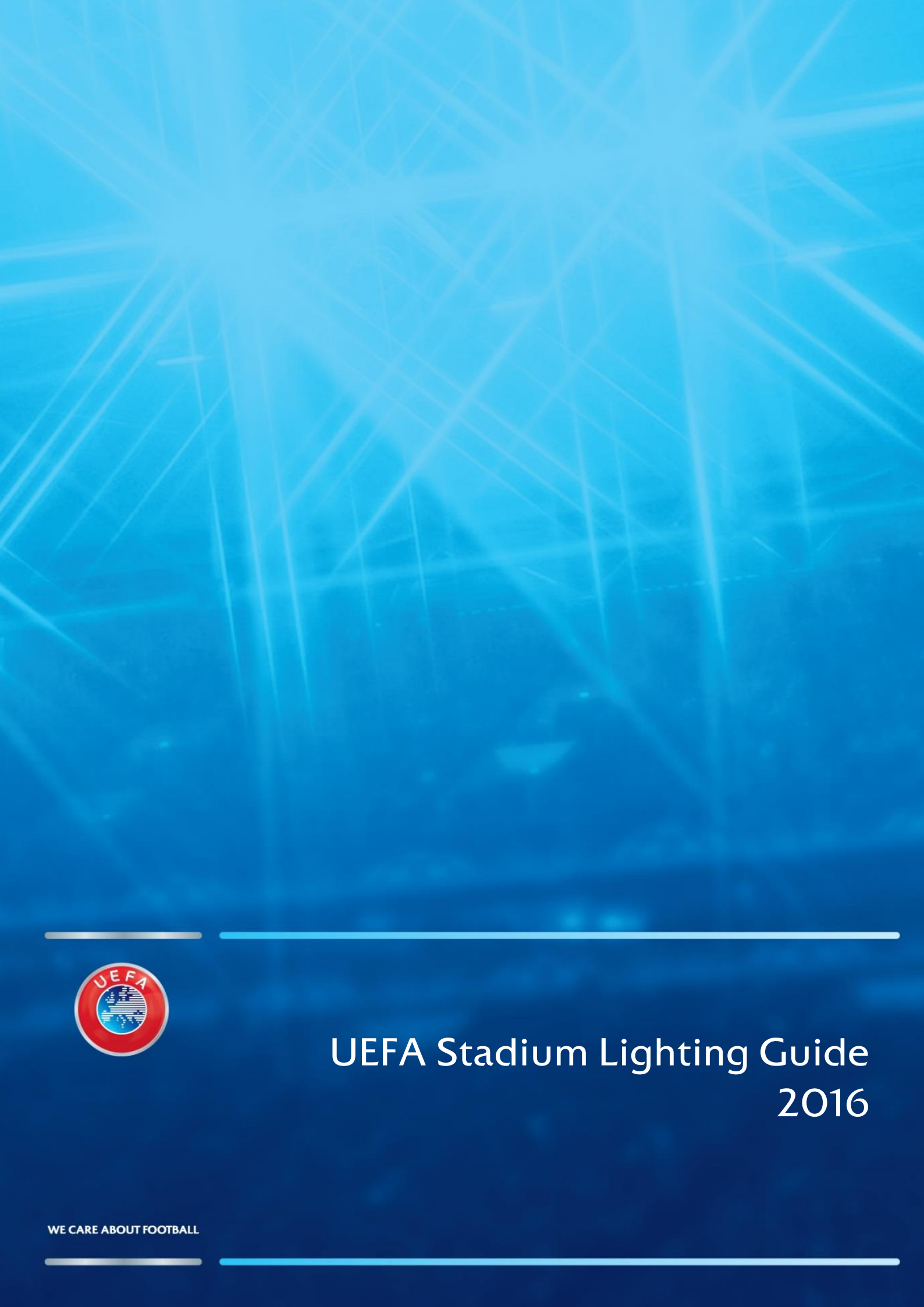


UEFA Stadium Lighting Guide 2016

WE CARE ABOUT FOOTBALL

Contents

1 Introduction

This document contains a set of recommendations that have been developed in response to the many requests that UEFA has received to provide detailed technical information on floodlighting levels and assessment.

UEFA's floodlighting requirements are listed in the UEFA Stadium Infrastructure Regulations, with further stipulations in the respective competition regulations and manuals. For finals or final tournaments, the staging agreements may include specific clauses regarding floodlighting.

These recommendations aim to help technical suppliers to meet these requirements. They also take into account recent technological developments and broadcasting needs to support stadium owners who are looking to install a high-quality system that is tailored to the current and anticipated future broadcasting environment and UEFA's competition requirements.

This lighting guide has been developed by UEFA in consultation with **International Illuminance Services (IIS**) to encourage and ensure the adoption of best practices in pitch illuminance system design in all UEFA stadiums.

2 Design guide

This document provides guidelines for the artificial illuminance systems used for football pitches. The principles applied to the design elements and how you apply these principles and combine them together in one design will determine how successful your design is.

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

2.1 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.
6. A successful pitch illuminance system will produce illuminance levels and uniformity that comply with the requirements of the relevant UEFA illuminance level, with soft shadows where possible.
7. The pitch illuminance system must be reliable and effective for the given 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.
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 illuminance level A stadiums.
12. Modern artificial lighting systems are able to provide high-quality illuminance conditions 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 pre/post-match lighting effects.
14. A stadium lighting design should always take account of the latest technological requirements for broadcast television.
15. A stadium lighting design should always assess the lighting equipment and technology that is available and consider if 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 terms of the selection of the relevant UEFA illuminance level is provided in Section 3.4.

3.1 New stadiums

During the design process for new stadiums, this guide should be used for guidance to determine the level of illuminance that is required. Once the installation of the illuminance system (i.e. floodlights) has been completed, a UEFA illuminance test report should be submitted to UEFA for analysis. A template for that test report can be found in Section 20.

3.2 Existing stadiums

Existing stadiums may want to evaluate their current illuminance system and ascertain how to meet the standards required for the relevant level of competition.

Again, a UEFA illuminance test report should be completed and submitted to UEFA for analysis. Information will be provided by UEFA with regard to the current illuminance conditions and any modifications that may be required. A template for that test report is available to in Section 20.

3.3 Illuminance levels

The requirements in terms of the artificial illuminance of a football pitch are split into five illuminance levels. The following table provides details of the recommended illuminance level for each competition round. If there is any uncertainty as to which level applies, UEFA should be contacted 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 of players, officials and spectators. The non-broadcast constitutes the minimum requirements.

3.4 Overview of illuminance levels for UEFA competitions

Type of match	UEFA illuminance level
UEFA EURO	Elite level A
UEFA Champions League final	Elite level A
UEFA Europa League final	Elite level A
UEFA Champions League: group stage to semi-finals	Level A
UEFA Super Cup final	Level A
UEFA Women's EURO	Level B
UEFA European Under-21 Championship: Final tournament	Level B
UEFA Champions League: Play-offs	Level B
UEFA Europa League: group stage to semi-finals	Level B
UEFA European Football Championship: qualifying matches	Level B
UEFA Champions League: third qualifying round	Level C
UEFA Europa League: third qualifying round and play-offs	Level C
UEFA European Under-21 Championship: qualifying matches	Level D
UEFA Champions League: first and second qualifying rounds	Level D
UEFA Europa League: First and second qualifying rounds	Level D
Youth and Women's Competitions: Qualifying rounds, group-stage and knock-out rounds (excluding final(s))	Level D
Non-broadcast matches	➢ 350 lux

4 UEFA illuminance requirements

4.1 Elite level A stadiums

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°	> 0.40
Uniformity U2v-0°	> 0.50
Ev ave-90° (vertical illuminance on 90° reference plane)	average > 1,500 lux minimum > 1,000 lux
Uniformity U1v-90°	> 0.40
Uniformity U2v-90°	> 0.50
Ev ave-180° (vertical illuminance on 180° reference plane)	average > 1,500 lux minimum > 1,000 lux
Uniformity U1v-180°	> 0.40
Uniformity U2v-180°	> 0.50
Ev ave-270° (vertical illuminance on 270° reference plane)	average > 1,500 lux minimum > 1,000 lux
Uniformity U1v-270°	> 0.40
Uniformity U2v-270°	> 0.50
Match continuity mode (MCM)	Eh ave >1,000 lux Ev4 ave > 600 lux
Flicker factor (FF)	average < 5% maximum < 5%
Minimum adjacent uniformity ratio (MAUR)	> 0.60
Colour temperature (Tk)	5,000–6,200K
Colour rendering	≥ 80 Ra
Glare rating (GR)	< 50
Maintenance factor (MF)	0.85
Power supply	Elite level A

4.2 Level A floodlighting 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)	Eh ave > 800 lux Ev4 ave> 500 lux
Flicker factor (FF)	average < 12% maximum < 15%
Minimum adjacent uniformity ratio (MAUR)	> 0.60
Colour temperature (Tk)	5,000–6,200K
Colour rendering	≥ 80 Ra
Glare rating (GR)	< 50
Maintenance factor (MF)	0.80
Power supply	Level A

4.3 Level B floodlighting 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)	Eh ave > 600 lux Ev4 ave > 300 lux
Flicker factor (FF)	average < 12% maximum < 15%
Minimum adjacent uniformity ratio (MAUR)	> 0.60
Colour temperature (Tk)	5,000–6,200K
Colour rendering	≥ 80 Ra
Glare rating (GR)	< 50
Maintenance factor (MF)	0.80
Power supply	Level B

4.4 Level C floodlighting illuminance

Eh ave (average horizontal illuminance)	> 1200 lux
Uniformity U1h	> 0.40
Uniformity U2h	> 0.60
Ev ave-0° (vertical illuminance on 0° reference plane)	average > 750 lux minimum > 350 lux
Uniformity U1v-0°	> 0.35
Uniformity U2v-0°	> 0.45
Ev ave-90° (vertical illuminance on 90° reference plane)	average > 750 lux minimum > 350 lux
Uniformity U1v-90°	> 0.35
Uniformity U2v-90°	> 0.45
Ev ave-180° (vertical illuminance on 180° reference plane)	average > 750 lux minimum > 350 lux
Uniformity U1v-180°	> 0.35
Uniformity U2v-180°	> 0.45
Ev ave-270° (vertical illuminance on 270° reference plane)	average > 750 lux minimum > 350 lux
Uniformity U1v-270°	> 0.35
Uniformity U2v-270°	> 0.45
Match continuity mode (MCM)	Eh ave > 300 lux Ev4 ave > 200 lux
Flicker factor (FF)	average < 20% maximum < 30%
Minimum adjacent uniformity ratio (MAUR)	> 0.50
Colour temperature (Tk)	4,200–6,200K
Colour rendering	> 70 Ra
Glare rating (GR)	< 50
Maintenance factor (MF)	0.70
Power supply	Level C

4.5 Level D floodlighting illuminance

Eh ave (average horizontal illuminance)	> 800 lux
Uniformity U1h	> 0.40
Uniformity U2h	> 0.50
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 (Tk)	4,200–6,200K
Colour rendering	> 65 Ra
Glare rating (GR)	< 50
Maintenance factor (MF)	0.70
Power supply	Level D

5 Illuminance design guidelines

The pitch illuminance system should provide the optimum conditions within the given illuminance level to ensure that players, officials, spectators and broadcasters are able to perform and enjoy the match without hindrance.

During the design process, the guidelines below should be used in order to establish a high-quality pitch illuminance system that satisfies the requirements of the relevant UEFA illuminance level.

5.1 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.

5.2 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.

5.3 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 specified in Section 4.

5.4 Luminaire mounting positions

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

In recent years, architectural requirements and design aesthetics have challenged the previous illuminance design guidelines. New stadiums are often designed and constructed in ways which require the pitch illuminance system to perform to the required standard while also remaining true to the architectural design.

There are now many examples of stadiums in Europe which have pitch illuminance systems that do not conform to the previous guidelines but do provide good illuminance conditions.

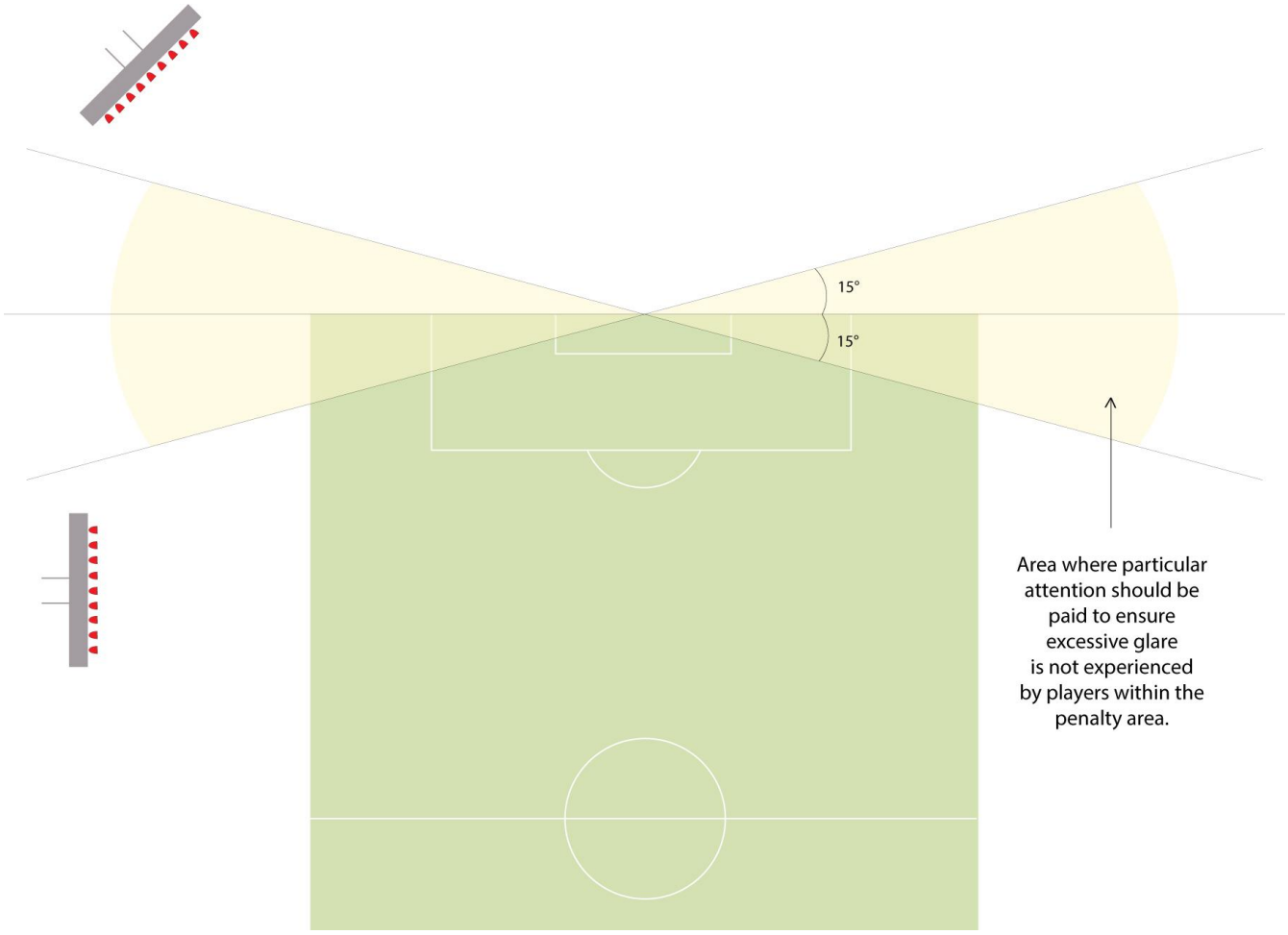
UEFA recommends that all new pitch illuminance designs focus primarily on ensuring that player comfort is maintained. Design solutions should ensure that the comfort of players, officials and spectators is maintained, while providing good operating conditions for broadcast television. Any new pitch illuminance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

