminaires at a greater lateral distance from the pitch.
Luminaires focus point angle	So that players and officials do not experience discomfort glare, a general rule during the design process is to ensure that luminaires' focus point angle is less than 70° from the line perpendicular to the pitch.

Design guide diagrams	
Position	Guidance
Pitch sides – luminaire mounting position	No stadium structures should impede the luminous flux of the pitch lighting system and cause shadows to be cast on the pitch.
Behind penalty area – luminaire mounting zone	To maintain good visual conditions both for attacking players in front of the goal and for the goalkeeper, luminaires should be mounted more than 60° from the goal line when in line with the penalty area.
Behind goal line – luminaire mounting zone	Luminaires positioned behind the goal and parallel to the penalty area should be mounted more than 60° from the goal line.
Behind goal line – second linear row	There should be adequate lateral distance between the luminaire mounting positions and the goal lines to achieve the required vertical illuminance level around the perimeter of the pitch. In some cases, a second linear run of luminaires may be installed under a stadium roof canopy to improve luminance in this area.
UEFA pitch dimensions	Official UEFA pitch size and penalty area dimensions.

6 — Diagrams of design guidelines

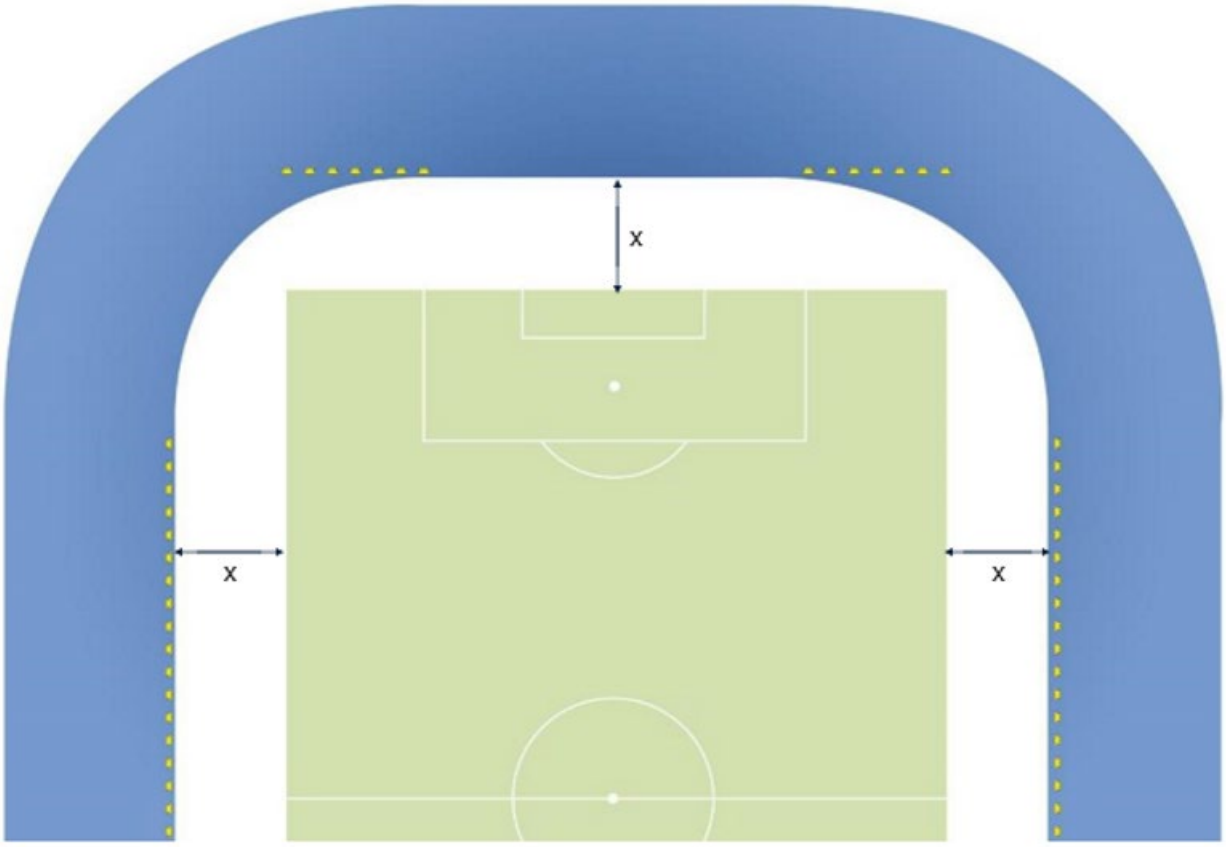
Corners – column/tower floodlight array



When pitch illuminance is provided by means of corner columns or towers with multiple luminaires in a group (as is generally seen in columns and towers), the luminaires should not be mounted within 15° of either side of the goal line (see diagram above).

Large multiple arrays of luminaires provide greater levels of discomfort glare and should not, therefore, be positioned in these areas. For this purpose, a consecutive line of luminaires with more than two rows is considered, to be a 'large multiple array'.

Linear — roof rim lighting



Lateral distance guide Luminaire height	20˚ angle Lateral distance (x)	27.5˚ angle Lateral distance (x)
16m	>5.8m	>8.3m
20m	>7.3m	>10.4m
24m	>8.7m	>12.5m
28m	>10.2m	>14.6m
32m	>11.6m	>16.7m

When the pitch illuminance is provided by a single linear run of luminaires around the stadium roof rim structure as seen in Linear — roof rim lighting diagram, the luminaires should be positioned with sufficient lateral distance from the pitch perimeter to ensure the required vertical illuminance levels and illuminance uniformity.

As a general guide an angle of greater than 20˚ between the pitch perimeter and the luminaires should be maintained. The optimum angle is 25°–30° for the majority of stadiums. The required lateral distance should be evaluated in conjunction with the proposed luminaire mounting position. Insufficient lateral distance may cause poor illuminance uniformity and the angle of luminous flux towards the pitch perimeter will cause deep and dark shadows on player faces as seen in Player face modelling diagram.

If the stadium design or existing installation requires luminaires to be positioned within a lateral distance which is less than 20˚ perpendicular to the perimeter of the pitch, or if the vertical illuminance requires improvement, a second linear run of luminaires may be required.

The focus position of each luminaire should ensure that player discomfort glare is maintained at an acceptable level. Further guidance may be seen in sections Corners – column/tower floodlight array and Luminaires focus point angle.

Player face modelling

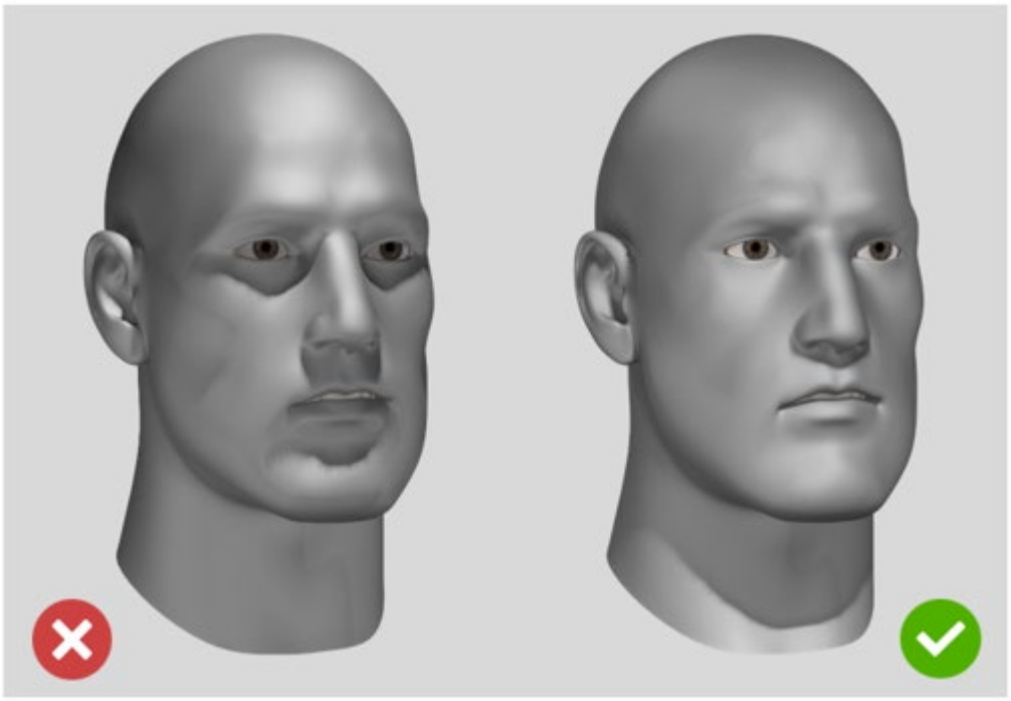


Figure 1
Example of poor face modelling

Figure 2
Example of good face modelling

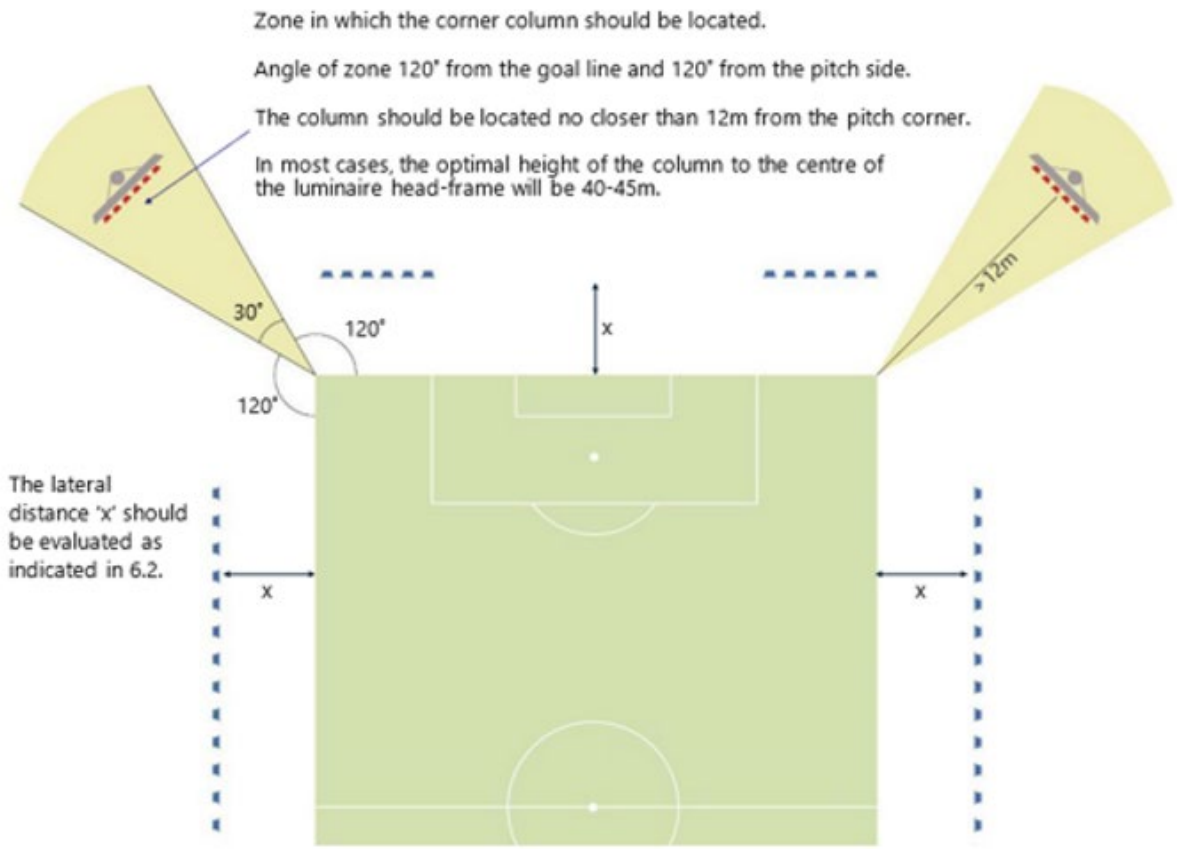
For high-quality television production, it is of fundamental importance that player faces are exposed correctly with good illuminance so that facial characteristics and expressions can be observed clearly.

During a football match, the players' positions and orientation will continually change, as will the camera viewpoint, therefore a football pitch is not expected to provide lighting for face modelling equivalent to that of a TV studio. However, it is possible to provide a consistent level of good illuminance conditions to ensure player face modelling is of good quality. For this, it is essential for the luminous flux to reach the pitch from the appropriate angle. If the incident light arrives from a steep angle the shadows cast upon the players' faces (as shown in figure 1) are deep and produce dark eye and nose shadows.

When the incident light reaches the face from the correct angle, the illuminance conditions and resultant face modelling (as in figure 2) are good from the point of view of both TV broadcasters and spectator/viewers.

It is considered necessary for luminaires to be positioned in such a way that the minimum angle to the perpendicular of the pitch perimeter is 20˚ (the optimum angle is 25°–30°) to ensure that player face modelling is of a good standard.

Column positions



Corner columns should be positioned in the zone as indicated in the diagram above. The zone is the area created by making an angle of 120° from the goal line and 120° from the pitch side. The column should be located no closer than 12m from the pitch corner. In most cases, the optimal height of the column to the centre of the luminaire head-frame will be 40m–45m.

Luminaires should be installed according to an angle between 25°and 45° in relation to the centre of the pitch.

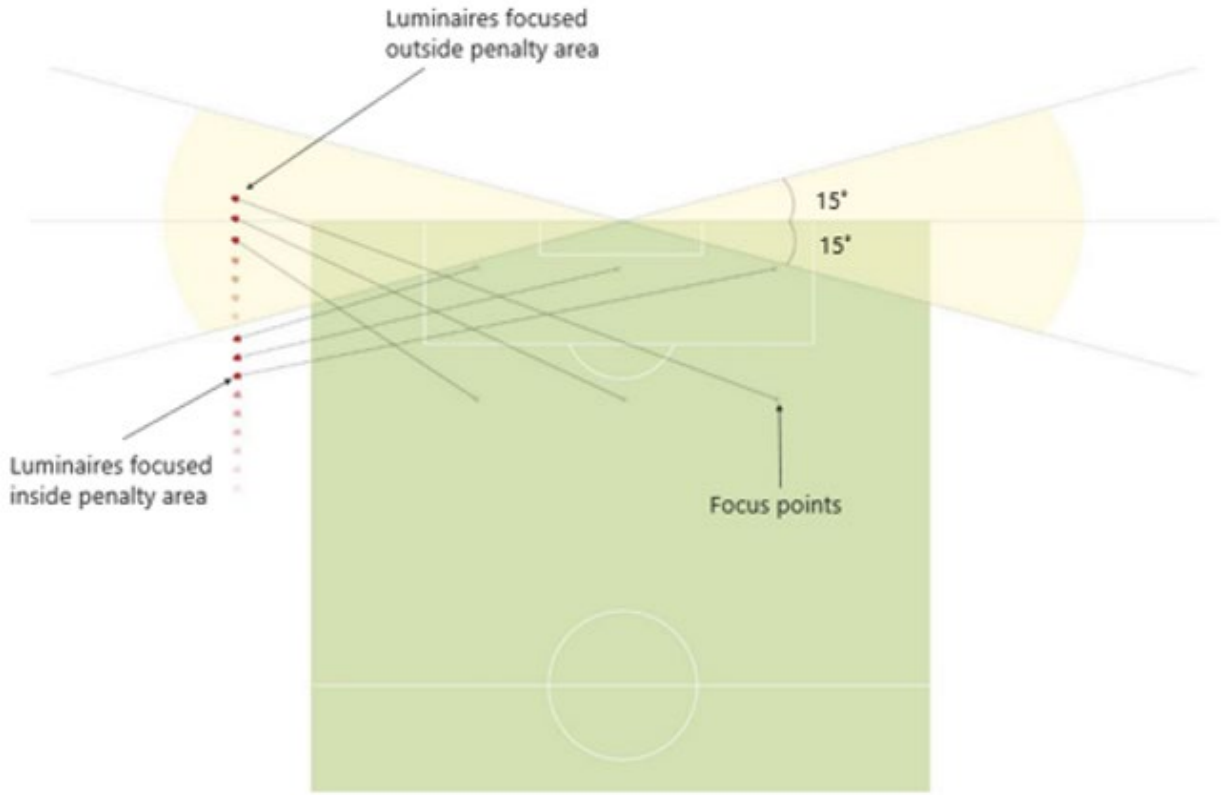
The corner column position may be compromised by land space, structural objects or foundation restrictions. However, where possible the guidance below should be followed to ensure the luminaires are positioned correctly to provide effective illuminance conditions.

Additional luminaires may be used in pitch illuminance systems that use corner columns. The diagram above shows lateral arrays of luminaires (in blue) attached to the stadium roof structure. The lateral distance 'x' should be evaluated as indicated in Linear — roof rim lighting.

In stadiums, it is essential for players to not be hindered by discomfort glare caused by the pitch illuminance system. The impact of discomfort glare should be considered at every stage of the design process.

