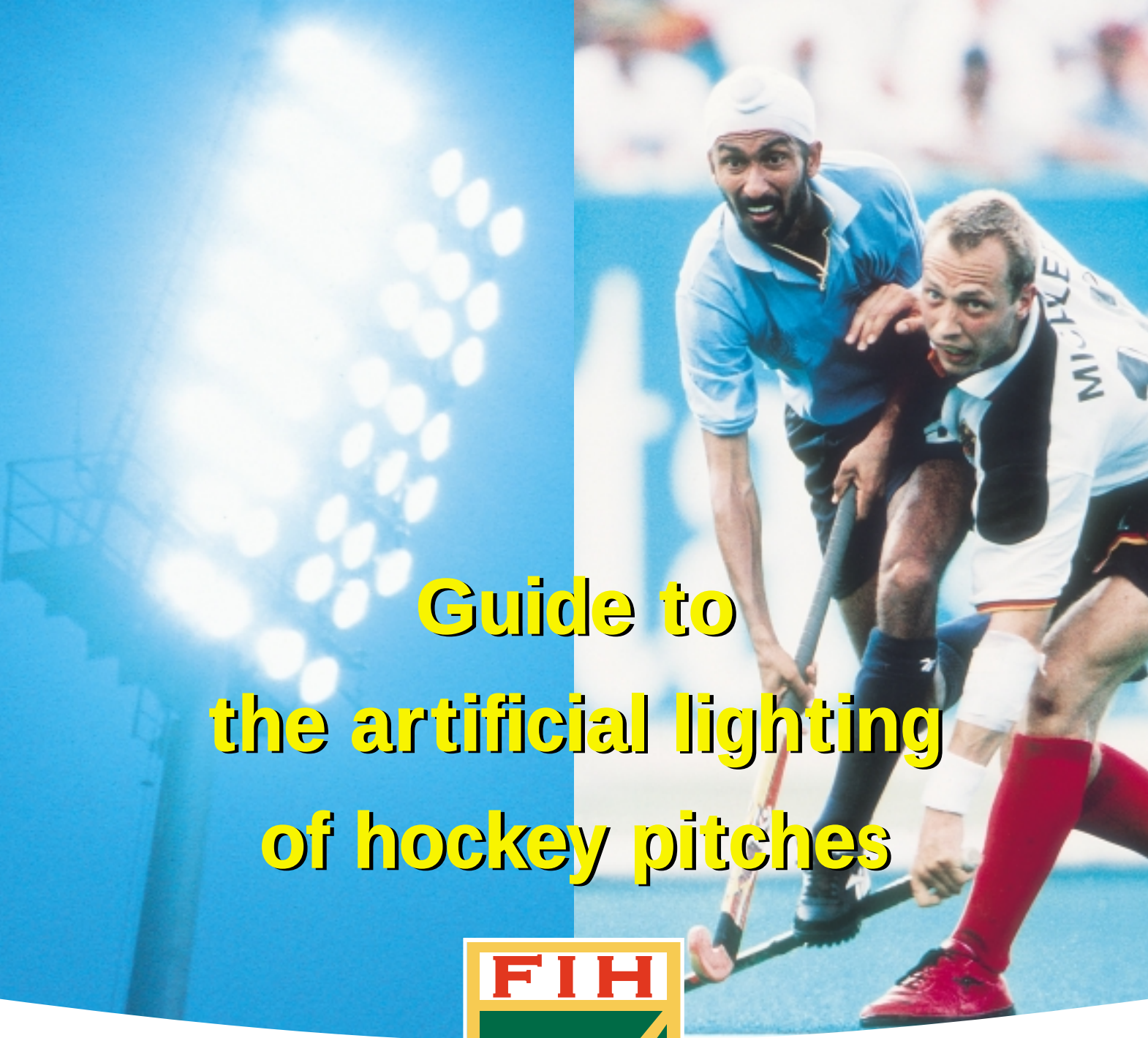

Guide to the artificial lighting of hockey pitches

INTERNATIONAL HOCKEY FEDERATION

fourth edition

This publication is the result of joint co-operation between the FIH and Philips Lighting B.V.

APPROVED BY THE COUNCIL
OF THE INTERNATIONAL HOCKEY FEDERATION (FIH)
For the guidance of FIH officials, Member Associations, technical consultants,
and hockey pitch proprietors generally.