5.5 Floodlight luminaire mounting guide

Ref.	Position	Guidance
6.1	Corners – column/tower floodlight array	To avoid excessive glare around the goal line, particular attention should be paid to the zone within 15° of either side of the goal line. Multiple luminaires, as used in column or tower installations, should not be placed in this zone.
6.2	Corners – linear floodlight array	If the installation design requires luminaires to be positioned within 15° 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.
6.3	Pitch perimeter – lateral distance to luminaire position	An adequate lateral distance between the luminaire mounting positions and the goal lines and side lines should be maintained in order to achieve the required vertical illuminance level around the perimeter of the pitch.
6.4	Pitch sides – 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.
6.5	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. In order to achieve improved vertical illuminance around the perimeter of the pitch, it may be necessary to install an additional linear row of luminaires with a greater lateral distance from the pitch.
6.6	Luminaire 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 luminaires' focus point angle is less than 70° from the line perpendicular to the pitch.
6.7	Pitch sides – luminaire mounting positions	Stadium structures should not impede the luminous flux of the pitch lighting system and cause shadows to be cast on the pitch.
6.8	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.
6.9	Behind penalty area – luminaire mounting zone	Luminaires positioned behind the goal and parallel to the penalty area should be mounted greater than 60° from the goal line.
6.10	Behind goal line – second linear row	An adequate lateral distance between the luminaire mounting position and the goal lines should be maintained in order 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 assist in this area.
6.11	UEFA pitch dimensions	Official UEFA pitch size and penalty area dimensions

6 Diagrams of design guidelines

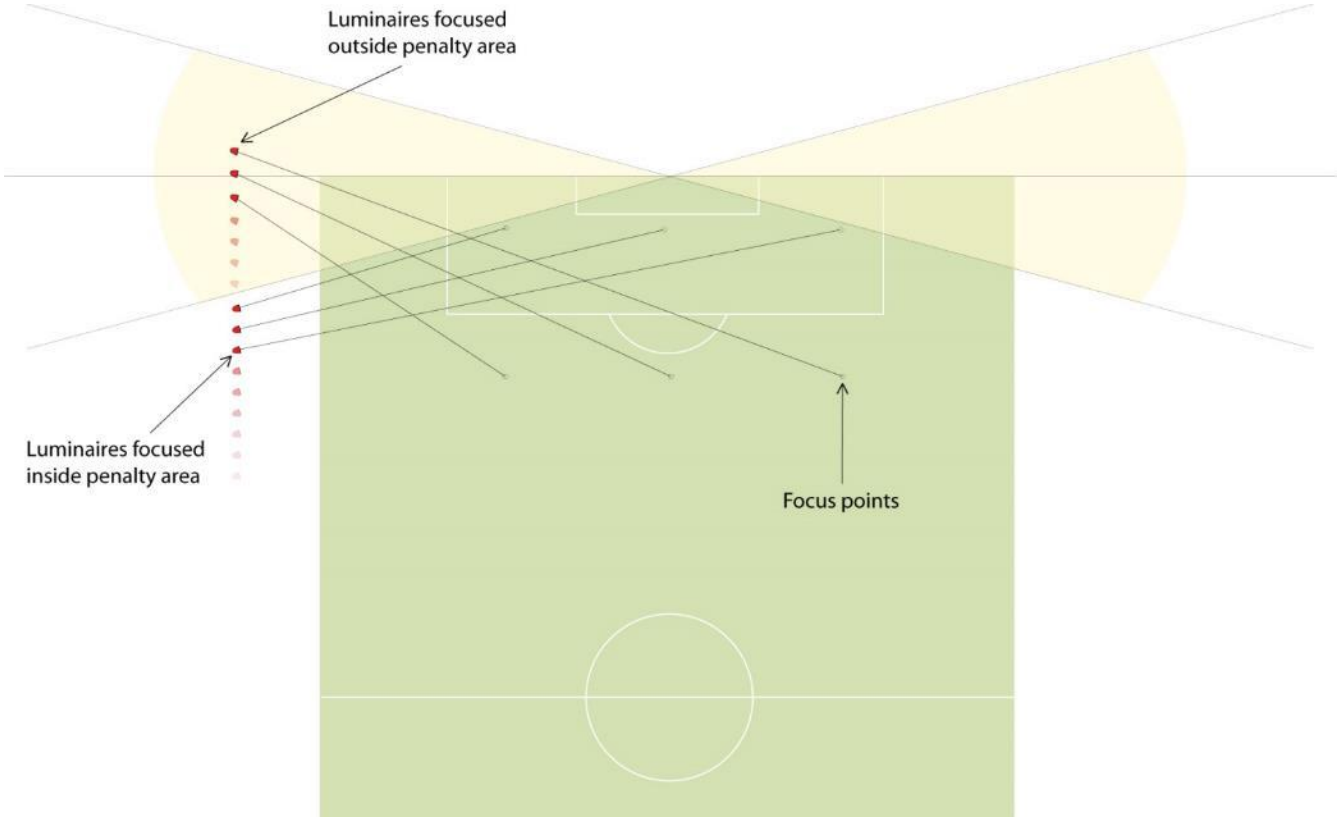
6.1 Corners – column/tower floodlight array



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. A consecutive line of luminaires with more than two rows is considered, for this purpose, to be a 'large multiple array'.

6.2 Corners – linear floodlight array



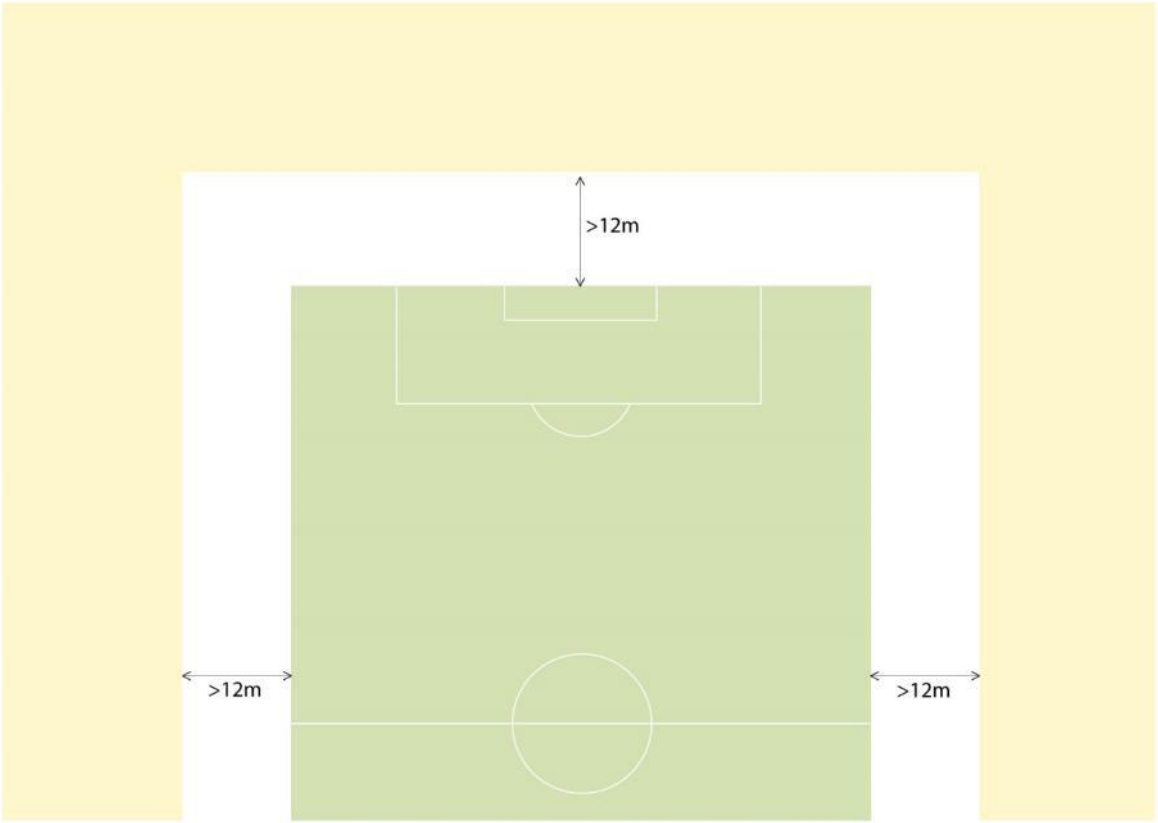
As regards players in the penalty area, the discomfort glare produced by a linear run of luminaires is considered to be within an acceptable level if the luminaires' focus points are such that players can stand in the penalty area and look towards the corners without hindrance.

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.

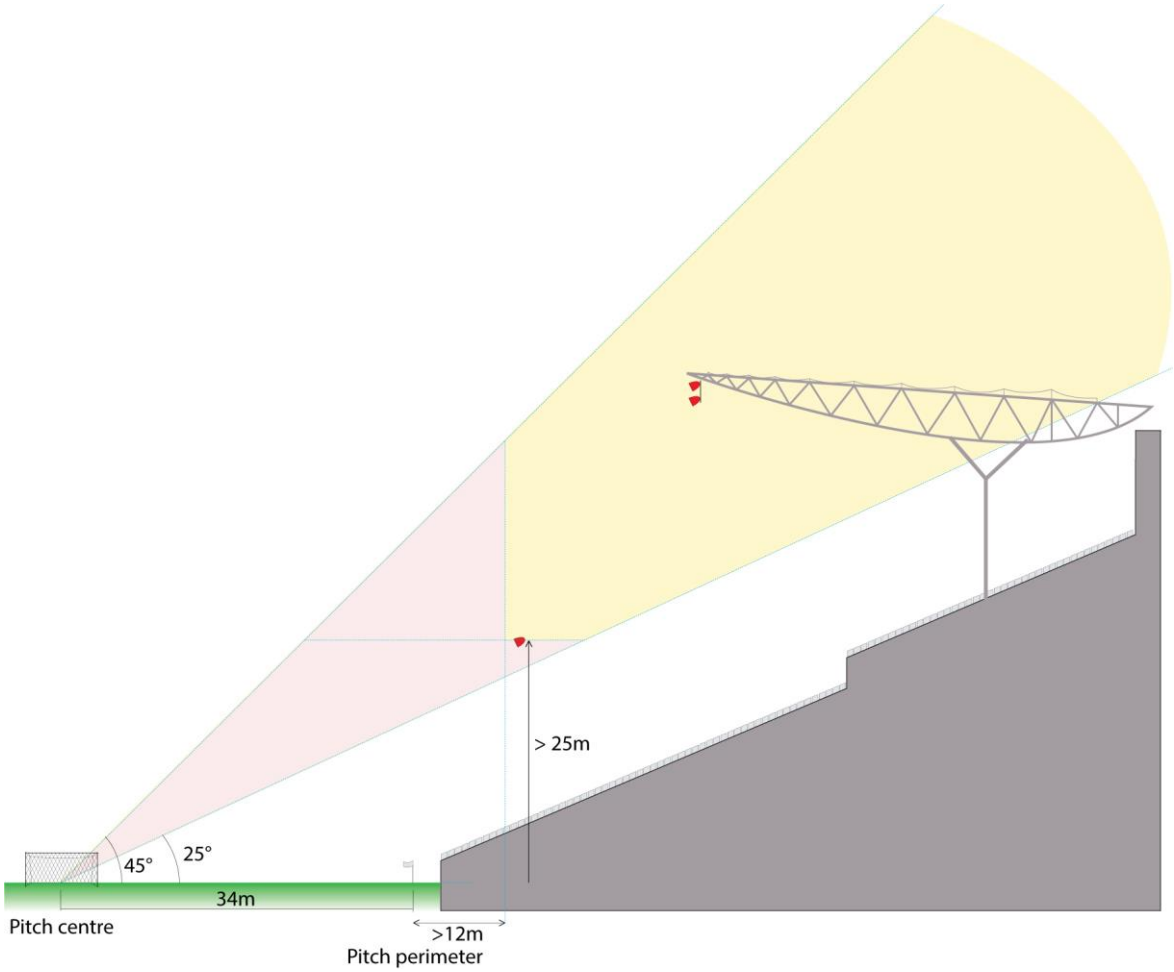
A linear array of luminaires used for this purpose should not comprise more than two rows.

6.3 Pitch perimeter – lateral distance



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 than12m.