Note that pitch illuminance systems that use four corner columns will generally not provide the required illuminance conditions to meet UEFA level A or elite level A requirements.

Corners – linear floodlight array



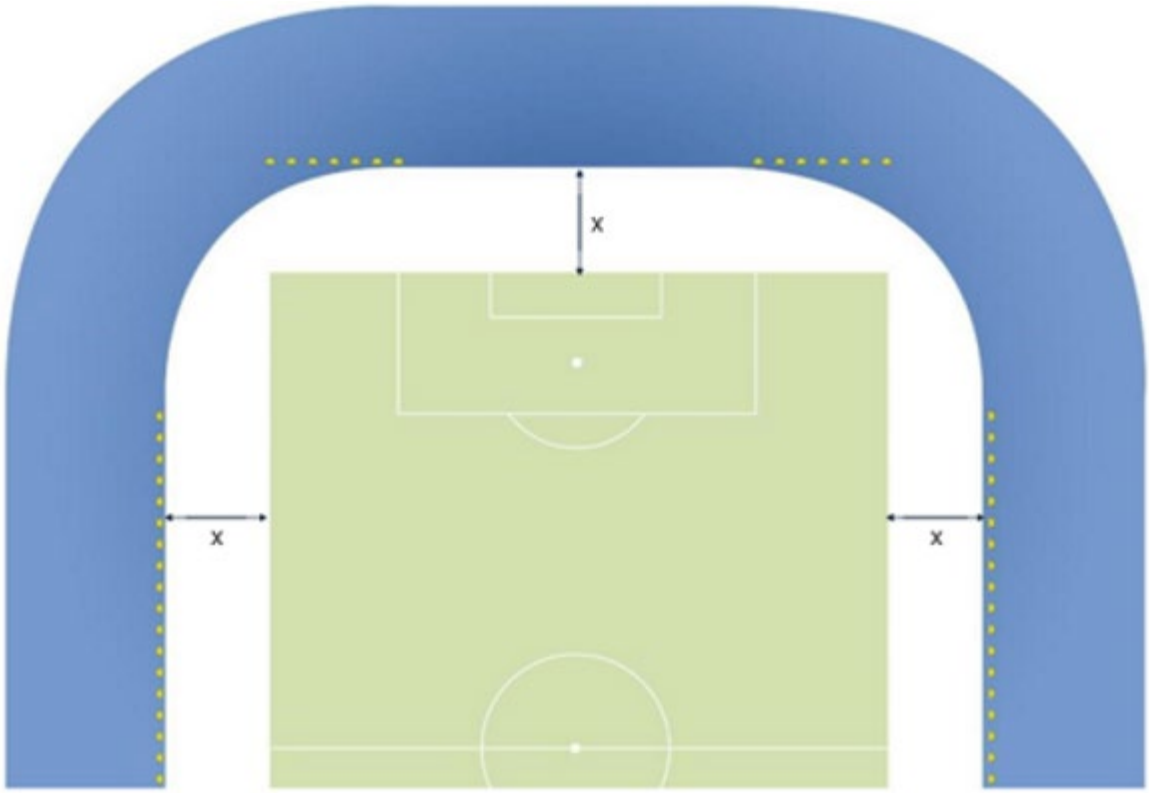
Additional consideration should be applied to ensure that players in the penalty area are not affected by discomfort glare. An acceptable level of discomfort glare can generally be achieved with a linear run of luminaires, if their focus points are placed such that players can stand in the penalty area and look towards the corners without hindrance.

Luminaires mounted within 15° of the goal line should be focused away from the penalty box, as indicated in the diagram above.

Multiple arrays of luminaires should not be positioned within 15° of either side of the goal line.

A linear array of luminaires used for this purpose should not comprise more than two rows.

Pitch perimeter – lateral distance to luminaire position



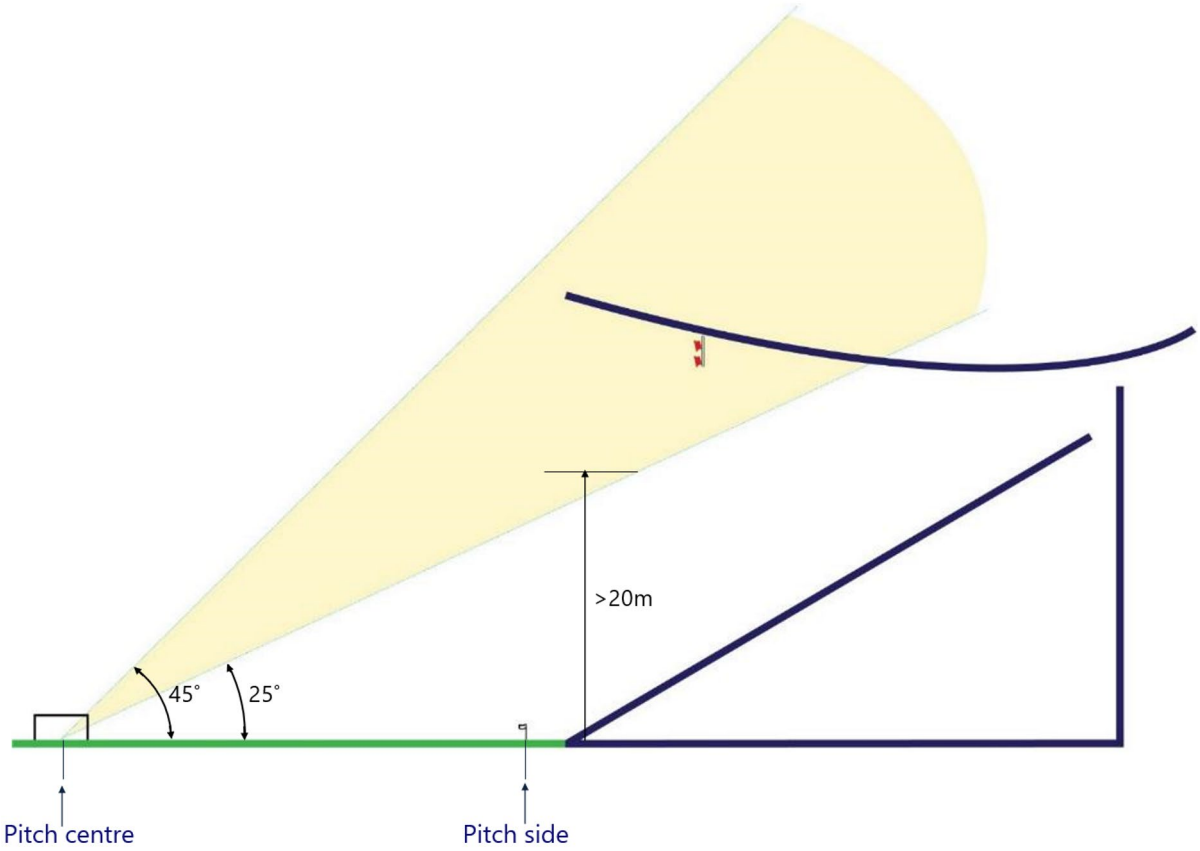
In order to achieve the required vertical illuminance around the perimeter of the pitch, the luminaires should have a mounting position with a minimum lateral distance from the pitch perimeter of greater than 12m at a height of approximately 24m.

Please note that this is a guide, lighting design solutions with additional luminaires with mounting locations either nearer to the pitch or further away may produce a design with a combined distribution of luminous flux which creates the correct illuminance conditions.

The table in Linear — roof rim lighting provides information which is relevant to single linear lines of luminaires.

When possible, to ensure that players maintain the maximum visual clarity and comfort it is good practice to locate the luminaires in areas that are not of critical importance when either attacking or defending in the goal area. When this is not possible, careful attention should be paid to the guidance provided here about luminaire positions and focus points and the impact upon discomfort glare.

Pitch perimeter – luminaire mounting zone



The luminaires should not be mounted less than 25° or more than 45° above the centre of the pitch.

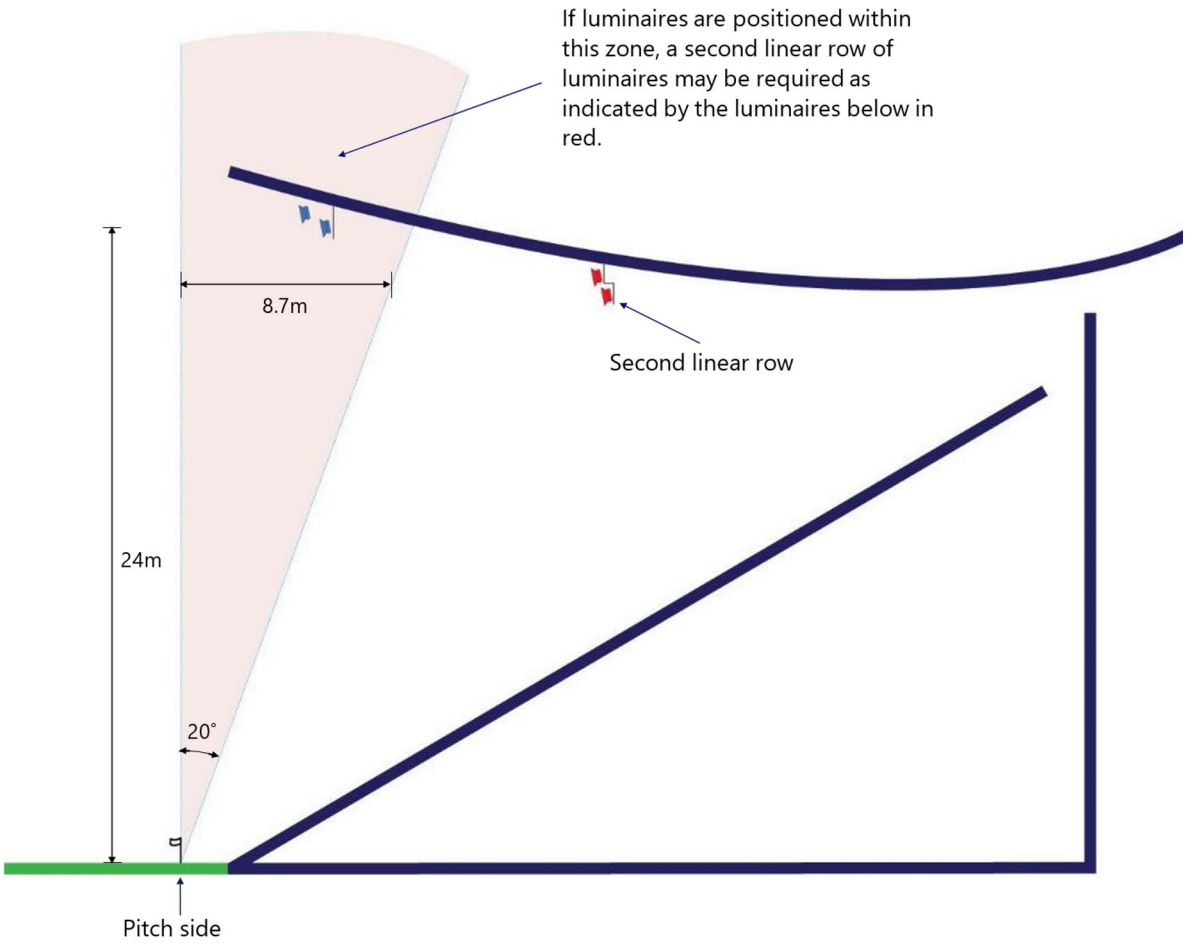
This is one of the general principles that will ensure that illuminance conditions comply with UEFA's guidelines.

If possible, luminaires should be mounted at least 20–25m above the pitch surface. If this is not possible, it is important to develop a design solution that considers the implications of that reduced height and any implications for player discomfort glare.

One way to ensure that players' discomfort glare is kept below R_G 50 (see Discomfort glare) is to limit the floodlight's angle of tilt to 70° for HID luminaires and 60° for flat panel LED luminaires as indicated in the diagram in the Luminaires Focus Point Angle section. However, the structural design of some stadiums may make this impossible. The level of discomfort glare should be evaluated during the design process and records maintained for reference.

The use of luminaires with asymmetric light distribution may be used along the pitch sides in order to produce good illuminance levels and uniformity along the adjacent pitch perimeter. In this way, asymmetric luminaires often help to reduce the levels of glare experienced by players and officials.

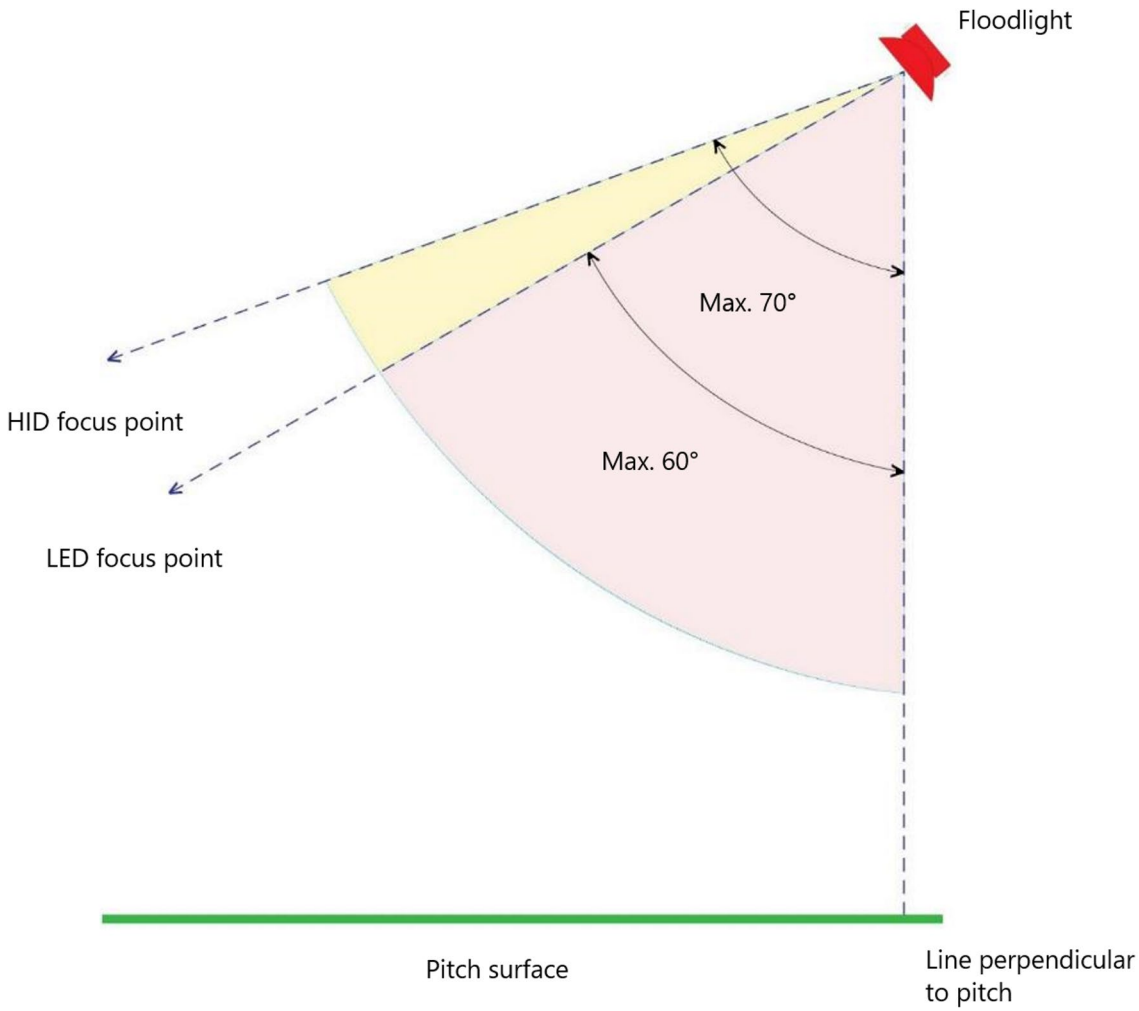
Pitch perimeter – second linear row



If the stadium design or existing installation requires luminaires to be positioned within a lateral distance of less than 20˚ perpendicular to the perimeter of the pitch, or if the vertical illuminance requires improvement, a second linear row of luminaires may be required. The optimum angle for a second linear row of luminaires is generally 25°–30° for the majority of stadiums. However, the optimum position of the luminaires should be evaluated in conjunction with the existing installation or the whole design proposal.

The diagram above shows that a luminaire installed at a height of 24m requires a lateral distance of no less than 8.7m from the pitch perimeter.