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1 Introduction

The installation of synthetic hockey pitches around the world is increasing at a rapidly growing rate. The best current estimates put the number of pitches available to hockey in 2000 at over 2000 in about 65 different countries. The most recent estimate of the increase is over 100 pitches per annum and that represents a very considerable investment by the hockey community each year. Many hockey organizations are realising that if they can solve the problem of the actual capital outlay and take good care of their investments they have a wonderful income generator in their hands. The pitch can be used for hockey and for other compatible activities seven days a week and up to 12 hours each day if the demand is there. Many of those 12 hours are hours of darkness and this is where the importance of pitch lighting is to be found. Because of the boost it gives to the earning potential of the pitch, these days a comprehensive artificial lighting system is almost an automatic adjunct to a new pitch installation. In addition, new or better lighting systems are being installed on older pitches in order to enhance their revenue potential.

This has brought in its train an appreciation at the level of international competition that tournament programmes can be varied to take advantage of the best climatic circumstances by holding matches under top class lighting conditions. The availability of such lighting also provides a guarantee for tournament sponsors that TV coverage will not suffer because of deteriorated natural light and that playing programmes can be tailored to suit TV audience demands.

For all these reasons FIH has decided that a document specifying the minimum lighting requirements for international competition is needed and that the same document can be of assistance to hockey organizations processing and contemplating the installation of pitch lighting for whatever purpose. What follows in this document will satisfy these needs.

The lay reader should not be dismayed by the technicalities in Sections 3 and 4. If they convey the message that pitch lighting is a little more complex than erecting a few masts and mounting some floodlights on top then they have served their purpose.
This information is more for the benefit of the engineer you should employ to design your lighting system as well as for the ultimate installer.
On the occasion of this fourth edition we want to pay tribute to the technical cooperation and financial support of Philips Lighting.

Equipment Committee FIH
April 2000

2 User requirements

The users of hockey facilities can be distinguished according to their activities:

- the players and umpires;
- the tournament directors, technical officers, judges and the team officials;
- the spectators entering, watching the game, leaving the sports facility;
- the television or film crew broadcasting and recording the action.

Players, umpires and match officials must be able to see clearly all that is going on in the playing area so that they can produce their best possible performance.
Spectators should be able to follow the performances of the players and the action of the game in an agreeable environment. The latter requirements means that they must be able to see the pitch and its immediate surroundings as well. The lighting should also help the spectators to safely enter and leave the sports facility. With large crowds this safety aspect is very important.
Finally, for television and/or film coverage, the lighting should provide the conditions necessary to guarantee good colour picture quality. Not only for pictures of the game, but also close-ups of the players and spectators.

For the purpose of considering the essential elements of good artificial lighting, hockey activities can be grouped as follows:

- non-competitive including physical training;
- ball-training as well as junior and low grade club competitions;
- high grade national club and international competitions;
- Wide screen TV and film coverage.

3 Lighting criteria

Knowing the general user requirements it is possible to say what the lighting criteria should be to satisfy each of these activities. The purpose of this section therefore is to identify these lighting criteria and, wherever possible, to derive the lighting parameter or parameters of interest in each case. A summary of minimum values is given (in Annex 1, page 22) for various situations. These minimum values are for clear atmospheric conditions and if these are not attained before or during the progress of a match a decision as to commencement or continuation will need to be made by the appropriate official. The recommended average illuminances as discussed below refer to outdoor installations.
As far as television and film coverage are concerned, a picture quality sufficiently high for both the action on the field and close-ups of players, umpires, officials and spectators has to be provided.
For indoor hockey different requirements apply; however, these venues will normally, as far as applicable for television and film coverage, be found in multi-purpose halls, where each sport has its own lighting requirements.

3.1 Horizontal illuminance

As the illuminated field forms a major part of the field of view of both the players and spectators, it is the illuminance on this horizontal plane at ground level, commonly called horizontal illuminance (Eh), that chiefly serves to establish the adaptation state of the eye.
Because of this, and because the illuminated field serves for the players, spectators and cameras as a visual background, an adequate horizontal illuminance on the pitch is important. To ensure safety of movement for the spectators when entering and leaving the stands or surrounds, adequate horizontal illuminance in these areas is also required.