6.4 Pitch perimeter – luminaire mounting zone



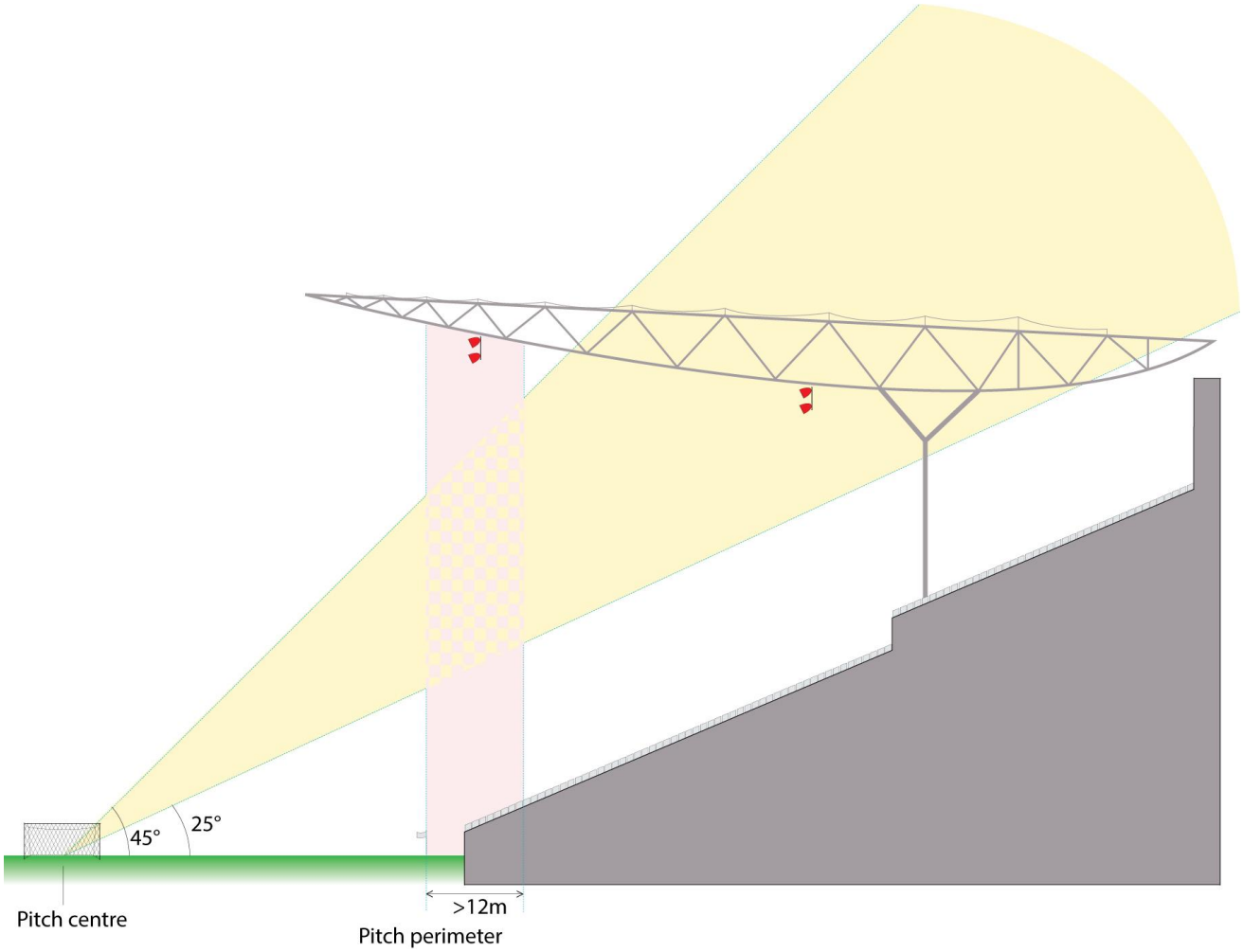
The luminaires should not be mounted less than 25° or more than 45° above the centre of the pitch.

This will generally ensure that illuminance conditions comply with UEFA's guidelines.

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

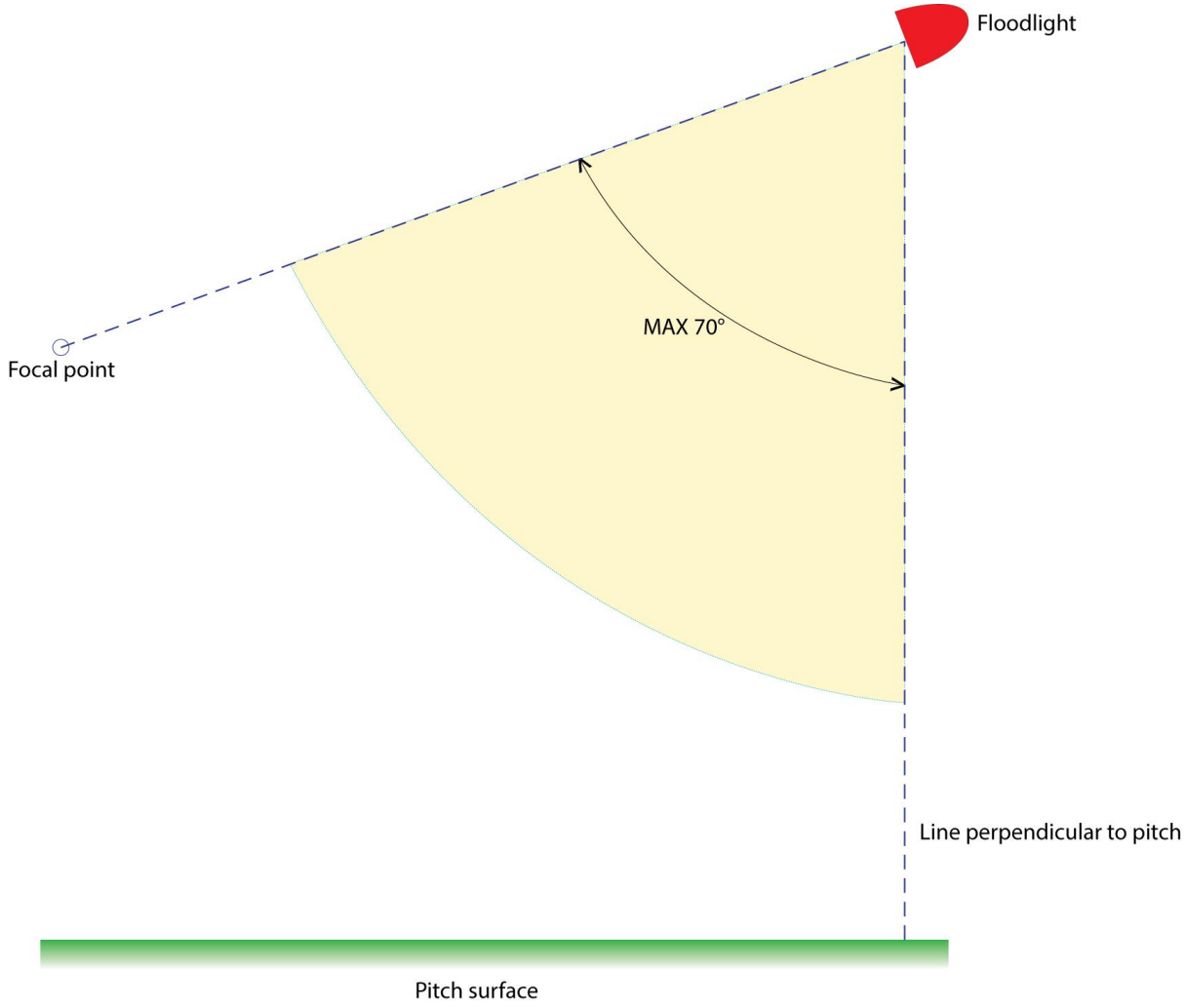
One way to ensure that players' discomfort glare is kept below 50 is to limit the angle of a floodlight's tilt to 70°, as indicated in the diagram in Section 6.6. However the structural design of some stadiums may make this impossible. In all glare rating evaluations, evidence should be provided of how the glare rating is kept below 50.

6.5 Pitch perimeter – second linear row



If the stadium design or existing installation requires luminaires to be positioned within a lateral distance of 12m of the perimeter of the pitch, or if the vertical illuminance requires improvement, a second linear run of luminaires should be used to achieve the required vertical illuminance around the perimeter of the pitch.

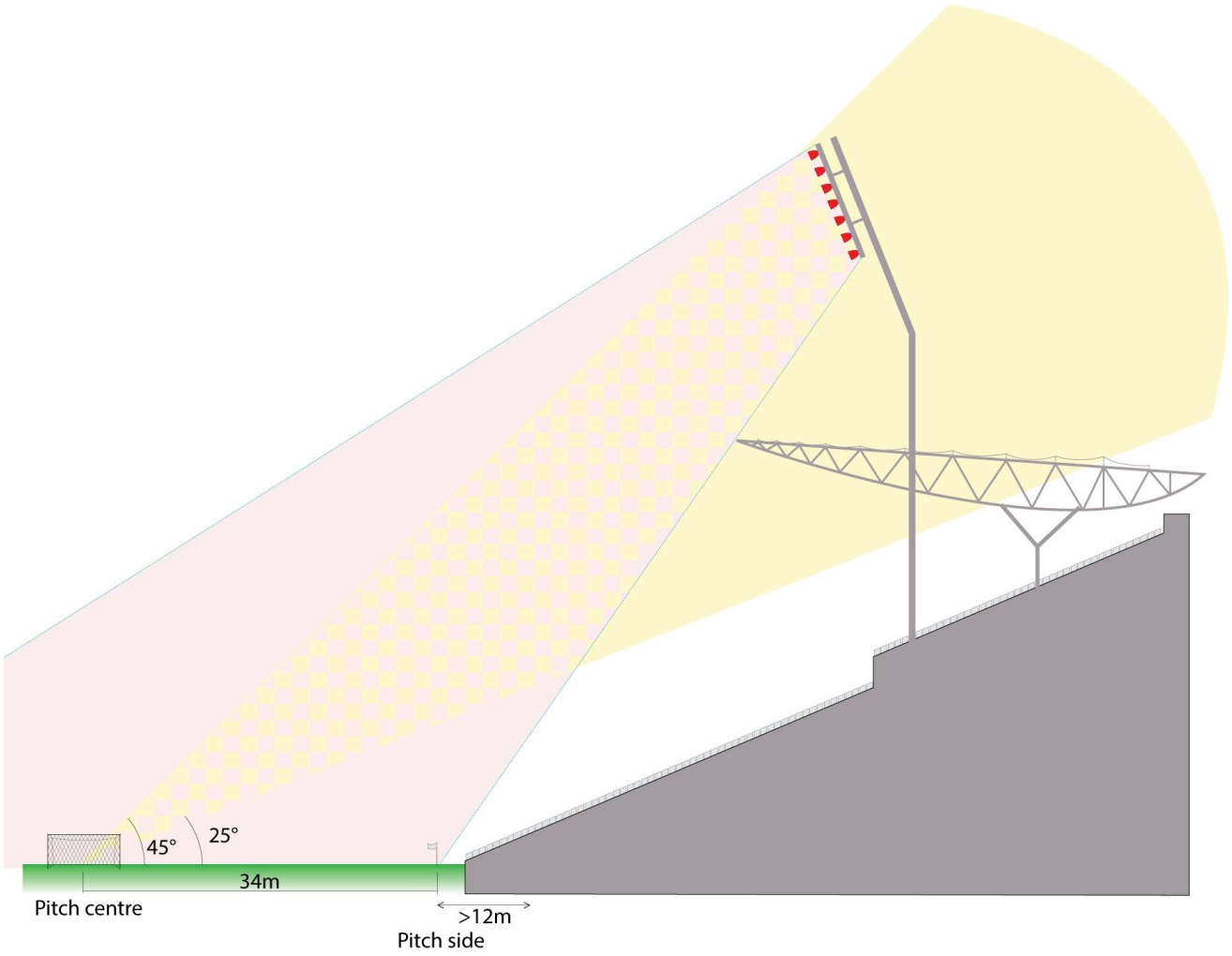
6.6 Luminaires' focus point angle



In order to avoid discomfort glare being experienced by players and officials, a general rule during the design process is to ensure that luminaires' focus point angle is no more than 70° 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.

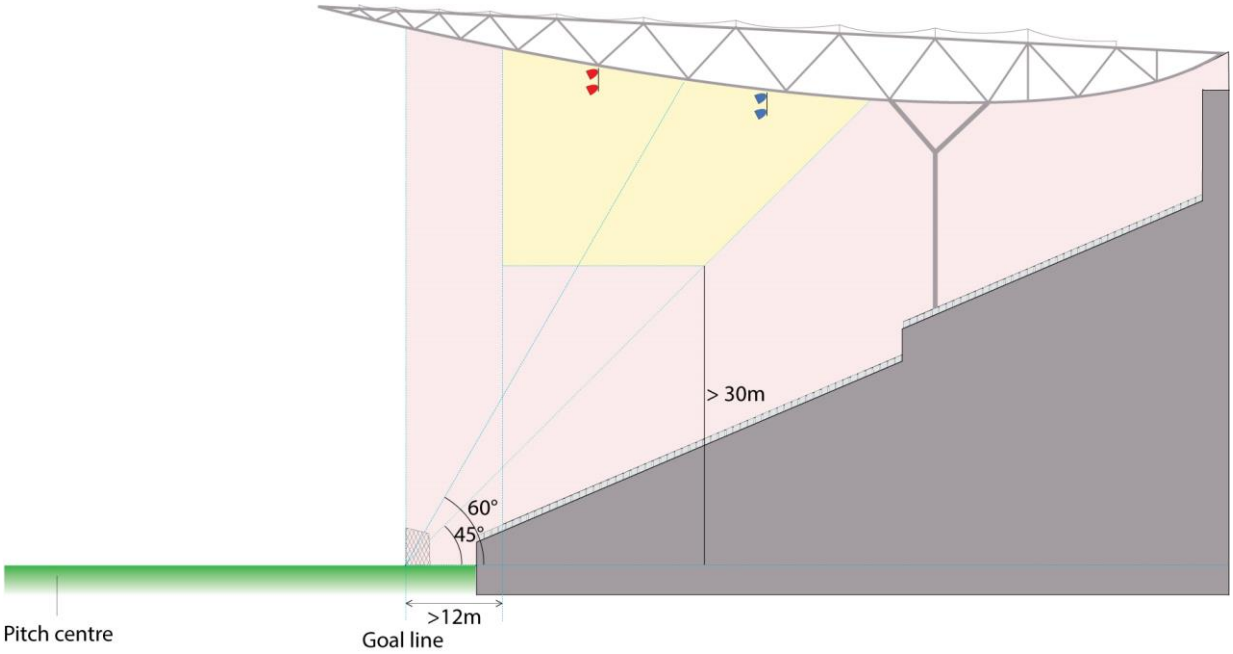
The above guidance is particularly relevant to point source illuminance systems, as generally seen with high-intensity discharge lamps. However, it may be necessary to re-evaluate this guidance when using LED luminaires, which will generally have large arrays of LEDs producing direct point source luminous flux.

