FIFA

FIFA Lighting Guide

Standards, requirements and guidance for pitch illuminance systems at FIFA tournament stadiums and training sites

Version Control

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FIFA Tournaments and Events Division – Stadium & Infrastructure Management Department – Technical Services Group

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- International Illuminance Services

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Contents

Introduction

This document contains a set of recommendations that have been developed to provide detailed technical information and guidance on floodlighting for football stadiums and training grounds.

FIFA's floodlighting requirements are specified for each event and listed in this guide. When assessed to be necessary FIFA may provide further stipulations in the respective competition regulations and manuals. For finals or final tournaments, the staging agreements may include specific clauses regarding floodlighting.

These standards and guidelines have been designed to promote best practice in the delivery of stadium infrastructure, and to ensure quality and consistency in all FIFA completion categories.

FIFA is committed to pitch illuminance systems that:

1. prioritise the comfort and unhindered performance of all players and officials
2. allow for use of competition-related systems if required (e.g. VAR, goal-line technologies)
3. enhance the experience and enjoyment of spectators at the venue
4. enable stadium broadcasters to produce world class content, without production constraints
5. are efficient and sustainable, minimise waste, and leave a useful post-tournament legacy

The FIFA Lighting Guide 2020 should be used by FIFA member associations and specifiers in order to develop the appropriate illuminance conditions at stadiums worldwide. The guide also takes into account recent technological developments and broadcasting requirements 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 FIFA's competition requirements.

During the design process for a pitch illuminance system, the efficiency should be evaluated and an environmentally aware solution should always be specified.

This lighting guide has been developed by FIFA to encourage and ensure the adoption of best practices in pitch illuminance system design at all FIFA stadiums.

Lighting obligations for FIFA competitions

All FIFA-appointed hosts must meet the following obligations when it comes to stadium lighting:

1. Illuminance levels on FIFA's five specified reference planes must comply with the relevant FIFA Lighting Standard.

2. Illuminance uniformity levels on all reference planes must be greater than the minimum levels stipulated for the relevant FIFA Lighting Standard.

3. Players and officials must be able to perform in comfort and free from discomfort glare.

4. The illuminance colour rendering properties of the pitch illuminance system must be greater than Ra80 at all FIFA Lighting Standard A, B, and C stadiums and above Ra70 at FIFA Lighting Standard D stadiums.

5. The illuminance colour temperature properties of the pitch illuminance system must be constant and between 5,000 - 6,200K at all FIFA Lighting Standard A, B, and C stadiums and 4,500 - 6,200K at FIFA Lighting Standard D stadiums.

6. A flicker factor of no greater than 1% in any pitch location is permitted at FIFA Lighting Standard A stadiums.

7. All FIFA Lighting Standard A stadiums must provide illuminance conditions on goal lines that deliver sufficient illuminance for goal line technology to operate effectively.

8. Illuminance conditions must be assessed in accordance with the FIFA Lighting Guide. When appropriate FIFA may offset the illuminance test reference points (by 5m on the 'x' or 'y' axis) from the standard positions in order to analyse the pitch illuminance conditions effectively. This option is used if illuminance irregularities are observed in areas of the pitch that are not assessed in the normal reference-point test process.

9. The power supply for the pitch illuminance system must be designed, installed and maintained in accordance with the power requirements for the relevant FIFA stadium category and the associated FIFA Lighting Standard.

10. The alternative power supply for the pitch illuminance system must be designed, installed and maintained in accordance with the power requirements for the relevant FIFA stadium category and the associated FIFA Lighting Standard.

11. The lighting control system for the stadium pitch illuminance system must be secure and provide an option of a complete fail-safe 'master override switch panel' that is independent from the lighting control system.

12. An annual illuminance test report in accordance with the FIFA Lighting Guide and must be provided for all stadiums prior to FIFA competition.

Design Guide

This section 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.

1.1. Main Points

1. It is essential that players' comfort and performance not be 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 FIFA Lighting Standard.
5. The relevant level of FIFA competition must be considered when assessing a stadium's needs to determine the appropriate FIFA Lighting Standard.
6. A successful pitch illuminance system will produce illuminance levels and uniformity that comply with the requirements of the relevant FIFA Lighting Standard 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 cost-effective and efficient, long-term solution.
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 FIFA Standard A and B stadiums or systems should be provided by LED luminaires. It is recommended LED luminaires are used in FIFA Standard C and D; HID luminaires should only be used for new installations when there are specific reasons to do so.
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 FIFA's requirements for FIFA Lighting Standard A.

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. Anyone designing a lighting system should take account of the latest technological requirements for broadcast television.

15. Anyone designing a lighting system should assess the lighting equipment and technology that are available and consider if they are appropriate for the desired lighting solution.

Overview of stadium illuminance requirements

It is essential to ascertain the level of FIFA competition that the stadium is intended to be used for. The pitch illuminance system should be designed to meet the requirements of the relevant FIFA Lighting Standard. 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 for the design process to give 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 FIFA Lighting Standard to allow for future development.

Guidance in terms of the relevant FIFA Lighting Standard is provided in Section 4.4.

1.2. New stadiums

During the design process for new stadiums, this guide can be used to help determine the standard of illuminance that is required. Once the installation of the illuminance system (i.e. floodlights) has been completed, a FIFA illuminance test report should be submitted to FIFA for analysis. A template for that test report can be found in section 6.

It should be noted that use of energy-efficient LED light sources is required by FIFA in many cases, and always strongly recommended as the preferred lights source for pitch illuminance systems. However, it remains important that the correct high-quality LED light source be specified.

1.3. Existing stadiums

For existing stadiums, it may be desirable to evaluate the current illuminance system and ascertain how to meet the standards required for the relevant level of competition.

Again, a FIFA illuminance test report should be completed and submitted to FIFA for analysis. Information will then be provided by FIFA 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 6.

1.4. Illuminance levels

The requirements of the artificial illuminance levels of a football pitch are split into four Lighting Standards. The following table provides details of the lighting standard for each competition and round. If there is any uncertainty as to which lighting standard applies, FIFA should be contacted for further guidance.

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

1.5. Overview of lighting standards for FIFA competitions

The following application of standards is indicative only. Actual application of standards for each tournament will be specified in the respective FIFA host agreements, based on individual tournament circumstances, and may differ slightly from those indicated below.

FIFA Competition	FIFA lighting standard	FIFA floodlight power supply standard
FIFA World Cup™	Standard A	FPS - A
FIFA Women's world Cup™ **Final (semi-finals and opening match by agreement)**	Standard A	FPS – A
FIFA Women's world Cup™ **Group matches, round of 16 matches and quarter-finals**	Standard B	FPS - B
FIFA Club World Cup™	Standard B	FPS - B
FIFA U-20 World Cup™	Standard B	FPS - B
FIFA U-20 Women's World Cup™ **Final and opening (semi & quarter finals by agreement)**	Standard C	FPS – B
FIFA U-20 Women's World Cup™ **Group matches and round of 16 matches**	Standard D	FPS - C
FIFA U-17 World Cup™ **Final and semi-finals**	Standard C	FPS – B
FIFA U-17 World Cup™ **Group matches, round of 16 and quarter-finals**	Standard D	FPS - C
Olympic Football Tournament (Men's & Women's)	Standard B	FPS – B / Defined by the IOC

FIFA lighting standards

1.6. FIFA lighting standard A

Ev 0° **(vertical illuminance on 0° reference plane)**	Minimum > 1,000 lux Average > 1,500 lux
Uniformity U1v-0°	> 0.50
Uniformity U2v-0°	> 0.60
Ev 90° **(vertical illuminance on 90° reference plane)**	Minimum > 1,000 lux Average > 1,500 lux
Uniformity U1v-90°	> 0.50
Uniformity U2v-90°	> 0.60
Ev 180° **(vertical illuminance on 180° reference plane)**	Minimum > 1000 lux Average > 1500 lux
Uniformity U1v-180°	> 0.50
Uniformity U2v-180°	> 0.60
Ev 270° **(vertical illuminance on 270° reference plane)**	Minimum > 1,000 lux Average > 1,500 lux
Uniformity U1v-270°	> 0.50
Uniformity U2v-270°	> 0.60
Eh ***(horizontal illuminance)***	Minimum > 1,500 lux Average > 2,500 lux
Uniformity U1h	> 0.50
Uniformity U2h	> 0.70
Match continuity mode (MCM)	No disruption to light continuity is permitted
Flicker factor (FF)	average < 1% maximum < 1%
Minimum adjacent uniformity ratio (MAUR)	> 0.60 ≤ 10 failures
Colour temperature (Tc)	5,000-6,200K
Colour rendering (Ra)	≥ 80Ra
Glare rating (RG)	< 50
Maintenance factor (MF)	0.90 for LED 0.80 for HID

1.7. FIFA lighting standard B

Ev 0° **(vertical illuminance on 0° reference plane)**	Minimum > 650 lux Average > 1,000 lux
Uniformity U1v-0°	> 0.40
Uniformity U2v-0°	> 0.50
Ev 90° **(vertical illuminance on 90° reference plane)**	Minimum > 650 lux Average > 1,000 lux
Uniformity U1v-90°	> 0.40
Uniformity U2v-90°	> 0.50
Ev 180° **(vertical illuminance on 180° reference plane)**	Minimum > 650 lux Average > 1,000 lux
Uniformity U1v-180°	> 0.40
Uniformity U2v-180°	> 0.50
Ev 270° **(vertical illuminance on 270° reference plane)**	Minimum > 650 lux Average > 1,000 lux
Uniformity U1v-270°	> 0.40
Uniformity U2v-270°	> 0.50
Eh ***(horizontal illuminance)***	Minimum > 1,200 lux Average > 2,000 lux
Uniformity U1h	> 0.50
Uniformity U2h	> 0.70
Match continuity mode (MCM)	Eh ave > 1000 lux within 3 minutes Eh ave > 2000 lux within 15 minutes
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)	≥ 80Ra
Glare rating (RG)	< 50
Maintenance factor (MF)	0.90 for LED 0.80 for HID

1.8. FIFA lighting standard C

Ev 0° **(vertical illuminance on 0° reference plane)**	Minimum > 350 lux Average > 700 lux
Uniformity U1v-0°	> 0.35
Uniformity U2v-0°	> 0.45
Ev 90° **(vertical illuminance on 90° reference plane)**	Minimum > 350 lux Average > 700 lux
Uniformity U1v-90°	> 0.35
Uniformity U2v-90°	> 0.45
Ev 180° **(vertical illuminance on 180° reference plane)**	Minimum > 350 lux Average > 700 lux
Uniformity U1v-180°	> 0.35
Uniformity U2v-180°	> 0.45
Ev 270° **(vertical illuminance on 270° reference plane)**	Minimum > 350 lux Average > 700 lux
Uniformity U1v-270°	> 0.35
Uniformity U2v-270°	> 0.45
Eh ***(horizontal illuminance)***	Minimum > 800 lux Average > 1,250 lux
Uniformity U1h	> 0.40
Uniformity U2h	> 0.60
Match continuity mode (MCM)	Eh ave > 1000 lux within 3 minutes Eh ave > 1250 lux within 15 minutes
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)	≥ 70Ra
Glare rating (RG)	< 50
Maintenance factor (MF)	0.90 for LED 0.80 for HID

1.9. FIFA lighting standard D

Ev 0° **(vertical illuminance on 0° reference plane)**	Minimum > 250 lux Average > 400 lux
Uniformity U1v-0°	> 0.35
Uniformity U2v-0°	> 0.45
Ev 90° **(vertical illuminance on 90° reference plane)**	Minimum > 250 lux Average > 400 lux
Uniformity U1v-90°	> 0.35
Uniformity U2v-90°	> 0.45
Ev 180° **(vertical illuminance on 180° reference plane)**	Minimum > 250 lux Average > 400 lux
Uniformity U1v-180°	> 0.35
Uniformity U2v-180°	> 0.45
Ev 270° **(vertical illuminance on 270° reference plane)**	Minimum > 250 lux Average > 400 lux
Uniformity U1v-270°	> 0.35
Uniformity U2v-270°	> 0.45
Eh ***(horizontal illuminance)***	> 1000 lux
Uniformity U1h	> 0.40
Uniformity U2h	> 0.60
Match continuity mode (MCM)	To be determined by FIFA on a case-by-case basis
Flicker factor (FF)	N/A
Minimum adjacent uniformity ratio (MAUR)	N/A
Colour temperature (Tc)	4,200-6,200K
Colour rendering (Ra)	≥ 70Ra
Glare rating (RG)	< 50
Maintenance factor (MF)	0.90 for LED 0.80 for HID

FIFA Pitch illuminance data and test procedure (IDATP)

FIFA uses illuminance data to assess the illuminance conditions at venues. For new systems, or systems to be upgraded, software must be used to provide modelled data in the same format as a physical test.

1.10. Introduction to the FIFA pitch illuminance test

FIFA requires that all venues that could potentially host a televised FIFA tournament match undergo assessments of their pitch illuminance systems. All tests must be conducted in accordance with FIFA's illuminance data and test procedure by qualified, independent and objective personnel using the correct equipment. Reports and data must be submitted promptly to FIFA. This is to ensure a consistent and objective analysis of the illuminance conditions.

Testing and reports are the responsibility of FIFA tournament hosts, but FIFA may also conduct testing independently. Stadium illuminance performance must normally be demonstrated to FIFA upon selection of a host venue, and within 6 months of a FIFA tournament commencing (if necessary by re-testing).

Inspection equipment

The illuminance meter used for the illuminance test should be suitable for a floodlighting environment, with a wide-angle receptive light sensor. Equipment must have been professionally calibrated within 12 months of the test date..

Test procedure

A FIFA football pitch normally measures 68m by 105m. This area is divided up into a grid of 96 points, including points at all corners and along boundary lines. 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. Correct orientation should be ensured by pre-measurement and marking out of grid positions. The orientation can be seen in the pitch orientation plan.

Time and 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.

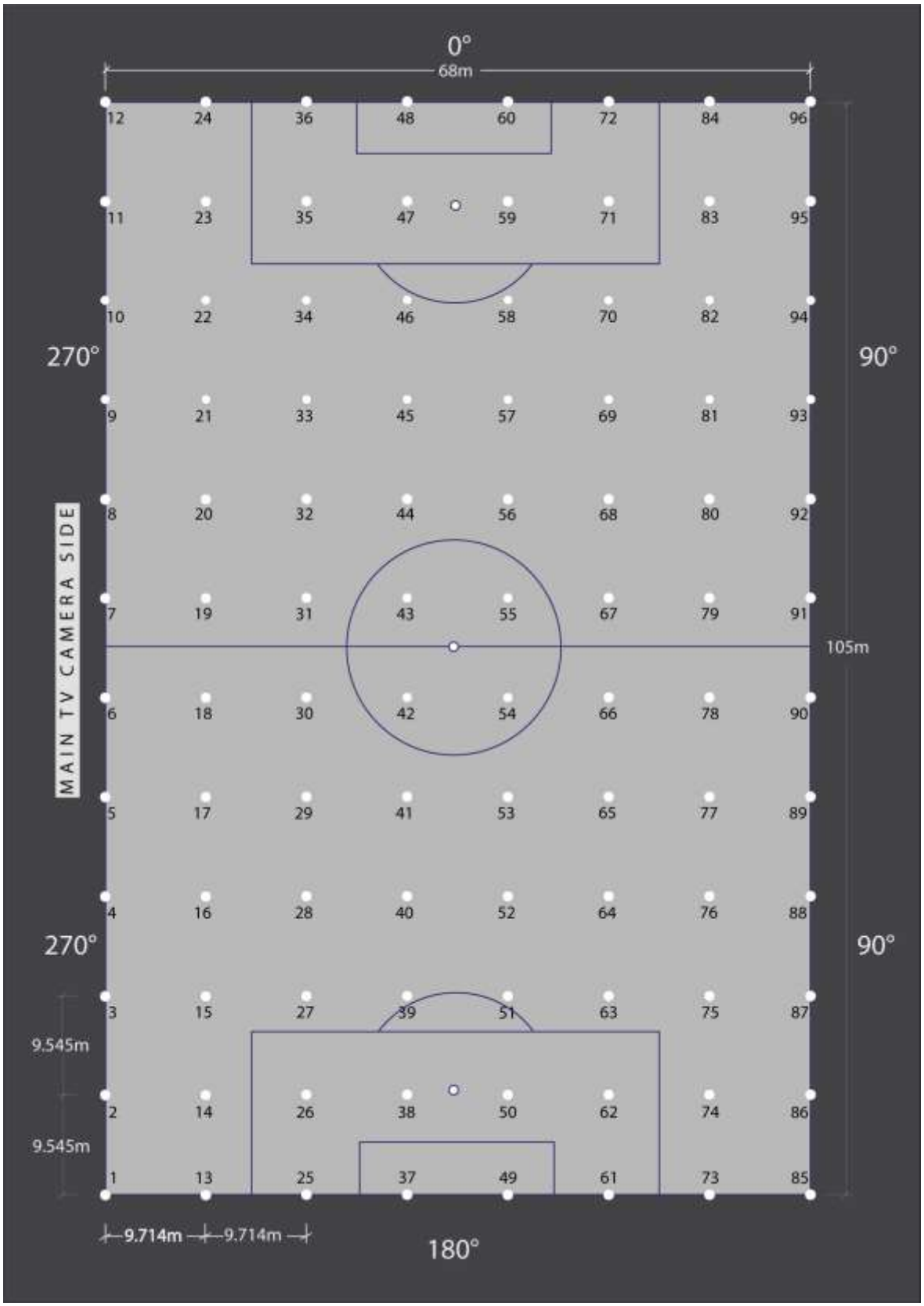
Horizontal test: the meter is positioned facing upwards, 1m above the playing surface, and parallel to the pitch, at every grid point.

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.

1.11. Report template - cover sheet

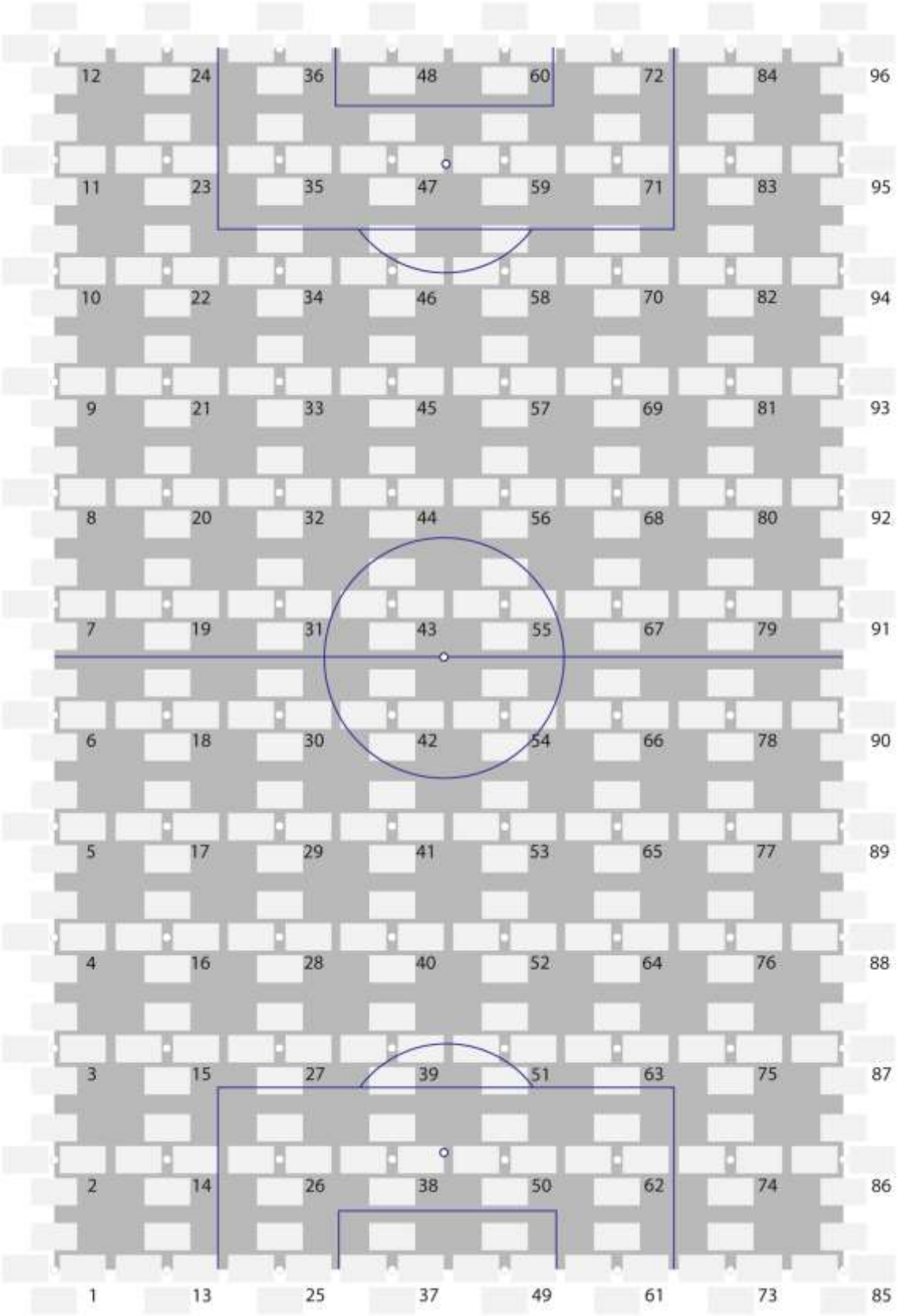
FIFA Lighting Test Report		
Name of stadium		
City / Location		
Date of inspection		
Time of inspection		
	Luminaire 1	**Luminaire 2** *(if applicable)*
Manufacturer		
Model / Product type		
Lamp specification		
Illuminance meter used		
Serial number of illuminance meter		
Calibration date		
Colour meter used		
Serial number of colour meter		
Calibration date		
Pitch measurements	(width)	(length)
Weather conditions		
Organisation inspecting		
Address		
Telephone number & email address		
Inspection by (name)		
Signature		

1.12. Illuminance test – pitch orientation and test grid plan (96 points)



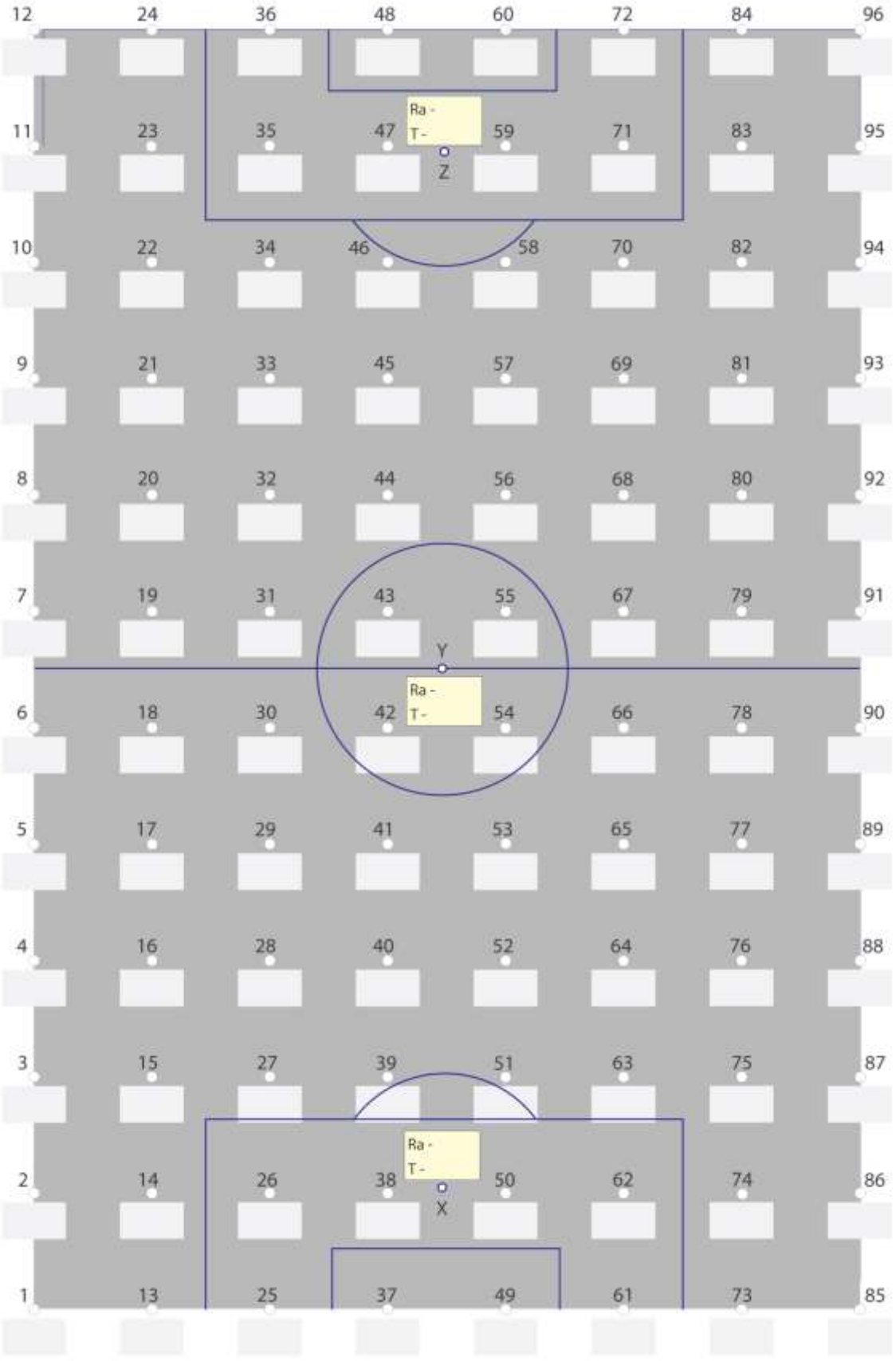
The pitch dimensions shown on this plan are for reference purposes. Adjustments may be required in order to maintain an equivalent and regular grid if the pitch dimensions vary, as permitted under the Laws of the Game. Adjustments must maintain grid points along perimeter lines.