3.2 Vertical illuminance

Illuminance on a vertical plane, commonly called vertical illuminance (Ev), is essential for viewing vertical objects. The side of a player that can be seen by an observer can be approximated by a vertical plane at right angles to the observer's line of view. The scene illuminance, and more particularly the vertical illuminance, has a major influence on the quality of the final television picture.
To guarantee a satisfactory identification of players from all directions, specified illuminances on a minimum of four mutually perpendicular vertical planes are required.
For this purpose, the vertical planes facing the two sidelines and two backlines of the playing area are usually taken. In practice, the vertical illuminances required for players and spectators will usually be obtained if the requirements regarding the horizontal illuminance are fulfilled.

Vertical illuminances need only to be listed as a design criterion when (Wide screen)TV and/or filming is considered.
For television or filming with fixed camera positions, it is sufficient to ensure that the illuminances on vertical planes, at right angles to the camera position(s), are adequate in order to obtain acceptable picture quality.

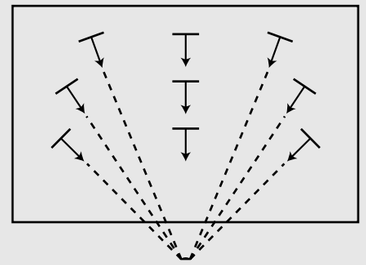

Figure 1:
Vertical planes at each grid point for a (fixed) camera position*

Apart from the requirements for (Wide screen)TV/film coverage, the illuminances on a vertical plane also have to guarantee that a ball in flight can be followed at any time and at the relevant height above the pitch by both the players and spectators.
Stands and spectators form part of the visual environment for all cameras involved, so an adequate vertical illuminance must be required here too. It is usually specified as a fraction of the average vertical illuminance on the field.

*number of grid points given is only for illustrative purposes

3.3 Uniformity

Good illuminance uniformity in both the horizontal and vertical planes is important in order to avoid, on the one hand, adaptation problems for players and spectators, and, on the other hand, adjustment problems for cameras, for different directions of view. If the uniformity is not good enough, there is a certain risk (especially with television cameras) that the ball or a player will not be clearly seen at certain positions on the field.
Uniformity can be expressed as the ratio of the lowest to the highest illuminance (U_1) and as the ratio of the lowest to the average illuminance (U_2). Also the ratio of uniformity of the illuminances at a single grid point over the four vertical planes facing the sides of the playing area should be considered.
Even when the illuminance ratios are acceptable, changes in illuminance can be disturbing if they occur over too short a distance. This problem is most likely to occur when panning a television or film camera to cover a rapid action sport. Therefore, the illuminance uniformity for (Wide screen)TV/film coverage at a certain grid point has to be expressed as a percentage change from the average illuminance in the eight adjacent grid points. This is commonly called the uniformity gradient.
To obtain a good visual condition between the players and the background, there should be (especially for cameras) a specified relation between the horizontal and the vertical illuminances.

3.4 Glare restriction and spill light

Glare has a disturbing effect on the visual comfort of both the players and spectators. Discomfort and disability glare can be minimised by paying careful attention to the siting, aiming and selection of floodlights relative to the main directions of view. When using compact light sources, disability glare can occur. The calculation for glare rating (GR) has to be made as stated in report No. 83 and No. 112 of the Commission Internationale de l'Eclairage (CIE) (see also section 4.4).
So far, glare has only been considered for the players and spectators on or very close to the lighted area. However, stray light also called spill light, from outdoor lighting installations can also be disturbing to people outside the lighted area, for example for traffic on adjacent roads and for inhabitants of houses in the neighbourhood of hockey pitches.
The parameter to quantify the degree of the disturbing effect of stray light is under preparation by the CIE and CEN; however, it is directly related to the optical qualities of the selected floodlights. In general, it can be said that floodlights, which can be installed with the front glass horizontally, will produce less stray light and will easily meet the new requirements for spill light.
In order to limit this problem, floodlights should not only be selected on the basis of their limited stray light outside the main beam, but they should also be properly arranged and aimed.

Lighting criteria 3

Modelling and shadows 3.5

Modelling is the ability of lighting to reveal form and texture. This "modelling" ability is particularly important to provide a pleasant overall impression of players, the ball and the spectators on and around the pitch. The quality of television pictures is directly influenced by good modelling. The design of the lighting for hockey pitches, based on two or more light points at intervals along each sideline and giving light from several directions, provides an appreciable degree of modelling.
The arrangement of the luminaires also determines the possible length and hardness of the shadows caused by the players.
To limit the length and the hardness of the shadows caused by the players, the ratio between the total flux installed, in case of an asymmetrical floodlight arrangement, should be ≤ 60% for the main camera side and, consequently, ≥ 40% for the opposite side.