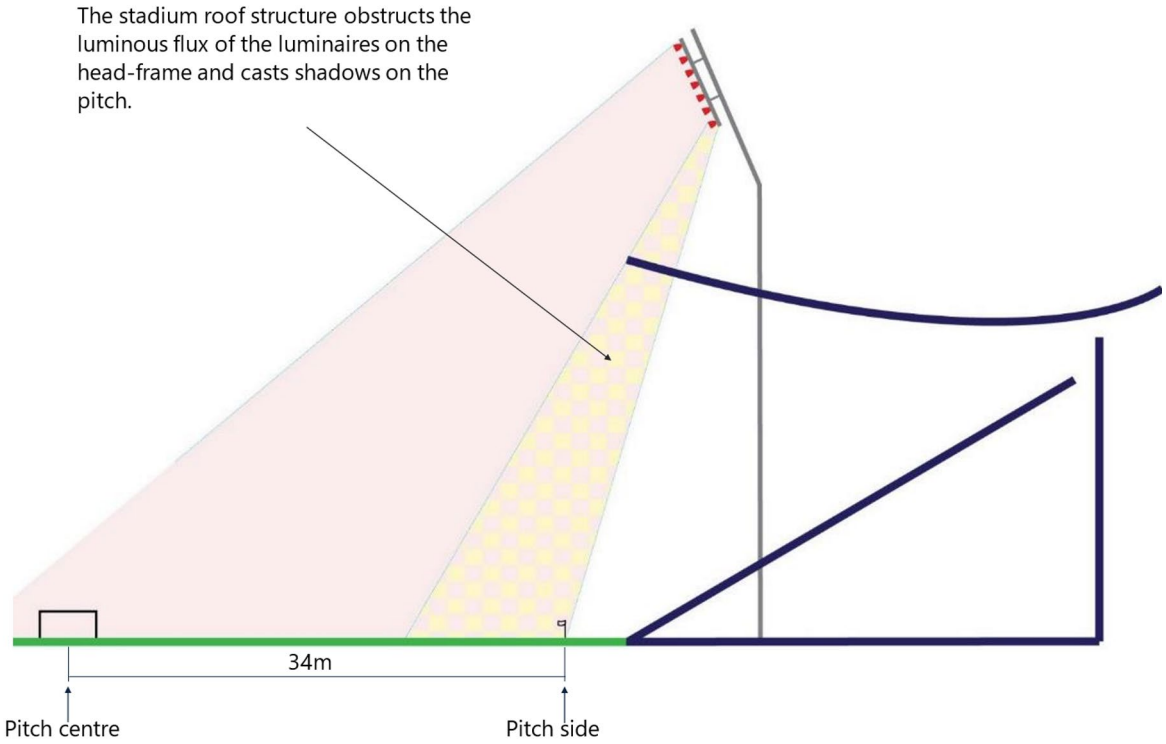
Luminaires focus point angle



In order to avoid discomfort glare being experienced by players and officials, a general rule during the design process is to ensure that HID luminaire focus point angle is no more than 70° from the line perpendicular to the pitch and the LED luminaire focus point angle is no more than 60° from the line perpendicular to the pitch, as in the diagram above. This is a good general guideline, but it will not always be possible owing to the constraints of the stadium's design.

The above guidance is particularly relevant to point source illuminance systems, as generally seen with high-intensity discharge lamps. However, it is necessary to re-evaluate this guidance when using LED luminaires, which will generally have large arrays of LEDs producing direct point source luminous flux. Note that, with flat panel LED luminaires, the angle of the floodlight focus point should be carefully assessed to ensure the level of discomfort glare on the pitch is maintained at an acceptable level and, depending upon the specifications of the luminaire, it is recommended that the maximum angle of the focus point perpendicular to the pitch should be no greater than 60°.

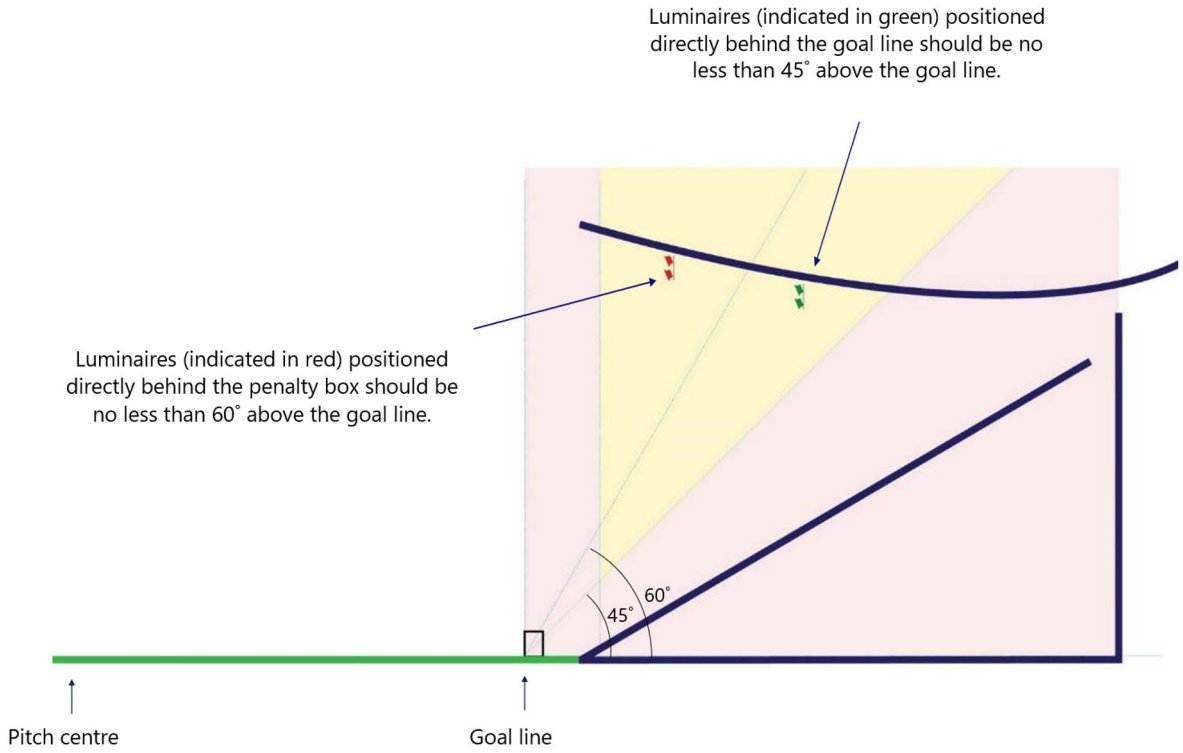
Pitch sides – luminaire mounting position



Stadium structures should not impede the luminous flux of the pitch lighting system and cause shadows to be cast on the surface of the pitch. Care should be taken to ensure that the luminous flux projection lines to the pitch surface are completely clear.

In the diagram above, the luminous flux of the corner column head-frame is obstructed by the stadium roof. To avoid this, the luminaires on the head-frame should be focused away from the stadium roof structure and additional illuminance provided by luminaires installed under the stadium roof structure.

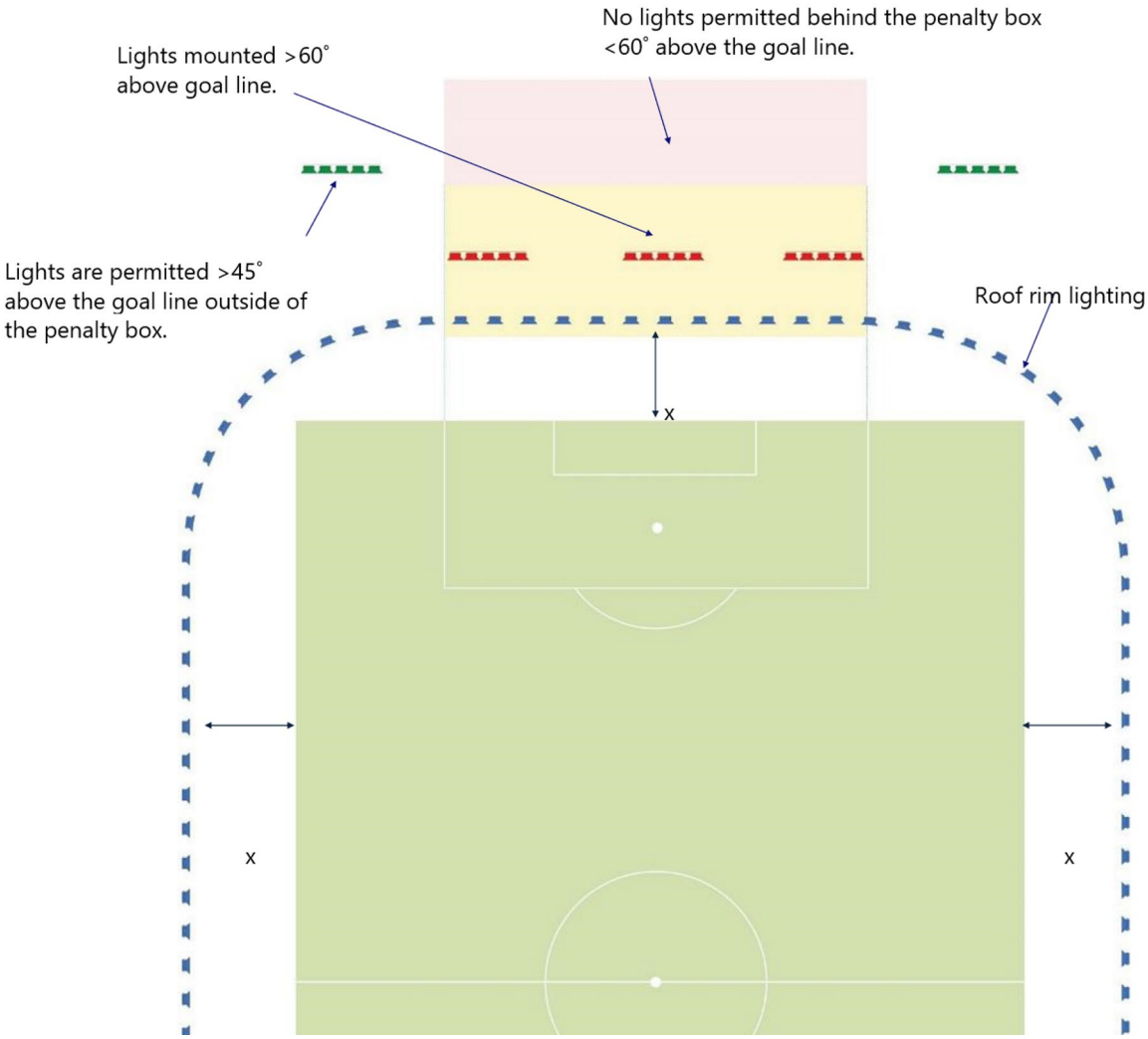
Behind penalty area – luminaire mounting zone



Increasing the installation angle of luminaires directly behind the penalty area (as shown in the diagram above) is an additional provision against discomfort glare for attacking players looking towards the goal. Luminaires positioned directly behind the goal area should be no less than 60˚ above the goal line.

Additional guidance is provided in design guideline reference Behind goal line – luminaire mounting zone.

Behind goal line – luminaire mounting zone



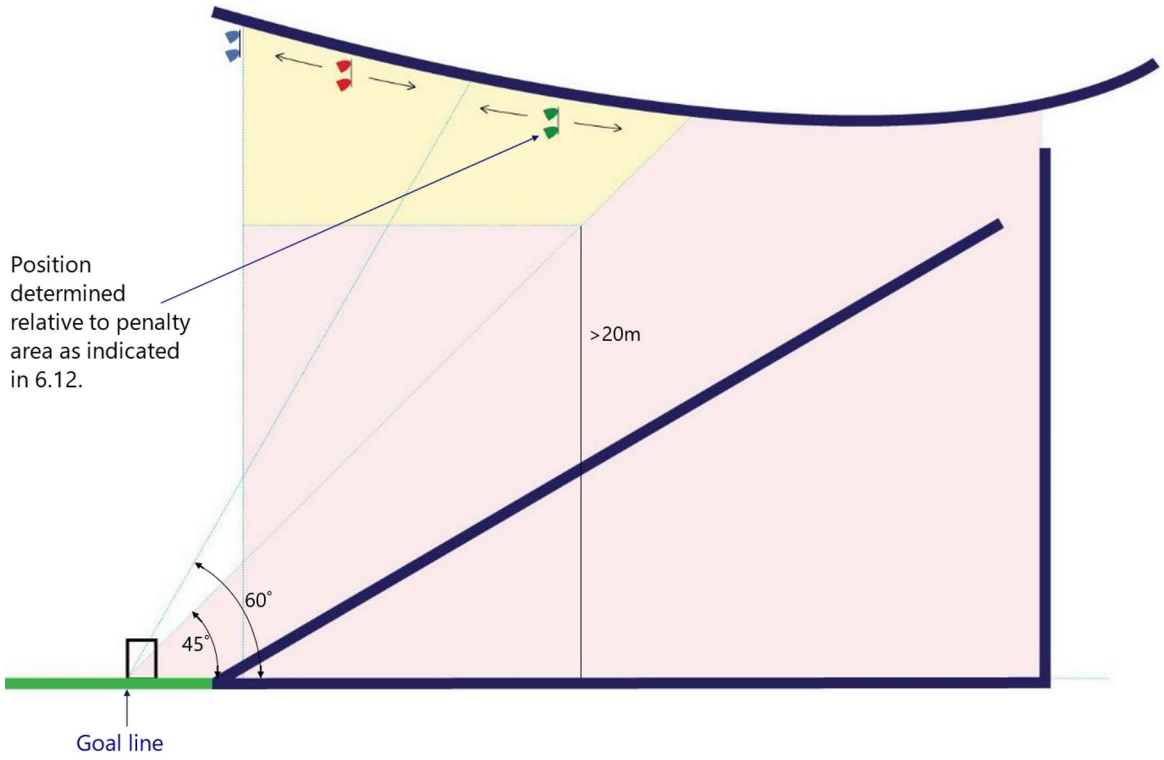
Luminaires positioned behind the goal and parallel to the penalty box as indicated in Pitch perimeter – second linear row should be mounted more than 60° from the goal line when behind the penalty area, as indicated in the diagram above. If a continuous 'roof rim' lighting method is to be used, it is necessary to calculate the required lateral distance 'x'. Further guidance can be found in Linear — roof rim lighting.

Luminaires that are not in line with the penalty box may be mounted at an angle of more than 45° from the goal line.

If only a single linear line of luminaires is used (in blue), the minimum lateral distance from the goal line 'x' is calculated by ensuring that the luminaires are positioned at an angle greater than 20˚ perpendicular to the pitch perimeter.

Further guidance can be found in Behind penalty area – luminaire mounting zone.

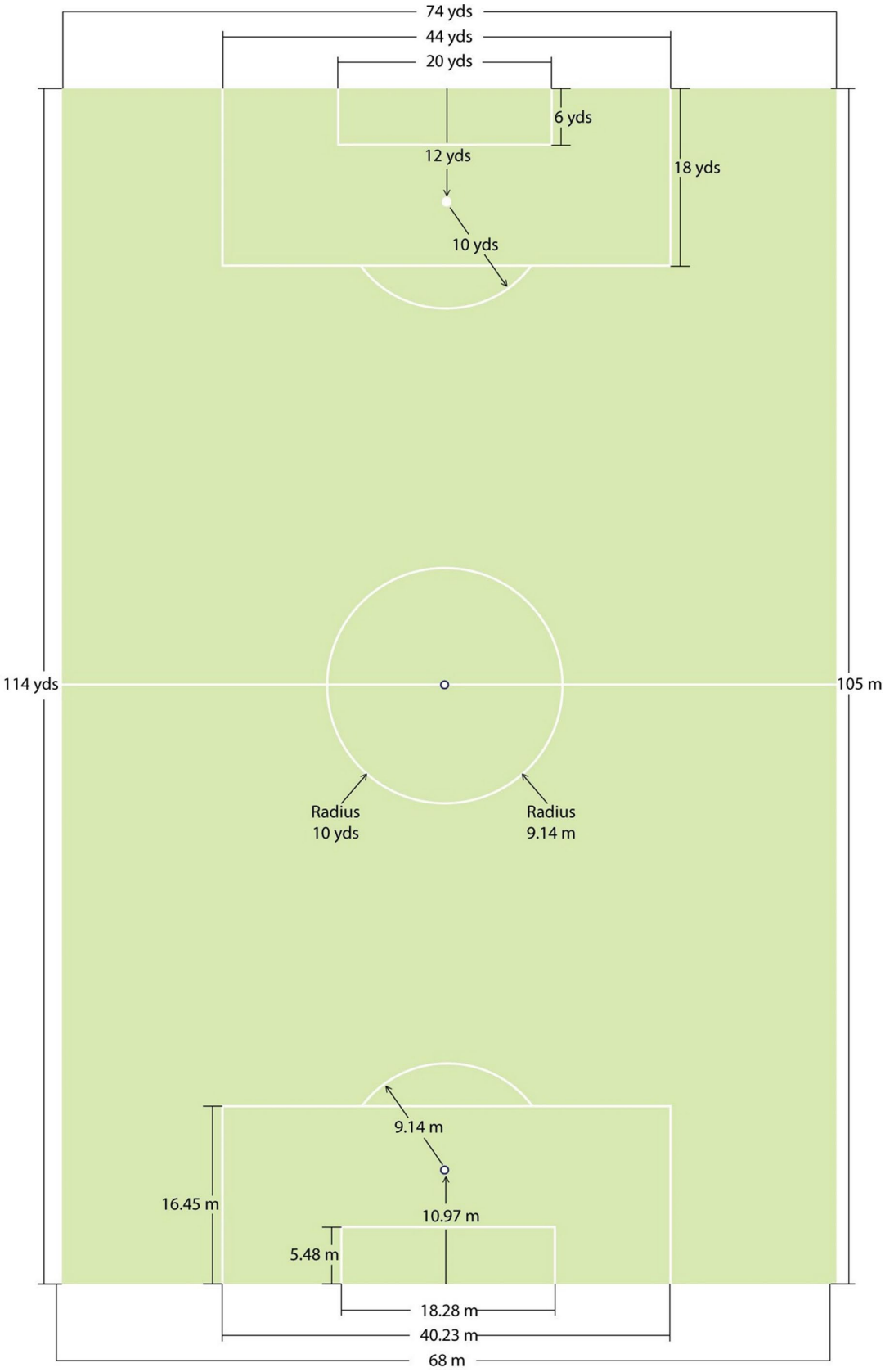
Behind goal line – second linear row



If the stadium design or existing installation requires luminaires to be positioned within a lateral distance of 20° perpendicular the goal line (in blue above) or if the vertical illuminance requires improvement, a second linear array of luminaires should be used to achieve the required vertical illuminance along the goal line and within the penalty area. Luminaires positioned directly behind the penalty area should be mounted at an angle of more than 60° (in red above). Outside the area parallel to the penalty area, luminaires may be mounted at an angle of more than 45° (in green).