6.7 Pitch sides – luminaire mounting position



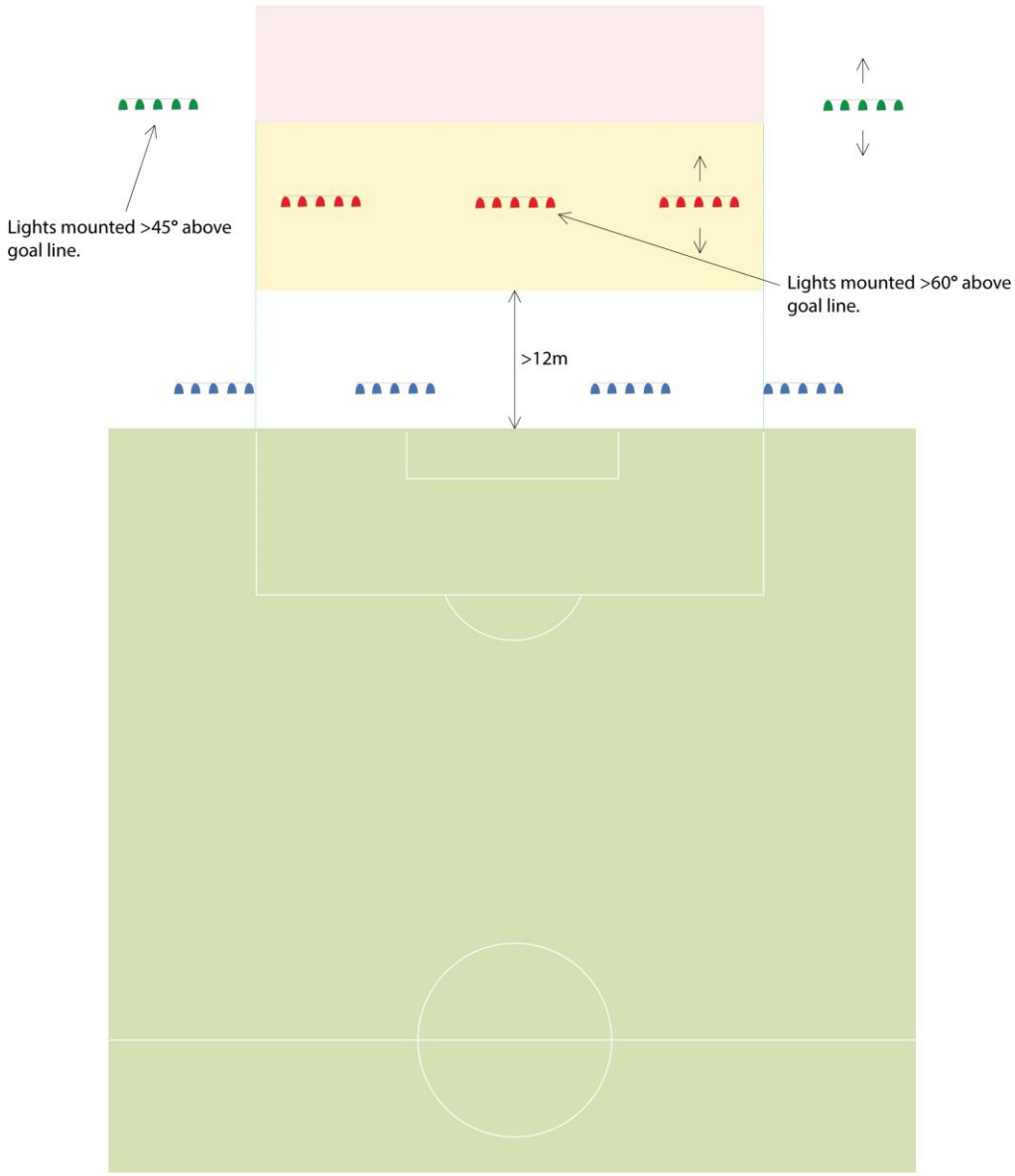
Stadium structures should not impede the luminous flux of the pitch lighting system and cause shadows to be cast on the surface of the pitch. Care should be taken to ensure that the luminous flux projection lines to the pitch surface are completely clear.

6.8 Behind penalty area – luminaire mounting zone



In order to avoid discomfort glare being experienced by attacking players looking towards the goal, additional provision is made by increasing the installation angle of luminaires directly behind the penalty area (as shown in the diagram above).

6.9 Behind penalty area – luminaire mounting zone

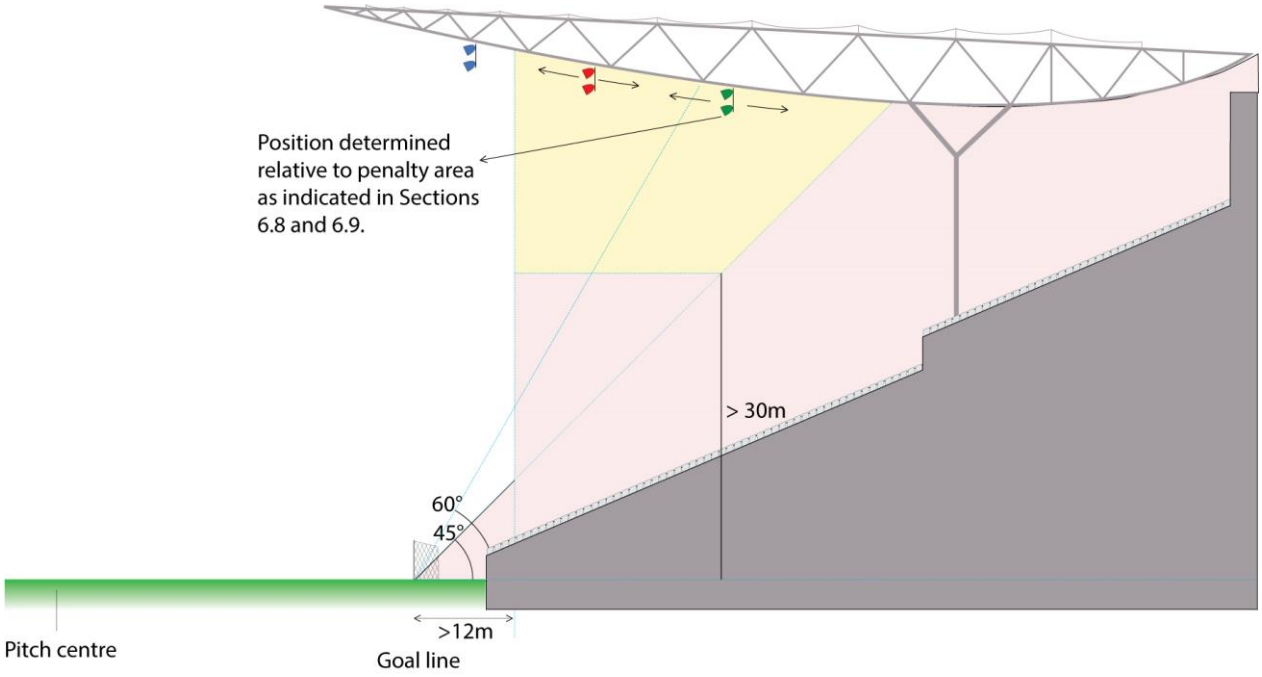


Luminaires positioned behind the goal and parallel to the penalty box as indicated in Section 6.8 should be mounted more than 60° from the goal line when in line with the penalty area, as indicated in the diagram above.

If only a single linear line of luminaires is used, the minimum lateral distance from the goal line should be 12m.

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

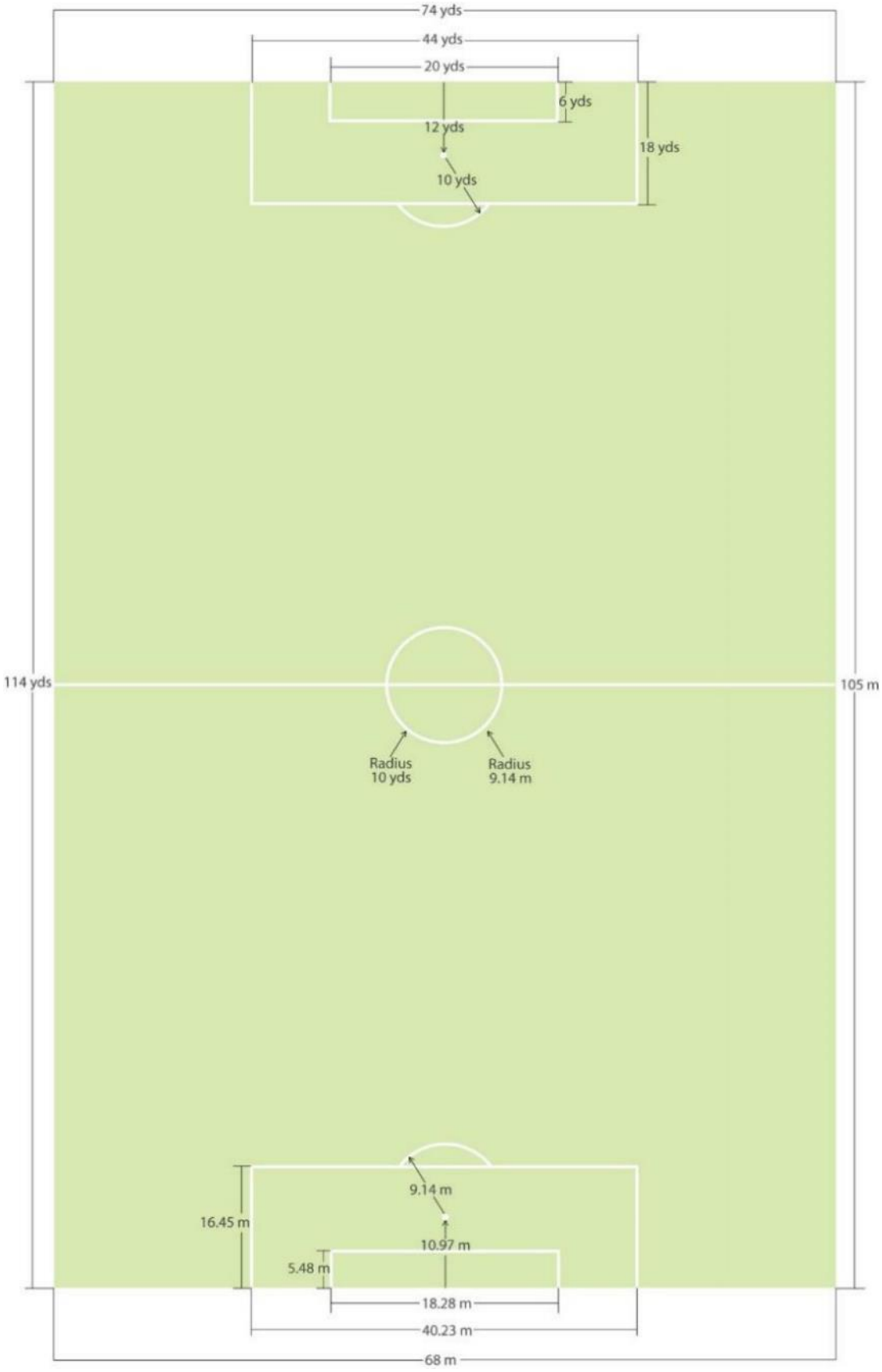
6.10 Behind goal line – second linear row



If the stadium design or existing installation requires luminaires to be positioned within a lateral distance of 12m from the goal line (as indicated by the blue luminaires in the diagram above) or if the vertical illuminance requires improvement, a second linear run 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° (as indicated by the red luminaires in the diagram above). Outside the area parallel to the penalty area, luminaires may be mounted at an angle of more than 45° (as indicated by the green luminaires).

Where possible, all luminaires behind the goal line should be a minimum of 30m 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 takes it into account.

6.11 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 will contribute 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 will contribute to the visual comfort experience.

Horizontal uniformity of illuminance

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

U2h A measure of horizontal uniformity of illuminance – 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 uniformity of illuminance 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.

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

8 Glare

8.1 Glare

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

8.2 Discomfort glare

Discomfort glare is caused by direct glare from luminaires which 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 got used to the dark, it is particularly susceptible to the impairment and depression of central vision when a bright light enters the field of vision.

8.3 Evaluation of glare

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

Glare is a subjective factor, for which a practical evaluation system has been 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 – http://div5.cie.co.at/?i_ca_id=599&pubid=166 - defines a glare rating (GR) with an assessment scale of 10 to 90. The lower the glare rating, the better the glare situation.

The validity of this system is restricted to viewing directions below eye level, and it is mainly used for predicting the degree of glare. During the lighting design phase, a glare assessment based on CIE 112-1994 should be carried out. Calculations should be made for observer positions using the grid points on page 58. Assessments should be made every 15°, starting from 0° or 180°, over a total of 360°. Observer positions should be 1.75m above the pitch surface.

The maximum glare rating and the corresponding direction should be displayed 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)

9.1 Full match mode

This involves the pitch illuminance system operating in a manner that satisfies the requirements specified for the relevant UEFA illuminance level.

9.2 Match continuity mode

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

In terms of the uniformity of illuminance, 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 process. In order for this mode to operate successfully, the power supply facilities and options available must be carefully considered during the design process.

9.3 Training mode

This involves the pitch illuminance system operating with an average horizontal illuminance of 500 lux.

9.4 Maintenance mode

This involves the pitch illuminance system operating with an average horizontal illuminance of 250 lux.

10 Flicker factor (FF)

10.1 Flicker factor guidance

During broadcasts, we can often see that some illuminance systems cause the picture to flicker during slow-motion replays. The flicker is distracting and impairs the viewer's experience, so it should be eliminated where possible. The circumstances that produce the flicker will vary depending on the modulation of the flicker, the alternating voltage frequency and the camera frame rate.

The term 'flicker factor' refers to the amount of modulation of luminance 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:

$$\mathbf{FF} = \mathbf{1/2} \times \frac{\mathbf{E}max - \mathbf{E}min}{\mathbf{E}\ average} \times \mathbf{100\%}$$

or

$$\mathbf{FF} = \frac{\mathbf{E}max - \mathbf{E}min}{\mathbf{E}max + \mathbf{E}min} \times \mathbf{100\%}$$

Where:

E represents the illuminance level during a complete cycle.