Colour and colour properties of lamps 3.6

Colour perception is important in most sports, and while some colour distortion attributable to the artificial lighting is acceptable, there should not be a problem of colour discrimination (possibly between partly distorted colours). Two important aspects of the colour properties of lamps have to be distinguished:

- The colour appearance of the light. This is the colour impression of the total environment created by the lamp.
- The colour rendering of the light. This is the ability of the light to reproduce the colours of an object faithfully.

Both the colour appearance and the colour rendering of lamps are fully dependent upon the spectral energy distribution of the light they emit.
An indication of the colour appearance of a lamp can be obtained from its correlated colour temperature, T_k, which varies mainly between 2000 and 6000 K. The lower the colour temperature, the "warmer" the colour impression of the light; the higher the colour temperature, the "cooler" or more bluish the impression of the light.
The colour rendering properties of a light source can be indicated by the colour rendering index R_a. The theoretical maximum value of the colour rendering index is 100, which can be compared with a daylight situation.
The visual ambience of the environment depends considerably on the R_a. The higher the R_a, the more agreeable the environment.

3.7 Design

The lighting design should fulfil all the required lighting criteria, as indicated in Chapter 3 and specified in Chapter 4.
The required results of a lighting design should be obtained by performing the appropriate lighting calculations for which standard computer programs are available world-wide.
The area to be calculated, and which is the basis for calculating the E_h, E_v, U1, U2, the uniformity gradient, the GR, etc., should be divided into grid points with a (maximum) spacing of 5 by 5 meters, when a (Wide screen) TV installation is required. For the other levels of activity, without any (Wide screen) TV requirements, a calculation grid of 10 x 10 meters will also be acceptable. Spacing between the grid points and the back- and/or sidelines should always be limited to 2.5 meters. Grid points should be symmetrically divided over the playing area as indicated in Chapter 6, Figure 7.

Note:
The new European standard CEN norms regarding "Light & Sports Lighting" have been published (prEN 12193, final draft , April 1999). The theoritical calculation of grid points spacing is done with a generic formula which, when applied to hockey, results in grid spacing of 4.81 meters length and width. For practical reasons, this 4.81 meters value will be rounded up to 5.0 meters being the current FIH recommendation.

Horizontal illuminance 4.1

The recommended horizontal illuminance for the different user requirements is given in Table 1 below:

Activity	E_h
Non-competitive including physical training	200 lux
Ball-training, as well as junior and low grade club competitions	300 lux
High grade national club and international competitions	500 lux

Table 1:
Average (maintained) minimum horizontal illuminance (E_h) for field hockey, at ground level.

To guarantee the recommended average illuminances during the whole period of operation of an installation, the lighting level should, during use, never fall below the indicated value. Therefore, the recommended illuminances are "maintained" values. To arrive at "initial values" (100 h), these maintained values should be multiplied by a factor of at least 1.25.
To ensure that spectators can safely enter and leave the stands or surrounds, a certain minimum horizontal illuminance in these areas must be maintained. A value of 10 per cent of the average playing field illuminance will suffice, although for reasons of comfort a value of 20 per cent is preferred.

Vertical illuminance 4.2

It is important to note that the requirements placed on the vertical illuminance are those needed to give camera operators the full freedom which they need during the broadcasting of complete sports events. The recommended minimum vertical illuminances are given in Table 2 as a function of the maximum shooting distance for the camera at a level of 1.5 m above the playing area.

Camera shooting distance	Ev
≤ 75 meters	1000 lux
≤ 150 meters	1400 lux
Wide screen TV	2000 lux

Table 2:
Average (maintained) minimum vertical illuminance (Ev) at a height of 1.5 m above the playing area in the direction of the camera position.

Illuminance levels for other distances can be linearly interpolated. As also mentioned for the horizontal illuminances, the recommended values are "maintained" values. To arrive at "new values" the given maintained values should be multiplied by a factor of 1.25.

4.3 Uniformity

The recommended uniformity will be obtained when installed floodlights are properly aimed. The uniformity requirements for both the horizontal and the vertical illuminances are more stringent for colour television and filming than for the players and spectators. The human eye is more flexible than the sensitivity of cameras. It is principally the horizontal uniformity that determines the brightness range of the overall scene, so this has to satisfy the more stringent requirements.