1.13. Template for recording vertical illuminance measurements (Ev)



Measurements must also be submitted to FIFA in digital format (a spreadsheet or table)

1.14. Template for recording horizontal illuminance measurements (Eh, Ra, T)



Measurements must also be submitted to FIFA in digital format (a spreadsheet or table)

1.15. Report template - summary of results

Stadium name & location	Test date
Metric	**Results**
Ev min-0° **(minimum illuminance on the 0° vertical reference plane)**	
Ev max-0° **(maximum illuminance on the 0° vertical reference plane)**	
Ev ave-0° **(average illuminance on the 0° vertical reference plane)**	
Uniformity U1v-0°	
Uniformity U2v-0°	
MAUR 0° fails **(number of failures in the 0° vertical reference plane)**	
Ev min-90° **(minimum illuminance on the 90° vertical reference plane)**	
Ev max-90° **(maximum illuminance on the 90° vertical reference plane)**	
Ev ave-90° **(average illuminance on the 90° vertical reference plane)**	
Uniformity U1v-90°	
Uniformity U2v-90°	
MAUR 90° fails **(number of failures in the 90° vertical reference plane)**	
Ev min-180° **(minimum illuminance on the 180° vertical reference plane)**	
Ev max-180° **(maximum illuminance on the 180° vertical reference plane)**	
Ev ave-180° **(average illuminance on the 180° vertical reference plane)**	
Uniformity U1v-180°	
Uniformity U2v-180°	
MAUR 90° fails **(number of failures in the 90° vertical reference plane)**	
Ev min-270° **(minimum illuminance on the 270° vertical reference plane)**	
Ev max-270° **(maximum illuminance on the 270° vertical reference plane)**	
Ev ave-0° **(average illuminance on the 270° vertical reference plane)**	
Uniformity U1v-270°	
Uniformity U2v-270°	
MAUR 180° fails **(number of failures in the 180° vertical reference plane)**	
Eh min ***(minimum horizontal illuminance)***	
Eh max ***(maximum horizontal illuminance)***	
Eh ave ***(average horizontal illuminance)***	
Uniformity U1h	
Uniformity U2h	
MAUR horizontal fails **– number of failures in the horizontal plane**	
Average Flicker Factor	
Maximum Flicker Factor	
Colour temperature (Tc)	
Colour rendering (Ra)	
Glare rating (R_G)	

1.16. Report template – floodlight power supply information

It is essential that the power supply for the pitch illuminance floodlight system be reliable and resilient in order to ensure that matches and television broadcasts can continue without disruption. This form must be completed and returned to FIFA as part of a complete lighting performance report:

Pitch illuminance power supply						
Stadium name & location						
Primary power supply on match-days *(grid power / generators / other)*						
Primary power supply detail: • *If grid power*: number of MV feeder lines to the venue and supply arrangement (e.g. open half-ring), and number of transformers (& respective capacities and loading) supplying floodlight sections, and supply arrangement description • *If generators*: please describe number, size and redundancy of generator groups normally used, and if generators are temporarily rented or owned/permanently on-site • *If other:* please describe fully						
Secondary power supply on match-days *(second grid source/generator(s)/UPS & batteries / other)*						
Secondary power supply detail: *Please describe and fully detail the match-day secondary power supply* • *Grid / generators (including numbers, types, sizes and loading)* • *UPS & battery systems (numbers, sizes – kVA, autonomy time – minutes, date last tested)* • *Any other systems or arrangements*						
Secondary power supply operation *(e.g. parallel or instantaneously available / cold standby / hot-running standby)*						
Other back-up power supplies *Please detail any other pitch illuminance power resiliency or redundancy equipment or procedures not detailed above.*						
Information on switching between primary and secondary power supplies						
Is the switchover from primary to secondary power automatic or manual?	Auto		Manual			
How long does the switchover take?					Minutes / seconds	
Please describe the process of back-up power operation in case of a primary power interruption, including any relevant switching and communications which are part of the process:						
Match Continuity Mode (MCM) implications						
Is the pitch illuminance system supported by a UPS or other uninterruptible power system (guaranteeing evenl lighting across whole pitch area)? *Yes – all / Yes – partially / No*						
If 'Yes – partially' – please give details *i.e. the % or proportion of MCM lighting, or the illuminance performance of the MCM lighting alone*						
Electrical diagrams Please attach electrical overviews diagram(s) of the stadium power system from medium-voltage (>0.4kV) transformers, including main switchboards and back-up systems and onwards to low voltage final circuits. Diagrams should clearly identify and highlight all pitch lighting circuits. Match day operation mode and switching process/logic must either be shown on the diagram(s), or else be accompanied by a description (in English).	MV diagram attached? (Yes/No)		LV diagram attached? (Yes/No)		Switching process & logic on diagram(s)?	
	Number of MV diagrams / sheets?		Number of LV diagrams / sheets?		Switching process & logic description?	

1.17. Standardised measurement of illuminance (lux levels)

HORIZONTAL ILLUMINANCE TEST

The receptor head of the light meter 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 of the light meter 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.

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 FIFA Lighting Standard.

1.18. 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.

1.19. 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.

1.20. 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 detailed in section 4.

1.21. Pitch illuminance system design guide

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.

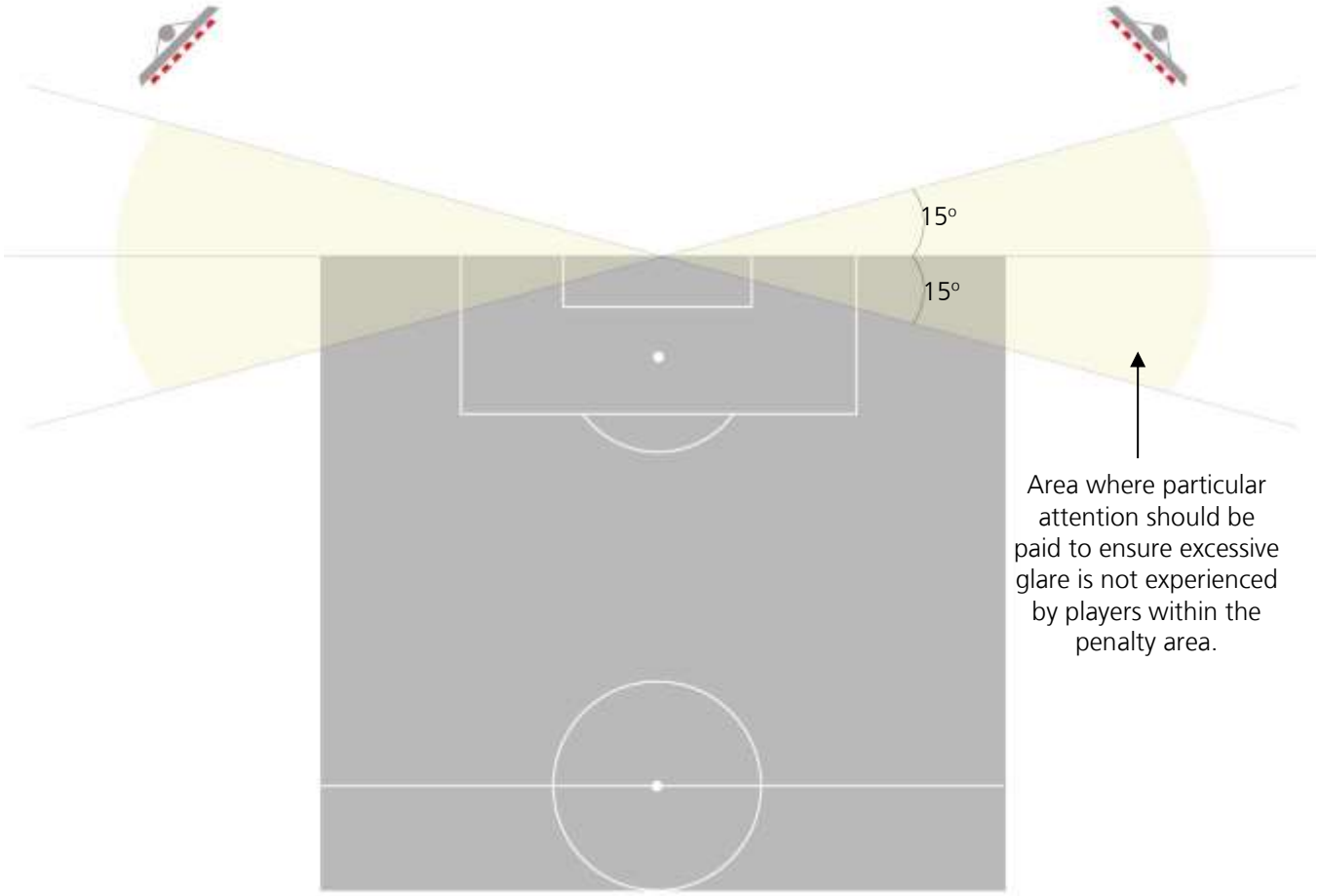
In recent years, architectural requirements and design aesthetics have challenged the previous illuminance design guidelines. New stadiums are often designed and constructed in ways which require the pitch illuminance system to perform to the required standard while also remaining true to the architectural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

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

Diagrams of design guidelines

Ref.	Position	Guidance
8.1	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.
8.2	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 with sufficient lateral distance to the pitch perimeter
8.3	Player face modelling	The luminous flux must arrive upon players at the correct angle to provide the required face modelling. Dark shadows across players faces should always be avoided irrespective of the direction in which they are facing.
8.4	Column positions	A corner column should be positioned appropriately in order to provide the illuminance conditions that will be effective. Generally corner columns should not be used for FIFA Lighting Standard A stadiums unless additional luminaires are installed around the perimeter.
8.5	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.
8.6	Pitch perimeter – lateral distance to luminaire position	An adequate lateral distance between the luminaire mounting positions and the goal lines and sidelines should be maintained in order to achieve the required vertical illuminance level around the perimeter of the pitch.
8.7	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.
8.8	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.
8.9	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.
8.10	Pitch sides - luminaire mounting positions	It is not acceptable for any stadium structures to impede the luminous flux of the pitch lighting system and cause shadows to be cast on the pitch.
8.11	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 behind the penalty area.
8.12	Behind goal line - luminaire mounting zone	Luminaires positioned behind the goal and parallel to the penalty area should be mounted greater than 60° from the goal line.
8.13	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.
8.14	FIFA pitch dimensions	Official FIFA pitch size and penalty-area dimensions

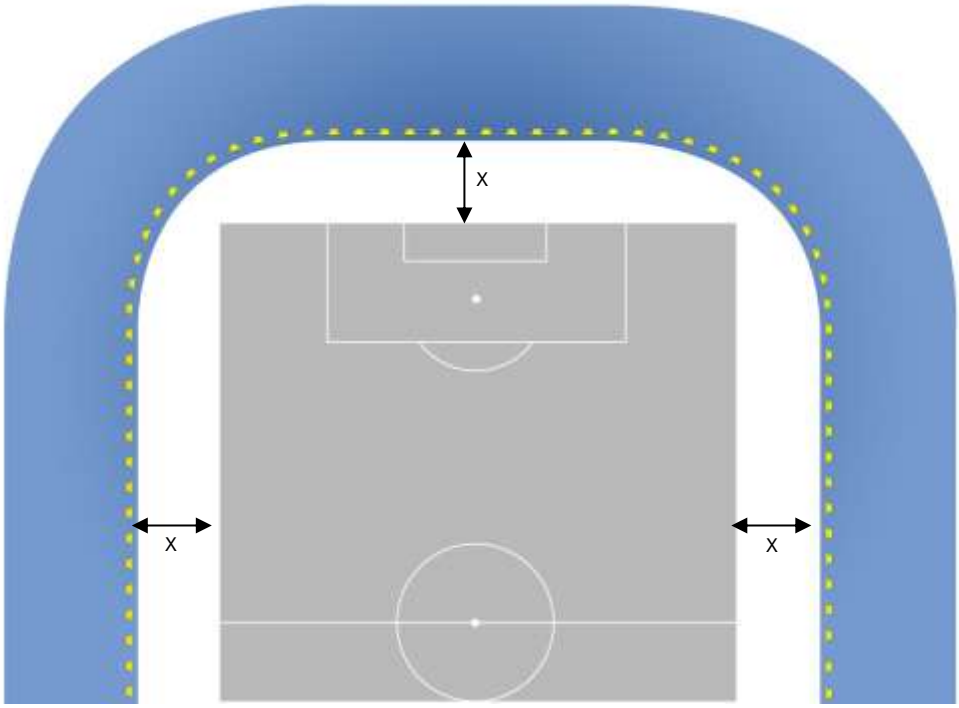
1.22. Corners – column/tower floodlight arrays



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. More than two consecutive rows of luminaires are for this purpose, to be a 'large multiple array'.

1.23. Linear - roof rim lighting



Lateral Distance (Guide)	20° angle	27.5° angle
Luminaire height	**Lateral distance (x)**	**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 means of a single linear run of luminaires around the stadium roof rim structure as seen in the diagram above, the luminaires should be positioned with a sufficient lateral distance from the pitch perimeter to ensure the required vertical illuminance levels and illuminance uniformity may be achieved.

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. An insufficient lateral distance may cause poor illuminance uniformity and the angle of luminous flux towards the pitch perimeter will result in deep and dark shadows on player faces, as seen in diagram 8.3.

A second linear run of luminaires may be required if either:

- the stadium design requires luminaires to be positioned within a lateral distance of the perimeter of the pitch such that luminaire angles are less than 20˚, or
- the vertical illuminance performance needs improvement

The focus position of each luminaire should adhere to the requirement to ensure that player discomfort glare is maintained at an acceptable level. Further guidance may be seen in sections 8.5. and 8.9.

1.24. Player face modelling

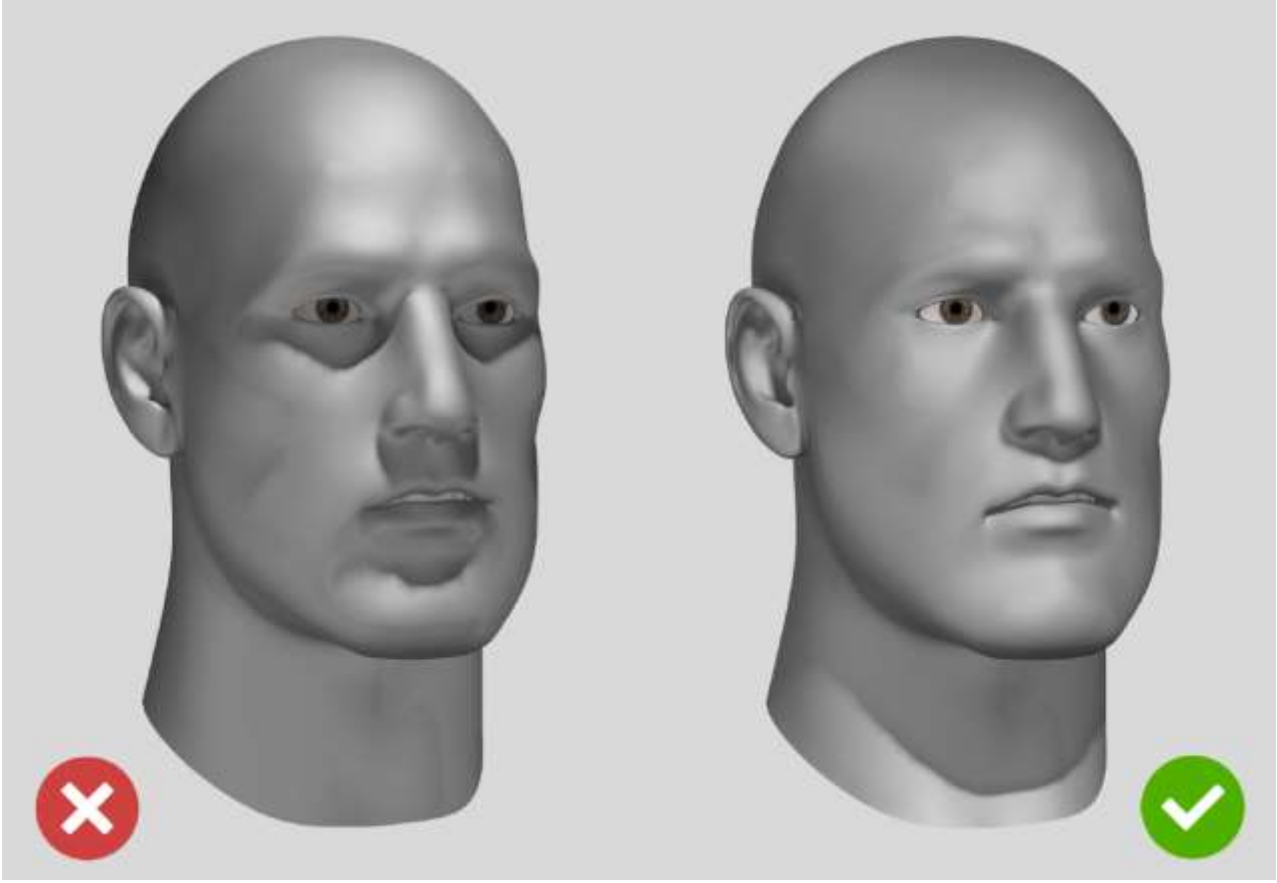


Figure 1
Example of poor face modelling

Figure 2
Example of good face modelling

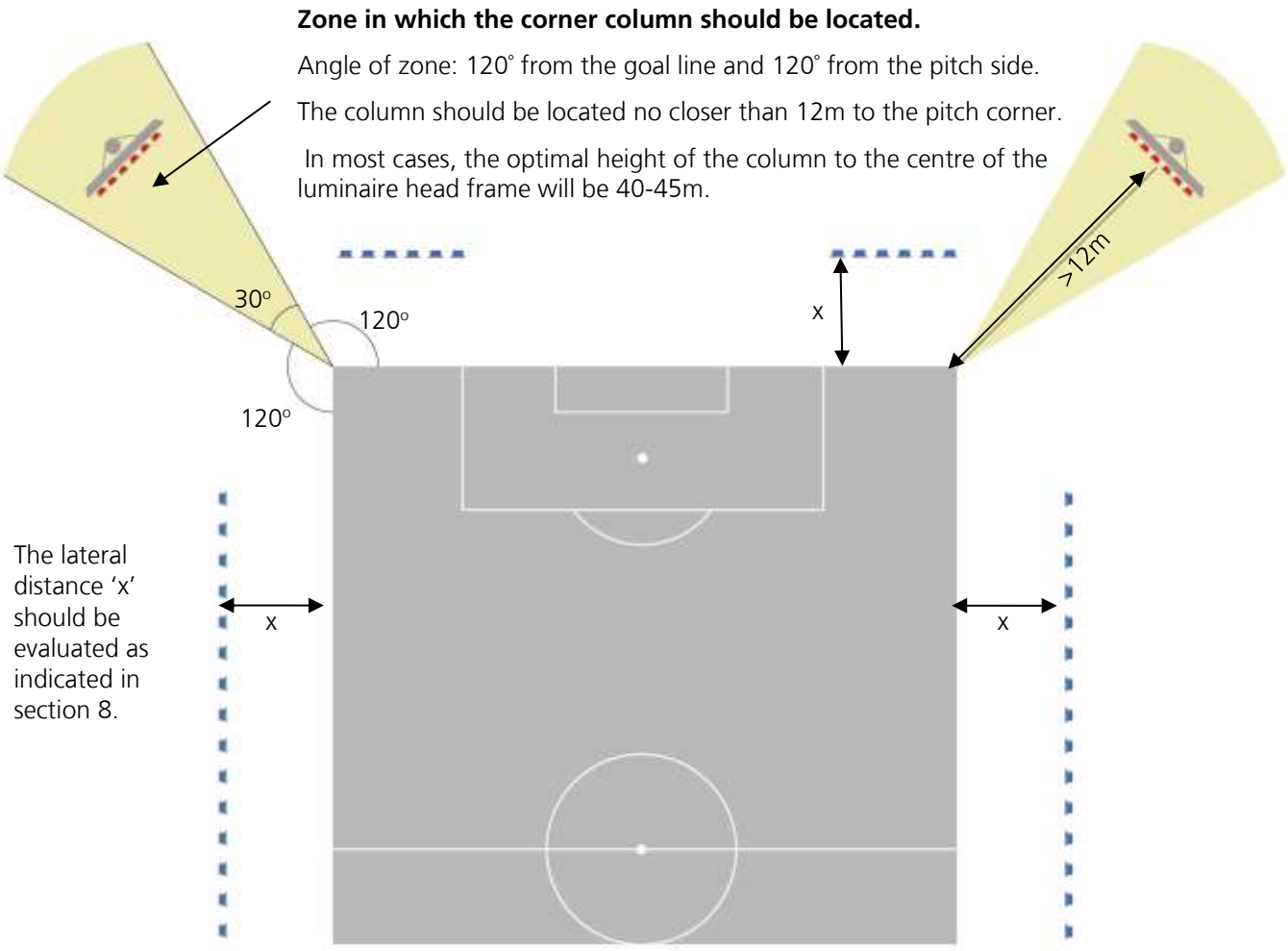
For high-quality television production it is of fundamental importance that player faces be exposed correctly, with good illuminance that produces player face modelling to allow facial character and expressions to be observed clearly.