Where possible, all luminaires behind the goal line should at least 20m above the pitch surface. If this is not possible, it is important to develop a design solution that considers the implications of that reduced height.

UEFA pitch dimensions



7 — Uniformity

A critical element of a pitch illuminance system is the uniformity of illuminance across the whole pitch in all of UEFA's reference planes. The uniformity of illuminance can be defined as how evenly light is distributed over a given reference plane.

The uniformity of illuminance is expressed using two illuminance ratios: U1 and U2.

U1 The total illuminance range, from minimum to maximum, that a person or camera will be exposed to.

The U1 value contributes to the visual performance experience.

U2 The difference between a person's normal adapted exposure and the lowest illuminance level on the given plane. The U2 value contributes to the visual comfort experience.

Horizontal uniformity of illuminance

U1h A measure of horizontal illuminance uniformity – the ratio of minimum horizontal illuminance to maximum horizontal illuminance across all 96 reference points.

U2h A measure of horizontal illuminance uniformity – the ratio of minimum horizontal illuminance to average horizontal illuminance across all 96 reference points.

Vertical uniformity of illuminance

U1v-(angle°) A measure of vertical illuminance uniformity on the specified reference plane – the ratio of minimum vertical illuminance to maximum vertical illuminance across all 96 reference points.

U2v-(angle°) A measure of vertical uniformity of illuminance on the specified reference plane – the ratio of minimum vertical illuminance to average vertical illuminance across all 96 reference points.

Note that UEFA's requirements are the minimum standards for the various illuminance levels. Experience shows that the uniformity values calculated during the design process are a good guide but are often higher than the values measured once the illuminance system has actually been installed. For this reason, UEFA recommends that the illuminance uniformity values calculated during the design process be higher than the minimum requirements to allow for potential declines when real values are measured.

Illuminance reference points

At UEFA's discretion, the UEFA pitch illuminance test reference grid may be offset by 5m along both the X and Y axes if the illuminance conditions are considered poor in positions not assessed by the standard reference grid.

8 — Glare

Definition

Glare is the sensation produced by luminance within the field of vision that is so much stronger than the eyes are accustomed to that it causes annoyance, discomfort or impaired visibility and visual performance.

Discomfort glare

Discomfort glare is caused by direct glare from luminaires that are too bright, inadequately shielded or too large in size. It is also caused by reflected glare from specular surfaces lit by other sources, which in a stadium may be the sun.

When the eye has become used to the dark, it is particularly susceptible to impairment and depression of central vision when a bright light enters the field of vision.

Evaluating glare

Determining the glare effect of a light source or a group of light sources is complicated. Glare will certainly increase as the number and size of light (or glare) sources increases. The size, luminance and position of light sources will all affect the level of glare experienced.

Glare is subjective but can be evaluated using a system devised for outdoor sports applications by the International Commission on Illumination (CIE) on the basis of extensive field tests. The CIE 112-1994 Glare Evaluation System for Use within Outdoor and Area Lighting – defines a glare rating (R_G) with an assessment scale of 10 to 90. The lower the glare rating, the better.

The validity of this system is restricted to viewing directions below eye level, and it is mainly used for predicting the degree of glare. The lighting design phase should include a glare assessment based on the CIE 112-1994 Glare Evaluation System for Use within Outdoor and Area Lighting. Calculations should be made for observer positions at each of the 96 UEFA reference grid points. Assessments should be made every 15°, starting from 0° or 180°, over a total 360°. Observer positions should be 1.75m above the pitch surface.

The maximum glare rating and the corresponding direction should be recorded for each observer position.

9 — Pitch illuminance switch mode (PISM)

The pitch illuminance system should be pre-programmed with various different modes. The number of modes may vary from stadium to stadium. The list below provides a few examples:

- Mode 1: Full match mode (FMM)
- Mode 2: Match continuity mode (MCM)
- Mode 3: Training mode (TM)
- Mode 4: Maintenance mode (MM)

Full match mode

In this mode, the pitch illuminance system satisfies the requirements specified for the relevant UEFA illuminance level.

Match continuity mode

This mode should automatically be activated when the primary power supply fails. The pitch illuminance system should switch to MCM and perform at or above the minimum standards specified for the relevant UEFA level.

In terms of illuminance uniformity, U1 must be greater than 0.5 on the horizontal plane and 0.4 on the vertical plane. It is not considered necessary to evaluate U2 for the MCM.

The MCM is essential and should be part of the design. For this mode to operate successfully, the power supply and other power supply options available must be carefully considered during the design process.

Training mode

In this mode, the pitch illuminance system operates with an average horizontal illuminance of 500 lux.

Maintenance mode

In this mode, the pitch illuminance system operates with an average horizontal illuminance of 250 lux.

10 — Flicker factor (FF)

Flicker factor guidance

During broadcasts, we can often see that some illuminance systems cause the picture to flicker during slow-motion replays.

This is distracting and impairs the viewer's experience, so it should be eliminated whenever possible. The circumstances that produce the flicker will vary depending on the modulation, the alternating voltage frequency and the camera frame rate.

The term 'flicker factor' refers to the amount of luminance modulation on a given plane during a complete cycle. It denotes the relationship between the maximum luminance value and the minimum luminance value over a full cycle and is expressed as a percentage.

Flicker: A rapid and repeated change in the brightness of light over time.

Modulation: A measure of light variation during periodic oscillations.

The flicker factor is calculated using the following formula:

$$FF = \frac{1}{2} \times \frac{E_{max} - E_{min}}{E_{average}} \times 100\% \quad \text{OR} \quad FF = \frac{E_{max} - E_{min}}{E_{max} + E_{min}} \times 100\%$$

Where E represents the illuminance level during a complete cycle.

In all but the most extreme circumstances, it is possible to eliminate the flicker seen during slow-motion replays. The table on the next page provides a general indication of the flicker factor values produced by various light sources.

A flicker factor of less than 3% will not generally cause problems for slow-motion replays of up to 300 frames per second. While the number of frames per second will vary depending on the technology used, a light source with a flicker factor of less than 3% will eliminate perceived flicker for most technology used within the sports television industry.

Illuminance flicker is commonly eliminated by installing electronic control ballasts or square-wave form ballasts in the illuminance system. This technology can generally be added to existing installations, as well as being available for new installations.

The flicker observed with very high numbers of frames per second can also be eliminated using computer processing. However, this method has other limitations.

The level of flicker considered acceptable is indicated in the tables in UEFA illuminance requirements.

Flicker factor reference table

Flicker factor reference table	
Type of light source	FF value (guide only)
Natural daylight	0%
LED luminaires (flicker dependent on the type of LED power supply used)	<1%
HID lamps with 100% electronic ballasts	<3%
HID lamps with magnetic ballasts spread uniformly across three-phase power supply	8–20%
HID lamps with magnetic ballasts on single-phase power supply	30-50%

Flicker factor on spectator seating

Light modulation on spectator seating areas may also be clearly observed in high frame rate broadcast pictures and should be eliminated whenever possible. The flicker caused by the light modulation is distracting and impairs the viewer's experience. The circumstances that produce the flicker will vary depending on the modulation of the flicker, the alternating voltage frequency and the camera frame rate.

It should be noted that, in stadiums where the pitch illuminance system is observed to be flicker-free when using high frame rate cameras, there will still be background flicker in broadcast pictures if the light falling upon the spectator areas is not flicker-free. We recommend that you assess the illuminance on the spectator areas and change them to flicker-free where appropriate.

Flicker factor with three-phase power supply

Pitch illuminance systems that use standard-frequency ballasts with typical sine wave luminance modulation characteristics will produce a wide range of flicker factor test results. This is due to the variation at test points in the overlapping of luminous flux from different luminaires at different angles. With careful planning, it may be possible to design the luminaire focus points for all areas and planes of the pitch to receive overlapping luminous flux from luminaires at different angles. This may produce substantial improvements and may meet UEFA's requirements for level B and level C stadiums.

Although the above method may produce substantial improvements, it will not meet the requirements for elite level A stadiums without additional solutions to reduce the luminance modulation. A mixture of electronic or square wave ballasts with standard-frequency sine wave ballasts may produce a flicker factor below 5%. This system will be more successful in larger installations where a greater number of luminaires are available to provide overlapping luminous flux from different angles.

A pitch illuminance system that involves overlapping luminous flux from different angles should use a larger number of flicker factor test points to ensure that the flicker factor values are consistent in all areas. It is recommended that 24 test points are used.

Measures to reduce the flicker factor should not impinge upon the illuminance uniformity of any plane.

Flicker factor testing

It is possible to measure the flicker factor precisely for any given stadium. The measurement should be carried out by a competent technician with a suitable meter, which should be recalibrated annually.

The flicker factor test should be conducted as indicated.

12-point flicker factor test

A vertical flicker factor reading should be taken at a height of 1m on the 90° and 270° planes at each of the six positions indicated in Flicker factor test reference points – 12-point high-frequency test. The 12-point average is calculated by dividing the sum of those 12 values by 12.

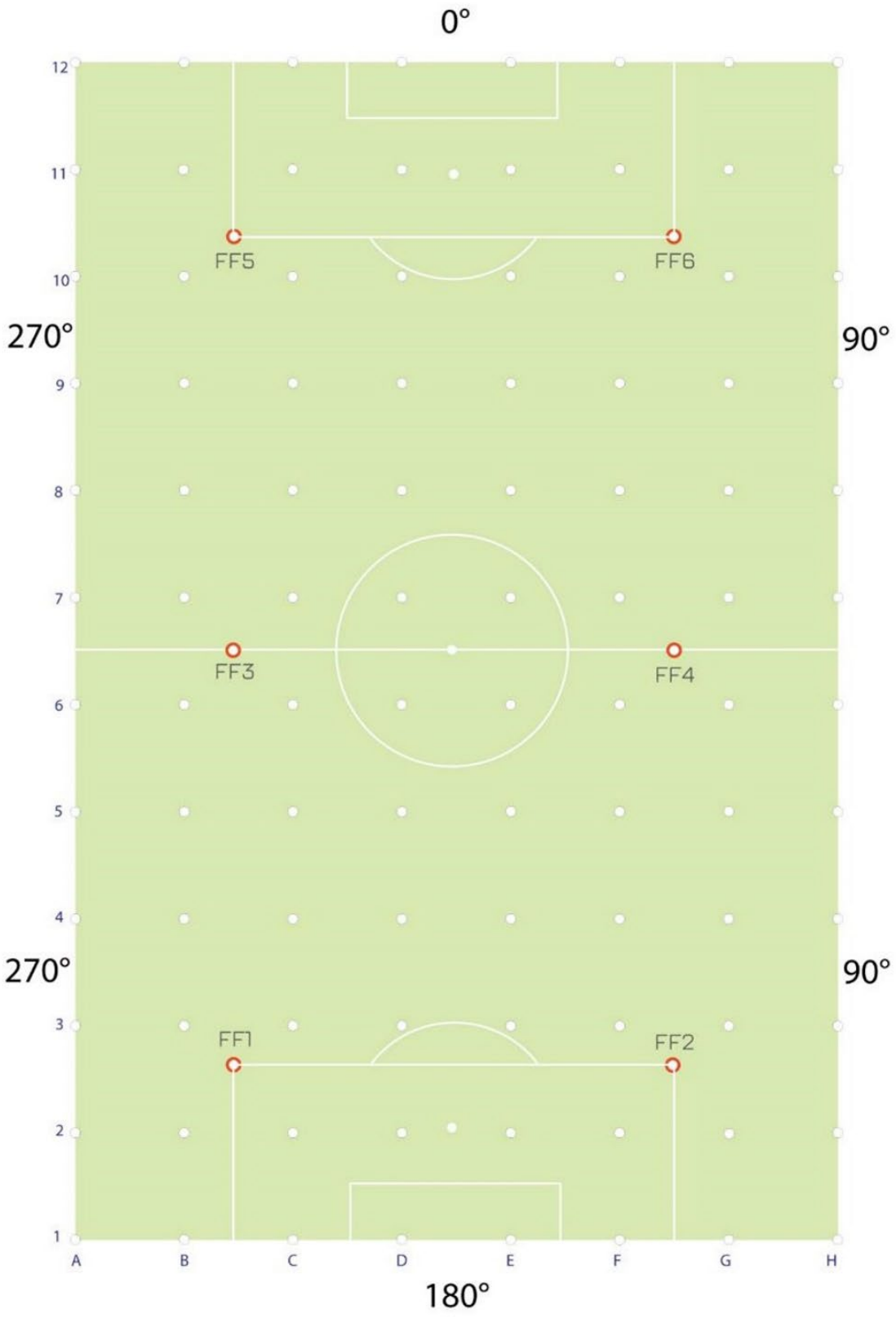
The maximum flicker factor value is the highest measured value of the 12 points.

The maximum permitted flicker factor is listed below for each UEFA level.

Flicker factor requirements	
Elite level A	
12 or 24-point average	<3%
Maximum value	<3%
Level A	
12 or 24-point average	<5%
Maximum value	<5%
Level B	
12-point average	<12%
Maximum value	<15%
Level C	
12-point average	<20%
Maximum value	<30%

Flicker factor test reference points – 12-point high-frequency test

The maximum flicker factor value is the highest measured single value at any given test points.



11 — Minimum adjacent uniformity ratio (MAUR)

Any rapid change in the illuminance level on a given plane will cause camera exposure inconsistencies. During a fast-moving football match, it is unrealistic to expect the camera settings to be consistently changed successfully when the camera and the subject are both moving rapidly. The MAUR is used to ensure greater consistency in camera exposure and therefore give the camera operator greater freedom to provide dynamic pictures. The difference between the illuminance values of any two adjacent points on any given plane in any direction should be no greater than the permitted level stipulated in the tables in UEFA illuminance requirements. The requirement takes the form of a minimum permissible ratio between the two points and assesses illuminance values that are lower or greater than the primary reference point.

MAUR on the horizontal plane

The diagram below shows the secondary reference points that are considered in relation to a primary reference point. In this case, the primary reference point is 28, and the secondary reference points are 16, 29, 40 and 27.

Level A stadium – MAUR evaluation

Reference point 28 on horizontal plane

Reference point 28 – Eh = 2,325 lux

MAUR >0.60

Illuminance values lower than the primary reference point:

The illuminance value at the secondary reference points 16, 29, 40 and 27 on the horizontal plane must be greater than 2,325 x 0.60 = **1,395 lux.**

Illuminance values greater than the primary reference point:

The illuminance value at the secondary reference points 16, 29, 40 and 27 on the horizontal plane must be lower than 2,325 x 1.40 = **3,255 lux**.