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

A flicker factor of less than 5% 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, an illuminance system with a flicker factor of less than 5% 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 that is 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 that is considered acceptable is indicated in the tables in Section 4.

10.2 Flicker factor reference table

Type of illuminance system	FF value (guide only)
Natural daylight	0%
LED luminaires (flicker dependent on the type of LED power supply used)	< 3%
Discharge lamps with 100% electronic ballasts	< 4%
Discharge lamps with magnetic ballasts spread uniformly across three-phase power supply	8–20%
Discharge lamps with magnetic ballasts on single-phase power supply	30–50%

10.3 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 level A Elite stadiums without additional solutions to reduce the modulation of luminance. 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 coming from different angles.

A pitch illuminance system that involves overlapping luminous flux coming from different angles should use a greater 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 used to reduce the flicker factor should not impinge upon the uniformity of illuminance on any plane.

10.4 Flicker factor testing

It is possible to measure the flicker factor at a specific stadium to provide a precise evaluation. The assessment should be carried out by a competent technician with a suitable meter. That meter should be recalibrated on an annual basis.

The flicker factor test should be conducted as indicated.

10.5 12-point flicker factor test

At each of the six positions indicated in Section 10.8, a vertical flicker factor reading should be taken at a height of 1m on the 90° and 270° planes.

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.

10.6 Flicker factor requirements by stadium illuminance level

10.7 24-point flicker factor test

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

When testing stadiums, it is necessary to establish the type of illuminance system that is in operation. This will tell us what type of test should be used to ensure that the flicker factor is measured correctly. If the entire illuminance system comprises HID lamps with electronic ballasts, or if the luminaires are LEDs, the flicker factor can reasonably be expected to be constant in all areas of the pitch. In such cases, a 12-point test would be appropriate for the type of lighting technology in operation.

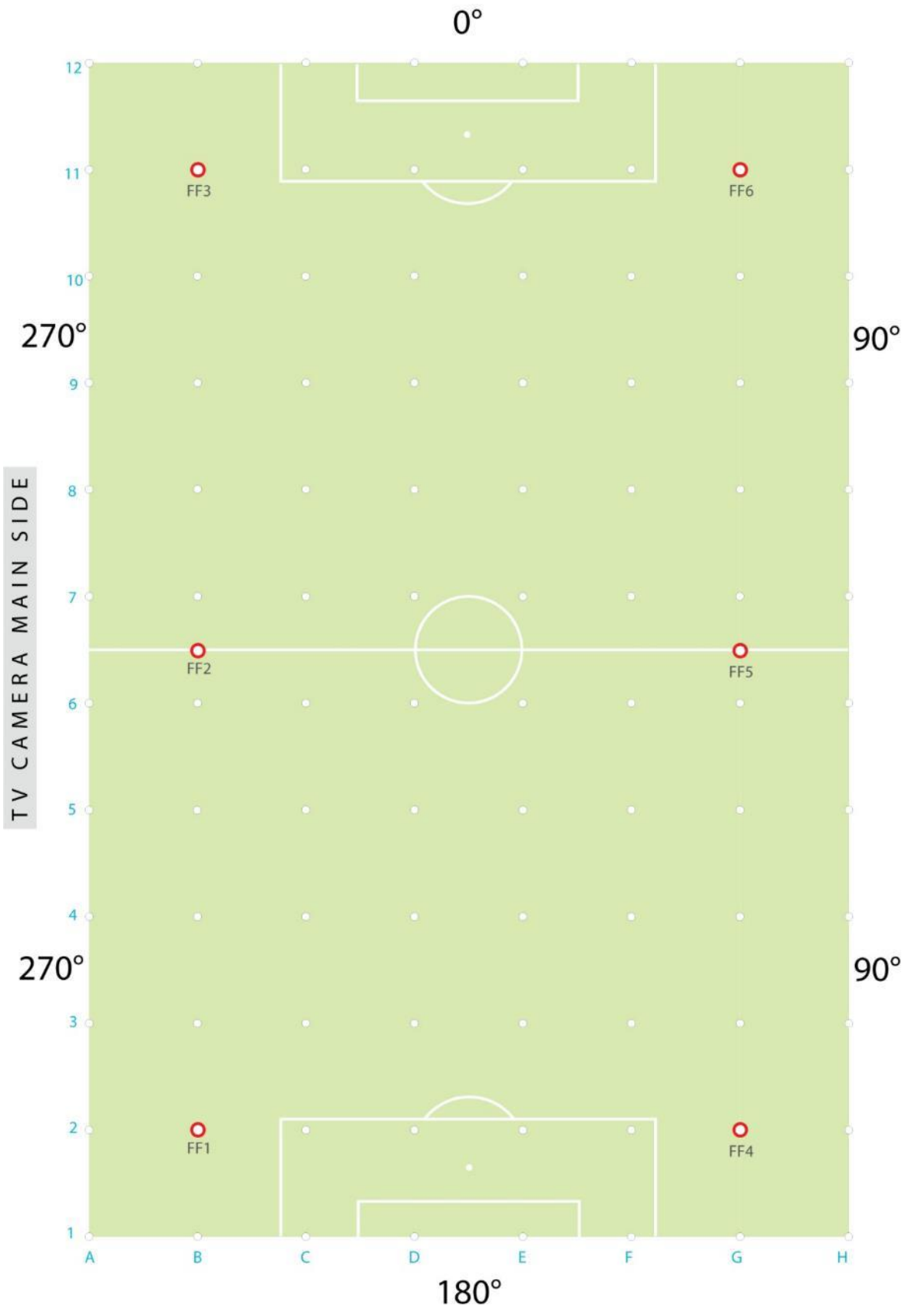
However, if the pitch illuminance system has a mixture of standard-frequency and high-frequency ballasts and may be reliant on overlapping luminous flux from luminaires at different angles, it will be necessary to perform a more rigorous flicker factor test. In this case, a 24-point flicker factor test should be used.

At each of the 12 positions indicated in Section 10.9, a vertical flicker factor reading should be taken at a height of 1m on the 90° and 270° planes.

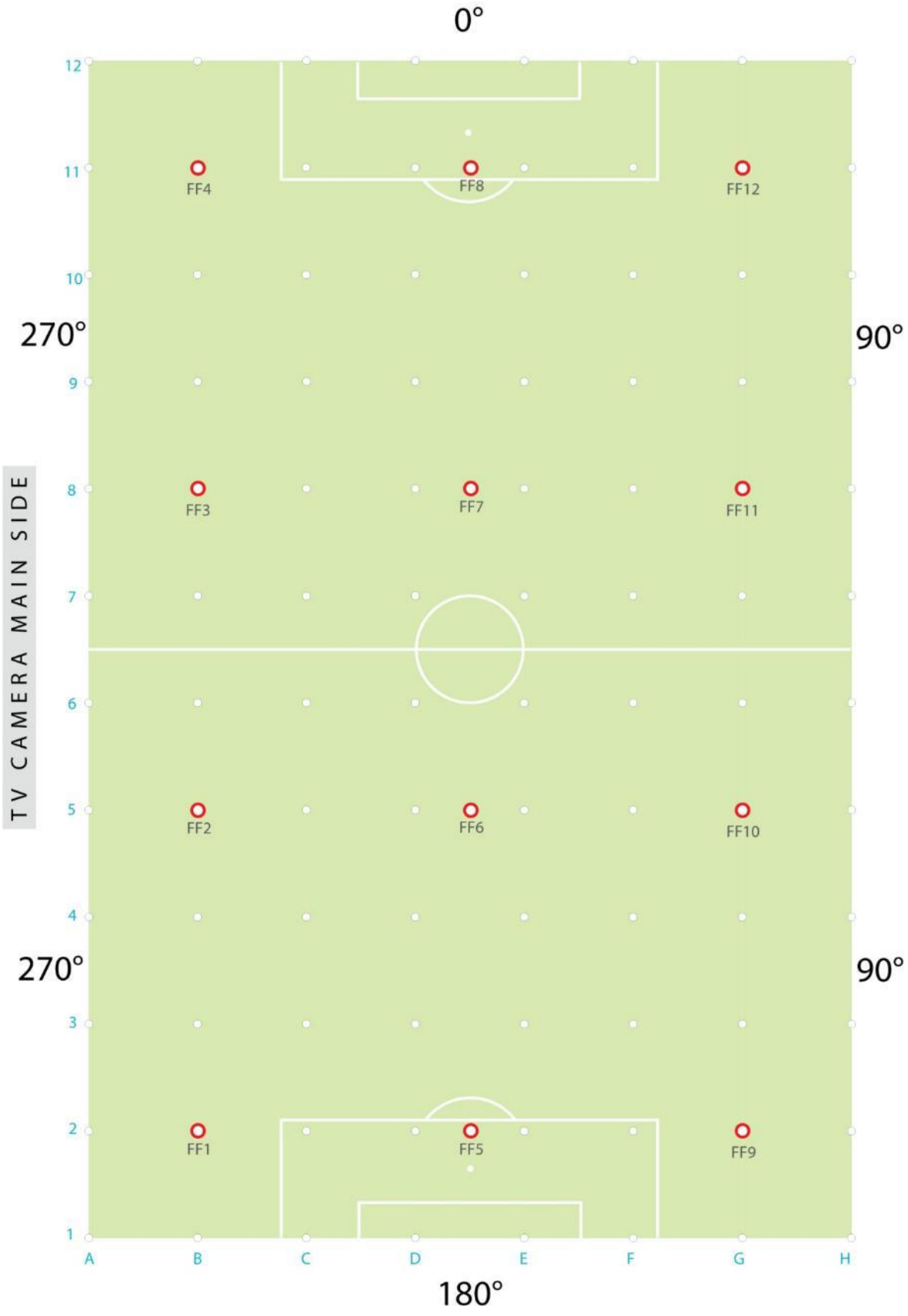
The 24-point average is calculated by dividing the sum of the 24 measured values by 24.

10.8 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.



10.9 Flicker factor test reference points – 24-point test



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 changed successfully on a consistent basis when the camera and the subject are both moving rapidly. The MAUR is used to ensure greater consistency in terms of camera exposure and thus greater freedom for the camera operator 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 Section 4. That requirement takes the form of a minimum permissible ratio between the two points.

11.1 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

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**.

11.2 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 – $E_{v\text{-}270°}$ = 1,548 lux
MAUR > 0.50

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**.

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 kelvins (K).

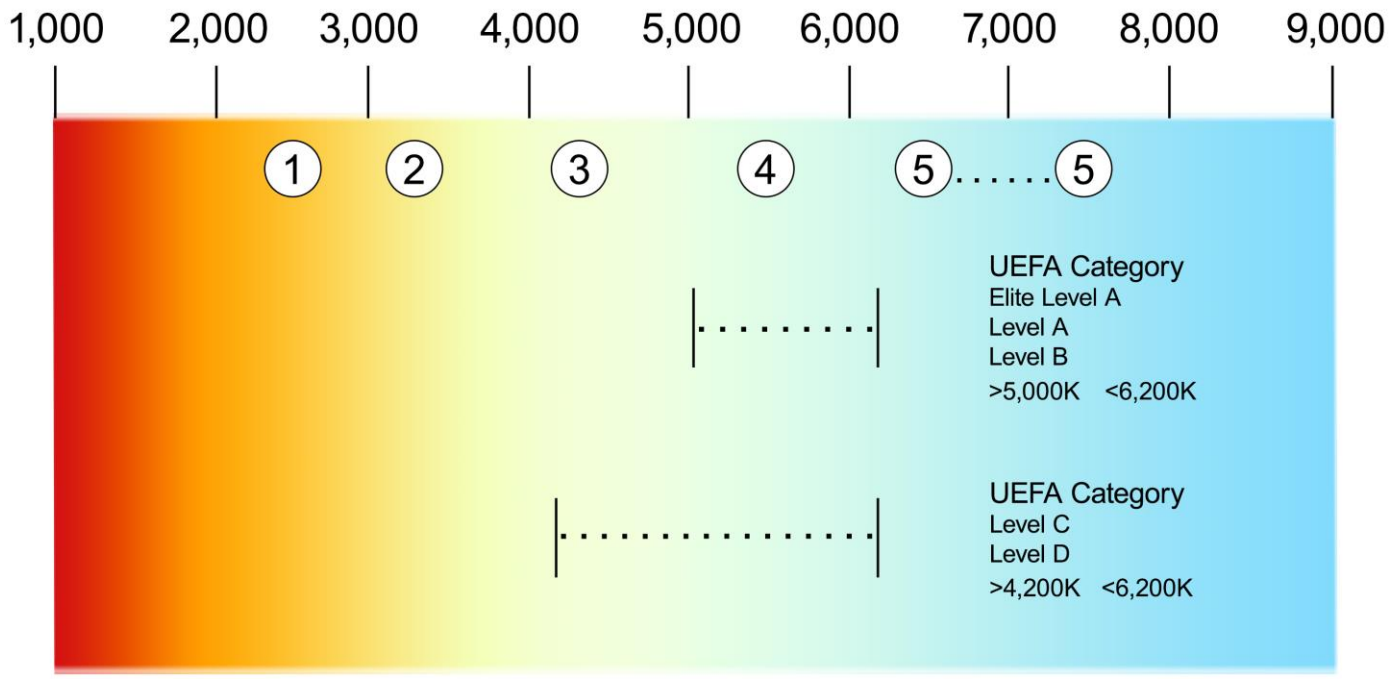
Digital camera technology allows video-produced media to be altered to 'gain' colour and contrast, as required to produce the desired colour quality. The required colour temperature range varies depending on the stadium illuminance level, with the minimum and maximum levels across all levels being 4,200K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

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

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

12.1 Colour temperature guide

1. Incandescent light bulb (2,680K)
2. Sun at sunrise/sunset (3,200K)
3. White fluorescent (4,200K)
4. Sun at daylight/noon (5,500K)
5. Overcast sky (6,500-7,500K)



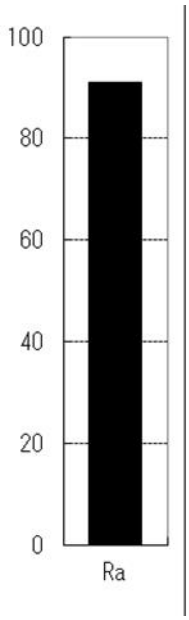
13 Colour rendering

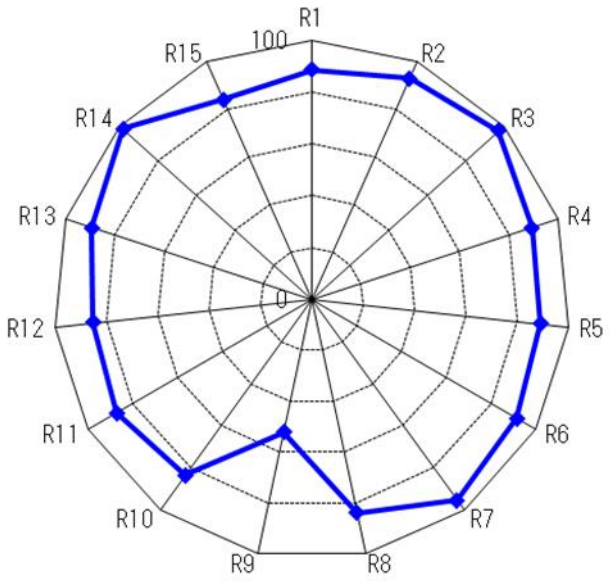
Colour rendering, which is expressed as a score between 0 and 100 Ra on the Colour Rendering Index (CRI), describes how a light source makes the colour of an object appear to human eyes and how well subtle variations in colour shades are revealed. The higher the CRI rating, the better the colour rendering.