During a football match the, player position and orientation as well as viewpoint will continually change; 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 a high quality. To do so, it is essential that the luminous flux from the pitch illuminance system arrives at the pitch from the appropriate angle. If the incident light arrives from a steep angle deep, dark eye and nose shadows are cast upon the players' faces as shown in fig 1)

When the incident light is delivered upon the face from the correct angle, the illuminance conditions and resultant modelling of the player face (as may be seen in figure 2)are good and beneficial for TV broadcasters and spectator/viewers.

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

1.25. Column positions



A corner column 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 about 40m.

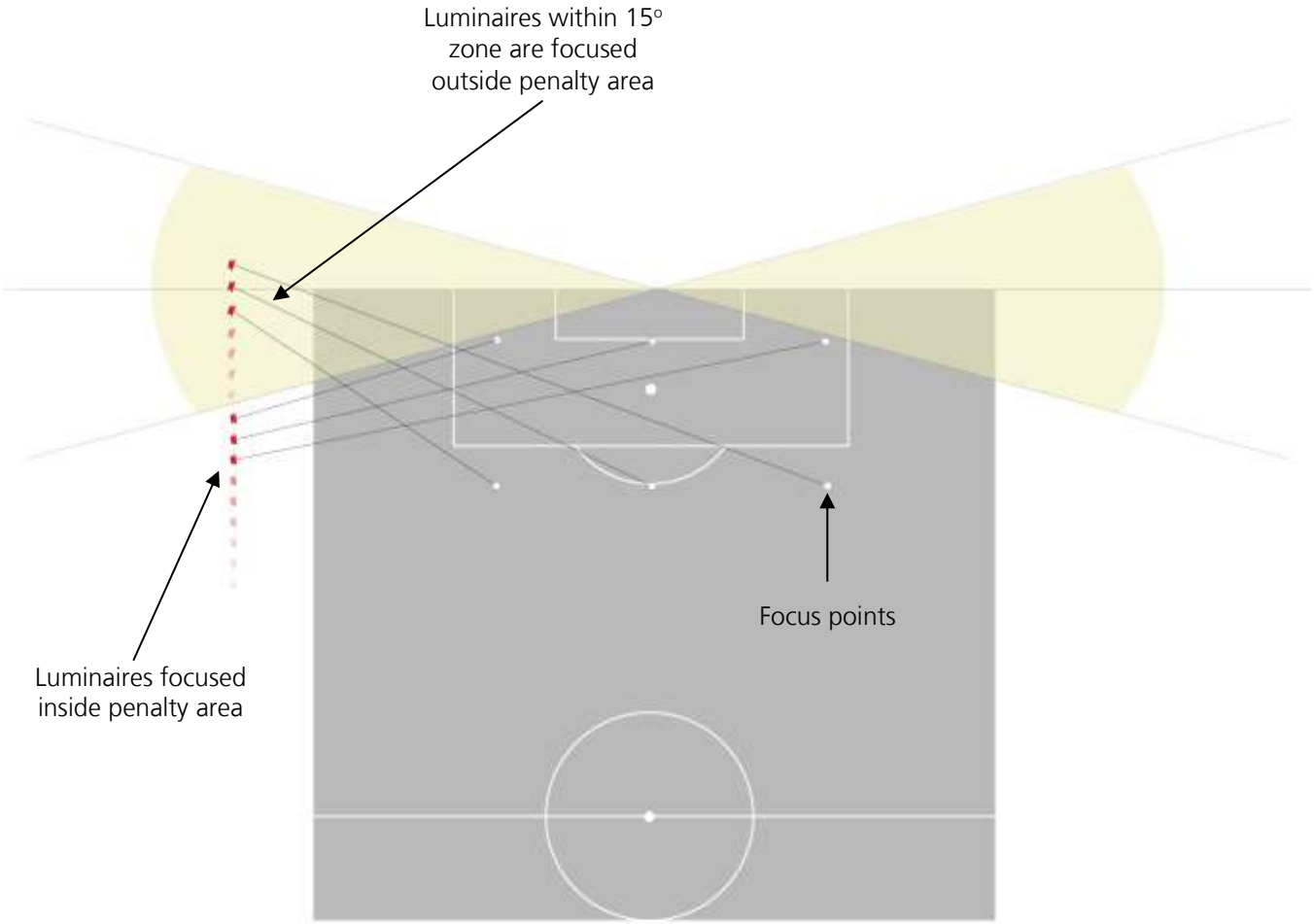
The corner column position may be compromised by land space, structural objects or foundation restrictions. However, where possible the following guidance should be implemented to ensure the luminaires are positioned correctly to provide effective illuminance conditions.

Additional luminaires may be used in illuminance systems that feature corner columns. In the diagram above, lateral arrays of luminaires attached to the stadium roof structure have been used which are shown in blue. The lateral distance marked 'X' should be evaluated as indicated in 8.2.

It is essential that players are not hindered by discomfort glare cause by the pitch illuminance system. At every stage of the design process the impact of discomfort glare should be considered.

It should be noted that pitch illuminance systems that are based upon the use of four corner columns alone will generally not provide the required illuminance conditions to meet FIFA Standard A or Standard B.

1.26. Corners – linear floodlight array



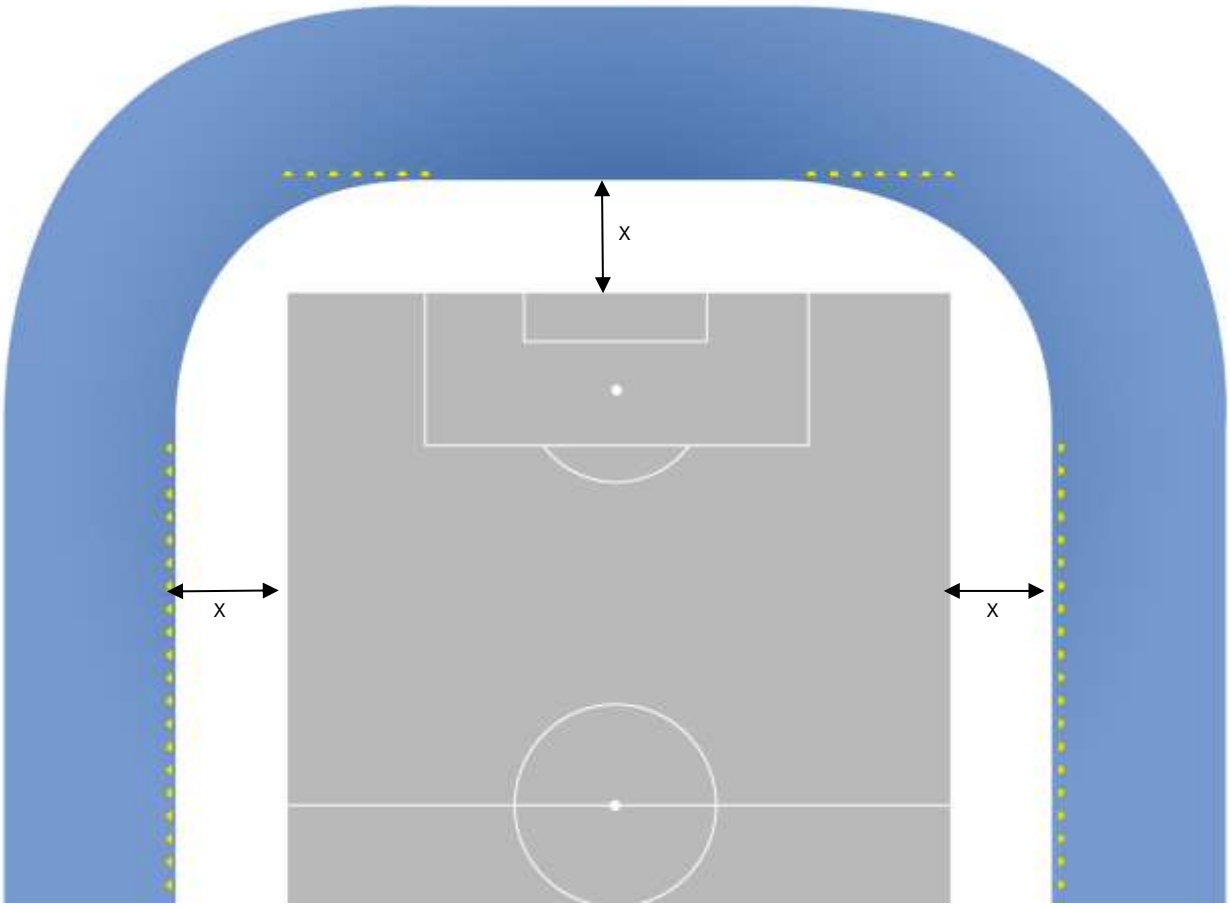
Additional consideration should be given to ensuring that players in the penalty area are not affected by discomfort glare. A linear run of luminaires is generally considered to be able to maintain an acceptable level of discomfort glare if the luminaires' focus points are such that players can stand 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.

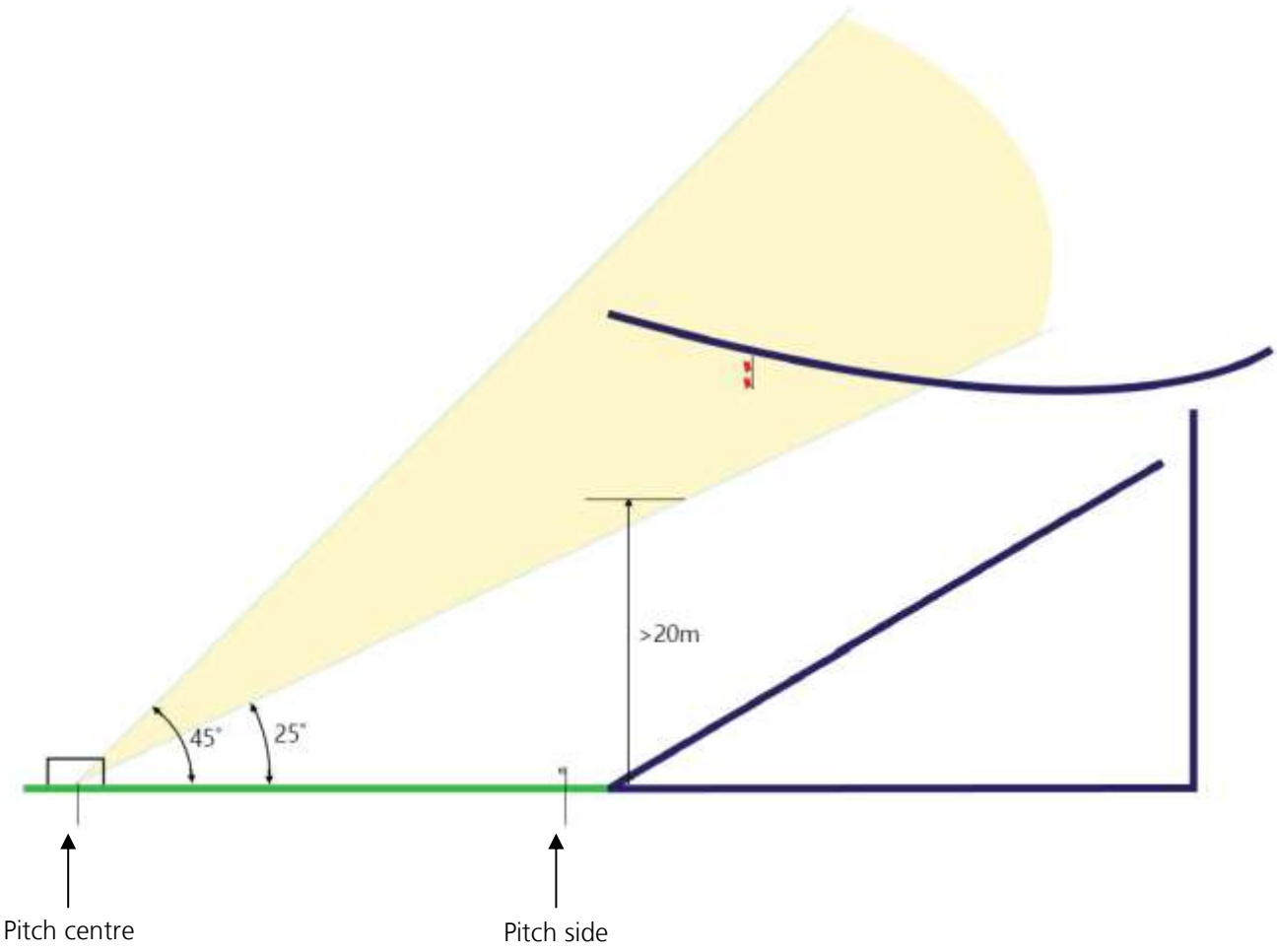
1.27. Pitch perimeter – lateral distance



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 than 12m.

When possible, it is considered good practice to arrange and locate the luminaires in areas that are not assessed to be of critical importance to ensure that players maintain maximum visual clarity and comfort when either attacking or defending in the goal area. When this is not possible, the guidance provided in this guide with reference to luminaires positions and focus points and the impact upon discomfort glare should be carefully applied.

1.28. Pitch perimeter – luminaire mounting zone



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

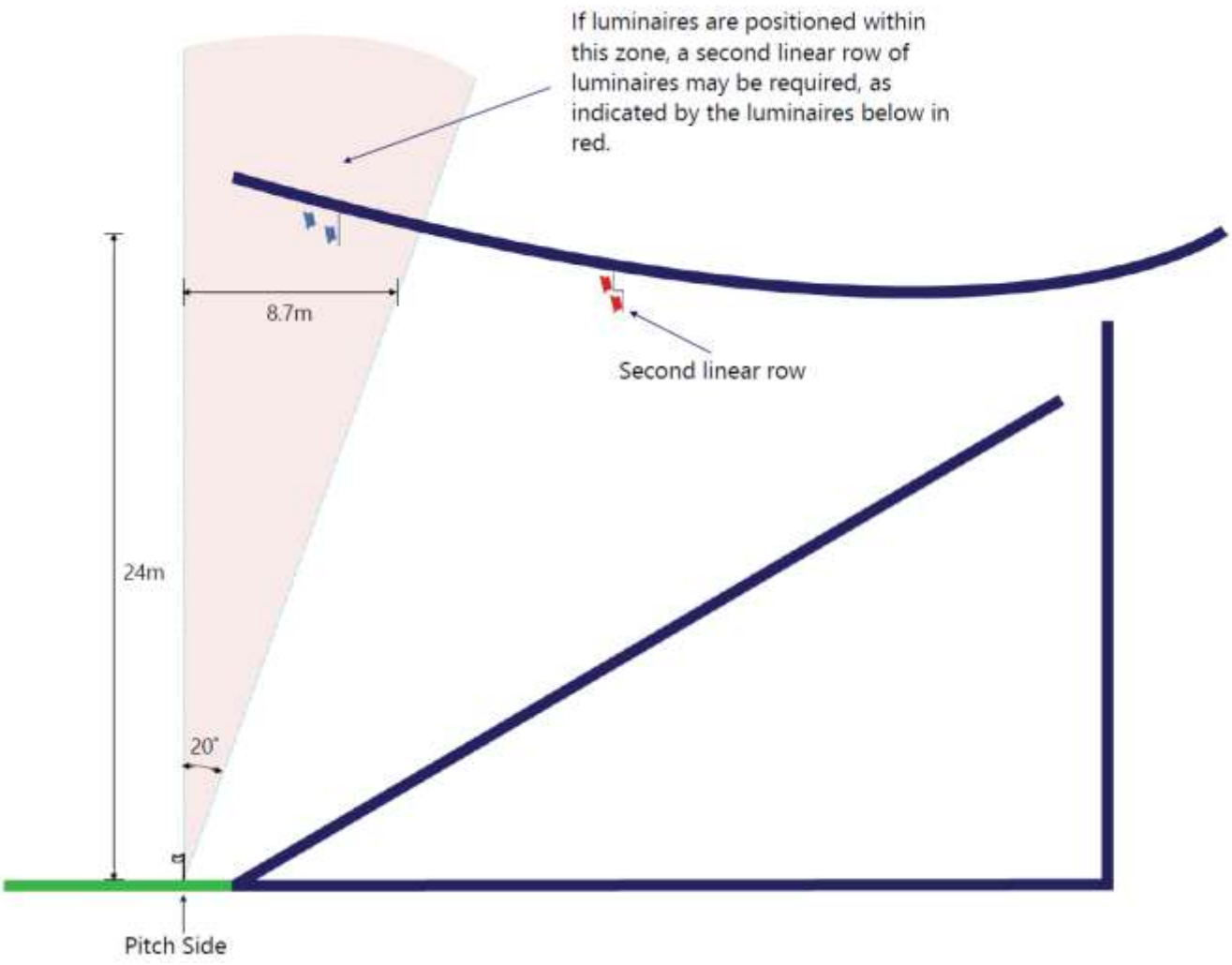
This is one of the attributes that will generally ensure that illuminance conditions comply with FIFA's guidelines.

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 into account any effects on player discomfort glare.

One way to ensure players' comfort, by keeping the glare rating below 50 is to limit the angle of a floodlight's tilt to 70° for HID luminaires and 60° for flat-panel LED luminaires, as indicated in the diagram in section 8.9. However, the structural design of some stadiums may make this impossible. The level of discomfort glare should be evaluated and determined during the design process and records of the process should be maintained for reference purposes.

Luminaires with an 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 application, the asymmetric luminaires are often seen to assist in reducing the levels of glare experienced by players and officials.

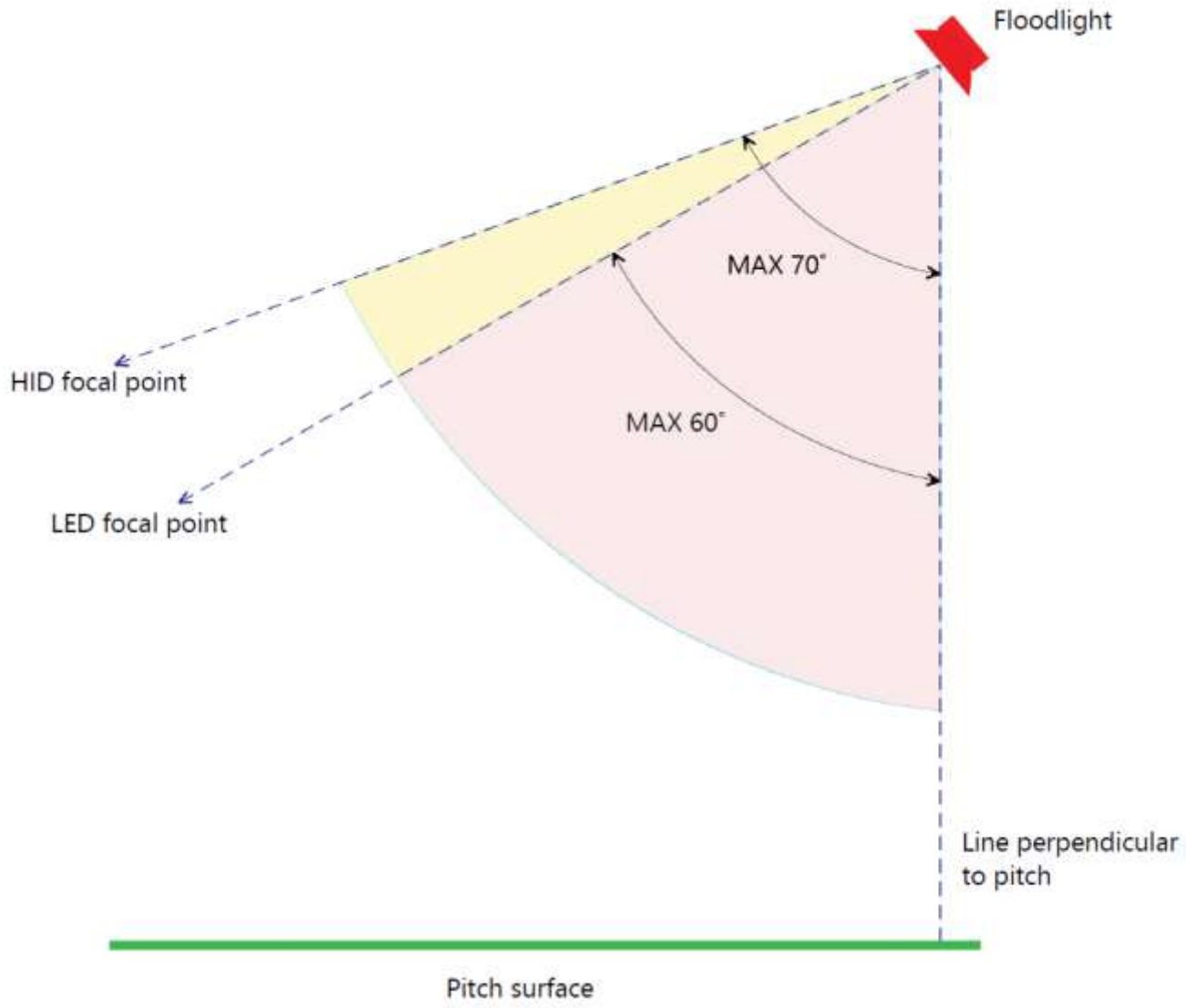
1.29. Pitch perimeter – second linear row



If the stadium design or existing installation requires luminaires to be positioned within a lateral distance of less than 20° of the perimeter of the pitch, or if the vertical illuminance requires improvement, a second linear run of luminaires may be necessary to be used to achieve the requisite vertical illuminance around the perimeter of the pitch. 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, with a luminaire height of 24m it is necessary to have a lateral distance of no less than 8.7m from the pitch perimeter.