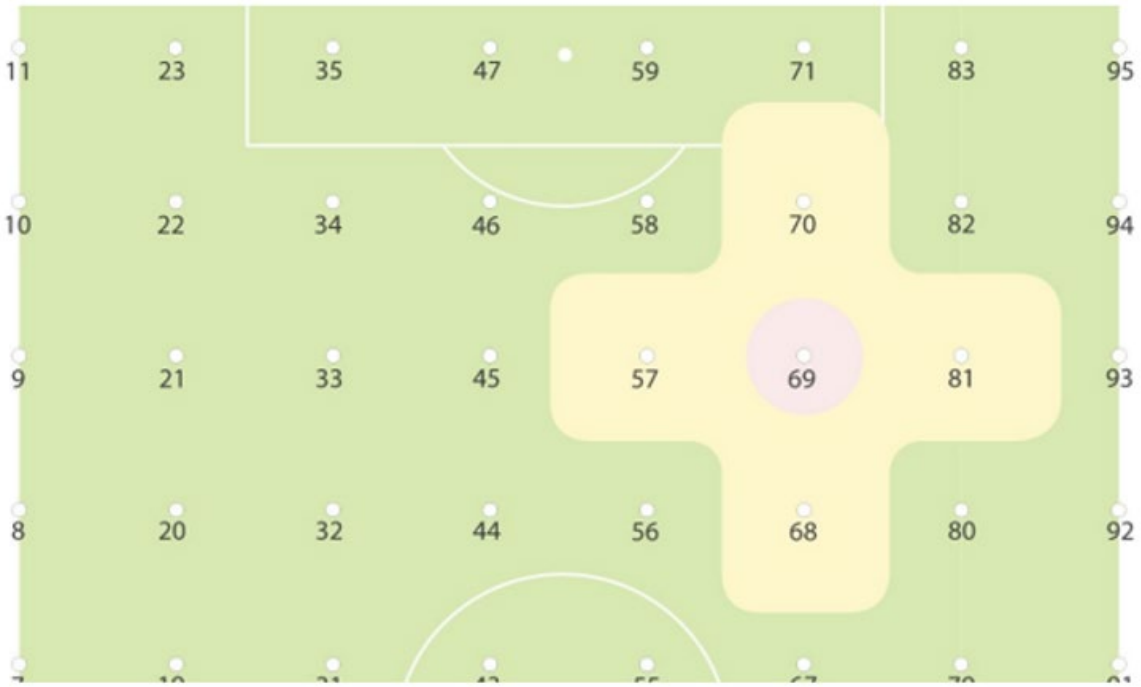
MAUR for UEFA elite level A

For a pitch illuminance system to meet the UEFA elite level A lighting requirements, there must be no more than 10 MAUR failures throughout the whole pitch.

MAUR on the vertical plane

The MAUR requirements are the same for all five planes. Each plane should be considered separately.

In the example below, reference point 69 is considered on the vertical plane for a level C stadium.



Level C stadium – MAUR evaluation

Reference point 69 on the 270° vertical plane

Reference point 69 – Ev-270° = 1,548 lux

MAUR >0.50

Illuminance values lower than the primary reference point:

The illuminance value at the secondary reference points 57, 70, 81 and 68 on the 270° vertical plane must be greater than:

1,548 x 0.50 = **774 lux.**

Illuminance values greater than the primary reference point:

The illuminance value at the secondary reference points 57, 70, 81 and 68 on the 270° vertical plane must be lower than:

1,548 x 1.40 = **2,322 lux.**

MAUR for UEFA elite level A

For a pitch illuminance system to meet the UEFA elite level A lighting requirements, there must be no more than 10 MAUR failures throughout the whole pitch.

Note - The total number of MAUR failures for each UEFA lighting category is determined by calculating the total number of failures across all 96 reference points for each of the five reference planes.

12 — Colour temperature

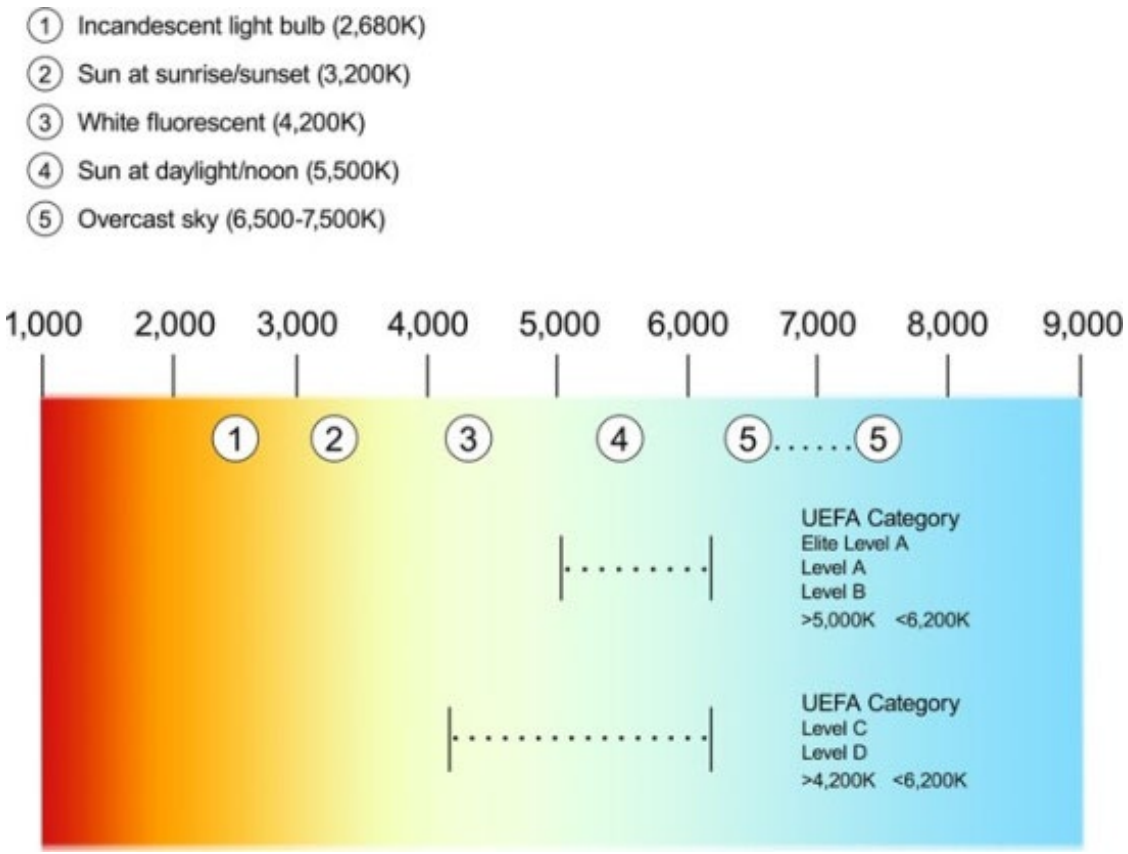
'Colour temperature' describes the feeling or appearance of how warm (red) or cool (blue) a certain type of illumination appears to be. It is measured in Kelvin (K).

Digital camera technology allows digitally produced video media to be altered as required to 'gain' colour and contrast in order to produce the desired colour quality. The required colour temperature range varies depending on the stadium illuminance level, with the minimum and maximum across all levels being 4,200K and 6,200K respectively.

It is often necessary to start broadcasting a football match in daylight and finish with all pitch illuminance provided by the floodlighting system. On these occasions, the artificial lighting should generally be used at the start of the broadcast to allow a gradual change from daylight to artificial illuminance. During this period, the broadcast engineers will be able to make gradual minor adjustments to the camera settings as required.

The diagram below provides a guide to the colour temperature range required for UEFA stadiums.

Colour temperature guide



13 — Colour rendering

Colour rendering, which is expressed as a score between Ra 0 and 100 on the **Colour Rendering Index (CRI)**, describes how a light source makes the colour of an object appear to human eyes and how well subtle variations in colour shades are revealed. The higher the CRI rating, the better the ability of a light source to accurately reproduce the colours of the object it illuminates.

UEFA's requirements stipulate that for the artificial illumination system to produce good colour, the CRI rating needs to be greater than Ra 80 for UEFA elite level A, levels A and B, Ra 70 for level C, and Ra 65 for UEFA level D stadiums.

The **CRI** generally provides a good level of assessment of the chromaticity of large-scale lighting systems in stadiums. Designers and suppliers of football stadium illuminance systems must nevertheless be aware of the potential areas of concern in which the CRI may not sufficiently evaluate the colorimetric quality of a light source in a particular range of the spectrum. In video and film production, the colour spectrum of luminance produced by LED lighting in specific wavelength bands may not provide sufficient colour rendition.

The extended Re (also sometimes expressed as CRI) provides additional information for the whole colour spectrum of a light source and is measured during test and evaluation process. It should be noted that LED luminaires should be carefully evaluated, and it is generally recommended that the CRI R9 (wavelengths longer than 600 nm) values are assessed to be sufficient. The extended CRI is denoted by the symbol Re and along with the Television Lighting Consistency Index is recognised as providing a detailed and thorough analysis of a light source. However, the UEFA Lighting Guide 2023 continues to use the more basic version of Ra in order to provide consistent continuity of this assessment. This will also ensure existing stadiums that produce a Ra of the appropriate level are assessed to meet the requirements. As an example, it should be noted that for many LED light sources that are tested to provide a Ra value of 80, the same light source will produce a Re value in the region of Re 75–76.

The **Television Lighting Consistency Index (TLCI)** was developed as an alternative method to evaluate the chromaticity quality of a light source within the television environment. Rather than assess the performance of a luminaire directly, as the CRI does, the TLCI mimics a complete television camera and display, using only those specific features of cameras and displays which affect colour performance. The TLCI is recognised to be an effective method for evaluating the chromaticity quality of a light source and is recommended as good supplementary information when evaluating different light-source products.

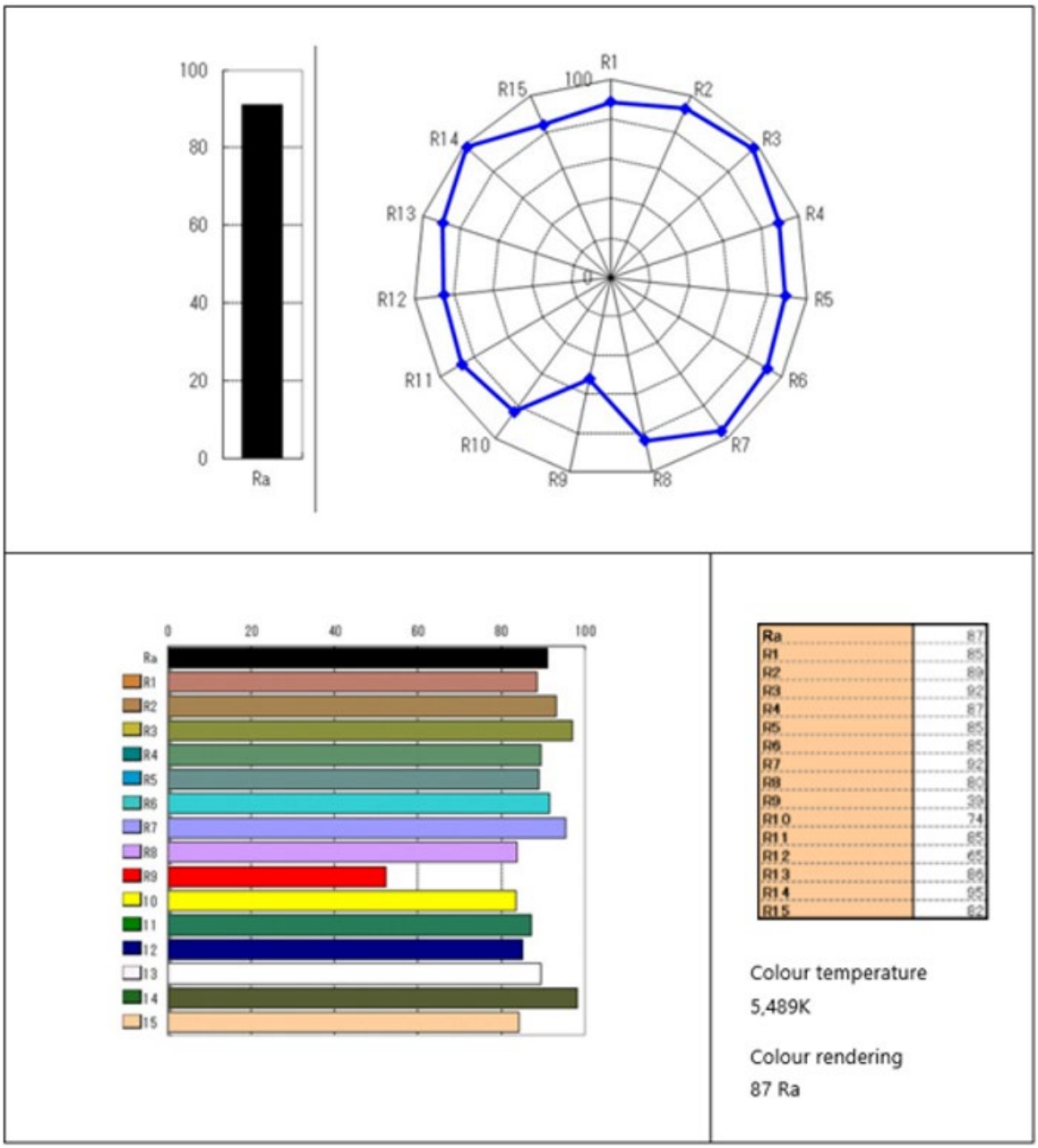
CRI(e)/Re test colour samples (TCS)

Chromaticity values of lamp/LED

The following diagram provides an example for a chromaticity test and should be used as a guide to the level of information required for all new and old UEFA stadiums.

Note that only the extended Colour Rendering Index, CRI(e), is used for both test and evaluation purposes.

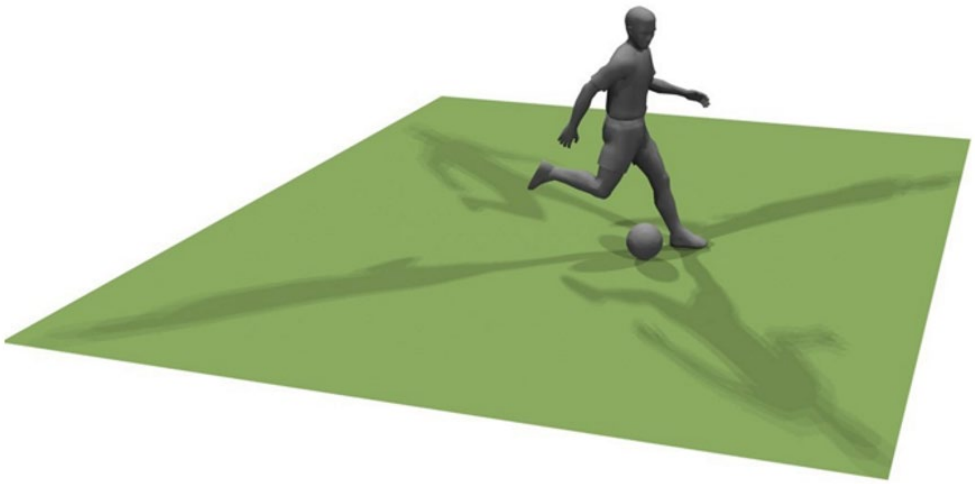
Chromacity values of lamp/LED after testing



14 — Player shadows

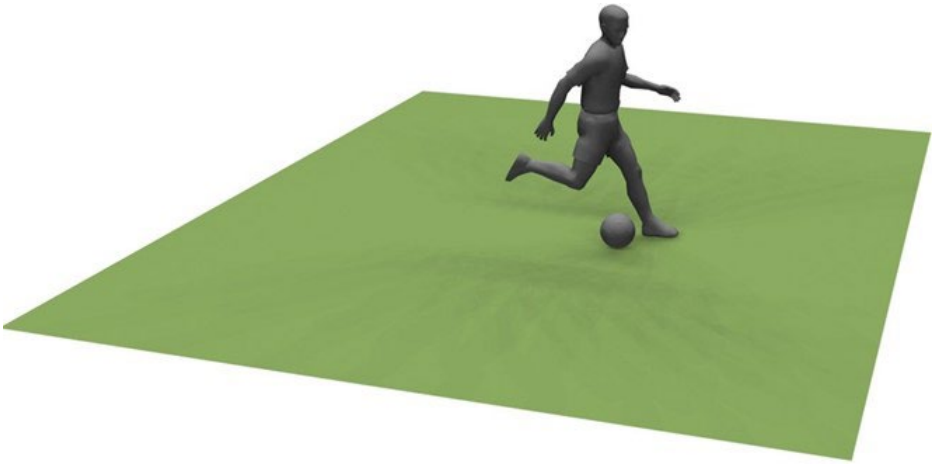
Artificial shadows on the pitch caused by floodlighting systems detract from visual clarity for both spectators and television broadcasters. The shadows impinge upon the viewing experience and should be eliminated where possible or reduced to soft shadows.

During the pitch illuminance design, it is important to evaluate the production of player shadows and eliminate any hard shadows. This is generally done by using multiple light sources from various locations for each area of the pitch. Shadows are reduced and players benefit from good illuminance modelling around their entire bodies. This is essential for adequate vertical illuminance and uniformity on all planes.