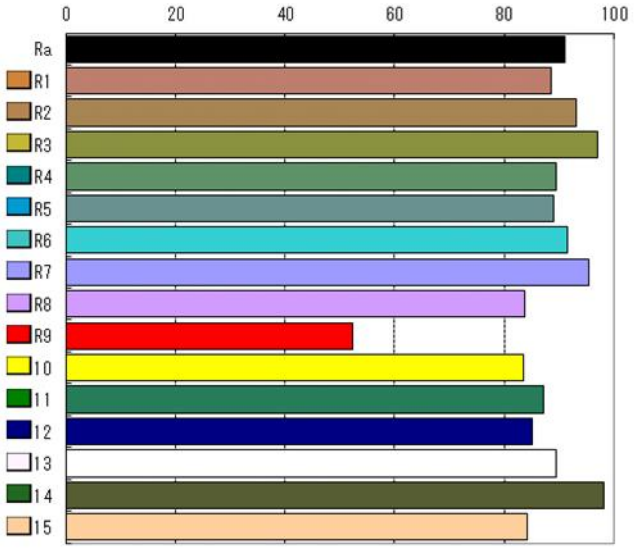
UEFA's requirements stipulate that for good colour production by the artificial illumination system, the CRI rating needs to be ≥ 80 for level A and level B stadiums, ≥ 70 for level C stadiums and ≥ 65 for level D stadiums.

The following diagram provides test information of chromaticity values and should be used as a guide to what is required for all new and old UEFA stadiums:

Chromaticity values of lamp performance







Ra	91
R1	88
R2	93
R3	97
R4	89
R5	89
R6	92
R7	96
R8	84
R9	52
R10	84
R11	87
R12	85
R13	89
R14	98
R15	84

Colour temperature

5,489K

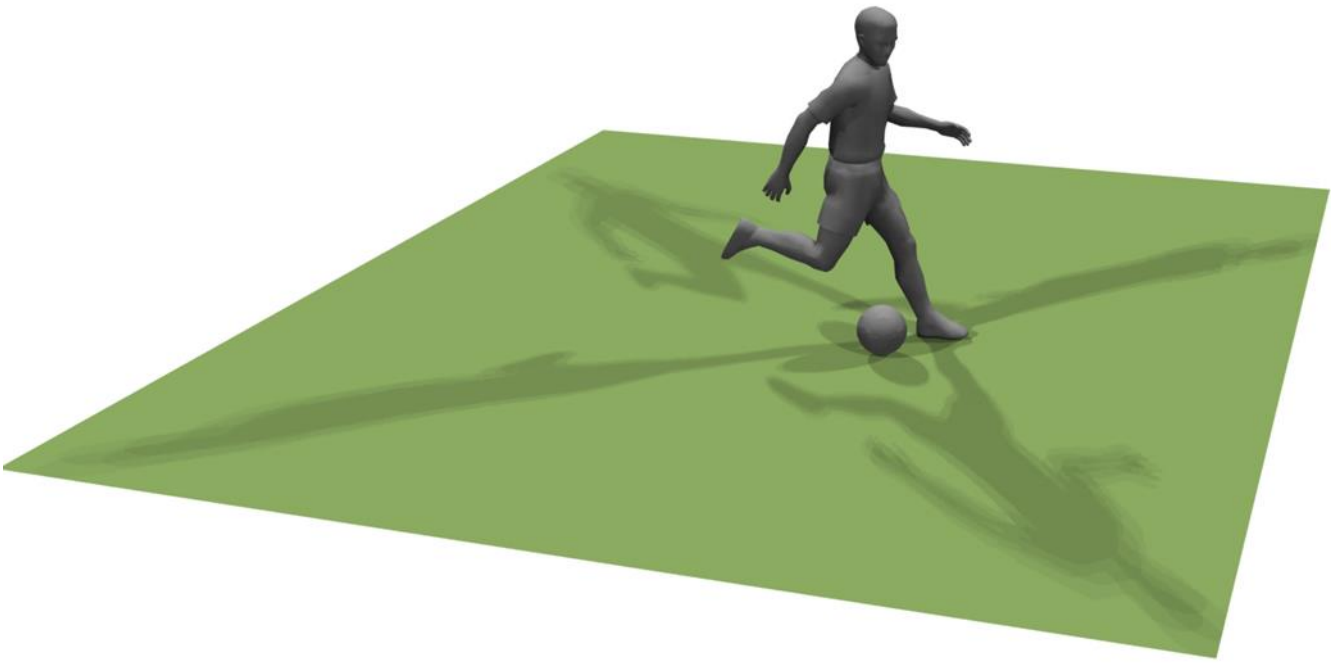
Colour rendering

91 Ra

14 Player shadows

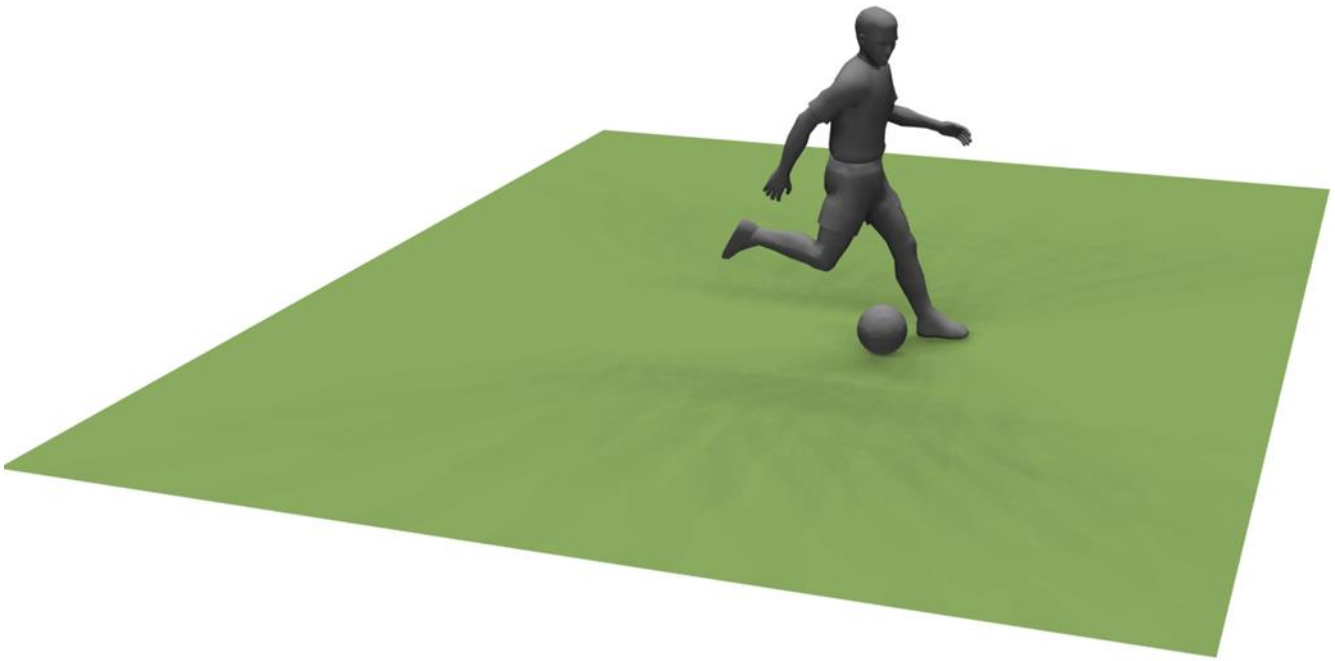
Artificial shadows on the pitch caused by floodlighting systems detract from visual clarity for both spectators and television broadcasters. The shadows impinge upon the viewing experience and should be eliminated where possible or reduced to soft shadows.

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

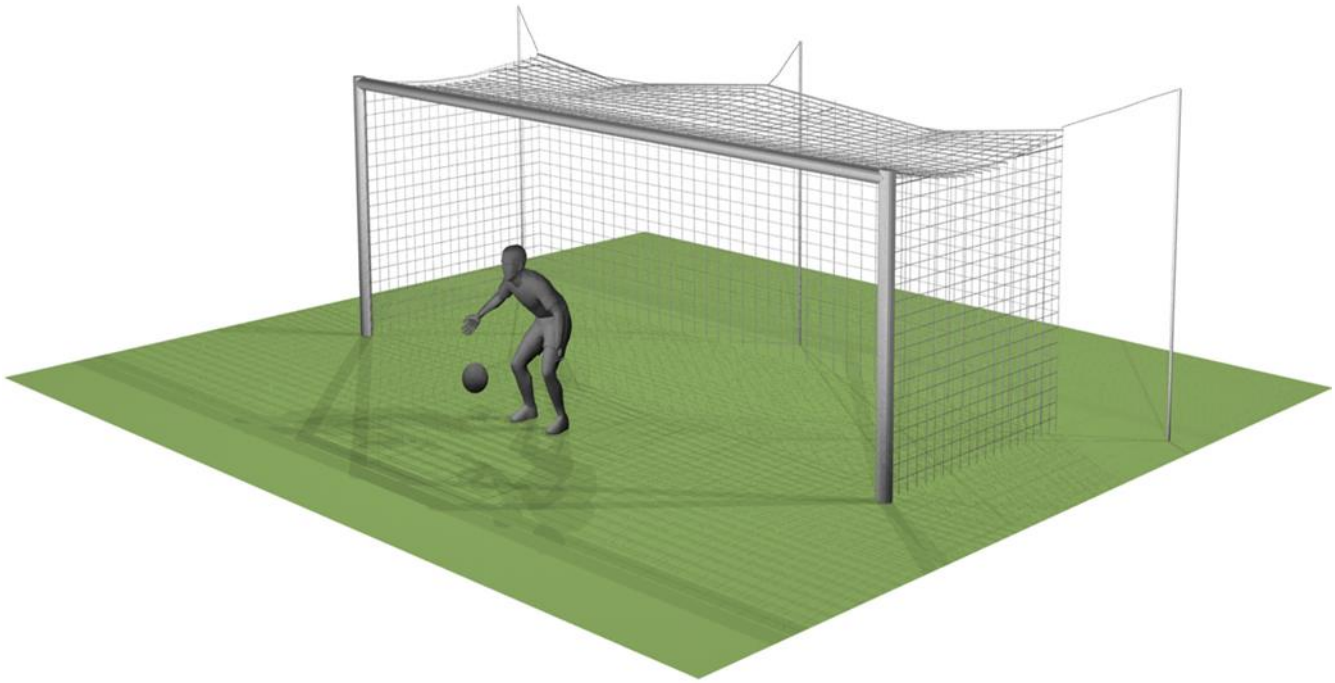


The image above demonstrates the impact of player shadows on a football pitch.

In some stadiums, the existing infrastructure will mean that a four-corner tower/column floodlighting system is the only viable option in terms of the 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 required by the tables in Section 4 should be achieved during matches. However, 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 Section 4 should be used.

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

Reasons to alter the maintenance factor are provided below:

- A proactive and frequent maintenance programme. This would require the implementation of 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. In order to alter the maintenance factor, a documented schedule of work including luminaire cleaning, voltage regulation and illuminance testing should be implemented. It is not recommended to increase the maintenance factor beyond a value of 0.90 when using LED luminaires in normal circumstances.

- Lumen depreciation may be compensated for by the use of 'constant illumination lamp technology'. This system 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 be necessary to provide 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, it will be necessary to lower the maintenance factor 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.

16 Power supply

It is essential that the power supply for the pitch illuminance system is reliable to ensure that matches and television broadcasts can continue without disruption. A suitable alternative back-up power supply is required in case the primary source fails in some way. A power supply evaluation is required by UEFA for all existing stadiums. For newly built stadiums, it is recommended that the power supply system is designed to meet the requirements stipulated for the relevant UEFA illuminance level.

The following points apply to all levels:

i The primary power source is the main power source for the pitch illuminance system – generally the national grid.

ii The secondary power source is the alternative power source used as a back-up supply in case the main power source fails – generally an on-site generator.

iii The two power supplies should be completely independent of each other, with one system not reliant on the other to operate.

iv In the event of disruption to the primary power supply, the secondary power supply should be engaged automatically, with no disruption to the pitch illuminance system or other stadium facilities.

v The disruption caused by lighting systems switching to a different power supply will vary depending on the duration of the power disruption and the type of floodlight luminaire. If the primary power supply is disconnected and the secondary power supply is engaged with immediate effect, it may take up to 10–15 minutes before a discharge lighting system is fully operational. This is due to the time required for lamps to cool down before re-striking and then running up to full colour temperature. To ensure pitch illuminance continues without disruption, a UPS system is often used in the pitch illuminance power system.

vi If the primary power source fails, the secondary power source must be fully operational within the specified period of time.

vii After the initial power failure, the pitch illuminance system must operate at the illuminance level stipulated for the relevant level.

viii After the initial power failure, the illuminance system must be operational at the required level within 12 minutes.

ix Once the pitch illuminance system is being powered by the secondary power supply, it is necessary to ensure that the primary power supply can only be re-engaged manually. This will ensure that any further disruption is minimised and controlled.

The specific power supply requirements for each UEFA illuminance level are listed in the tables on the following pages.