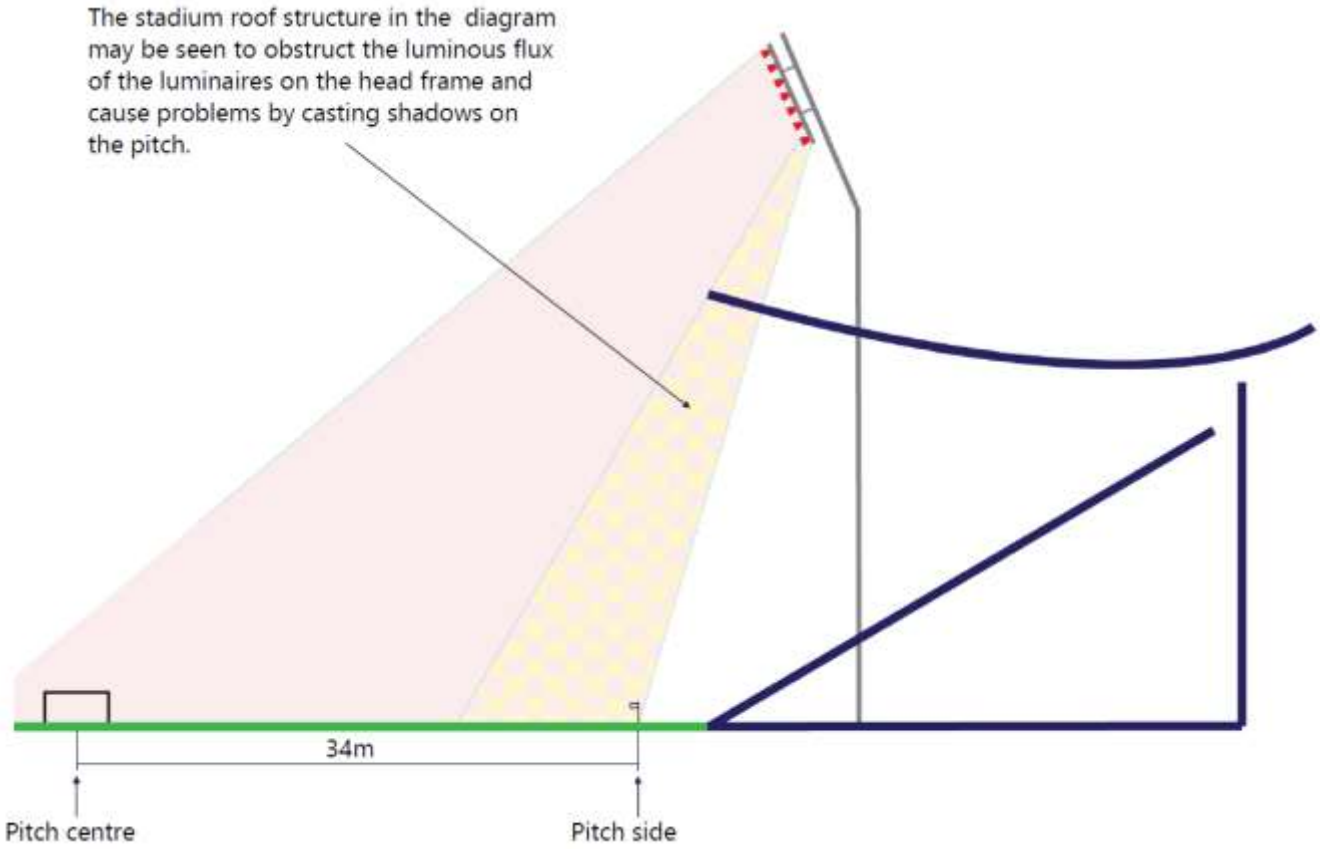
1.30. Luminaires focus point



In order to avoid discomfort glare being experienced by players and officials, a rule of thumb 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 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. It should be noted 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 football pitch is maintained at an acceptable level. When using 'flat-panel LED' luminaires 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°.

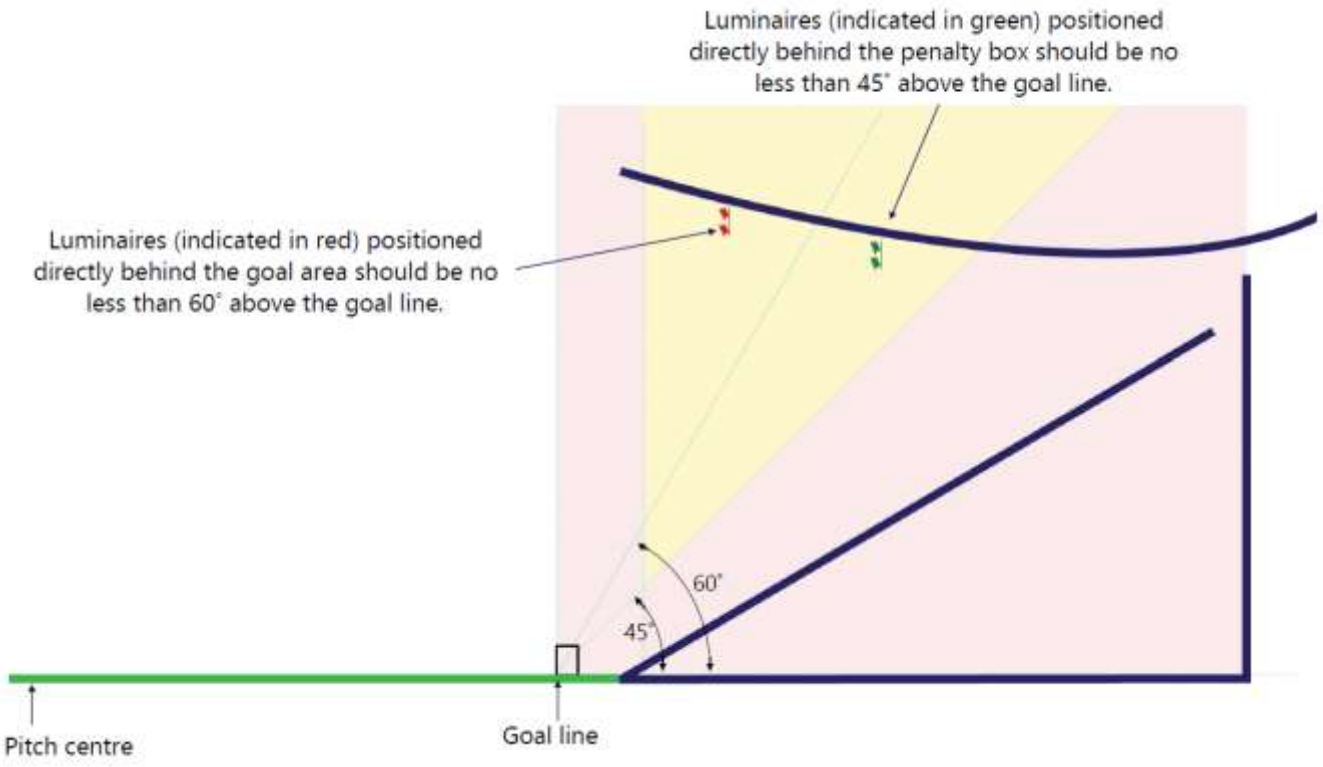
1.31. Pitch sides – luminaire mounting position



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, it may be seen that the luminous flux of the corner column head frame is obstructed by the stadium roof. In such cases, it is necessary to focus the luminaires on the head frame away from the stadium roof structure and provide additional illuminance by means of installing luminaires under the stadium roof structure.

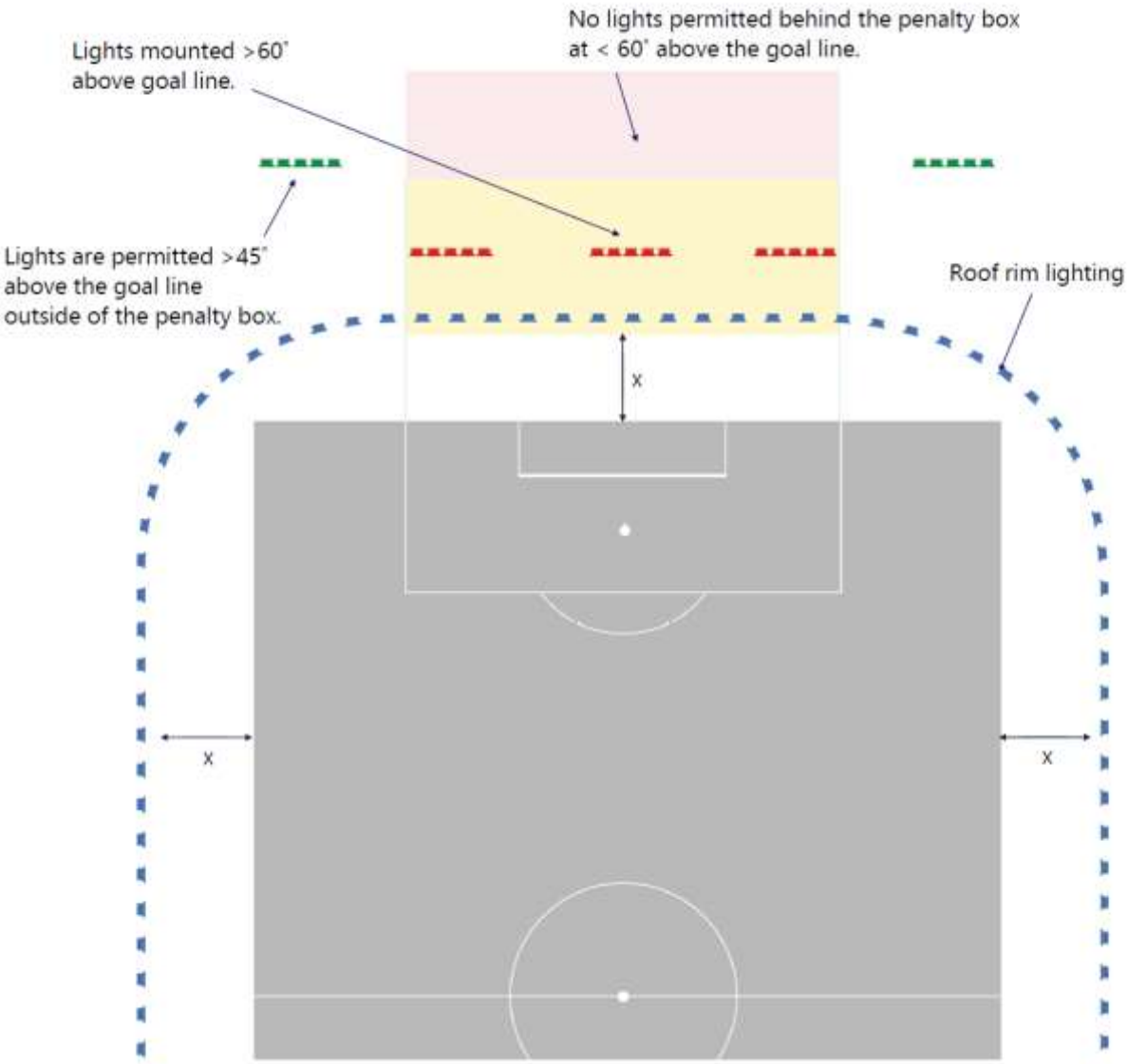
1.32. Behind penalty area – luminaire mounting zone



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). Luminaires positioned directly behind the goal area should be no less than 60˚ above the goal line.

Additional guidance is provided in section 8.12.

1.33. Behind goal line – luminaire mounting zone



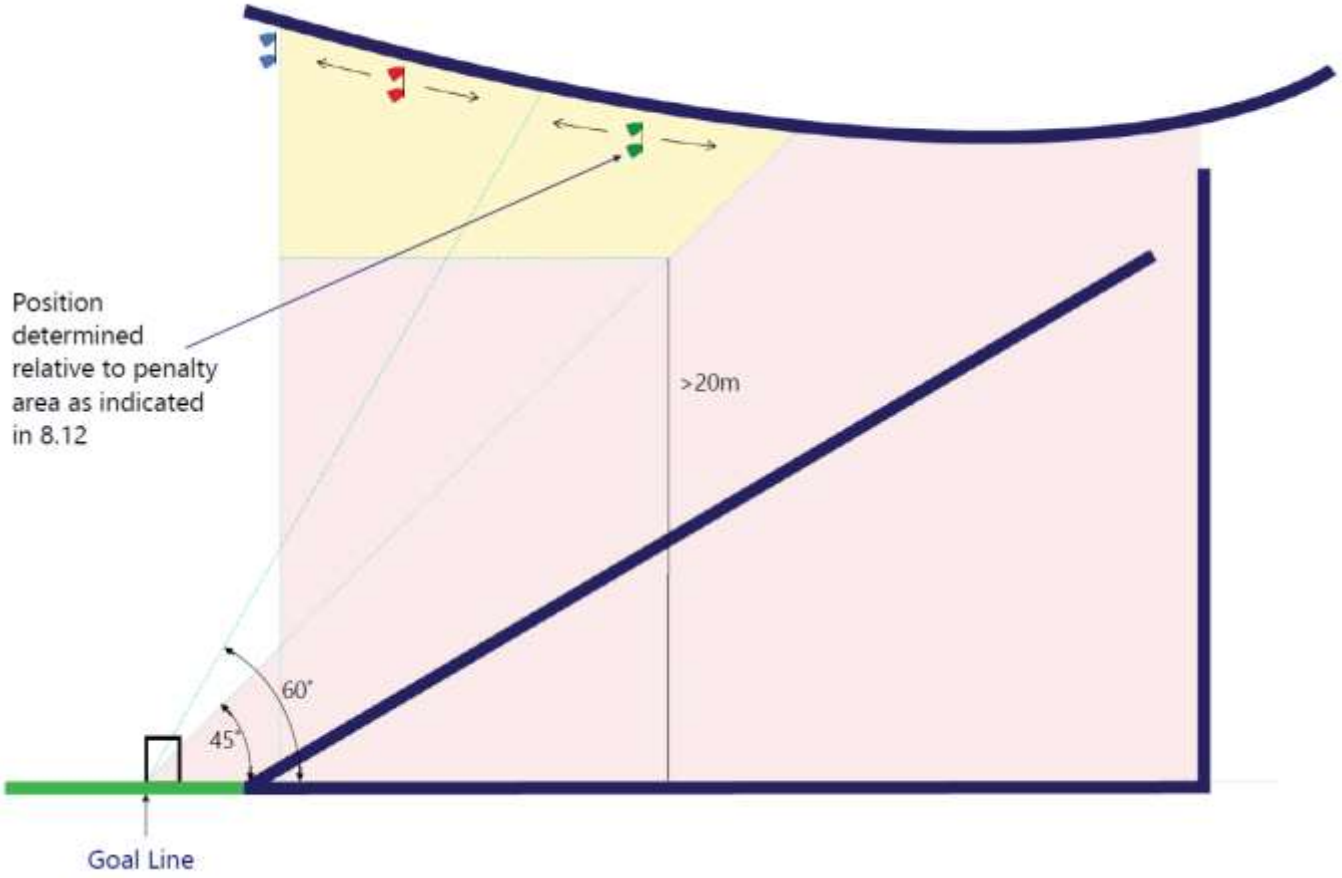
Luminaires positioned behind the goal and parallel to the penalty box as indicated in section 8.11 should be mounted more than 60° from the goal line when in line with the penalty area, as indicated in the diagram above. If a pitch illuminance system with a continuous 'rim' lighting method is to be used it is necessary to calculate the required lateral distance as indicated by 'x'. Further guidance may be provided in section 8.2 on page 26.

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 run of luminaires is used as indicated by the blue luminaires, the minimum lateral distance from the goal line (as indicated by 'x') may be calculated by ensuring that the luminaires are positioned at an angle of greater than 20˚ perpendicular to the pitch perimeter.

Further guidance may be obtained by viewing reference 8.11.

1.34. Behind goal line – second linear row

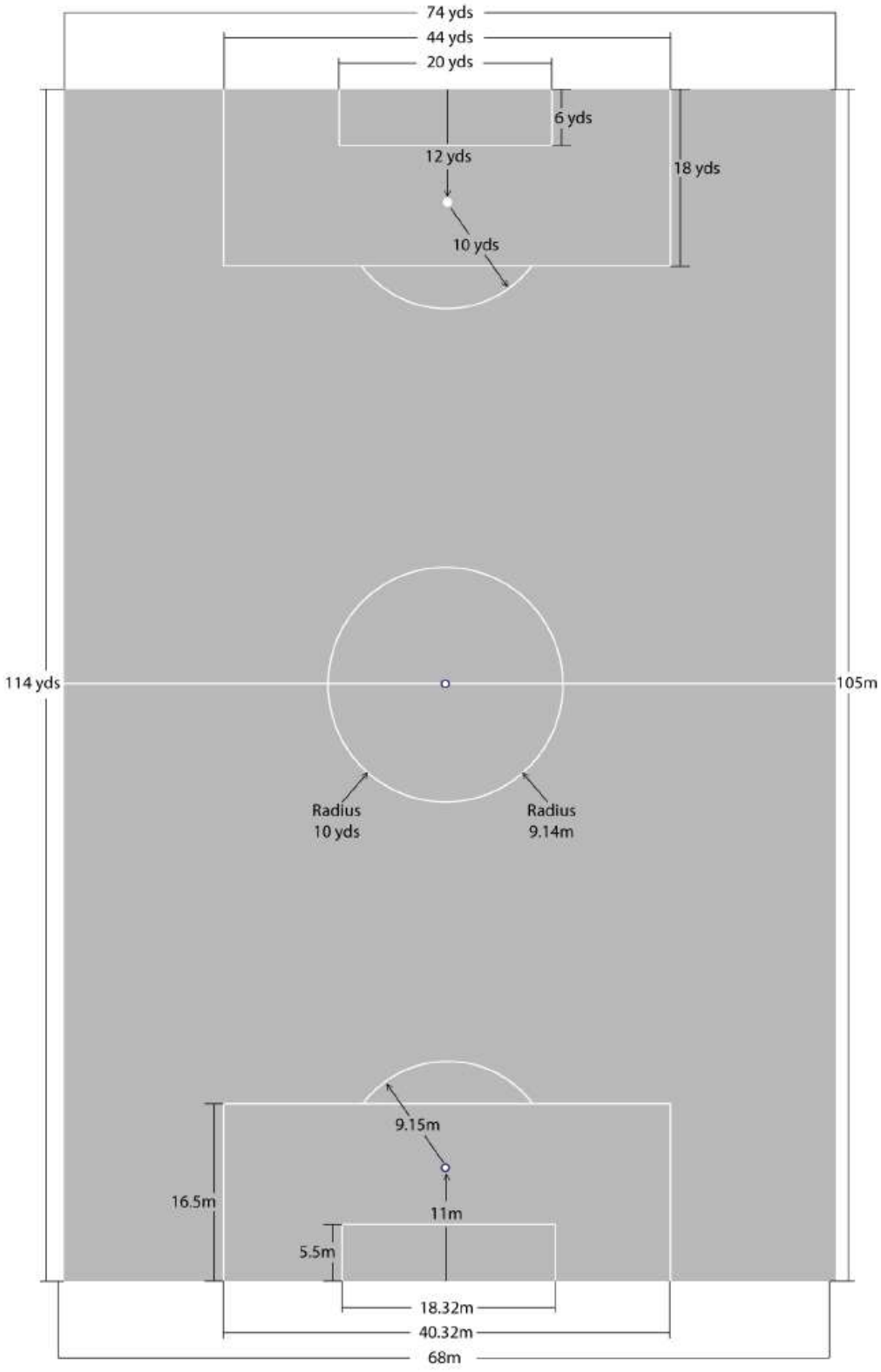


If the stadium design or existing installation requires luminaires to be positioned within a lateral distance of 20° of the goal line (as indicated by the blue luminaires in the diagram above) or if the vertical illuminance requires improvement, a second linear run of luminaires should be used to achieve 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 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 and takes them into account.

1.35. FIFA pitch dimensions

The pitch dimensions shown on this plan, and the test grids and templates specified in this guide, are given for reference purposes. Adjustments may be required if the dimensions vary, as permitted under the Laws of the Game (https://www.theifab.com/laws). Field of Play at FIFA tournaments are normally assumed to be 68m x 105m, according to the respective competition requirements.



Training pitches

FIFA training pitches must provide appropriate illuminance conditions to accommodate the requirements of players and coaches.

Two examples of effective lighting solutions for each grade of FIFA training pitches are provided in this document.

1.36. FIFA training facilities pitch illuminance

All training pitch facilities which require artificial illuminance must provide pitch illuminance conditions that meet the FIFA requirements as specified here.

There are three levels of illuminance conditions for FIFA training pitches.

Grade 1 – FIFA World Cup Training Pitch

Grade 2 – FIFA Match Practice

Grade 3 – FIFA Standard Training

1.37. Design specifications

The table below details the design specification required in order to provide illuminance systems in accordance with the selected FIFA Training Standard.

The information below that should be used as an example and the illuminance data of the selected luminaire must be used in design calculations. The relevant approval from local building control and planning authorities must be sought for any proposed illuminance system.

To ensure good illuminance efficiency and limit the impact of light pollution upon the local environment, FIFA recommends that only luminaires that are appropriately designed to deliver a lighting coefficient of utilisation (CU) greater than 85% of luminous flux to the pitch surface be specified.

FIFA training standard	Number of poles	Luminaires per pole	Pole height	Total system lumens	Eh average (Lux)
Grade 1	6	6 x 10	22-25m	11,500klm	> 750 lux
Grade 1	8	8 x 8	18-22m	11,500klm	> 750 lux
Grade 2	4	4 x 10	22-25m	6,200klm	> 500 lux
Grade 2	8	8 x 5	16-18m	6,200klm	> 500 lux
Grade 3	4	4 x 7	22-25m	4,500klm	> 300 lux
Grade 3	8	4 x 4 4 x 3	16-18m	4,500klm	> 300 lux

1.38. Main points

1. The pitch illuminance systems for FIFA training pitches are not designed to meet the requirements of TV broadcast cameras and are therefore designed and assessed differently.

2. FIFA requires the illuminance data for proposed new installations of training pitch illuminance systems to be provided to FIFA for assessment using the FIFA Training Pitch IDATP (Illuminance Data and Test Procedure).

3. When considered to be necessary, FIFA will test and assess the illuminance conditions of an existing training pitch using the FIFA Training Pitch IDATP.

4. The correct level of illuminance requirements should be assessed for the training pitch in order to select the appropriate FIFA Training Standard.

5. Due to building restrictions and planning control, it is often necessary to install a pitch illuminance system with a reduced pole height. A pole height of 15m is considered to be the minimum height that will allow for the required illuminance conditions for a FIFA training pitch.

6. It is important to ensure the correct luminaires are used when designing a pitch illuminance system for a training pitch, to ensure the players are able to train in an environment where the glare does not impinge upon their comfort and performance.

7. The pitch illuminance system must not create a negative impact upon the local environment and community. The pitch illuminance system design must assess the light spill into adjacent areas and communities.

8. The selection of appropriate luminaires will ensure the system is efficient with a high ratio of illuminous flux delivered as intended to the pitch surface. Generally, an efficiency of greater than 70% is expected.

9. FIFA promotes environmental good practice. Only high-quality and efficient luminaires should be considered for new fixed installations of pitch illuminance systems.

10. For specific events there may be additional requirements to ensure the illuminance conditions are suitable for the TV broadcast operations. The World Cup requires additional standards to be fulfilled. The additional requirements are to be implemented alongside the other conditions as set out in the Grade 1 standard for a World Cup Training Pitch. The additional requirements are:

    - Flicker factor (FF) - in all areas of the pitch the flicker factor must be less than 1%.
    - Goal line illuminance test - the illuminance conditions on the goal line between the goal posts must provide illuminance levels of greater than 500 lux on the horizontal reference plane (>500 lux on Eh) and 350 lux on each of the vertical reference planes (>350 lux on Ev0˚,90˚,180˚,270˚).
    - Each goal line is tested at the centre point between the goal posts at a height of 1m.