Activity	$U1 = E_{min}/E_{max}$	$U2 = E_{min}/E_{av}$
1/ Non-competitive including physical training	0,5	0,7
2/ Ball training, as well as junior and low grade club competitions	0,5	0,7
3/ High grade national club and international competitions	0,5	0,7
4/ TV Horizontal	0,5	0,7
TV Vertical	0,4	0,6
5/ Wide screen TV Horizontal	0,7	0,8
Wide screen TV Vertical	0,6	0,7

Table 3.
Uniformity requirements

The ratio of the minimum and maximum illuminances at a single grid point over the four vertical planes, facing the sides of the playing area, should be ≥ 0.60.
In fast games, like hockey, the illuminance uniformity and the illuminance gradient should be such as to avoid problems when panning the camera. Illuminance gradients better than 25% per 5m are advisable.

For good picture quality it is very important that the luminance contrast between vertical objects and the horizontal background is limited. In order to guarantee this for the most common reflectances (viz. that of the playing field itself and of the players' clothing), the ratio of the average horizontal to the average vertical illuminance should, for the main camera, always be between 0.5 and 2.

Glare restriction and spill light 4.4

For hockey pitch lighting installations, the glare restriction (GR) is relevant, and should be in accordance with the GR values as given in publication number 83 and 112 of the CIE. The calculated GR value is also dependent upon the reflectance of the pitch. For pitches, a diffuse reflected value between 0.25 and 0.35 is usually a realistic value.
The maximum value of GR = 50, judged on a scale of 0 to 100, is termed “just admissible” and should be based on the given standard observer positions, at a height of 1.5 meters above the playing area, looking into the direction of the goal- and sidelines at ground level, as indicated in Figure 2.
The effect of stray light outside the venue has to be indicated by calculating the veiling luminance for the five positions (as indicated in Figure 2). The viewing direction for these five points is the centre of the playing area, at a level of 1.5 meters above the playing area. In some countries a maximum value for the veiling luminance has been defined by the national lighting organization or by the national standard organisation.
The parameter to quantify the degree of the disturbing effect of stray light is under preparation by the CIE and CEN

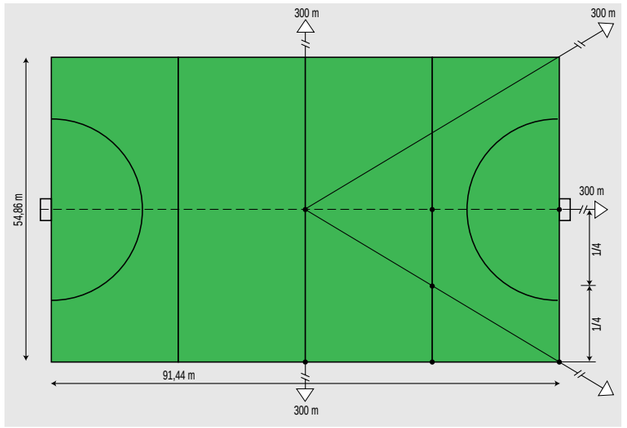

Figure 2:
Observer positions (•), at a height of 1.5 meters above the playing area, for calculating the GR and the reference positions (—//—▷) for calculating the veiling luminance outside the venue.

4.5 ..... Colour

The correlated colour temperature, except for (Wide screen) TV and film coverage, is a question of comfort only. The following table suggests minimum values for the colour rendering index R_a.

Activity	Ra
Non-competitive activities including physical training	20
Ball training, as well as junior club and low grade club competitions	65
High grade national club and international competitions	65
TV and film coverage	65 (90 preferred)
Wide screen TV	90

Table 4:
Minimum colour rendering Ra values

For (Wide screen) TV and film coverage, lamps with a correlated colour temperature in the range from 3000 to 7000 K give no matching (or colour balance) problems, provided the differences in the colour temperatures of the individual lamps are not too great. If the artificial lighting is to be used also in combination with daylight (during the transition from daylight to artificial lighting) the lamps should have correlated colour temperatures higher than 4000 K to avoid colour balance problems.

4.6 ..... Summary of recommended minimum lighting parameters and data to be enclosed with any offer

This summary of technical requirements has been added to these recommendations as Annex 1 page 22.
Whenever requesting designs for the artificial lighting of hockey pitches, the level of activity should - in addition, of course, to all other necessary information - be clearly stated.
The lighting designer/potential supplier and/or potential contractor always has to submit, at the earliest possible stage of a project, all data/parameters as discussed in this guide (per required individual level of activity). This is to enable the consultant, the hockey organization, pitch/venue owner and/or any other body, to organise a technical evaluation before entering into any negotiation phase.