16.1 UEFA power supply requirements – elite level A

i	**Primary power source**	Meets 100% of requirements at 100% duty cycle
ii	**Secondary power source**	Meets 100% of requirements at 100% duty cycle
iii	**Primary power supply completely independent from secondary power supply?**	Yes
iv	**Automatic switching between the two power supplies in the event that one power source fails?**	Yes
v	**Disruption to the pitch illuminance system caused by failure of the primary power source before the match continuity illuminance conditions are operational**	No disruption permitted
vi	**Uninterrupted illuminance conditions (as specified in point vii) without disruption after the primary power supply fails?**	Yes
vii	**Illuminance conditions maintained after the primary power supply fails**	Minimum of Eh 1,000 lux Minimum of Ev4 600 lux
viii	**Illuminance conditions re-established within 12 minutes**	100% of normal match illuminance conditions required
ix	**Manually controlled operation to re-engage primary power supply after power disruption?**	Yes

16.2 UEFA power supply requirements – level A

i	**Primary power source**	Meets 100% of requirements at 100% duty cycle
ii	**Secondary power source**	Meets 100% of requirements at 100% duty cycle
iii	**Primary power supply completely independent from secondary power supply?**	Yes
iv	**Automatic switching between the two power supplies in the event that one power source fails?**	Yes
v	**Disruption to the pitch illuminance system caused by failure of the primary power source before the match continuity illuminance conditions are operational**	No disruption permitted
vi	**Uninterrupted illuminance conditions (as specified in point vii) without disruption after the primary power supply fails?**	Yes
vii	**Illuminance conditions maintained after the primary power supply fails**	Minimum of Eh 800 lux Minimum of Ev4 500 lux
viii	**Illuminance conditions re-established within 12 minutes**	100% of normal match illuminance conditions required
ix	**Manually controlled operation to re-engage primary power supply after power disruption?**	Yes

16.3 UEFA power supply requirements – level B

i	**Primary power source**	Meets 100% of requirements at 100% duty cycle
ii	**Secondary power source**	Meets > 70% of requirements at 100% duty cycle
iii	**Primary power supply completely independent from secondary power supply?**	Yes
iv	**Automatic switching between the two power supplies in the event that one power source fails?**	Yes – or effective and approved manual procedure
v	**Disruption time caused by failure of the primary power source before the secondary power supply is fully operational**	Three minutes permitted
vi	**Uninterrupted illuminance conditions (as specified in point vii) without disruption after the primary power supply fails?**	No
vii	**Illuminance conditions re-established within three minutes**	Minimum of Eh 400 lux Minimum of Ev4 300 lux
viii	**Illuminance conditions re-established within 12 minutes**	Minimum of 70% of normal match illuminance conditions
ix	**Manually controlled operation to re-engage primary power supply after power disruption?**	Yes

16.4 UEFA power supply requirements – level C

i	**Primary power source**	Meets 100% of requirements at 100% duty cycle
ii	**Secondary power source**	Meets > 50% of requirements at 100% duty cycle
iii	**Primary power supply completely independent from secondary power supply?**	Yes
iv	**Automatic switching between the two power supplies in the event that one power source fails?**	Yes – or effective and approved manual procedure
v	**Disruption time caused by failure of the primary power source before the secondary power supply is fully operational**	15 minutes permitted
vi	**Uninterrupted illuminance conditions (as specified in point vii) without disruption after the primary power supply fails?**	No
vii	**Illuminance conditions re-established within three minutes**	Minimum of Eh 350 lux
viii	**Illuminance conditions re-established within 12 minutes**	Minimum of 50% of normal match illuminance conditions
ix	**Manually controlled operation to re-engage primary power supply after power disruption?**	Yes

16.5 UEFA power supply requirements – level D

i	**Primary power source**	Meets 100% of requirements at 100% duty cycle
ii	**Secondary power source**	-
iii	**Primary power supply completely independent from secondary power supply?**	-
iv	**Automatic switching between the two power supplies in the event that one power source fails?**	-
v	**Disruption time caused by failure of the primary power source before the secondary power supply is fully operational**	-
vi	**Uninterrupted illuminance conditions (as specified in point vii) without disruption after the primary power supply fails?**	-
vii	**Illuminance conditions re-established within three minutes**	-
viii	**Illuminance conditions re-established within 12 minutes**	-
ix	**Manually controlled operation to re-engage primary power supply after power disruption?**	-

17 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 guidelines 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 panel should operate within UEFA guidelines so as not to affect the camera balance or exposure during the match coverage.

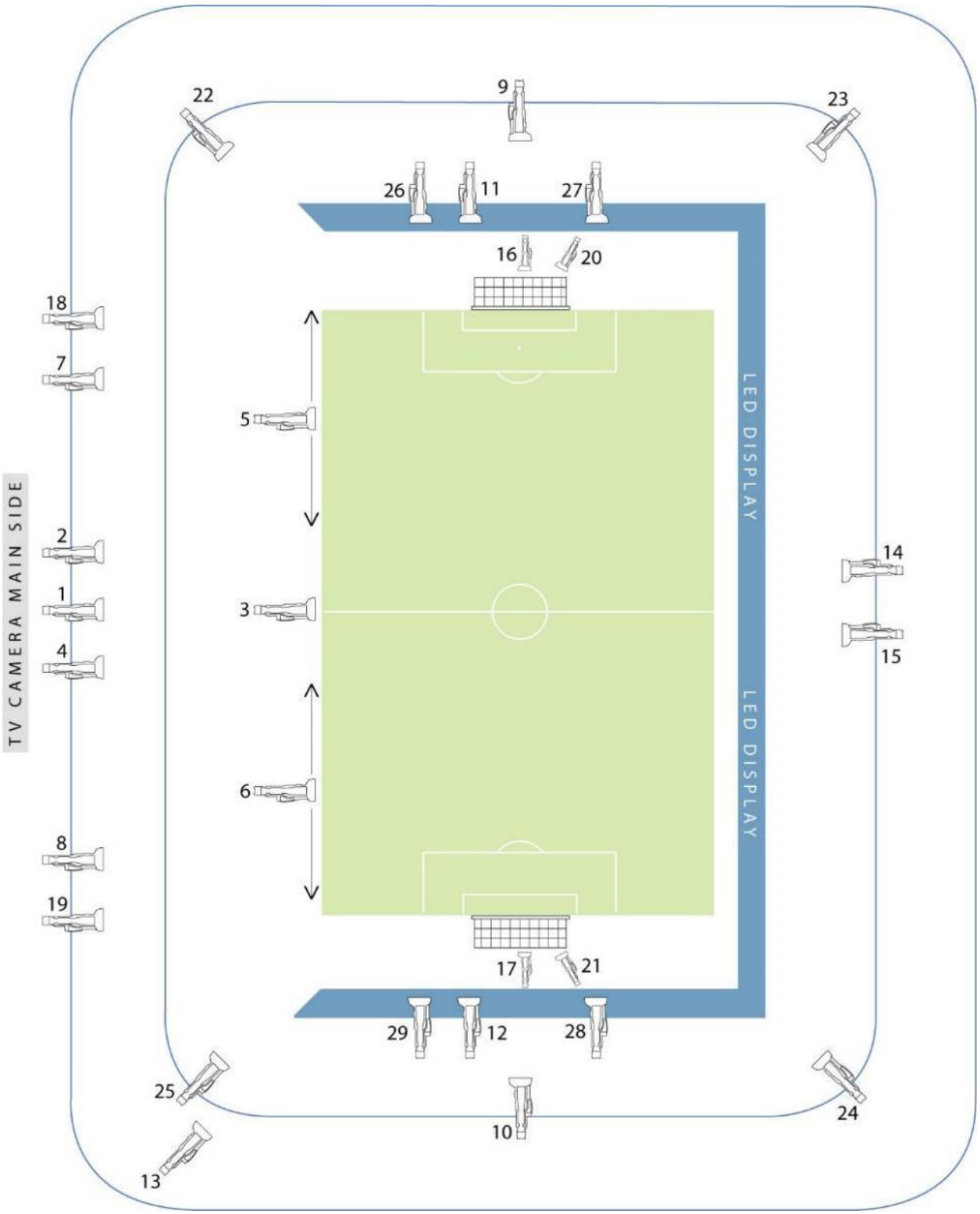
The basic minimum technical specifications are listed below and will be valid until 2018:

- LED configuration: 3-in-1 SMD
- Screen height: Minimum of 90cm; maximum of 100cm
  (maximum height more for existing systems to avoid losing seats)
- Total length: Minimum length of 246m; ideal length of 257m
- Pixel pitch: Ideal minimum quality level: 12.5mm x 12.5mm (real)
  (pitch can be symmetrical or asymmetrical)
- Horizontal viewing angle: Minimum of 140°
- Refresh rate: Minimum of 2,800Hz
- Luminance: Minimum of 5,500Nit
- Data feeds: Control signal connection via two redundant feed points;
  data ring loop configured

For further information, consult the latest version of the guidelines or contact UEFA.

18 TV broadcast camera plan

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



18.1 Key to camera plan

That 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 different 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
2	CLOSE-UP CAMERA
3	PITCHSIDE HALFWAY CAMERA
4	CLOSE-UP CAMERA
5-6	STEADICAMS
7-8	22-YARD CAMERAS
9-10	HIGH-BEHIND-GOAL CAMERAS
11-12	LOW-BEHIND-GOAL CAMERAS
13	BEAUTY SHOT CAMERA
14-15	REVERSE ANGLE CAMERAS
16-17	MINI-CAMERAS
18-19	GOAL LINE CAMERAS
20-21	HOT HEAD CAMERAS
22-25	CORNER CAMERAS
26-29	HI-MOTION OR BIG LENS CLOSE-UP CAMERAS

The camera plan above does not show the cameras used for presentation/interview and analysis purposes, which are not relevant for this document.

19 Environmental guidance

There are a number of bodies that provide certification for buildings which are designed and constructed in line with strict sustainability guidelines. The most prominent of these bodies are BREEAM (in Europe) and LEED (in the US). Both of these bodies provide an extensive list of parameters and checklists which need to be followed and implemented, after which the designated certification body 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 one of these two certification bodies. However, it is ultimately down 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 within the project brief and (iii) direct the design consultants accordingly.

19.1 Environmental impact of illuminance

Many countries will have regulations and guidelines aimed at ensuring that the quantity 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 with adequate reference points in areas around the stadium showing the illuminance levels created by the pitch illuminance system on the horizontal and vertical planes. The report should comply with the guidelines produced by the relevant authorities and be submitted for their 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. For lower-illuminance level stadiums the stray light produced by the pitch illuminance system should be lower.

19.2 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.

20 UEFA Pitch Illuminance Test Report introduction

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. Equipment must have been recalibrated within the last 12 months.

The UEFA Pitch Illuminance Test Report can be found across pages 55-62 of these guidelines.

UEFA Pitch Illuminance Test Report

UEFA requires that all venues which could potentially host a televised match undergo assessments of their pitch illuminance systems.

Such illuminance tests must be conducted in accordance with UEFA's guidelines to ensure a consistent and objective analysis of the illuminance conditions at all relevant stadiums.

The illuminance test procedure and requirements are detailed below.

Inspection equipment
The illuminance meter used for the illuminance test should be suitable for a floodlighting environment, with a wide angle receptive light sensor. The meter must be recalibrated on an annual basis.

Test procedure
A football pitch measures 68m by 105m. This area is divided up into a grid containing 96 points. At each point, an illuminance test is carried out to measure both the horizontal illuminance and the vertical illuminance at four different angles. Thus, the test will require 480 illuminance tests 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.

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.

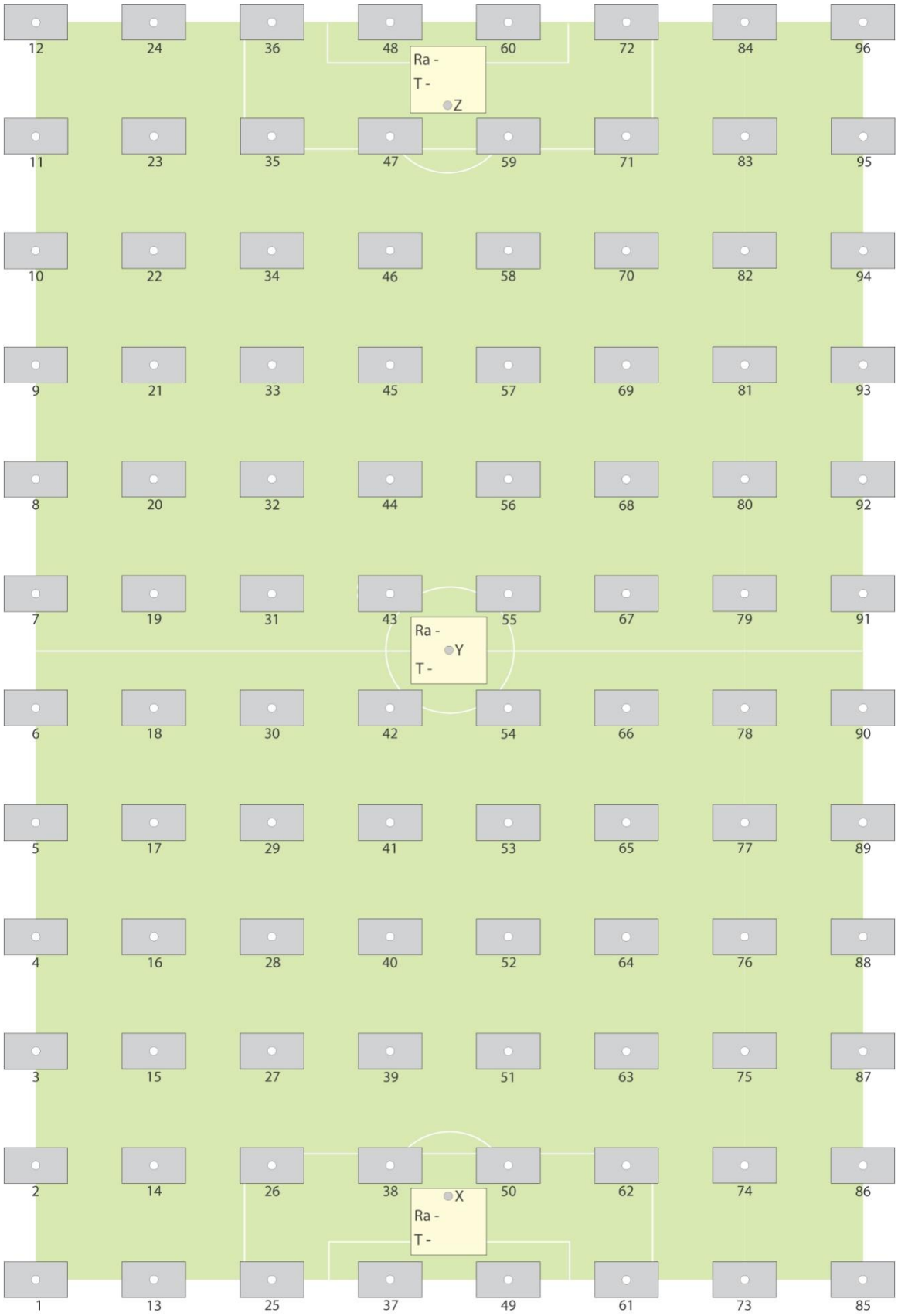
Horizontal test: The meter is positioned facing upwards, 1m above the playing surface, and parallel to the pitch, at every grid point.