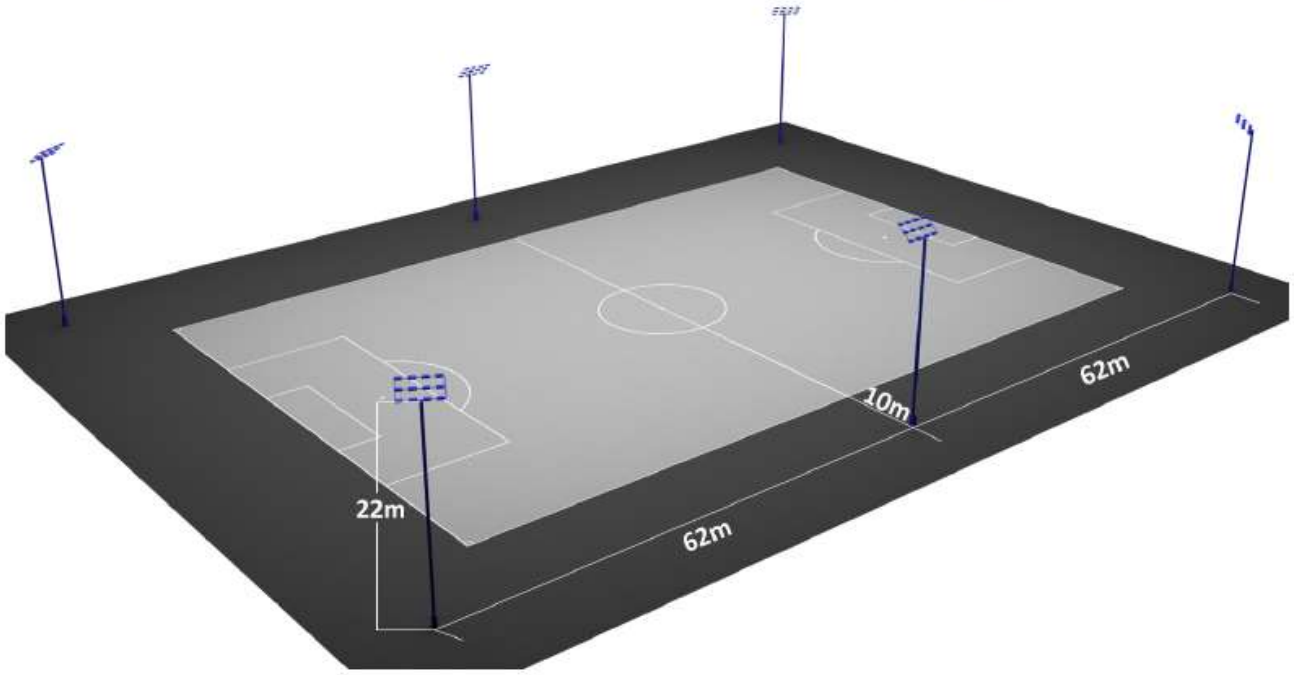
1.39. FIFA lighting standards for training pitches

Illuminance requirements	Grade 3 Standard training	Grade 2 Match practice	Grade 1 FIFA World Cup training
Ev 0° (vertical illuminance on 0° reference plane)	*not applicable*	*not applicable*	Minimum > 350 lux Average > 500 lux
Uniformity **U1v-0°**	*not applicable*	*not applicable*	> 0.30
Uniformity b	*not applicable*	*not applicable*	> 0.40
Ev 90° (vertical illuminance on 90° reference plane)	Minimum > 150 lux Average > 200 lux	Minimum > 275 lux Average > 400 lux	Minimum > 350 lux Average > 500 lux
Uniformity **U1v-90°**	> 0.30	> 0.30	> 0.30
Uniformity **U2v-90°**	> 0.40	> 0.40	> 0.40
Ev 180° (vertical illuminance on 180° reference plane)	*not applicable*	*not applicable*	Minimum > 350 lux Average > 500 lux
Uniformity U1v-180°	*not applicable*	*not applicable*	> 0.30
Uniformity U2v-180°	*not applicable*	*not applicable*	> 0.40
Ev 270° (vertical illuminance on 270° reference plane)	Minimum > 150 lux Average > 200 lux	Minimum > 275 lux Average > 400 lux	Minimum > 350 lux Average > 500 lux
Uniformity **U1v-270°**	> 0.30	> 0.30	> 0.30
Uniformity **U2v-270°**	> 0.40	> 0.40	> 0.40
Eh ave (average horizontal illuminance)	Average > 300 lux	Average > 500 lux	Average > 750 lux
Uniformity **U1h**	> 0.40	> 0.40	> 0.40
Uniformity **U2h**	> 0.60	> 0.60	> 0.60
Flicker factor (FF)	*not applicable*	*not applicable*	< 1%
Reference grid	40 points	40 points	96 points
Goal line illuminance test	*not applicable*	*Required for FWWC. Otherwise not applicable.*	Required
Colour temperature (Tc)	4,200–6,200K	5,000–6,200K	5,000–6,200K
Colour rendering (Ra)	≥ 70Ra	≥ 70Ra	≥ 80Ra
Glare rating (RG)	< 50	< 50	< 50
Maintenance factor (MF)	0.9 LED or 0.8 HID	0.9 LED or 0.8 HID	0.9 LED or 0.8 HID
Power supply	FPS D	FPS D	FPS D

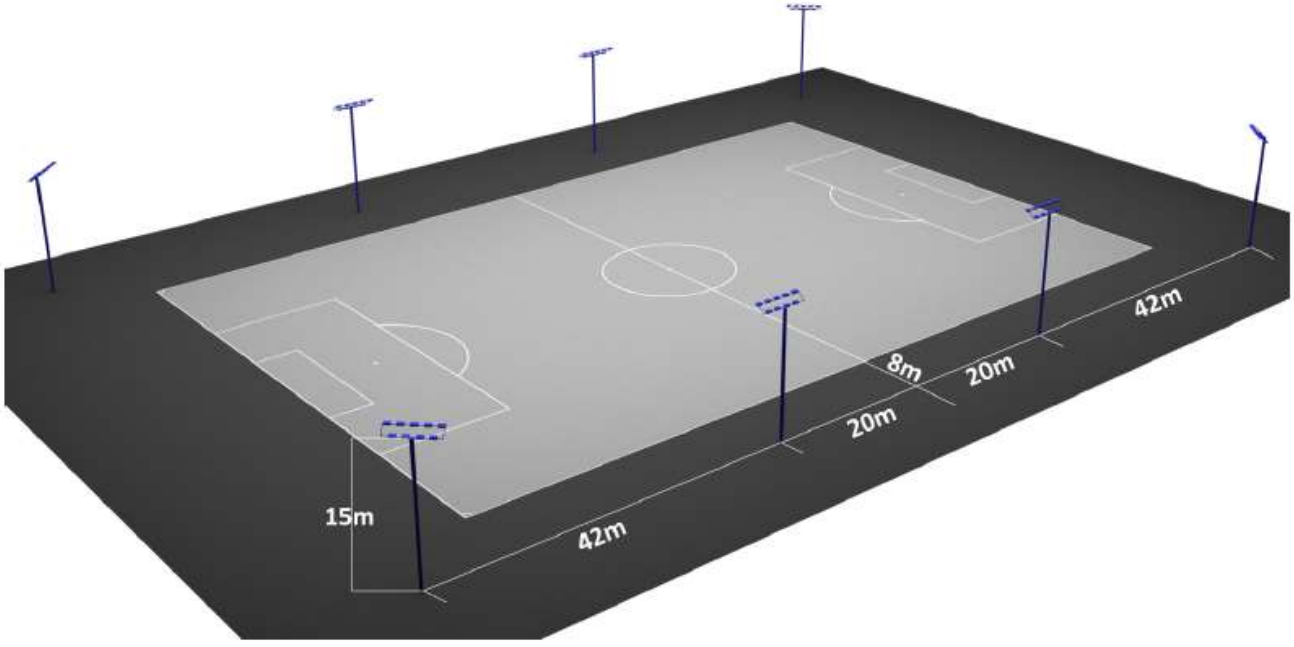
NOTE: The required FIFA training pitch Illuminance Data and Test Procedure (IDATP) is different from that of stadium pitches; a training pitch must fulfil different illuminance requirements. The IDATP for training pitches is therefore designed to assess training pitches to the appropriate standard. The IDATP for training pitches uses 40 reference points, with the exception of FIFA World Cup which is 96 points.

1.40. Design examples: Grade 1 - FIFA World Cup Training Pitch

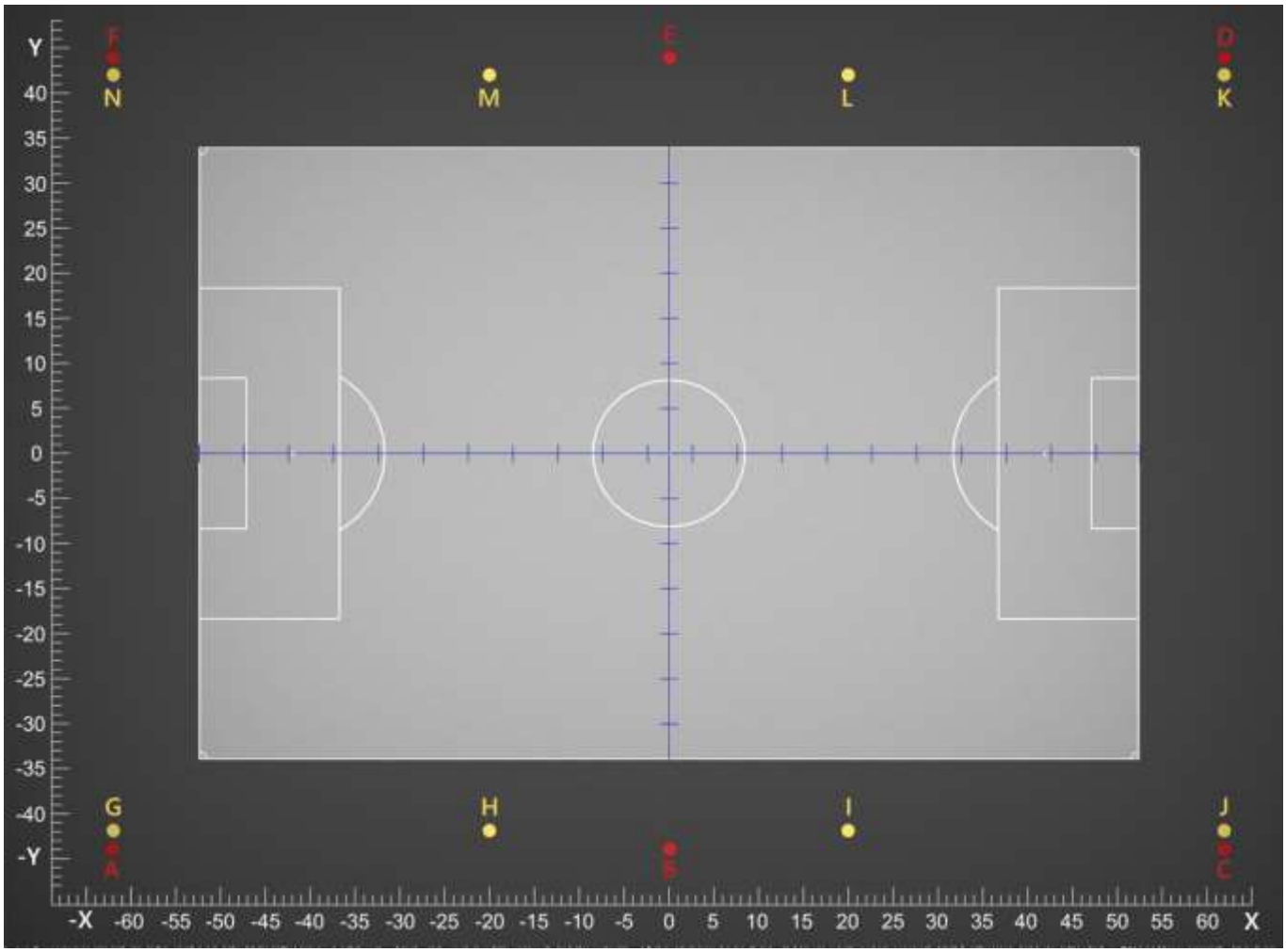
Grade 1 – FIFA World Cup Training Pitch
Eh > 750 lux
6-pole system
Pole height: 18-25m



Grade 1 – FIFA World Cup Training Pitch
Eh > 750 lux
8-pole system
Pole height: 18-22m



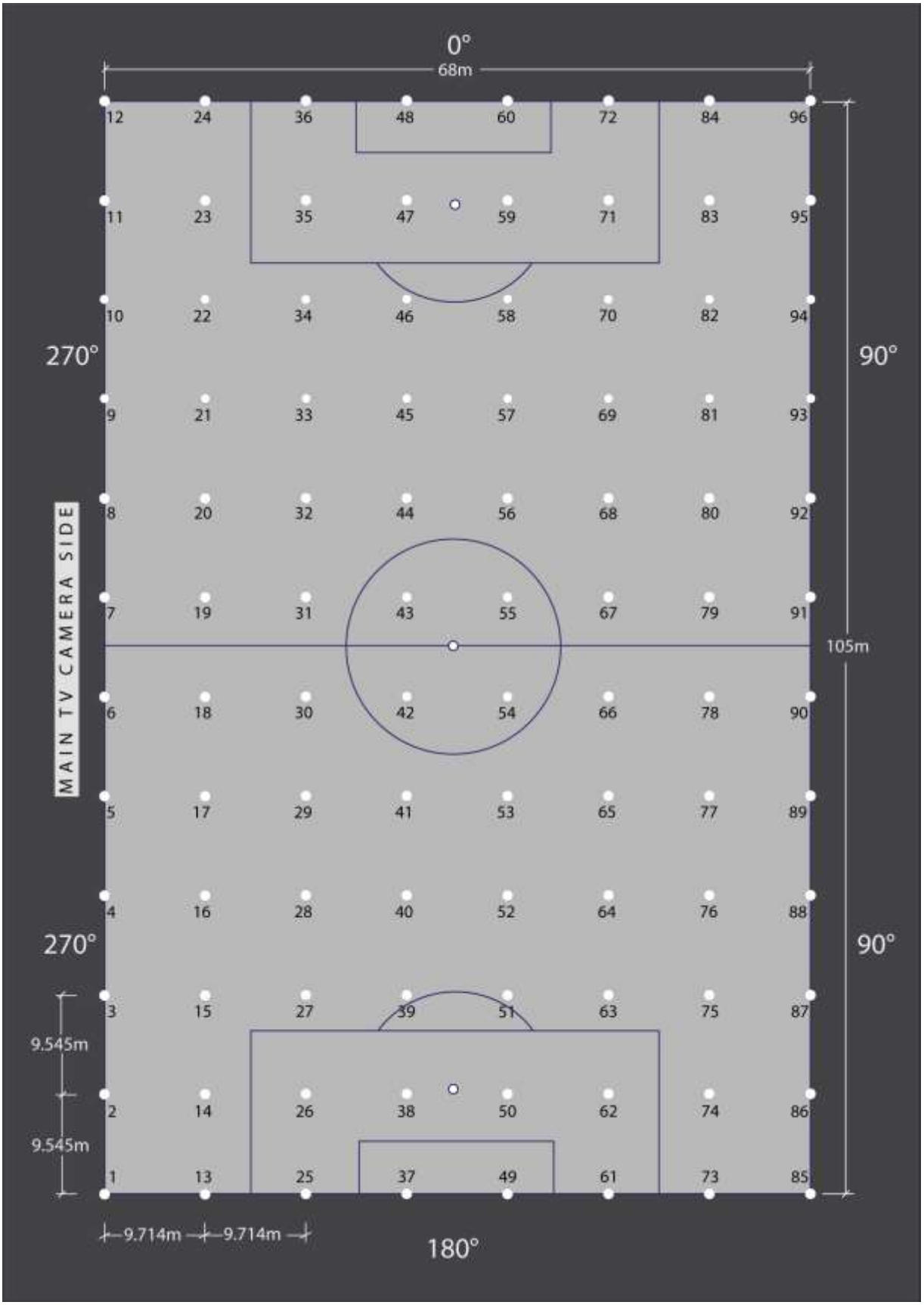
FIFA training pitch pole locations (grade 1)



System type	Pole coordinates (m)		
6-pole system	X	Y	Z
A	-62	-44	25
B	0	-44	25
C	62	-44	25
D	62	44	25
E	0	44	25
F	-62	44	25
8-pole system	X	Y	Z
G	-62	-42	17
H	-20	-42	17
I	20	-42	17
J	62	-42	17
K	62	42	17
L	20	42	17
M	-20	42	17
N	-62	42	17

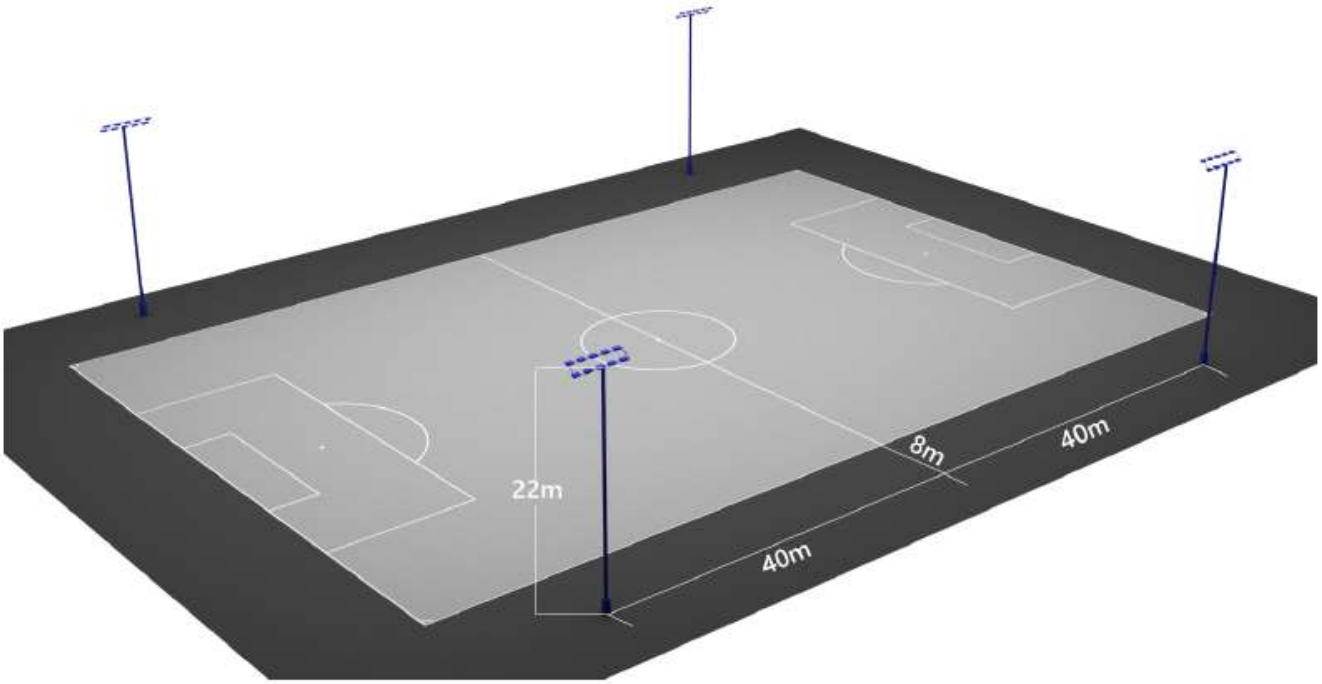
1.41. Training pitch illuminance test grid (96-point)

The pitch dimensions shown on this plan are for reference purposes. Adjustments may be required if the dimensions vary, as permitted under the Laws of the Game.