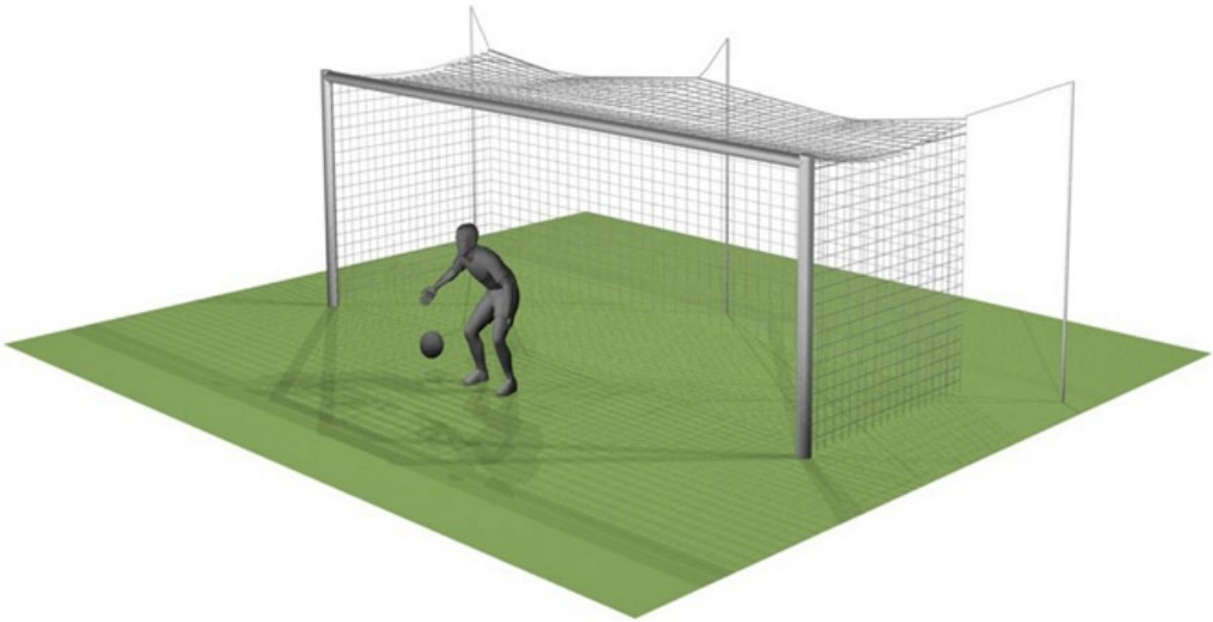


The image above demonstrates the impact of player shadows on a football pitch.

In some stadiums, the existing infrastructure will mean that a four-corner tower/column floodlighting system is the only viable option in pitch lighting design. Corner tower illuminance systems will generally produce hard shadows, which will vary in different areas of the pitch. With this type of installation, it is not possible to produce consistently soft shadows.



The image above is an example of the soft shadows created by an effective solution involving multiple light sources from different locations.



The image above is an example of hard shadows in the goal area. Shadows should be reduced where possible, while ensuring that players are not hindered by discomfort glare.

15 — Maintenance factor

The average illuminance values set out in the tables in UEFA illuminance requirements should be achieved during matches. A maintenance factor is used to take account the depreciation of luminous flux caused by the ageing and soiling of the light sources, reflectors and front glasses. In the absence of any other information, the maintenance factor indicated in the relevant table in in UEFA illuminance requirements should be used.

However, if relevant information is available and systems are in place that facilitate a calculated alteration to that value for a given project, it is possible to modify that maintenance factor.

Reasons to alter the maintenance factor are as follows:

- A proactive, frequent maintenance programme. This requires a comprehensive and documented schedule of lamp replacement, luminaire cleaning, voltage regulation and illuminance testing. Most stadium pitch illuminance systems would not be suitable for this kind of very proactive maintenance.
- Luminaires that use LED technology. The rate of lumen depreciation is very low with this technology. To alter the maintenance factor, there should be a documented schedule of work including luminaire cleaning, voltage regulation and illuminance testing. It is not recommended to increase the maintenance factor beyond 0.90 when using LED luminaires in normal circumstances.
- Lumen depreciation may be compensated for by using 'constant illumination lamp technology', which would need to be available and supported by the luminaire manufacturer, with documented analysis of the pitch illuminance system's performance with voltage regulation. It would also require a schedule of lamp replacement, luminaire cleaning, voltage regulation and illuminance testing.
- If the stadium environment is subject to harsh weather conditions or airborne dirt that could affect the long-term performance of the luminaires, the maintenance factor needs to be lowered to an appropriate level. In such circumstances, a study should be carried out to evaluate the conditions. A typical maintenance factor in the above circumstances might be 0.70 or 0.75 for HID luminaires and 0.8 for LED luminaires.

16 — Power supply

The power supply for the pitch illuminance system must be reliable to ensure that matches and television broadcasts can continue without any disruption greater than what is permitted for the relevant competition category. There must be a suitable alternative backup power supply in case the primary source fails. UEFA requires a power supply evaluation for all stadiums. For newly built stadiums, it is recommended that the power service level is designed to meet the requirements stipulated for the relevant UEFA illuminance level.

UEFA has therefore defined three Floodlight Power Supply Levels FPSL A-C. FPSL A and FPSL B have two options: one for HID and one for LED systems. In principle, each FPSL is based on a specific electrical design approach or technology capable of achieving that level. Please therefore note that FPSL B for HID (which may actually still be considered to be the most common design principle for stadium floodlight power supply) includes several different illuminance levels and recovery times that corresponds to the particular UEFA illuminance levels required for the various competitions/matches.

UEFA FPSL A and FPSL B for LED were eveloped to take advantage of the instantaneous operation of LED luminaires between zero to full illuminance performance. It provides an efficient and effective option for pitch illuminance continuity that permits a very low level of disruption for a limited period of time.

The relevant floodlight power supply level is determined by the requirement of UEFA competition, the FPSL may be determined by checking the UEFA competition level table in Overview of illuminance levels for UEFA competitions, and this information is also available in Floodlight power supply level table below

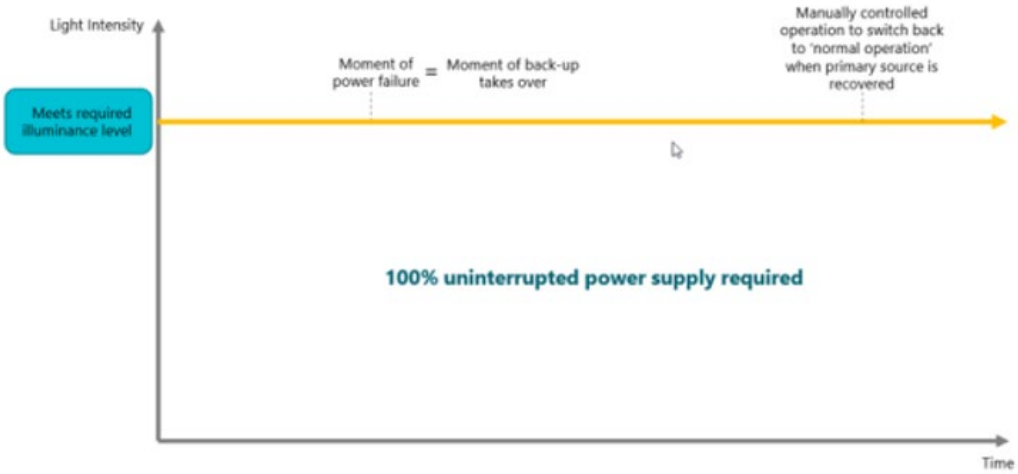
The specific FPSL requirements for each UEFA lighting category are listed below.

Floodlight power supply level table

UEFA illuminance level	Floodlight power supply levels (FPSL) FPSL A	FPSL B	FPSL C
Elite level A	EURO Final Tournament UCL Final UEL Final UECL Final		
Level A	UEFA SCUP	UEFA Champions League: group stage to semi-finals	
Level B	UEFA Nations League: finals	UWCL Final UEFA Women's EURO Final Tournament UEFA European Football Championship: qualifying matches UEFA Nations League: league phase UEFA Champions League: play-offs UEFA Europa League: group stage to semi-finals UEFA Europa Conference League: group stage to semi-finals UEFA European Under-21 Championship: final tournament	

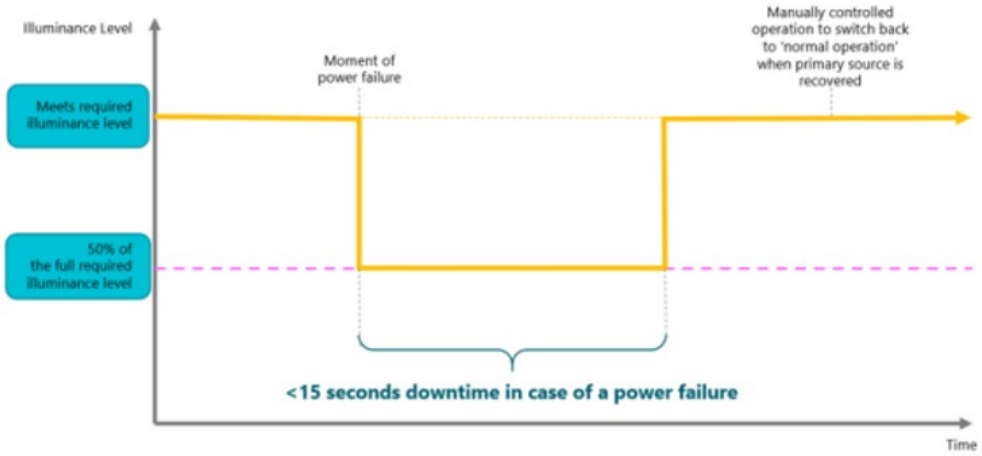
UEFA illuminance level	Floodlight power supply levels (FPSL) FPSL A	FPSL B	FPSL C
Level C		UEFA Champions League: third qualifying round UEFA Europa League: third qualifying round and play-offs UEFA Europa Conference League: third qualifying round and play-offs	
Level D		UEFA Champions League: first and second qualifying rounds UEFA Europa League: first and second qualifying rounds UEFA Europa Conference League: first and second qualifying rounds UEFA Women's Champions League: group stage to semi-finals UEFA Women's EURO qualifying rounds UEFA European Under-21 Championship: qualifying matches FIFA Women's World Cup: qualifying rounds UEFA Youth League: qualifying rounds and finals Men's & Women's youth competitions: final tournament UEFA Regions' Cup: preliminary round to final UEFA Youth League: qualifying rounds and finals	
≥350 lux Eh			Non-broadcast matches UEFA Women's Champions League: preliminary round, round 1 and round 2 Men's & Women's youth competitions: qualifying rounds UEFA Youth League: qualifying rounds UEFA Regions' Cup: preliminary round

Floodlight power supply level A for HID



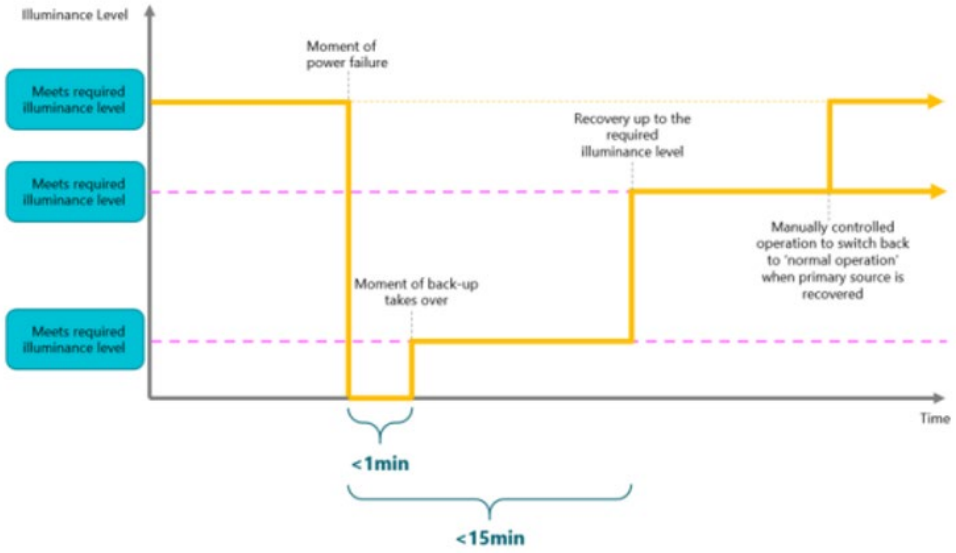
FPSL A for HID	
System design	The stadium is fed by a primary source. Ideally, a fully independent secondary source should be available, e.g. in a 'open half-ring' grid design. In addition to the primary source for the floodlights in the 'normal' operation mode, a backup system must be available to power 100% of the floodlights, e.g. by a UPS battery or a rotating-wheel system.
System functionality	In the normal operation mode, the primary source must be able to provide power for the full illuminance level required. If the primary source fails, a backup system must be able to take over the full floodlights without interruption; no disruption to the match illuminance conditions is permitted. Switching back from the backup mode to the 'normal' operation must be manually controlled from the moment the primary power supply is recovered.

Floodlight power supply level A for LED



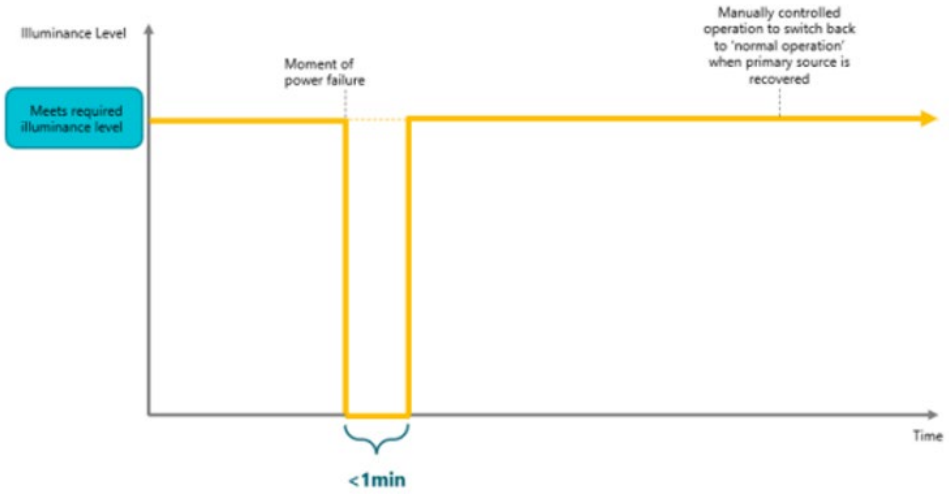
FPSL A for LED	
System design	The LED pitch illuminance system must be split into two independent sources: primary and secondary. Each of the two independent LED systems must operate effectively and produce uniform illuminance across the pitch. They must be supplied and operate completely independently of each other and not be reliant upon the operation status of the other system or of the pitch lighting control system.
System functionality	In normal operation mode, each of the two sources supplies power for 50% of the full illuminance level uniformly across the pitch. Each source must have sufficient capacity to supply the entire floodlight system in the event of a failure. If one source fails, the other source must take over the extra 50% in a fully automated switchover process within less than 15 seconds. Switching back from the backup mode to the 'normal' operation must be manually controlled from the moment the primary power supply is recovered.

Floodlight power supply level B for HID



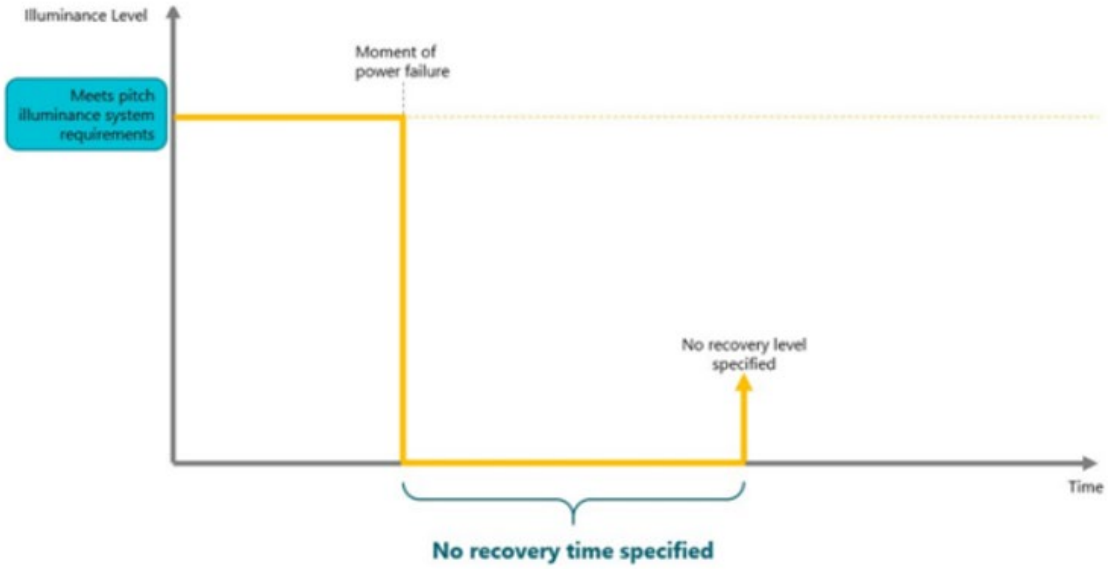
FPSL B for HID	
System design	The stadium is fed by a primary source. Ideally, a fully independent secondary source should be available, e.g. in a 'open half-ring' grid design. In addition to the primary source for the floodlights in the 'normal' operation mode, a backup system must be available to power the floodlights up to a certain level, depending on the floodlight illuminance level required (see below). The backup system could be designed either with a diesel generator that is started up when the power failure occurs or a secondary source with a fully automated switchover. The backup system must be capable of providing power to a certain number of hot restrike HID systems within a minute of the failure. An additional number of cold restrike HID systems must then be in operation after a maximum of 15 minutes.
System functionality	In the normal operation mode, the primary source must be able to provide power for the full illuminance level required. If the primary source fails, a backup / secondary system must be able to supply power to achieve the following illuminance values. **Within a minute for floodlight illuminance level:** Level A: 100% of normal match conditions Level B: Eh > 800 lux Level C: Eh > 500 lux Level D: Eh > 20 lux **Within a maximum of 15 minutes for floodlight illuminance level:** Level A: 100% of normal match conditions Level B: 100% of normal match conditions Level C: Eh > 800 lux Level D: Eh > 500 lux Switching back from the backup mode to the 'normal' operation must be manually controlled from the moment the full primary power supply is recovered.