Vertical test: The meter is positioned perpendicular to the pitch, 1m above the playing surface, at every 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 and are at 0°, 90°, 180° and 270°. This procedure should be repeated at all 96 grid points.

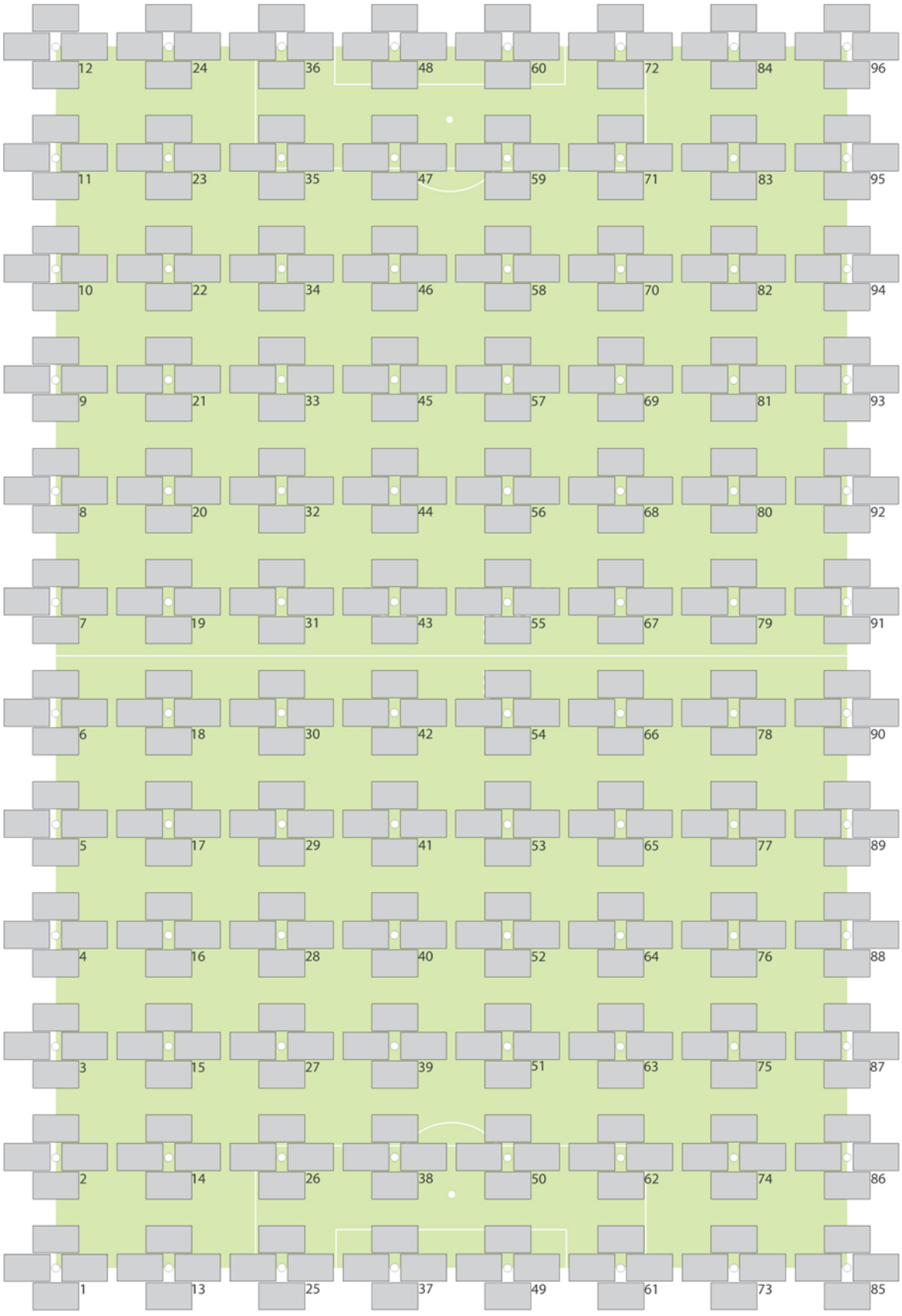
Report template

Name of stadium:		
Name of club:		
Date of inspection:		
Time:		
	Luminaire 1:	**Luminaire 2:**
Manufacturer:		
Model:		
Lamp:		
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:		

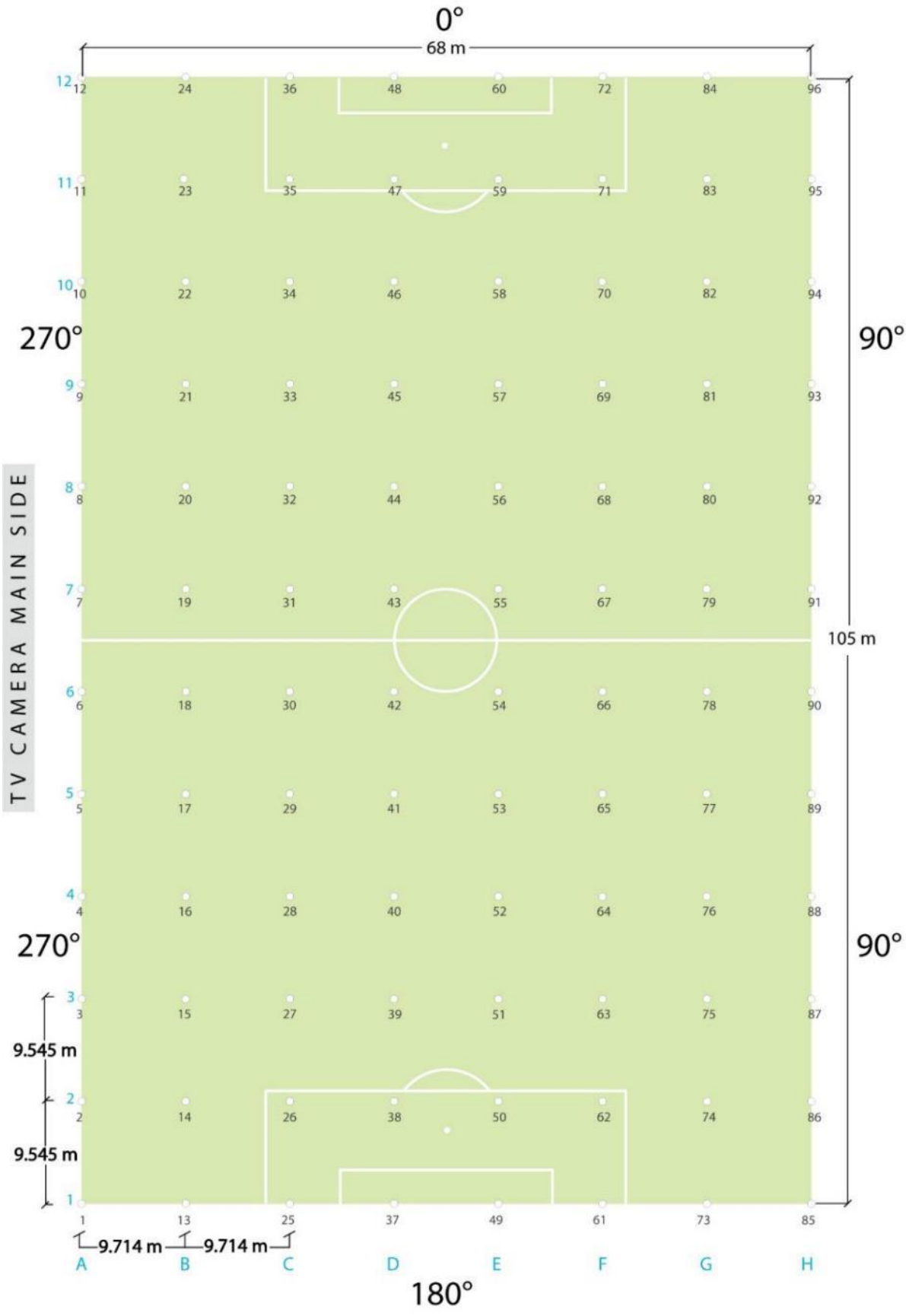
Horizontal illuminance grid plan



Vertical illuminance grid plan



Illuminance test – pitch orientation plan



Summary of report data

Test measurements	Stadium readings
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 (GR)	
Colour rendering (Ra)	
Colour temperature (K)	

Pitch illuminance power supply

Power supply evaluation

It is essential that the power supply for the pitch illuminance system is reliable to ensure that matches and television broadcasts can continue without disruption. A suitable alternative secondary power supply is also required in case the primary source fails in some way.

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

Name of stadium:

Grid power supply

No. of feeder lines+transformers/kV/MW:

Supplydesign (e.g. open half-ring):

Back-up power supply (Second grid source / Generator / UPS batteries)

Type: Grid Generator (no/MW)UPS (no/kW)

Switching between grid and back-up power supplies

Back-up operation (parallel/standby/standby running):

Is the switchover process (grid to back-up) automatic: Yes No

Please describe the process of back-up operation in case of a grid power failure:

Is a UPS battery system installed in the stadium illuminance system? Yes / No

What percentage of lights are connected to the UPS battery system?

What is the operations time at full load of the UPS system? minutes

Type of lights

Cold re-strike % overall / % on uninterrupted back-up:

Hot re-strike % overall / % on uninterrupted back-up:

Please provide an electrical overview diagram of the stadium power system from mid-voltage /0.4kV transformers, including main switch boards and back-up systems towards the illuminance system. The diagram needs to show the operation process for the illuminance system in case of a grid power failure.

Measurement of illuminance

HORIZONTAL ILLUMINANCE TEST

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

Ensure that the meter is always positioned in the same way and is level with the ground. 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° and 270° at all 96 points.

Ensure that the meter is always positioned in the same way and is level. This can be achieved with the aid of a spirit level or another such device.

21 Glossary of terms

E	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 4 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)** across the 96 reference points.
Ev4-96 max (4 point max)	The maximum value for **Ev4 (4 point ave)** across the 96 reference points.
Ev4-96 ave (4 point ave)	The average value for **Ev4 (4 point ave)** across the 96 reference points, measured in lux. Calculated by adding together the values for **Ev4 (4 point ave)** for all 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°** for all 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/m^2
lumen (lm)	The unit of measurement for luminous flux.
CRI	Colour Rendering Index. This measures the quality of the colour reproduction produced by a light source relative to natural daylight on a scale of 0 Ra to 100 Ra.
Ra	The specific value given to a light source to indicate the level and quality of colour reproduction (CRI) on a scale of 0 Ra to 100Ra.
Tk	The colour temperature of a light source, measured in kelvins (K).
FF	The flicker factor – the modulation of luminance on a given plane during a complete cycle. This denotes the relationship between the maximum luminance value and the minimum luminance value, expressed as a percentage.
GR	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.
U1h	A measure of horizontal uniformity of illuminance. The ratio of minimum horizontal illuminance to maximum horizontal illuminance across all 96 reference points.
U2h	A measure of horizontal uniformity of illuminance. The ratio of minimum horizontal illuminance to average horizontal illuminance across all 96 reference points.
U1v	A measure of vertical uniformity of illuminance. The ratio of minimum vertical illuminance to maximum vertical illuminance on the given plane across all 96 reference points.
U2v	A measure of vertical uniformity of illuminance. The ratio of minimum vertical illuminance to average vertical illuminance on the given plane across all 96 reference points.
U1v	A measure of vertical illuminance and illuminance modelling uniformity. The ratio of **Ev4 (4 point min)**

(4-96 point)	minimum vertical illuminance to **Ev4 (4 point max)** maximum vertical illuminance across all 96 reference points.
U2v (4-96 point)	A measure of vertical illuminance and illuminance modelling uniformity. The ratio of **Ev4 (4 point min)** minimum vertical illuminance to **Ev4 (4 point ave)** average vertical illuminance across all 96 reference points.
U1v-270°	A measure of vertical uniformity of illuminance on the 270° plane. The ratio of minimum vertical illuminance to maximum vertical illuminance across all 96 reference points.
U2v-270°	A measure of vertical uniformity of illuminance on the 270° plane. The ratio of minimum vertical illuminance to average vertical illuminance across all 96 reference points.
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 Section 4.
MF	The maintenance factor – a factor used to calculate the deterioration of lamps and luminaires' performance.
UPS	An uninterruptible power supply – a power system providing instantaneous power (normally by means of energy stored in batteries) in the event that the primary power source fails.
PISM	Pitch illuminance switch mode. The pitch illuminance system should be pre-programmed with various different modes, catering for a number of different situations. The number of modes may vary from stadium to stadium.
FMM	Full match mode. This involves the complete pitch illuminance system operating in match conditions for the relevant UEFA illuminance level.
MCM	Match continuity mode. This is the mode that is engaged to allow a match to continue after the primary power supply has failed. In terms of the uniformity of illuminance, only U1 is evaluated. It should be greater than 0.5 on the horizontal plane and 0.4 on the vertical plane.
TM	Training mode. This mode provides sufficient pitch illuminance for training requirements.
MM	Maintenance mode. This mode provides sufficient pitch illuminance for maintenance requirements.

Main camera side

This indicates the plane of the main camera position for a television broadcast. The main TV camera will be positioned on the TV camera gantry. This is used in this guide to ensure that the pitch orientation is correct and consistent for all stadiums. The main camera side is also referred to as the 270° plane.

Main camera position

This indicates the position of the main camera for a television broadcast. The main TV camera will be positioned on the TV camera gantry. This is used in this guide to ensure that the pitch orientation is correct and consistent for all stadiums.

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