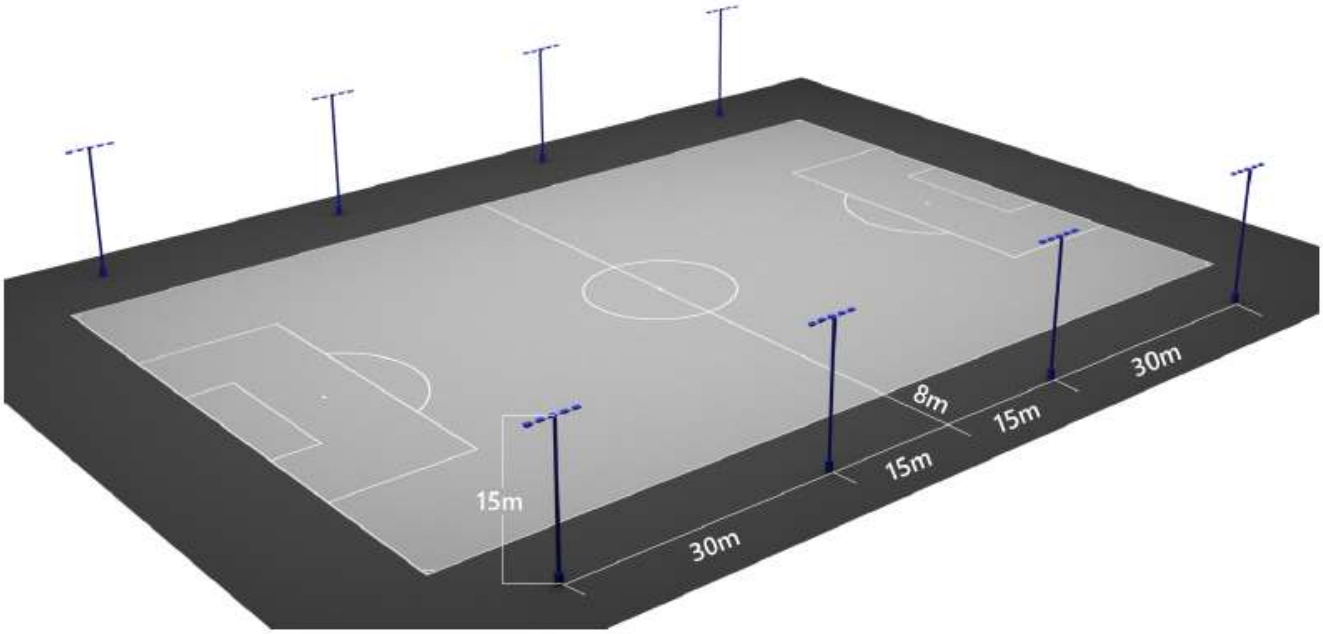


1.42. Design examples: Grade 2 - Match practice

Grade 2 – Match practice
Eh > 500 lux
4-pole system
Pole height: 22-25m

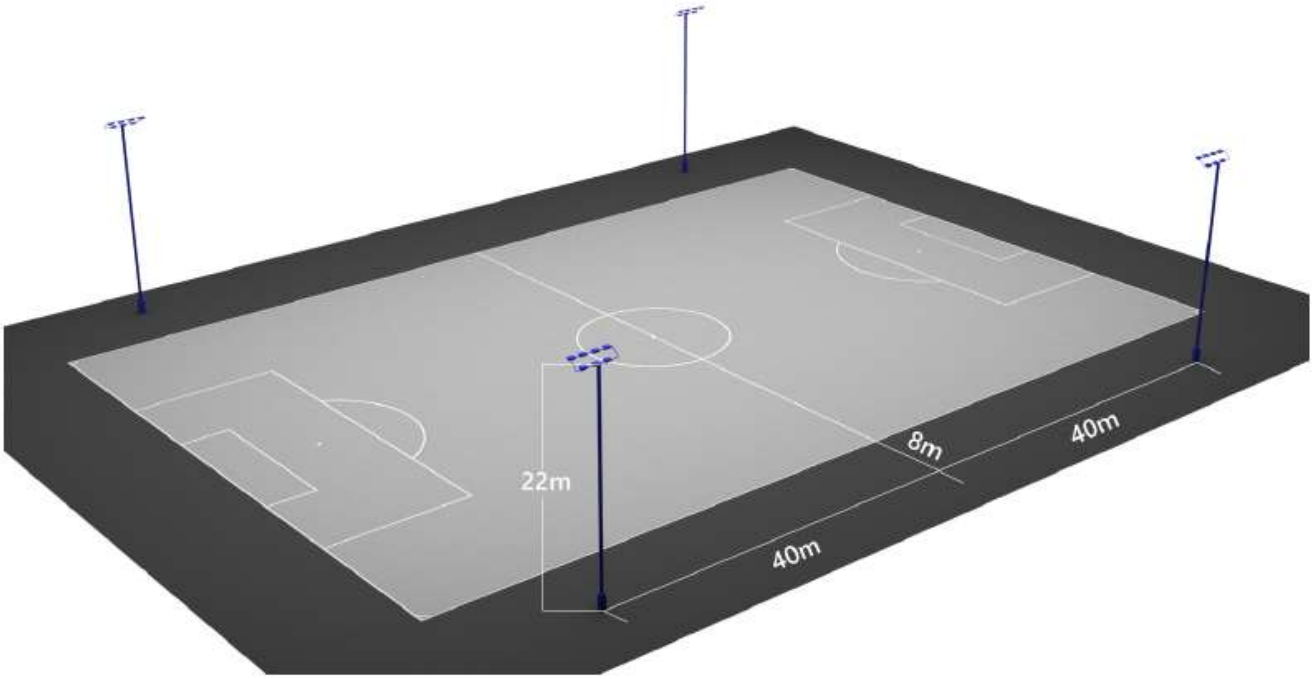


Grade 2 – Match practice
Eh > 500 lux
8-pole system
Pole height: 16-18m

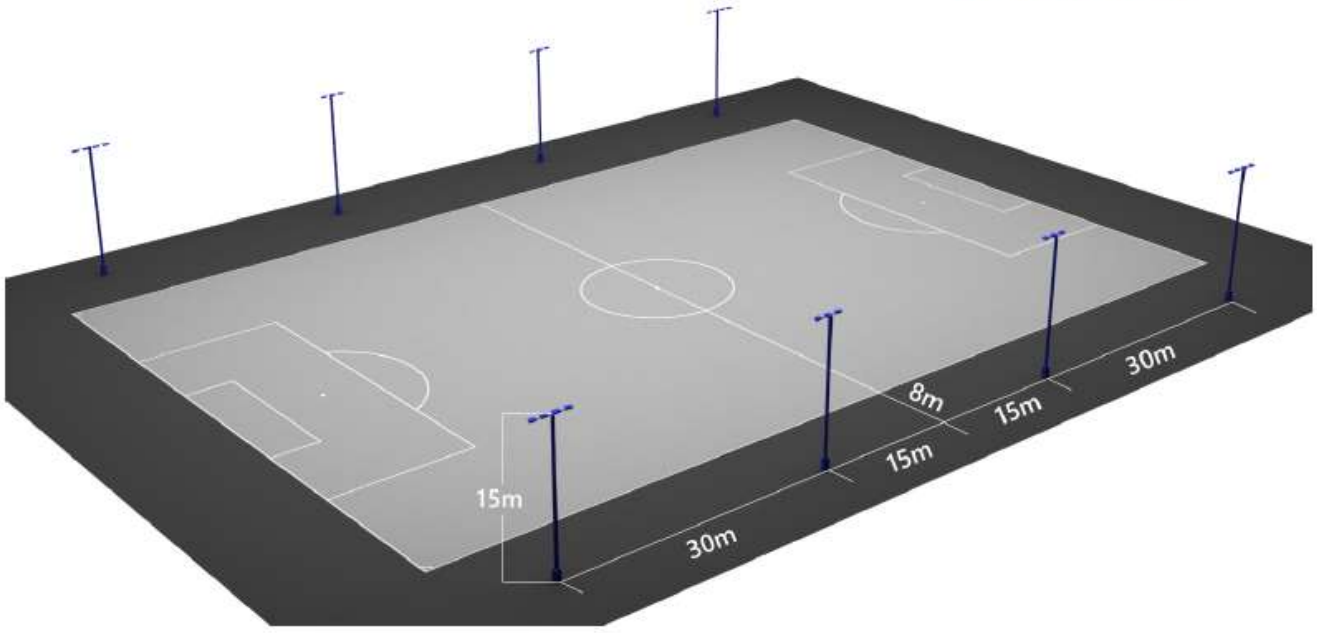


1.43. Design examples: Grade 3 - Standard training

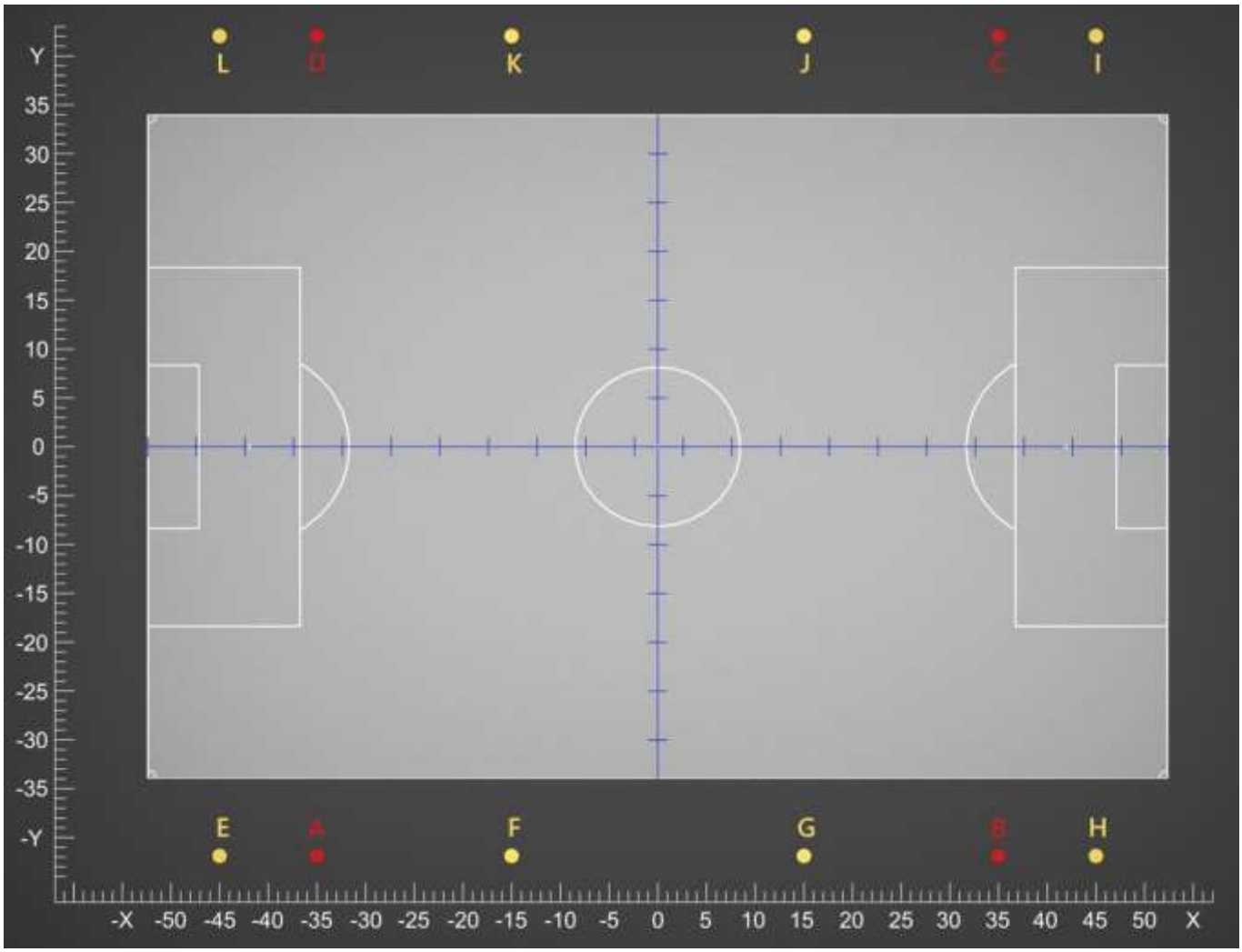
Grade 3 – Standard training
Eh > 300 lux
4-pole system
Pole height: 22-25m



Grade 3 – Standard training
Eh > 300 lux
8-pole system
Pole height: 16-18m



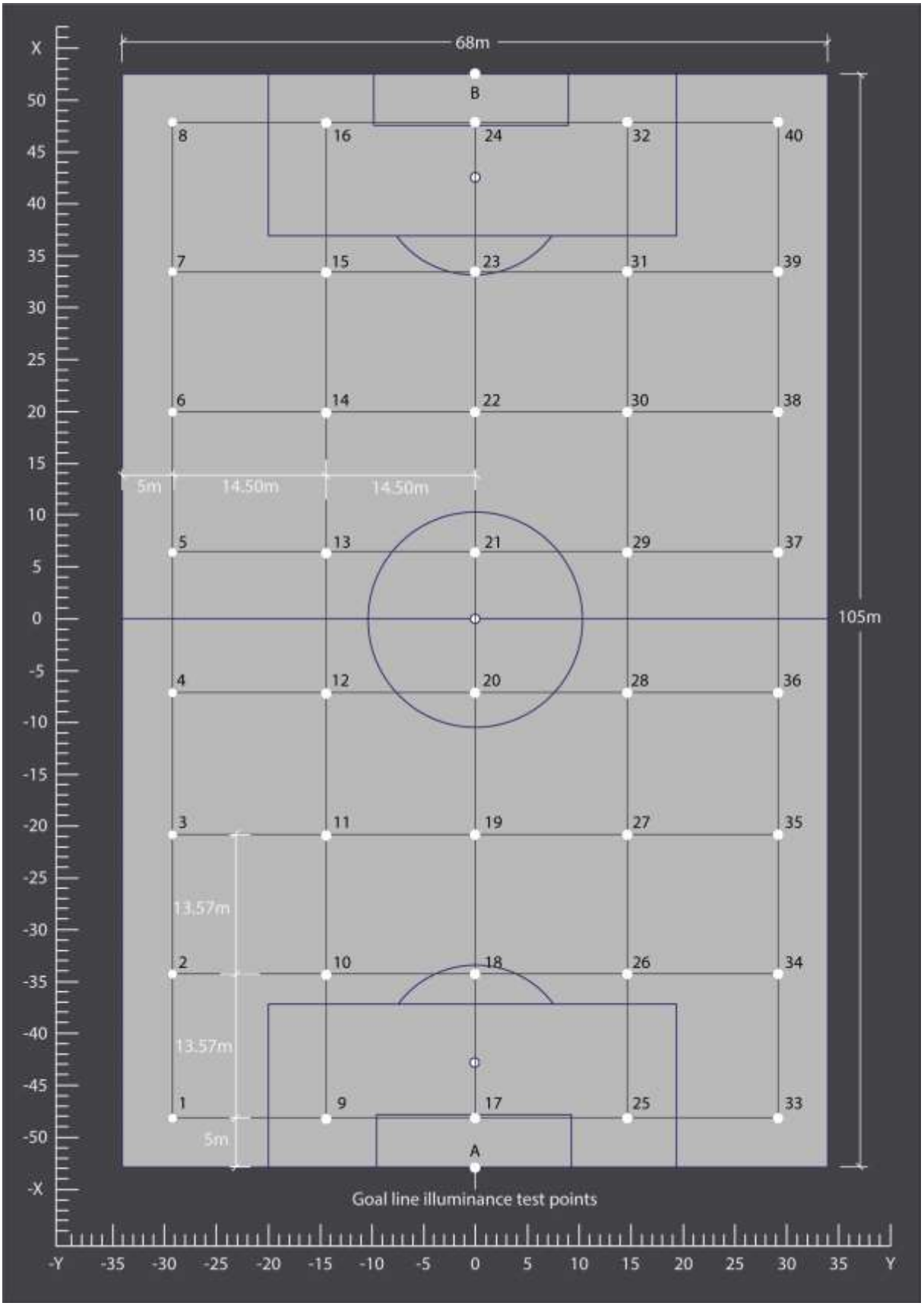
FIFA training pitch pole locations (grades 2 & 3)



System type	Pole coordinates (m)		
4-pole system	X	Y	Z
A	-35	-42	25
B	35	-42	25
C	35	42	25
D	-35	42	25
8-pole system	X	Y	Z
E	-45	-42	17
F	-15	-42	17
G	15	-42	17
H	45	-42	17
I	45	42	17
J	15	42	17
K	-15	42	17
L	-45	42	17

1.44. Training pitch illuminance test grid (40-point)

The pitch dimensions shown on this plan are for reference purposes. Adjustments may be required if the dimensions vary, as permitted under the Laws of the Game.



Uniformity

A critical element of a pitch illuminance system is the uniformity of illuminance across the whole pitch in all of FIFA'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 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 FIFA's requirements are the minimum standards for the various illuminance levels. Experience shows that uniformity values 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. FIFA therefore 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 the discretion of FIFA the FIFA pitch illuminance test reference grid may be offset by 5m on both the 'X' and 'Y' axis if it is assessed that the illuminance conditions area poor in positions not assessed by the standard reference grid.

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.

1.45. Discomfort glare

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

When the eyes have got used to the dark, they are particularly susceptible to the impairment and depression of central vision when a bright light enters the field of vision.

1.46. 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) sources increases. The luminance and position of light sources 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 – defines a glare rating (R_G) 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 17. 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.

Pitch illuminance switch mode (PISM)

The pitch illuminance system should be pre-programmed with various 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)

1.47. Full match mode

This involves the pitch illuminance system operating in a manner that satisfies the requirements specified for the relevant FIFA Lighting Standard.

1.48. Match continuity mode

This mode should be automatically 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 FIFA 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.

1.49. Training mode

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

1.50. Maintenance mode

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

Flicker factor (FF)

1.51. 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:

$$\textbf{FF\%} = \textbf{0.5} \times \frac{\textbf{E}\text{max} - \textbf{E}\text{min}}{\textbf{E}\text{ average}} \times \textbf{100\%}$$

or

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

(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 waveform 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 5.

1.52. 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)	< 1%
Discharge lamps with 100% electronic ballasts	< 3%
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%

1.53. 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 FIFA's requirements for Standard B and C stadiums.

Although the above method may produce substantial improvements, it will not meet the requirements for Standard A 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 be used.

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

1.54. 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 below, the 12-point test.

1.55. 12-point flicker factor test

At each of the six positions indicated in section 13.6, a vertical flicker factor reading should be taken at a height of 1m on the 90° and 270° planes.

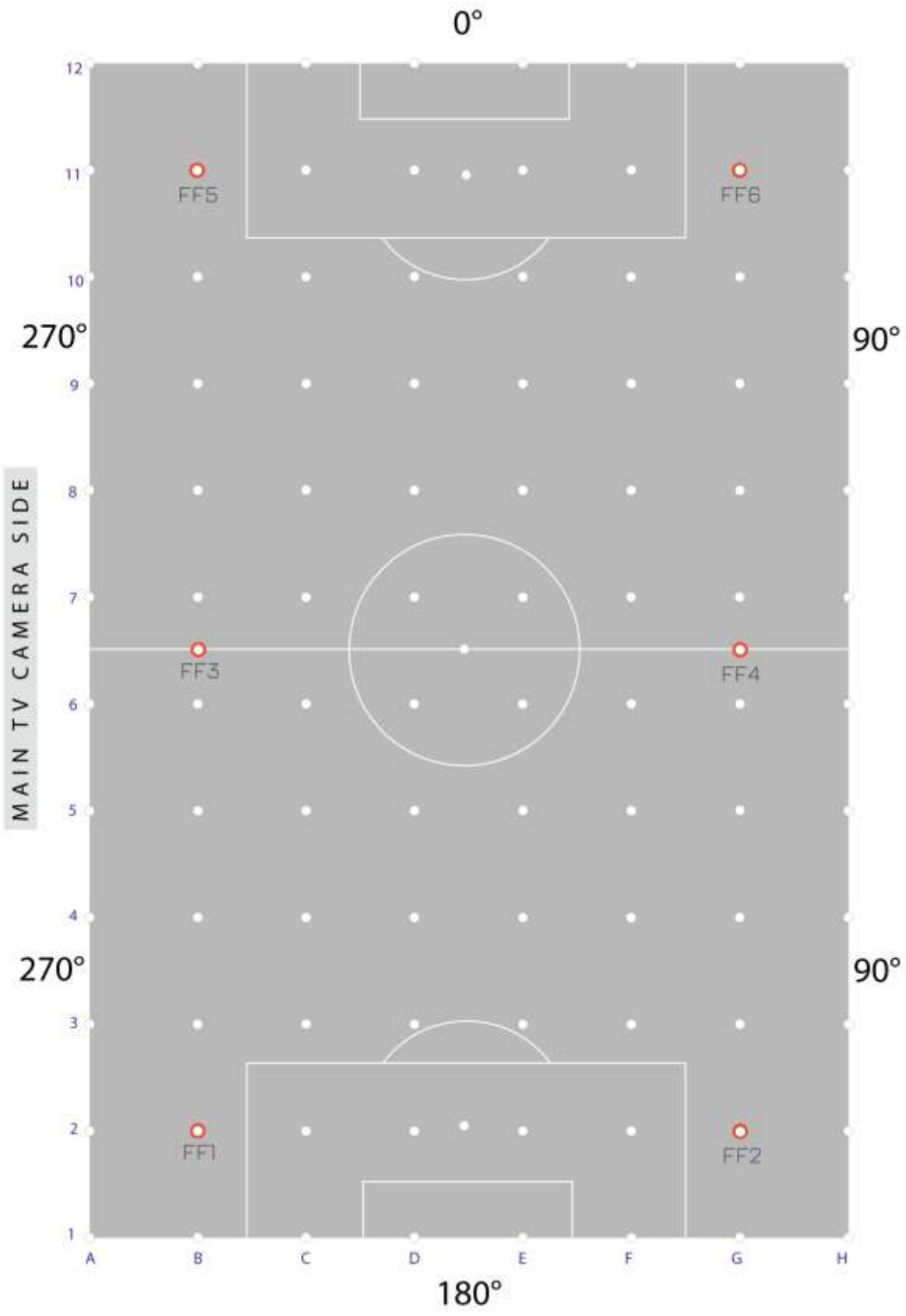
- The 12-point average is calculated by dividing the sum of those 12 values by 12.
- The maximum flicker factor value is the highest measured value of the 12 points.

The maximum permitted flicker factor is listed below for each FIFA standard.

FIFA flicker factor requirements	
Standard A	
12-point average	< 1%
Maximum value	< 1%
Standard B	
12-point average	< 12%
Maximum value	<15%
Standard C	
12-point average	< 20%
Maximum value	< 30%
Standard D	
12-point average	Not applicable
Maximum value	Not applicable

1.56. Flicker factor test reference points - 12-point high-frequency test

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

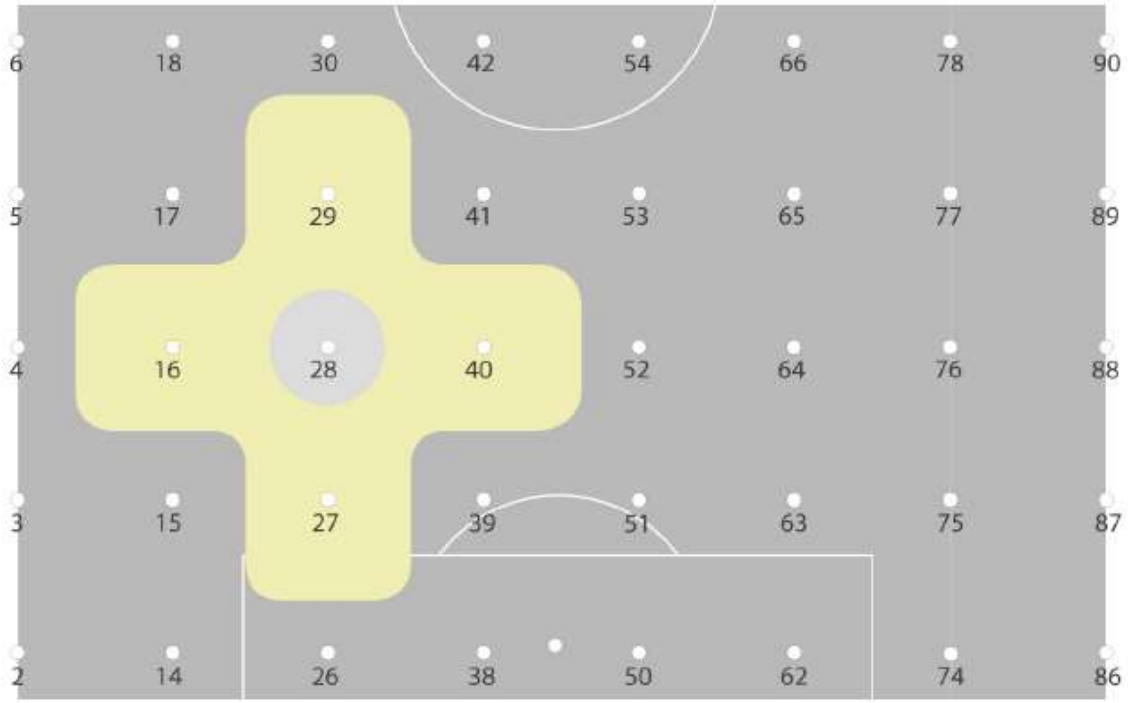


Minimum adjacent uniformity ratio (MAUR)

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 5. That requirement takes the form of a minimum permissible ratio between the two points.

1.57. 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.