Floodlight power supply level B for LED



FPSL B for LED	
System design	The stadium is fed by a primary source. Ideally, a fully independent secondary source should be available, e.g. in a 'open half-ring' grid design. In addition to the primary source for the floodlights in the 'normal' operation mode, a backup system must be available to power up the floodlights back to 100% within 1 minute. The backup system could be designed either with a diesel generator that is started up when the power failure occurs or a secondary source with a fully automated switchover.
System functionality	In the normal operation mode, the primary source must be able to provide power for the full illuminance level required. If the primary source fails, a backup / secondary system must be able to supply power to achieve a 100% recovery within 1 minute. Switching back from the backup mode to the 'normal' operation must be manually controlled from the moment the full primary power supply is recovered.

Floodlight power supply level C



FPSL C	
System design	Standard grid power supply
System functionality	If the grid power fails, the system will shut down until the grid supply source is recovered.

17 — Lighting control systems

Lighting control management

LED pitch illuminance systems are now common. The control system is very different from what may have been previously installed at stadiums with HID pitch illuminance systems. It is an integral element of the illuminance system operations that must be assessed and proven to be both reliable and resilient to failure due to various causes.

All LED pitch illuminance systems should have a master override switch (MOS) to operate the pitch illuminance system in the event of a control system fault or inappropriate operation (for any reason). The MOS must be completely independent and take precedence over the normal control system to switch the pitch illuminance system to full match operation conditions. It should be located in a secure facility, normally the stadium operations room.

Entertainment lighting

The **UEFA Guide for Stadium Entertainment Lighting** contains up-to-date recommendations on best practices and requirements when using the pitch illuminance system to provide an entertainment light show during UEFA match events and may be found in the UEFA Documents library.

These recommendations were developed in response to the many requests for UEFA to provide detailed practical and technical advice.

These recommendations should be consulted when designing and operating the pitch illuminance system for a stadium light show and used to provide clear, concise information for the various parties involved.

The health and safety requirements listed below must always be applied.

Entertainment lighting–Health and safety requirements

Emergency and escape lighting

During the light show, it is essential for spectators, employees, etc. to be able to move safely around the stadium facilities. All emergency and escape lighting must remain active.

Stadium safety lighting

The stadium must provide a safe environment for spectators, employees, etc. at all times. During a light show, the ambient light level within the stadium may be low; however, it is important for the illuminance system to always provide sufficient light to ensure the safe movement of everyone within the stadium.

Light show warning

UEFA's recommendation is that it is good practice to provide three audio and, if possible, visual warnings (on large LED screens) that there will be a change in the normal stadium lighting conditions at a pre-determined time. These warnings will reassure the spectators that they are in a safe and ordered environment. It is essential for sufficient ambient light to be provided to ensure that everyone can move safely around the stadium during the light show.

Stroboscopic lighting effects

Stroboscopic lighting effects should be avoided in stadiums owing to the large spectator numbers and potentially harmful reactions, such as photosensitive epilepsy, among people who are sensitive to fast flashing lights. If the stadium management are unsure about the exact nature and relevance of this concern and the light show contains a sequence of flashing images, a series of warnings should be provided for all spectators and employees at the stadium. The warning signs must clearly state that 'flashing images and lights will be used in pre- and post-match production lighting'. Television broadcasters may also want to give suitable warnings if they are using the light show as part of the TV production.

18 — LED pitch perimeter display systems

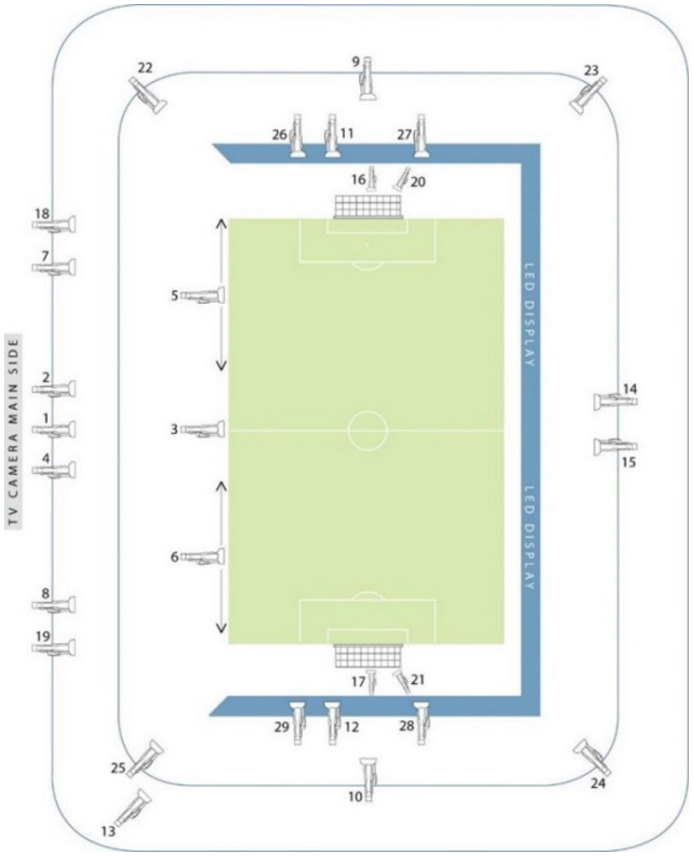
Pitch perimeter display systems provide an opportunity to tailor advertising and stadium management information to each individual event.

UEFA's LED pitch perimeter board criteria should be consulted prior to broadcasts. The LED advertising system should be assessed on installation and tested prior to each broadcast event. The LED display panels should operate within UEFA guidelines so that they do not affect the camera balance or exposure during the match coverage.

For further information, consult the latest version of the **UEFA LED technical specifications for club competitions** that may be found in the UEFA Documents library.

19 — TV camera plan

It is important for people designing lighting systems for football stadiums to understand the requirements of television cameras and the positions they operate from. Below is a typical camera plan for a high-specification TV broadcast of a football match.



Key to camera plan

This camera plan is fairly typical, but some broadcasters and TV directors will deviate from it slightly. The purpose of the plan is to help you understand how the various elements of the lighting design should be used to ensure the correct illuminance conditions in all areas of the pitch.

Key to camera plan:

1	Main camera	**13**	Beauty-shot camera
2	Close-up camera	**14-15**	Reverse-angle camera
3	Pitchside halfway camera	**16-17**	Mini-cameras
4	Close-up camera	**18-19**	Goal-line cameras
5-6	Steadicams	**20-21**	Hot-head cameras
7-8	Penalty area cameras	**22-25**	Corner cameras
9-10	High-behind-goal cameras	**26-29**	Hi-motion or big-lens close-up cameras
11-12	Low-behind-goal cameras		

Note that the camera numbers may be different and will depend on the TV broadcaster at that particular event.

The above plan should be used as a guide; however, it does not show the cameras used for presentation/interview and analysis purposes, which are not relevant for this document.

20 — Environmental guidance

There are a number of bodies that provide certification for buildings that are designed and constructed in line with strict sustainability guidelines. The most prominent of these bodies are BREEAM in Europe and LEED in the USA. Both provide an extensive list of parameters and checklists which need to be followed and implemented, after which the body in question assesses the level of compliance and issues the appropriate certification for the building. Both UEFA and FIFA recommend that all modern stadiums adhere to the standards stipulated by either of these two certification bodies. However, it is ultimately up to the stadium developers themselves to (i) be fully aware and supportive of the need for an environmentally responsible approach; (ii) proactively include sustainability initiatives in the project brief; and (iii) direct the design consultants accordingly.

Environmental impact of illuminance

Many countries have regulations and guidelines aimed at ensuring that the amount of stray illuminance does not have an undue impact on the local community.

The type of stadium structure and pitch illuminance system will determine the level of illuminance that is produced in areas outside the stadium. A report should be produced based on adequate reference points in areas around the stadium and showing the illuminance levels created by the pitch lighting system on the horizontal and vertical planes. The report should comply with the guidelines from the relevant authorities and be submitted to them for approval.

For reference purposes, pitch illuminance systems should not produce illuminance levels greater than 50 lux on the vertical plane at a height of 1.5m and a distance of 50–200m from the stadium perimeter. In the case of lower-illuminance level stadiums, the stray light from the pitch illuminance system should also be lower.

Environmental impact of glare

The pitch illuminance system should be designed in such a way that it does not produce levels of disability glare or discomfort glare that could cause disturbance to people within the local community. Particular attention should be devoted to ensuring that no drivers of vehicles on adjacent roads are affected by the pitch illuminance system.

21 — Illuminance test report

UEFA uses illuminance test reports to assess the illuminance conditions at venues. Tests should only be carried out by qualified personnel using the correct equipment, which must have been recalibrated within the last 12 months.

The UEFA pitch illuminance test report template can be found on UEFA pitch illuminance test report.

UEFA pitch illuminance test report

UEFA requires all venues which could potentially host a televised match to have their pitch illuminance systems assessed. Such illuminance tests must be carried out in accordance with UEFA's guidelines, to ensure a consistent and objective analysis of the lighting conditions.

The illuminance test procedure and requirements are detailed below.

Inspection equipment

The illuminance meter used for the test should be suitable for a floodlighting environment, with a wide-angle receptive light sensor, and should be recalibrated annually.

Test procedure

A football pitch measures 68m by 105m. This area is divided up into a grid containing 96 points. An illuminance test is carried out at each of these points to measure the horizontal illuminance and the vertical illuminance from four different angles. Thus, the test will require 480 illuminance measurements in total. Please ensure that the correct orientation is used when marking out the grid positions. The orientation can be seen in the pitch orientation plan on Horizontal illuminance grid plan.

Care should be taken when recording illuminance readings: the illuminance meter should always be positioned at the correct angle for the intended measurement. Personnel carrying out the test must not create any shadows that could impinge upon the illuminance meter. The meter should be 1m above the playing surface.

The illuminance reading for each grid point should be recorded on the relevant illuminance grid plan.

It is important for all five reference planes to be tested during the illuminance test and the results submitted in the test report. The five reference planes comprise one horizontal plane and four vertical planes.

Horizontal test:

The meter is positioned facing upwards, 1m above the playing surface, and parallel to the pitch, at each grid point.

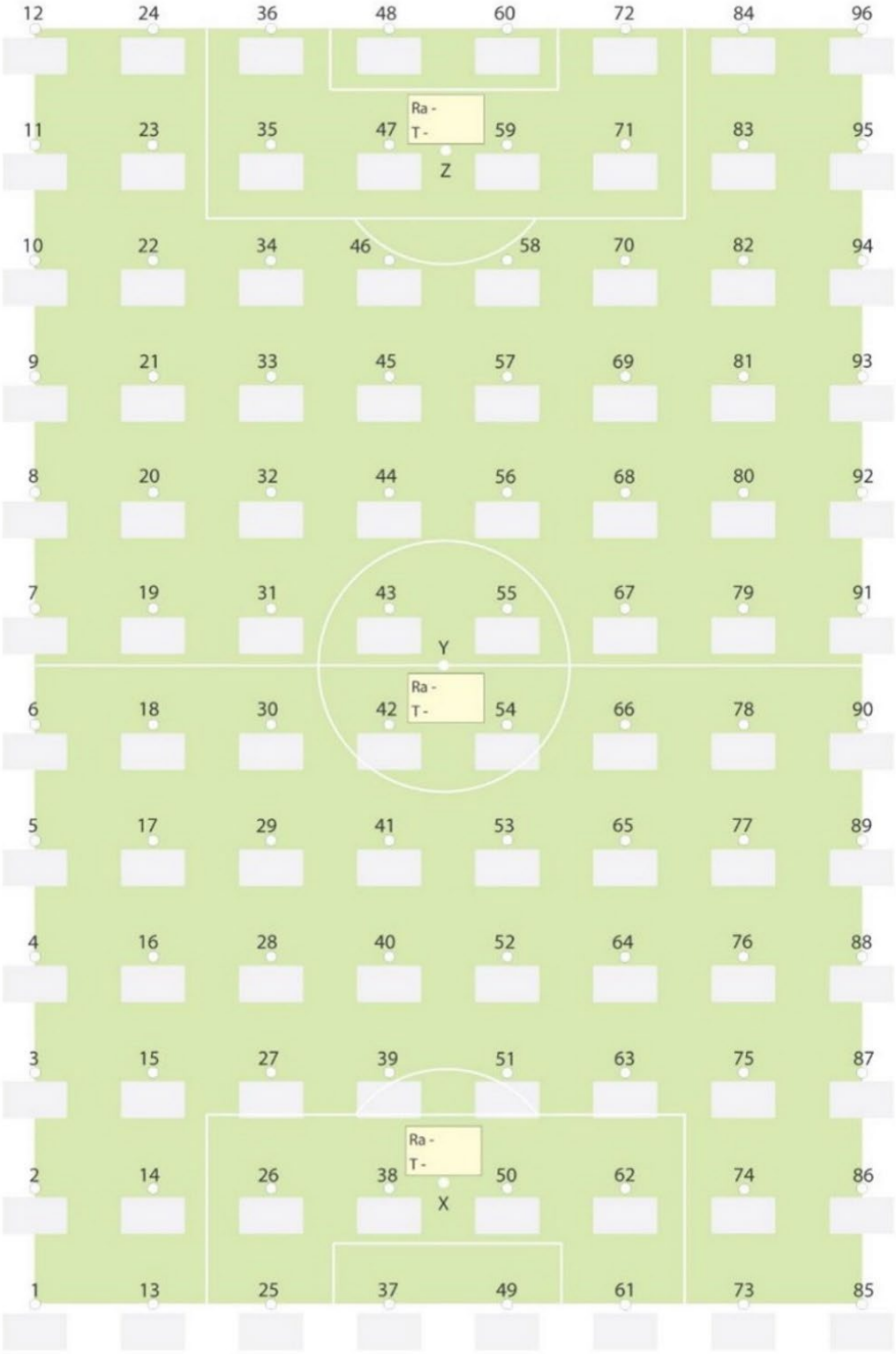
Vertical test:

The meter is positioned perpendicular to the pitch, 1m above the playing surface, at each grid point. The meter should then be adjusted for each of the four test positions. The test positions are indicated on the vertical illuminance grid plan (Vertical illuminance grid plan) and are at 0°, 90°, 180° and 270°. This procedure should be repeated at all 96 grid points.