Example:

Standard A stadium – MAUR evaluation
Reference point 28 on horizontal plane

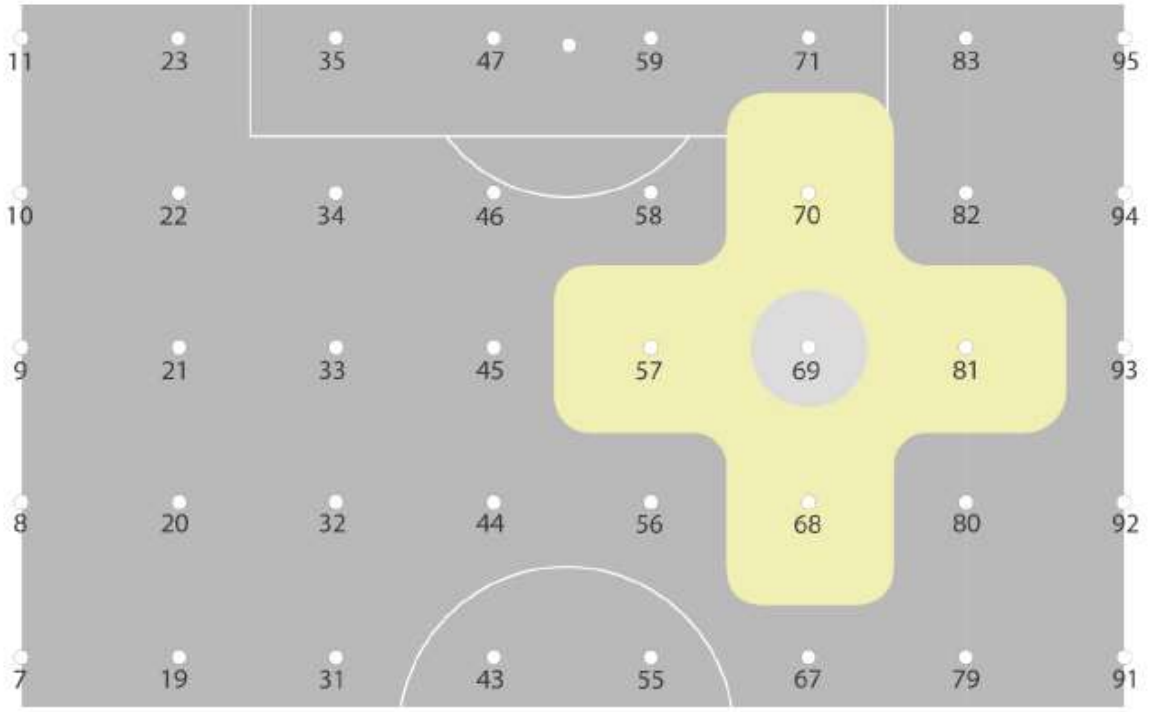
Reference point 28 – Eh = 2,325 lux
MAUR > 0.60

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.**

MAUR for FIFA Standard A
In order for a pitch illuminance system to meet the FIFA Lighting Standard A requirements there must be no more than 10 MAUR failures throughout the whole pitch.

1.58. 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 Standard C stadium.



Example:

Standard C stadium – MAUR evaluation
Reference point 69 on the 270° vertical plane

Reference point 69 – Ev-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.**

MAUR for FIFA Standard C
In order for a pitch illuminance system to meet with the FIFA Lighting Standard C requirements there must be no more than 30 MAUR failures throughout the whole pitch.

Note: The total number of MAUR failures for each FIFA Lighting category is determined by calculating the total number of failures across all 96 reference points for each of the five reference planes.

Colour temperature

Colour temperature (Tc) describes the feeling or appearance of how warm (red) or cool (blue) a certain type of illumination is It is measured in kelvins (K).

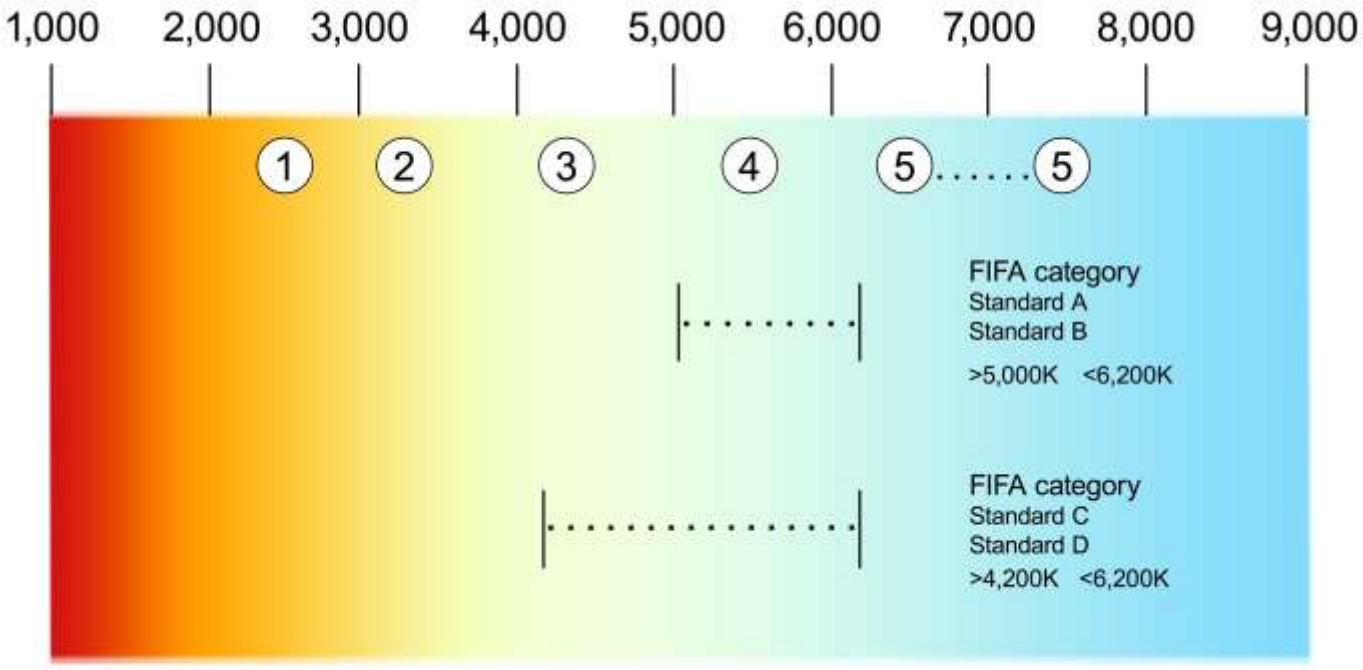
Digital camera technology allows video-produced media to be altered to 'gain' colour and contrast, as required to produce the desired colour quality. The required colour temperature range varies depending on the stadium illuminance level, with the minimum and maximum levels across all levels being 4,200K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

1.59. 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)



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 ability of a light source to accurately reproduce the colours of the object it illuminates.

FIFA's requirements stipulate that illumination systems must produce good colour, with CRI rating greater than Ra 80 for FIFA Standard A & B and greater than Ra 70 for FIFA Standard C & D.

The Colour Rendering Index (CRI) generally provides a good level of assessment of the chromaticity quality of large scale lighting systems within the environment of stadiums. It remains important for designers and suppliers of football stadium illuminance systems to 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 CRI(e) 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 evaluated carefully 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 TLCI is recognised as providing a detailed and thorough analysis of a light source. However the FIFA guidelines continue to use the more basic version of Ra in order to provide consistent continuity of this assessment, this will also ensure existing stadiums which produce a Ra of the appropriate level are assessed to meet with 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.

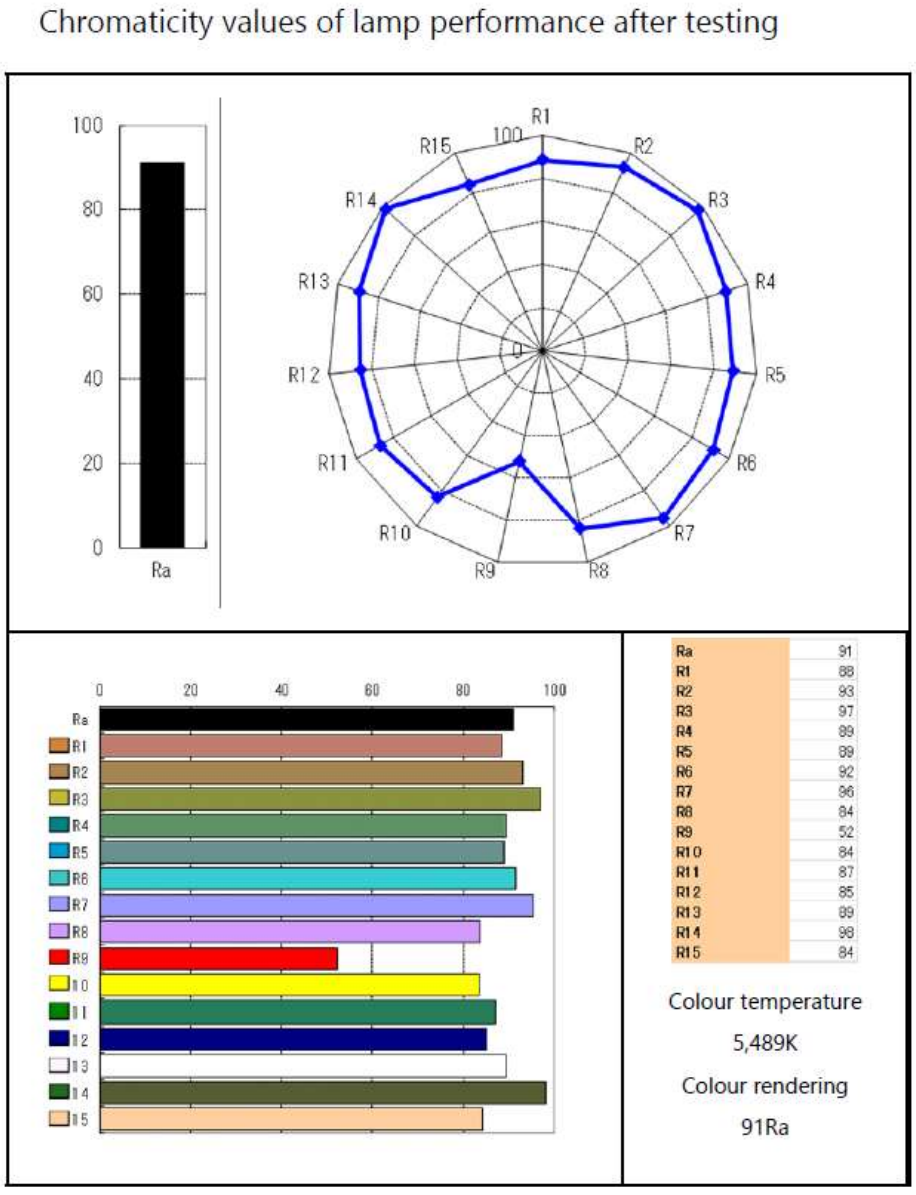
The **Television Lighting Consistency Index (TLCI)** was developed as an alternative method to evaluate the chromaticity quality of a light source within the television environment. Rather than assess the performance of a luminaire directly, as the CRI does, the TLCI mimics a complete television camera 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)/Ra test colour samples (TCS)

Chromaticity values of lamp performance

The following diagram provides test information regarding chromaticity values and should be used as a guide to the level of information that is required for all new and old FIFA stadiums.

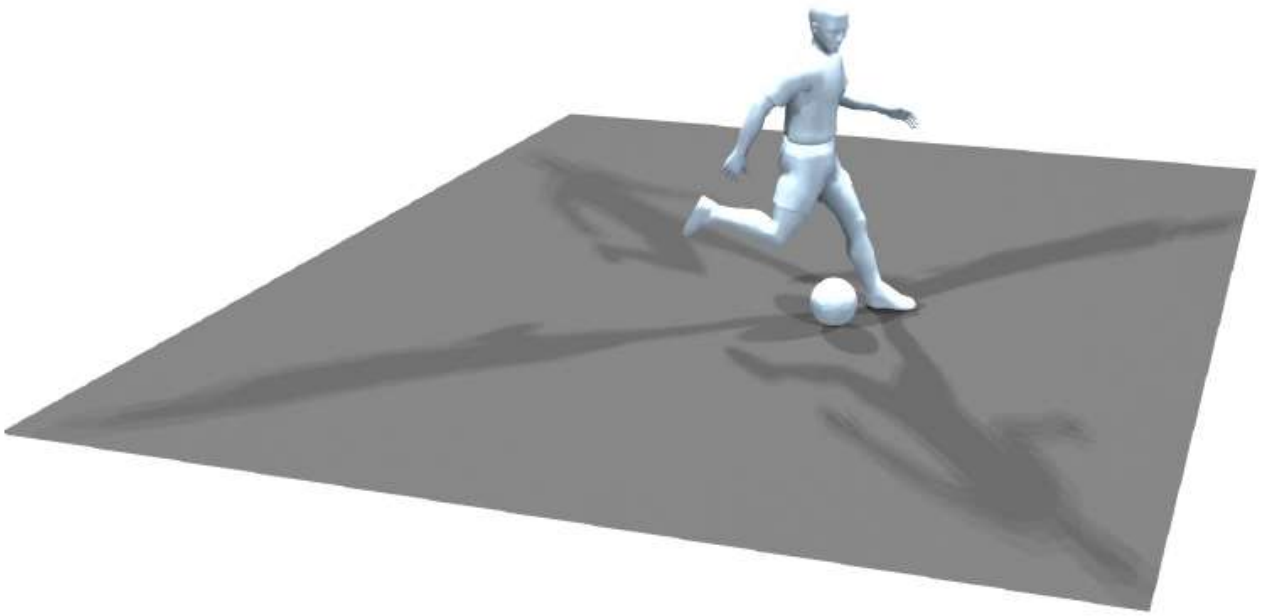
It should be noted that only the extended Colour Rendering Index CRI(e) is used for both test and evaluation purposes.



Player shadows

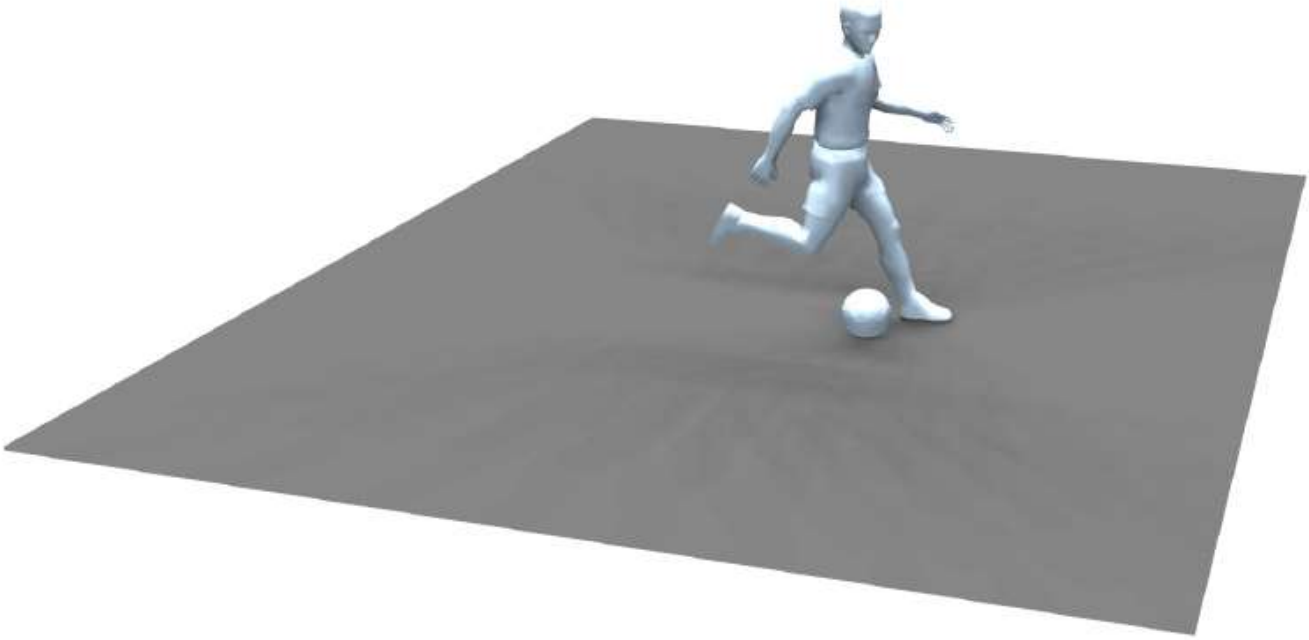
Artificial shadows on the pitch caused by floodlighting systems detract from visual clarity for both spectators and television broadcasters. The shadows impinge upon the viewing experience and should be eliminated where possible or reduced to soft shadows.

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 achieved by using multiple light sources from various locations for each area of the pitch. This will mean that shadows are reduced and spectators (and, to a degree, players) will benefit from good illuminance modelling around their entire bodies. This is essential to provide adequate vertical illuminance and uniformity on all planes.

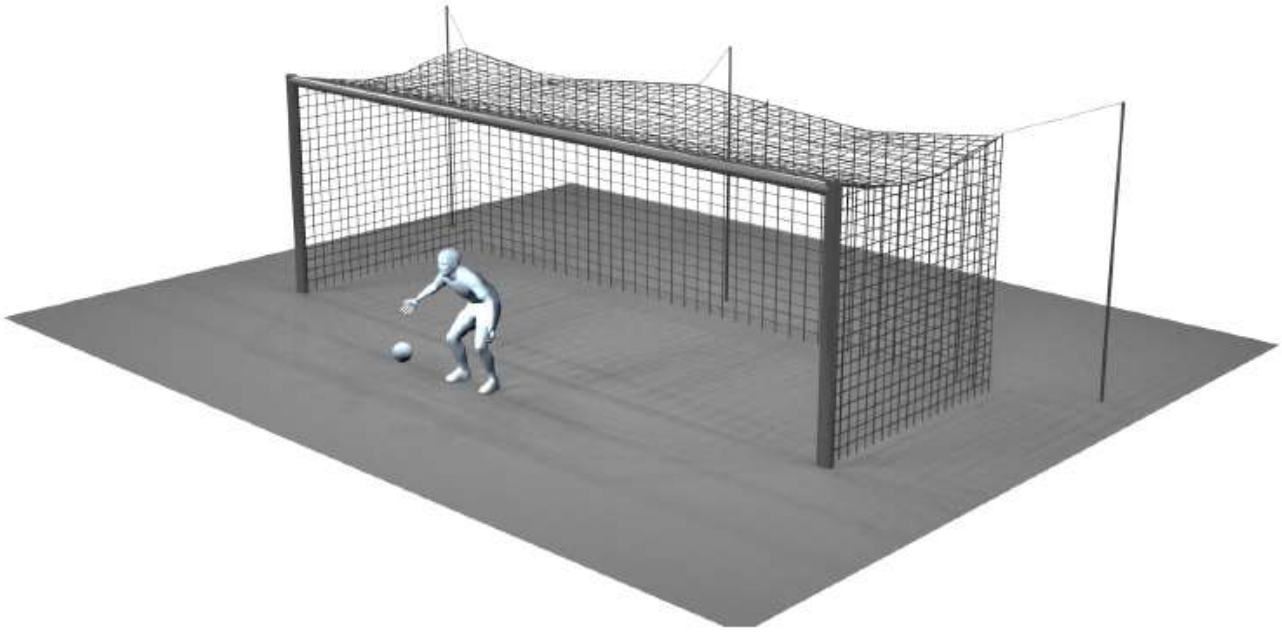


The image above demonstrates the impact of player shadows on a football pitch.

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.

Maintenance factor

The average illuminance values listed in the tables in section 5 should be achieved during matches. However, a maintenance factor is used to take into 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 5 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 through 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 for HID luminaires and 0.8 for LED luminaires.

Power supply

It is essential that the power supply for the pitch illuminance system (floodlights) be reliable to ensure that matches and television broadcasts can continue without unacceptable disruption. A suitable alternative power supply is required in case the primary source fails. A power supply evaluation is required by FIFA for all selected stadiums. For newly built stadiums, it is recommended that the power systems be designed to meet the requirements stipulated by FIFA without modification – but possibly with temporary augmentation.

It is acknowledged that the power supply service level required at stadiums may be provided effectively for LED pitch illuminance systems in ways that are not considered to be acceptable for HID pitch illuminance systems. Therefore, FIFA has defined four Floodlight Power Supply Standards (FPS A to D, including two options for the last three: one for HID and one for LED systems).

1.60. Floodlight power supply standards for FIFA competitions

FIFA Competition	FIFA floodlight power supply (FPS) standard
World Cup™	FPS A
Women's World Cup™(final)	FPS A
Women's World Cup (group and knockout)	FPS B
Club competition 2021+ (final)	FPS A
Club competition 2021+ (all other matches)	FPS B
Club World Cup™	FPS B
U-20 World Cup™ (final)	FPS C
U-20 World Cup™ (all other matches)	FPS D
U-20 Women's World Cup™ (final)	FPS C
U-20 Women's World Cup™ (all other matches)	FPS D
U-17 World Cup™ (final)	FPS C
U17 World Cup™ (all other matches)	FPS D
U-17 Women's World Cup™ (final)	FPS C
U-17 Women's World Cup™ (all other matches)	FPS D

1.61. FIFA floodlight power supply (FPS) standard A

No disturbance to match illuminance: Uninterruptible Venue Technical Power (A+) with enhanced physical and electrical redundancy.

Note: Further details about Venue Technical Power and other terminology may be seen on page 69.

	Description	Capability / Arrangement
Primary power supply	May be local (e.g. on site generator) or non-local (e.g. utility/grid power). Must be dedicated to the stadium in low and medium voltage. Normally expected to be utility power, with access to two independent medium-voltage(MV) feeds.	Capable of supporting all connected loads, including 100% of floodlights.
Secondary power supply	Fully independent power supply to the primary power supply: no shared single point of failure upstream of the switching point. Normally expected to be local (on the stadium site). If the secondary power supply proposed is non-local, acceptance will be at FIFA's sole discretion on the basis of a comprehensive utility power study demonstrating high-quality, protected and independent medium and high-voltage feeder lines.	Capable of supporting all connected loads – including 100% of floodlights in case of failure of the primary supply. Must either be synchronous with the primary supply, or else supplemented by an uninterruptable power supply device in order to provide 'ride-through' of switching disruption. See below for UPS details, if a UPS is used.
Switching in case of failure or disturbance	Automatic switching	
Switching in case of subsequent failure	Inhibited/manual return in case of primary supply restoration.	Automatic switchback to primary supply only in the case of subsequent failure to secondary supply (ideal).
UPS	Optional – necessary if secondary supply is not synchronous with the primary power supply, or otherwise instantaneously available to support all floodlighting loads (without disturbance) in case of primary supply failure.	UPS devices must guarantee autonomous running duration for a minimum period of either 10 minutes, or 5 times the maximum expected switching duration between primary and secondary power supplies, whilst supporting 100% of floodlighting loads – whichever is the longer period. If the UPS device itself is a potential single point of failure, then completely redundant parallel architecture must be used, and the device housed in a secure and protected location.
Power for lighting control	Lighting control equipment must also be provided with uninterruptable Venue Technical Power (A+)	
Wiring arrangement (special requirements)		Whether power supplies for floodlights are arranged in sectors or not, alternate luminaires (or small groups of adjacent luminaires) should be wired back to different main intermediary/main circuits, with cable paths being as physically separated as is practical. (FIFA World Cup™ only)

1.62. FIFA floodlight power supply (FPS) standard B

All HID and LED cases of >5-second switching:

- Uninterruptible Venue Technical Power (A+) to match continuity mode illuminance.
- Venue Technical Power (A) to remaining illuminance.

All-LED case:

- Venue Technical Power to all luminaires (MCM state not necessary)
- (Only) If the stadium's switching time between primary and secondary supplies is under 5 seconds, and if all luminaires are LED, a 5-second interruption is acceptable. Minimal illuminance of greater than Eh 100 lux must be maintained in the seating bowl throughout.

Note: Further details about Venue Technical Power and other terminology may be seen on page 69.

	Description	Capability / Arrangement
Primary power supply	May be local (e.g. on-site generator) or non-local (e.g. utility/grid power). Must be dedicated to the stadium in low and medium voltage. Normally expected to be utility power, with access to two independent MV feeds.	Capable of supporting all connected loads, including 100% of floodlights.
Secondary power supply	Fully independent power supply to the primary power supply: no shared single point of failure upstream of the switching point. Normally expected to be local (on the stadium site). If the second feed proposed is non-local, acceptance will be at FIFA's sole discretion on the basis of a comprehensive utility power study demonstrating high-quality, protected and independent medium and high voltage feeder lines.	Capable of supporting all connected loads – including 100% of floodlights in case of failure of the primary supply. Must either be synchronous with the primary supply, or else supplemented by an uninterruptable power supply(UPS)device in order to provide 'ride-through' of switching disruption. See below for UPS details, if a UPS is used.
Switching in case of failure or disturbance	Automatic switching	
Switching in case of subsequent disturbance	Inhibited/manual return in case of primary supply restoration.	
Match continuity mode	Luminaires providing the 'match continuity mode' illuminance state must be provided with uninterruptible power, unless all fixtures are LED, and would be restored to full illuminance within 5 seconds of a primary supply failure.	If MCM is necessary: MCM luminaires (as a minimum) must not be affected by power supply switching for more than 5 seconds. Non-MCM luminaires must regain full illuminance levels within 15 minutes of a supply failure and switchover.
UPS	Optional – necessary if secondary supply is not synchronous with the primary power supply, or otherwise instantaneously available to support MCM luminaires (without disturbance) in case of primary supply failure.	UPS devices must guarantee autonomous running duration for a minimum period of either 10 minutes , or 5 times the maximum expected switching duration between primary and secondary power supplies, whilst supporting 100% of floodlighting loads – whichever is the longer period.
Power for lighting control	Lighting control equipment must also be provided with uninterruptable Venue Technical Power (A+)	

1.63. FIFA floodlight power supply (FPS) standard C

Defined disruption to match continuity. Reduced illuminance level permitted:

- HID: Uninterrupted Venue Technical Power (A+) to MCM (match continuity mode) luminaires. Venue Domestic Power (B) to remaining luminaires.

- LED: Venue Technical Power (A) to all MCM luminaires, or all luminaires.
  (Only) If the stadium's switching time between primary and secondary supplies is expected to be under 15 seconds, and MCM lighting fixtures are LED, is a floodlight outage acceptable. Minimum illuminance levels of greater than Eh 50 lux within the stadium bowl must be maintained at all times.

Note: Further details about Venue Technical Power and other terminology may be seen on page 69.

	Description	Capability / Arrangement
Primary power supply	May be local (e.g. on-site generator) or non-local (e.g. utility/grid power). Must be dedicated to the stadium in low and medium voltage. Normally expected to be utility power, with access to two independent MV feeds.	Capable of supporting all connected loads, including 100% of floodlights
Secondary power supply	Fully independent power supply to the Primary power supply. If the second feed proposed is non-local, acceptance will be at FIFA's sole discretion on the basis of a comprehensive utility power study demonstrating high-quality, protected and independent medium and high-voltage feeder lines.	Capable of supporting all connected loads – including (at least) all MCM floodlights in case of failure of the primary supply. Must either be synchronous with the primary supply, or else supplemented by an uninterruptible power supply (UPS) device in order to provide 'ride-through' of switching disruption for (HID) MCM luminaires, or if supply switching duration is >15 seconds. See below for UPS details, if a UPS is used.
Switching in case of failure or disturbance	Automatic switching	
Switching in case of subsequent disturbance	Inhibited/manual return in case of primary supply restoration.	
Match continuity mode	Luminaires providing the 'match continuity mode' illuminance state must be provided with uninterruptible power, unless all fixtures are LED, in which case an interruption of 15 seconds is permissible. Minimum general illuminance in the stadium bowl of Eh 50 lux must be maintained at all times, even if fixtures are all LED and MCM fixtures are not provided with uninterruptible power. (see 4th bullet point above)	If MCM is necessary: MCM luminaires (as a minimum) must not be affected by power supply switching for more than 15 seconds. Non-MCM luminaires must regain full illuminance levels within 15 minutes of a supply failure and switchover.
Power for lighting control	Lighting control equipment must also be provided with uninterruptable Venue Technical Power (A+)	

1.64. FIFA floodlight power supply (FPS) standard D

Delayed restoration:

- Venue Technical Power (A) to all luminaires, or match continuity mode illuminance as a minimum.
- Venue Domestic Power (B) to remaining illuminance.
- Potential match disruption for a maximum period of 15 minutes.

Note: Further details about Venue Technical Power and other terminology may be seen on page 69.

	Description	Capability / Arrangement
Primary power supply	May be local (e.g. on-site generator) or non-local (e.g. utility/grid power). Normally expected to be utility power, with medium/low-voltage transformer(s) dedicated to the stadium.	Capable of supporting all connected loads, including 100% of floodlights.
Secondary power supply	Independent to the Primary power supply. If the second feed proposed is non-local, acceptance will be at FIFA's sole discretion on the basis of a comprehensive utility power study demonstrating high-quality, protected and independent medium and high voltage feeder lines. In the case of Grade 1 (FIFA World Cup™) training sites, the second feed must be a local generator.	Depending on the anticipated broadcast reach of the tournament, at FIFA's discretion, the secondary supply may be required to be local and synchronous with the primary supply (or supplemented by UPS). In the case of Grade 1 (FIFA World Cup™) training sites, the second feed of 'A Power' must either be synchronous with the primary supply, or else supplemented by an uninterruptible power supply (UPS) device in order to provide 'ride-through' of switching disruption.
Switching in case of failure or disturbance	Automatic switching, or a defined switching and operations procedure approved by FIFA (at FIFA's sole discretion).	Switch time to be less than 5 minutes.
Switching in case of subsequent disturbance	Inhibited/manual return in case of primary supply restoration.	
Power for lighting control	Lighting control must be provided with a small UPS, if a power outage could result in a prolonged disturbance to the pitch illuminance.	

1.65. FIFA power terminology

Power types and requirements are more fully defined within the respective hosting and stadium requirements of each FIFA tournament.

Electrical system arrangement and topology options for achieving FIFA's power requirements vary significantly for each tournament, and depend heavily on the arrangement and condition of existing electrical infrastructure. Prospective and selected hosts can obtain the power requirements for each FIFA tournament by contacting the FIFA Technical Services team. Power definitions and requirements as stated in hosting requirements and stadium requirements supersede these definition for prospective and appointed FIFA tournament hosts..

However, for guidance purposes, the following terms referenced in this document generally mean the following:

Power type	Short name	Short description
Uninterrupted venue technical Power	**A+**	Has at least one layer of local (on-venue) redundancy, and furthermore will experience no outage or interruption whatsoever in the event of a power supply failure or switching
Venue technical power	**A**	Has at least one layer of local (on-venue) supply redundancy. It is capable of supporting all venue technical loads, in the event of failure of or interruption to the primary source. Switching to local redundant sources must be complete within one minute in the event of source failure or interruption.
Venue domestic power	**B**	Is the stadium's normal match day power supply, which is normally expected to be good-quality and reliable utility power. Local (generator) redundancy is not normally expected as a minimum requirement, unless the quality and reliability of the primary source are assessed as posing an unacceptable risk to match continuity.

Stadium entertainment lighting

This section contains a set of recommendations that have been developed in response to the many requests that FIFA has received to provide detailed practical and technical advice with regard to the practice in using the pitch floodlighting system to provide entertainment effects before a FIFA football match.

The information provided in this section should only be used for the purpose of pre-match lighting effects and must not be used in any way that may affect the match illuminance conditions that are clearly specified in this guide.

In recent years there has been a substantial change to the technical attributes of some pitch illuminance systems. In the past the traditional light source of the illuminance system would be a HID (high-intensity discharge) lamp. A HID light source will not permit the instantaneous control that is required to produce a light show within a stadium environment. However, in recent years, some stadium pitch illuminance systems have been installed using LED luminaires which generally allow for a comprehensive element of control, which enables effective light shows to be designed whilst importantly ensuring that the match illuminance conditions will not be compromised.

The aim of these recommendations is to provide the essential framework to ensure stadium managers, TV broadcasters and FIFA event directors are all fully informed about the best practice to ensure a successful and therefore successfully implement the light show.

In order to provide clear and concise information to the relevant parties, these guidelines should be considered and applied throughout the process of designing and operating a stadium light show using the pitch illuminance system.

1.66. Light shows

Lighting design for light shows

The lighting design may be based upon a specific theme that is associated with the stadium or event. Clearly, the quality of the design will be subjective; however the stadium management team should understand that a successful design will provide a visual experience that is enjoyed by and beneficial to all viewers. The primary objective of the design should be to entertain the stadium spectators; secondary to this, a good design will also provide opportunities for the broadcasters to use the light show within the television production.

Communications for the event production schedule

It is essential that good communications be available between the stadium management, the event production director and in some cases the TV and audio broadcasters to ensure any potential disruption is reduced to a minimum and acceptable level.

A detailed production 'running order' must be provided to the FIFA match director well in advance of each match.

Lighting design viewing positions

In order to maximise the visual experience that may be delivered by the light show it is important for the designer to consider spectator viewing positions and broadcast camera positions at locations all around the stadium.

Light disruption to broadcasters

Where possible, any disruption caused by unexpected changes to illuminance levels within the stadium should be reduced to ensure production quality is maintained to a high level. If broadcasters are informed sufficiently, they should be able to ensure the changes to the stadium illuminance conditions will not impact adversely upon their own production.

Tribune illuminance for Broadcasters

It is important to provide a sufficient level of illuminance on the tribunes to allow for the correct camera exposure of TV broadcast pictures. If the tribunes are too dark to allow for the important 'fan reaction' camera shots to be exposed correctly the whole essence of the pre-match celebration is diminished and will be perceived poorly. The tribune seating areas must receive a constant illuminance level of no less than 100 lux on the vertical plane facing towards the pitch centre. The illuminance on the tribune areas should not drop below this level (too dark) even for a fraction of time because the camera exposure and broadcast pictures would be negatively affected.

1.67. Schedule

Duration of light show

It is essential that the light show be rehearsed with an exact time sequence and duration that may be used in the 'event production schedule'. It is generally considered that the light show should last no longer than 3 minutes. In practice, a duration of 30-60 seconds is seen as sufficient in most cases.

Light show options

There are two separate opportunities to conduct a light show prior to a match. Light shows may be held in either or both of these windows. For various reasons the event production schedule may need to be altered, sometimes at very short notice. The controllers of the light show must be able to accommodate changes to the event schedule.

Pre-warm-up

The pre-warm-up light show may be used until immediately before the players warm-up starts. Once any players (including goalkeepers) have exited on to the pitch to begin their warm-up, the floodlights must be at match conditions.

Post-warm-up and prior to player walk-on

The post warm-up light show may run anytime from the end of the player warm-up once the players have exited the pitch, but must be completed immediately prior to the players exiting the tunnel in preparation for the line-up. (This means that when the light show and club music finish, the match lighting conditions must be reinstated to 100% in conjunction with the playing of the competition walk-on music. The players must commence the walk-on from the tunnel within 10 seconds of the lights fading up to match conditions.)

Throughout any post-warm-up light show, the FIFA competition emblem must be sufficiently illuminated to be clearly observed by spectators and exposed correctly on broadcast camera pictures – in particular, for club competitions, this means that the centre-circle banner must be illuminated to be prominent at all times throughout the light show. The illuminance on the centre circle should remain constant and not flash on and off. The pitch should be illuminated equally on each side throughout the pre-match entertainment lighting period.

The stadium pitch illuminance system must be operating at full match conditions before the players exit the tunnel.

Half-time illuminance conditions

The pitch illuminance conditions may not be changed during the half-time period. The pitch illuminance system should operate at match conditions without any disruption.

Match illuminance conditions

The pitch illuminance conditions may not be changed at any stage during the match. After the player walk-on (noted above in 20.2), the pitch illuminance system must operate continuously at match illuminance conditions.

1.68. Light, sound and control

Light and Sound

In most cases, the light show will also be accompanied by an audio track. The audio track may also be required in the appropriate format by the television and radio broadcasters. The various parties should communicate to establish the preferred audio format and how it may be supplied to the broadcaster.

Sound disruption to broadcasters

Where possible any disruption to the broadcasters should be reduced. In specific broadcast locations such as television studios the external sound should be baffled to reduce noise interference.

Lighting control

The light show should be programmed and stored upon a suitable light controller. This is generally a DMX lighting console. The lighting console operator must be experienced and competent in the requirements to operate the light show effectively.

System override switch

At all times, a system override switch must be available to reinstate full match lighting conditions in the stadium. The system override switch must take precedence over all other light settings.

System switch-on

On completion of the light show and when the pitch illuminance system is switched back on after operating at 0%, it is recommended that a fade-in time from 0% to 100% be programed with a duration of 5-10 seconds. This will provide a greater comfort to the stadium spectators as full illuminance conditions are re-instated. The gradual fade-in time from 0% to 100% will also be beneficial to maintain good camera exposure for broadcasters by providing a smooth transition from low to high illuminance.

1.69. Broadcast requirements

Engineering requirements

The television broadcasters will require sufficient information about the light show to ensure they are prepared for the changes to the illuminance conditions within the stadium. This will allow the broadcasters to prepare the correct camera shots and camera exposure to ensure the optimum visual experience is captured on camera with good-quality images that are correctly exposed.

To ensure an acceptable level of exposure may be achieved for TV broadcast pictures, the tribune seating areas must receive a constant illuminance level of no less than 100 lux on the vertical plane facing towards the pitch centre. The illuminance level on the tribune areas should not drop below this level (too dark) even for a fraction of time because the camera exposure and broadcast pictures would be negatively affected.

Light show rehearsal

Should a request for the use of the stadium floodlights for entertainment in either of the above mentioned windows be approved by FIFA a full rehearsal of the light show must be conducted on MD-1 to provide the broadcaster the necessary opportunity to prepare and rehearse for the change in illuminance conditions. Ideally the rehearsal should be completed with the same ambient light conditions as those of the allotted time in the event production schedule.

LED board pitch displays

If it is expected that during the light show the average ambient light level will be significantly lower than normal operating conditions, it may be necessary to adjust the LED display intensity to a lower level during the light show to ensure the optimum exposure of the display on broadcast pictures.

Prior to the player walk-on it is essential that the FIFA agreed display content be used continuously on the LED advertising displays around the pitch for 120 seconds or more.

It will be necessary for the LED board operator to be made fully aware of this requirement well in advance of the tournament in order to properly plan any necessary adjustments to the LED intensity levels. During the light show rehearsal all relevant parties should establish the correct operating conditions which may be used for the live event.

1.70. Health and safety requirements

Emergency and escape lighting

During the period of the light show it is essential that spectators, employees and other people at the stadium are able to safely move within the stadium facilities. All emergency and escape lighting must remain active.

Stadium safety lighting

The stadium must provide a safe environment for spectators, employees and other people at all times. During a light show the ambient light level within the stadium may be low; however it is important that the illuminance conditions do not hinder the safe movement of people within the stadium at any time.

Light show warning

It is good practice to provide three audio and if possible visual (on large LED screens) warnings that there will be a change to the normal stadium illuminance conditions at the pre-determined time. The pre-warning will reassure the spectators that they are in a safe and orderly environment.

Stroboscopic lighting effects

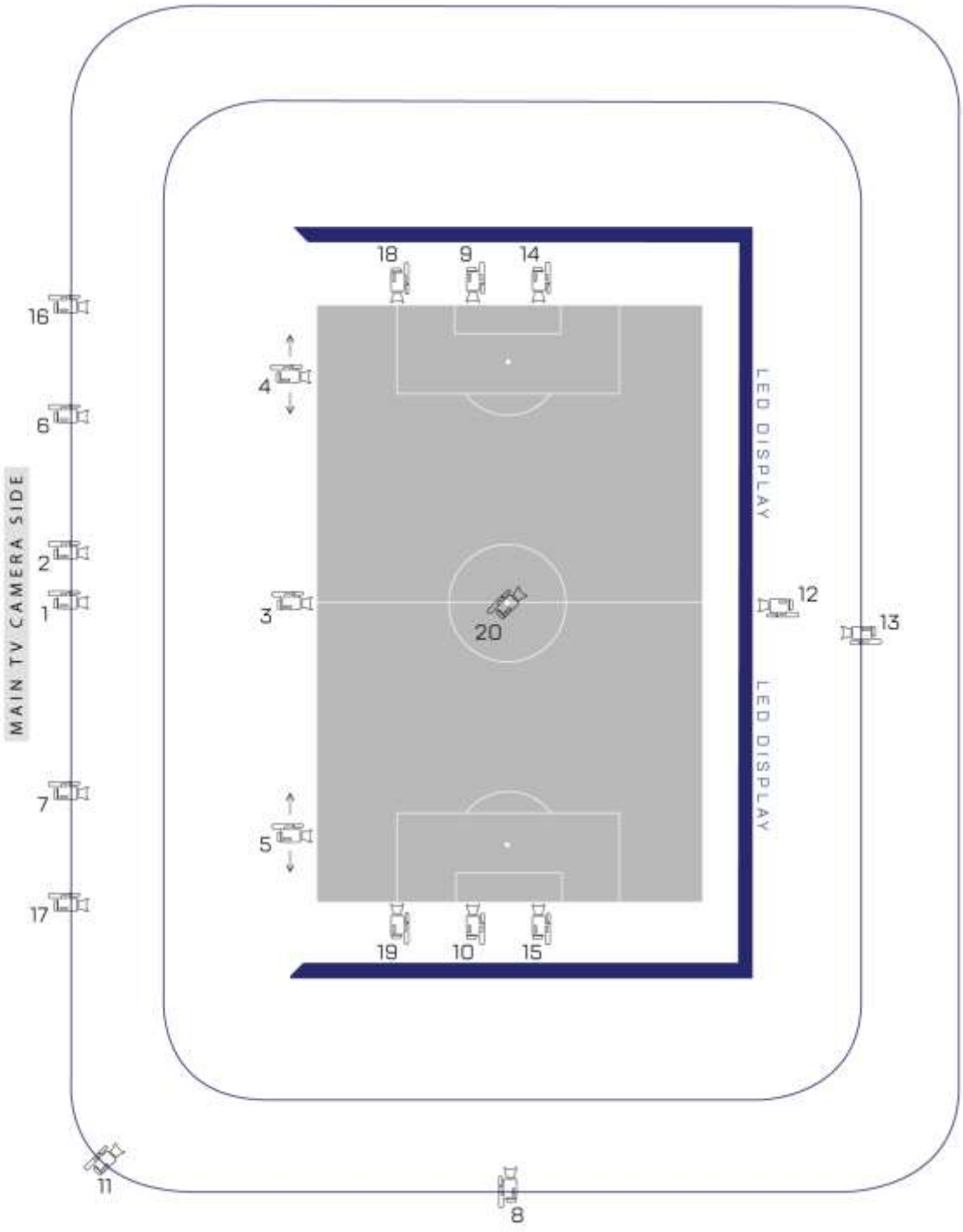
The use of stroboscopic lighting effects is not recommended within a stadium due the large spectator numbers and potential to cause a harmful reaction to people who may be sensitive or susceptible to a seizure triggered by photosensitive epilepsy. If the stadium management is unsure about the exact nature and relevance of this concern and the light show contains a sequence of flashing images a series of warning signs should be provided to inform all spectators and employees at the stadium. The warning signs must clearly state that 'flashing images and light will be used in pre- and post-match stadium production lighting'.

Television broadcasters should also be informed as they may also with to give suitable warnings to their audiences if the light show will be used within the TV production.

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.

FIFA TV productions always include cameras on all 4 sides of the pitch. Tournament-specific example camera plans can be provided upon request to appointed and prospective FIFA tournament hosts.



1.71. Camera plan key

The above camera plan is fairly typical, but will vary per tournament, and even possibly per stadium. It is provided for guidance purposes and to aid understanding of how the different elements of the lighting design should be used to ensure the correct illuminance conditions in all areas of the pitch, and for all likely camera positions.

Key to camera plan:

1	MAIN CAMERA
2	CLOSE-UP CAMERA
3	PITCHSIDE HALFWAY CAMERA
4-5	STEADICAMS
6-7	22-YARD CAMERAS
8	HIGH-BEHIND-GOAL CAMERA
9-10	LOW-BEHIND-GOAL CAMERA
11	BEAUTY SHOT CAMERA
12-13	REVERSE-ANGLE CAMERAS
14-15	MINI-CAMERAS
16-17	GOAL-LINE CAMERAS
18-19	HOT-HEAD CAMERAS
20	CABLE CAMERA

Camera numbers and exact positions may be different and will be determined by FIFA's host broadcaster. The above plan should be used as a guide only.

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

Environmental guidance

A number of bodies that provide certification for buildings which are designed and constructed in line with strict sustainability guidelines. The include BREEAM (mainly present in Europe) and LEED (mainly present in the US). Both of those 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.

FIFA recommends that all stadiums adhere to the standards stipulated by one of these two certification bodies as much as is possible, in order to limit negative environmental impacts.

However, it is ultimately down to stadium developers and owners 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 their design consultants and contractors accordingly.

1.72. 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 at 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.

1.73. 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.

Glossary of terms

Term	Definition / Description
E	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 0° / 90° / 180° 270°	The illuminance on the respective 0° or 90° o 180° or 270° vertical plane , for the specified reference test point 1.0m above the pitch surface, measured in lux.
Ev 0° / 90° / 180° 270° ave	The average illuminance on the respective 0° or 90° o 180° or 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° / 90° / 180° 270° max	The maximum illuminance on the 0° or 90° o 180° or 270° vertical plane for the specified reference test points 1.0m above the pitch surface, measured in lux.
Ev 0° / 90° / 180° 270° min	The minimum illuminance on the respective 0° or 90° o 180° or 270° 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 as measured 1.0m above the pitch surface, in lux. (Note: this metric does not apply to FIFA's grass-based tournaments)
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 Re to 100 Re.
Ra	The general version of assessing colour rendering of a specific value given to a light source to indicate the level and quality of colour rendering index (CRI) on a scale of 0 Ra to 100 Ra. Ra is calculated as the average value of the pre-defined colour samples R1 through R8.
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 0 Re to 100 Re. Re is calculated as the average value of the pre-defined colour samples R1 through R15.
Tc	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.
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.
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 (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 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 5.
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 FIFA lighting standard.
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.
Reverse (camera) side	This indicates the opposite plane, and opposite side of the stadium to main camera side. Reverse camera side is also referred to as the 90° plane.
Left goal side	This indicates the plane of the camera located behind the goal which is to the left of the main camera side/position (when facing the pitch).
Right goal side	This indicates the plane of the camera located behind the goal which is to the right of the main camera side/position (when facing the pitch).