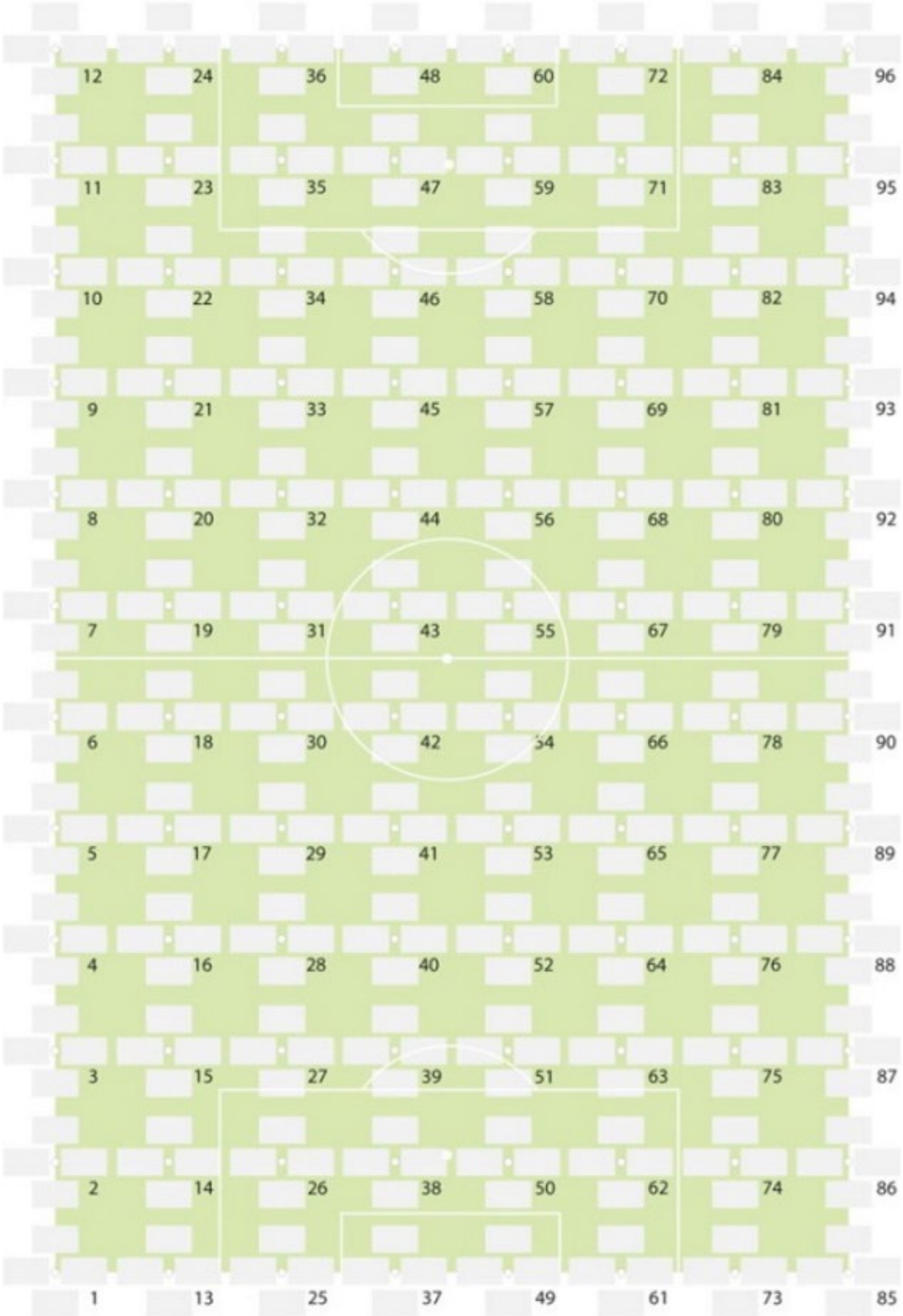
UEFA Illuminance test report template

Pitch illuminance report		
Name of stadium:		
Name of club:		
Date of inspection:		
Time:		
	Luminaire 1	Luminaire 2
Manufacturer:		
Model:		
Lamp/LED:		
Illuminance meter:		
Serial number:		
Calibration date:		
Colour meter:		
Serial number:		
Calibration date:		
Pitch measurements:		
Weather conditions:		
Illuminance test company:		
Address:		
Phone / email:		
Inspection by:		
Signature:		

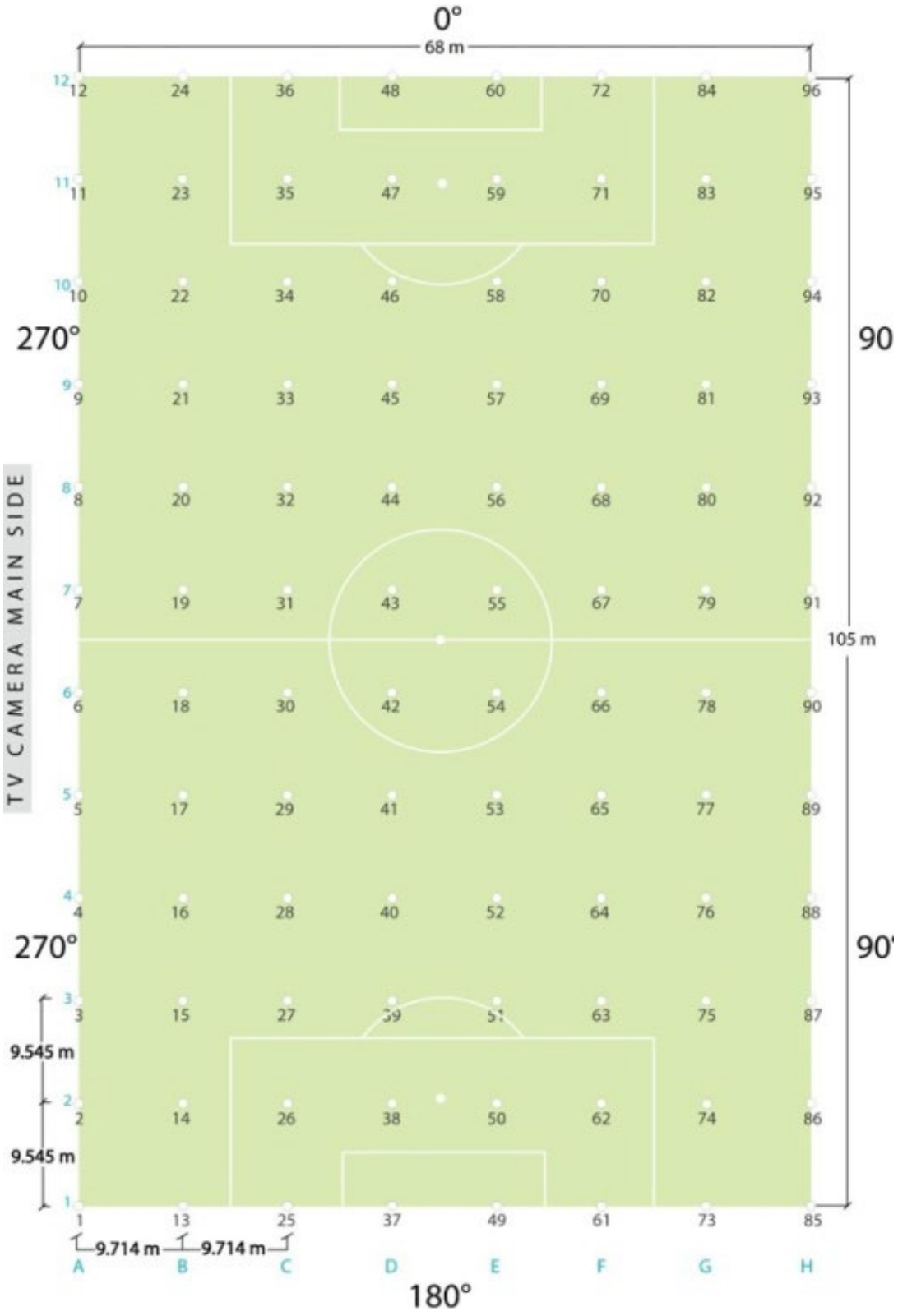
Horizontal illuminance grid plan



Vertical illuminance grid plan



Illuminance test – pitch orientation plan



Summary of report data

Stadium name	Test date

Test measurements	Results
Eh ave (average horizontal lux value)	
Eh max (maximum horizontal lux value)	
Eh min (minimum horizontal lux value)	
Uniformity **U1h**	
Uniformity **U2h**	
Ev ave-0° (average illuminance on 0° vertical plane)	
Uniformity **U1v-0°**	
Uniformity **U2v-0°**	
Ev ave-90° (average illuminance on 90° vertical plane)	
Uniformity **U1v-90°**	
Uniformity **U2v-90°**	
Ev ave-180° (average illuminance on 180° vertical plane)	
Uniformity **U1v-180°**	
Uniformity **U2v-180°**	
Ev ave-270° (average illuminance on 270° vertical plane)	
Uniformity **U1v-270°**	
Uniformity **U2v-270°**	
Maximum flicker factor	
Average flicker factor	
Glare rating (R_G)	
Colour rendering (Ra)	
Colour temperature (Tc)	

Measuring illuminance

Horizontal illuminance test

The receptor head is mounted parallel to the pitch, 1m above the pitch surface. A horizontal illuminance reading should be taken at all 96 points.

Ensure that the meter is always positioned in the same orientation at each test point and is level with the pitch. This can be achieved with the aid of a spirit level or another such device.

Vertical illuminance test

The receptor head is mounted perpendicular to the pitch, 1m above the pitch surface. A vertical illuminance reading should be taken at 0°, 90°, 180°, 270° at each of the 96 points.

Ensure that the meter is always positioned in the correct orientation for each test point and is perpendicular to the pitch. This can be achieved with the aid of a spirit level or another such device.

Pitch illuminance power supply form

Power supply evaluation

During a pitch illuminance test it may be required to evaluate the power supply.

The form below should be completed with the necessary details.

The power supply for the pitch illuminance system must be reliable to ensure that matches and television broadcasts can continue without any disruption greater than what is permitted for the relevant competition category. There must be a suitable alternative backup power supply in case the primary source fails.

Please complete the form below, providing details of the power supply and other operational information.

Pitch illuminance power supply form	
Name of stadium:	
Grid Power Supply	
No. of feeder lines+transformers/kVA/MWA:	
Supply design (e.g. open half-ring):	
Backup power supply (second grid source / generator / UPS batteries)	
Type: Grid	Generator (MWA) UPS (kWA)
Switching between grid and backup power supplies	
Backup operation (parallel/standby/standby running):	
Is the switchover process (grid to backup) automatic:	Yes / No
Please describe the backup procedure in the event of a grid power failure:	
Is a UPS battery system installed in the stadium illuminance system?	Yes / No
What percentage of the lights are connected to the UPS battery system?	
What is the operation time of the UPS system at full load, in minutes?	
Type of luminaire	
LED	
Cold restrike % overall / % on uninterrupted backup:	
Hot restrike % overall / % on uninterrupted backup:	

In the box below, provide an electrical overview diagram of the stadium power system from medium voltage/0.4kV transformers, including main switchboards and backup systems towards the illuminance system. The diagram needs to show the operation procedure in the event of a grid power failure.

22 — Glossary

E	The illuminance, the quantity of light falling on a surface at a given point, measured in lux.
Eh ave	The average illuminance on the horizontal plane for the specified reference test points 1.0m above the pitch surface, measured in lux.
Eh max	The maximum illuminance on the horizontal plane for the specified reference test points 1.0m above the pitch surface, measured in lux.
Eh min	The minimum illuminance on the horizontal plane for the specified reference test points 1.0m above the pitch surface, measured in lux.
Ev ave	The average illuminance on the vertical plane for the specified reference test points 1.0m above the pitch surface, measured in lux.
Ev 270°	The illuminance on the 270° vertical plane for the specified reference test point 1.0m above the pitch surface, measured in lux.
Ev4 (4-point ave)	The average of the illuminance values for the four vertical planes at a specified reference test point 1.0m above the pitch surface, measured in lux.
Ev4-96 min (4-point min)	The minimum value for Ev4 (4-point ave) at each of the 96 reference points.
Ev4-96 max (4-point max)	The maximum value for Ev4 (4-point ave) at each of the 96 reference points.
Ev4-96 ave (4-point ave)	The average value for Ev4 (4-point ave) at each of the 96 reference points, measured in lux. Calculated by adding together the values for Ev4 (4-point ave) at each of the 96 reference points and dividing the total by 96.
Ev 270° ave	The average illuminance on the 270° vertical plane for the specified reference test points 1.0m above the pitch surface, measured in lux. Calculated by adding together the values for Ev 270° at each of the 96 reference points and dividing the total by 96.
Ev 0° max	The maximum illuminance on the 0° vertical plane for the specified reference test points 1.0m above the pitch surface, measured in lux.
Ev 180° min	The minimum illuminance on the 180° vertical plane for the specified reference test points 1.0m above the pitch surface, measured in lux.
Ecam ave	The average illuminance towards the main camera for the specified reference test points 1.0m above the pitch surface, measured in lux.
lux	The unit of measurement for illuminance. 1 lux = 1 lumen/m2
lumen (lm)	The unit of measurement for luminous flux.
illuminance	The quantity of light falling on a surface at a given point, measured in lux.
CRI	CRI The Colour Rendering Index measures the quality of the colour reproduction produced by a light source relative to that produced by a reference illuminant. See ILV 17-222 on a scale of 0 Ra to 100 Ra.
Ra	Ra The general version of assessing colour rendering of a specific value given to a light source to indicate the level and quality of CRI on a scale of Ra 0 to Ra 100. Ra is calculated as the average value of the eight pre-defined reference colours R1 to R8.

Re	Re The extended version of assessing colour rendering using 15 reference colours. The specific value given to a light source to indicate the level and quality of Colour Rendering Index (CRI) on a scale of Re 0 to Re 100. Re is calculated as the average value of the pre-defined colour references R1 through R15.
TLCI	TLCI Television Lighting Consistency Index. An alternative method for evaluating the chromaticity of a light source within the television environment.
Tc	The colour temperature of a light source, measured in Kelvin (K).
FF	Flicker factor is the amount of luminance modulation on a given plane during a complete cycle. It is calculated by measuring the ratio between the maximum and minimum illuminance values, expressed as a percentage.
R_G	The glare rating – the degree of discomfort caused by the illuminance system to a person on the pitch. The glare rating is calculated at a height of 1.75m above the pitch surface.
MAUR	The minimum adjacent uniformity ratio. The maximum permissible difference between any two adjacent points on any given plane in any direction is determined by the MAUR stipulated in the relevant table in UEFA Illuminance Requirements.
U1h	A measure of horizontal uniformity of illuminance. The ratio of the minimum value on the horizontal illuminance to the average value of the total sum of horizontal illuminance values across all 96 reference points (the average value is calculated by dividing the total sum of the 96 values by 96).
U2h	A measure of horizontal uniformity of illuminance. The ratio of the minimum horizontal illuminance value to the maximum value of horizontal illuminance of all 96 reference points.
PISM	Pitch illuminance switch mode. The pitch illuminance system should be pre-programmed with various different modes, catering for a variety of situations. The number of such modes may vary from stadium to stadium.
FMM	Full match mode, which is when the complete pitch illuminance system operates under match conditions at the appropriate UEFA illuminance level.
MM	Maintenance mode, which provides sufficient pitch illuminance for maintenance requirements.
MCM	Match continuity mode, which allows a match to continue after the primary power supply has failed. Only U1 is evaluated for illuminance uniformity: U1 must be greater than 0.5 on the horizontal plane and 0.4 on the vertical plane.
TM	Training mode, which provides sufficient pitch illuminance for training requirements.
	Main camera side Also referred to as the 270° plane, this indicates the plane of the main camera position for a television broadcast. The main TV camera will be located on the TV camera gantry. This term is used in this guide to ensure that the pitch orientation is correct and consistent for all stadiums.
	Main camera position This refers to the position of the main camera for a television broadcast. The main TV camera will be located on the TV camera gantry. This term is used in this guide to ensure that the pitch orientation is correct and consistent for all stadiums.

	Direct point source luminous flux This refers to luminous flux emitted by a luminaire. Luminaires that have no or only limited control of luminous flux may cause a person to observe a significant number of light sources in an LED luminaire. Direct point source luminous flux will often create a greater level of discomfort glare (R_G) for an observer/player.
FPSL	Floodlight power supply level. Used to determine the type of power supply to be used with the pitch illuminance system.
Primary source	Grid power source that feeds a stadium floodlight system in normal operation mode.
Secondary source	Second grid power source that is fully independent from the primary source and that is either in use for normal operation mode (when the stadium is designed to be fed by two independent grid sources in normal operation mode) or that can be switched to if the primary source fails.
Backup system	A stadium's own power source, e.g. diesel generators, battery systems or rotating systems, that is used to back up the floodlighting (and other) system to reach the required service levels.

23 — Amendments to UEFA lighting levels

Elite level A floodlight illuminance on page 9		
Description	2016	2023
Ev (vertical illuminance uniformity)	U1: >0.40, U2: >0.50	U1: >0.50, U2: >0.60
Flicker factor (FF)	ave <5%, max <5%	ave <3%, max <3%
Minimum adjacent uniformity ratio (MAUR)	>0.60	>0.60, ≤10 failures
Maintenance factor (MF)	0.85	0.90 LED, 0.80 HID

Level A floodlight illuminance on page 10		
Description	2016	2023
Minimum adjacent uniformity ratio (MAUR)	>0.60	>0.60, ≤20 failures
Maintenance factor (MF)	0.80	0.90 LED, 0.80 HID

Level B floodlight illuminance on page 11		
Description	2016	2023
Minimum adjacent uniformity ratio (MAUR)	>0.60	>0.60, ≤30 failures
Maintenance factor (MF)	0.80	0.90 LED, 0.80 HID

Level C floodlight illuminance on page 12		
Description	2016	2023
Minimum adjacent uniformity ratio (MAUR)	>0.50	>0.50, ≤30 failures
Maintenance factor (MF)	0.70	0.90 LED, 0.70 HID

Level D floodlight illuminance on page 13		
Description	2016	2023
Eh (horizontal illuminance uniformity)	U1: >0.40, U2: >0.50	U1: > 0.40, U2: > 0.60
Ev (vertical illuminance uniformity)	U1 >0.35, U2 > 0.45	removed
Maintenance factor (MF)	0.70	0.90 LED, 0.70 HID

Additions to UEFA design guide diagrams
Description
Linear — roof rim lighting
Player face modelling
Column positions
Luminaires focus point angle

Changes to the power supply requirements
Description
Floodlight power supply level (FPSL)
Floodlight power supply level tables
Addition to lighting control requirements
Description
Lighting control systems

WE CARE ABOUT FOOTBALL