Pole arrangement and mounting height ••••••••••••••••4.4

Around the marked playing area of the pitch there must be an obstacle-free overrun area which is 5 m. beyond the two backlines and 4 m. outside the two sidelines. It is absolutely not allowed to erect lighting masts within the overrun area.
For non-competitive activities, the recommended mounting height will be 15 m. A mounting height of at least 18 m is required for club competitions and ball training to avoid glare.
To avoid disturbing shadows for the goalkeeper, 8 or at least 6 masts must be used. The masts at the corner on the diagonal of the area behind the goal-line guarantee good illumination for the goalkeeper at corner shots (see Fig. 3a and 3b.)

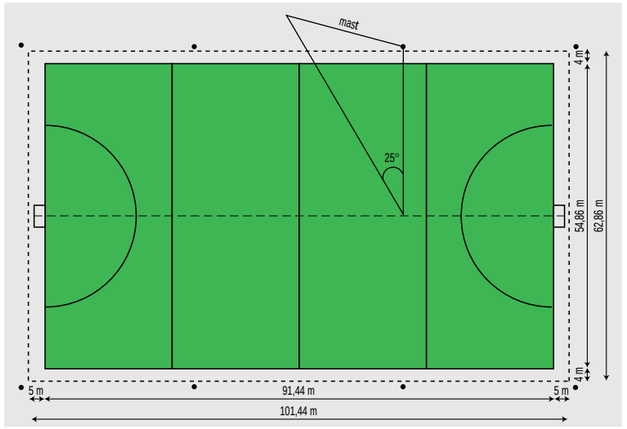

Figure 3a:
Pole arrangement for 8 masts

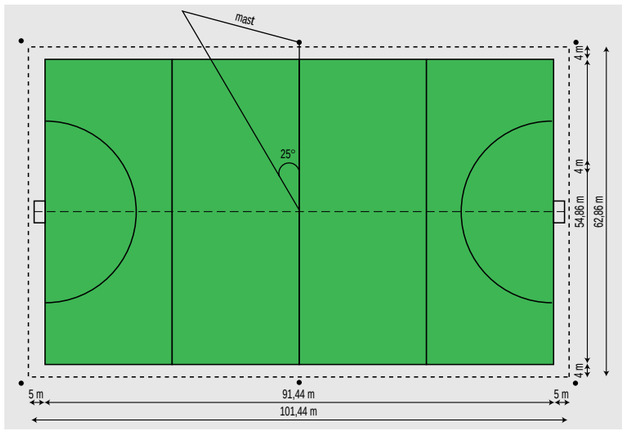

Figure 3b:
Pole arrangement for 6 masts

To avoid intolerable glare for the players, the aiming angle of the luminaires from any one of the masts should be limited.
If, it is not possible for competition purposes, to achieve masts with a height of 18 m, then the height of the masts must be chosen to ensure that the aiming angle from any one of the eight masts, measured from the top of the mast at right angles to the lengthwise centre line of the field. , should not be smaller than 25 degrees (see Fig. 3 and 4).
To avoid or minimise any visual interference to spectators the poles should either be placed to the rear of the spectator accommodation or fabricated with a minimal cross section dimension.
If the nature of the area beyond the backline/sideline is such that the mast has to be placed further from the line, than the height of the mast must be proportionally greater to achieve the 250. requirement (Fig. 4).

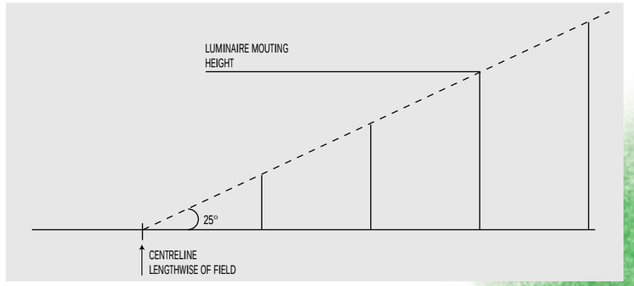

Figure 4.
Mast height as a function of the distance
to the lengthwise centreline of the pitch

For national and international competitions, basically two alternative lighting arrangements are suitable: side arrangement and four-corner arrangement.

Side arrangement. With this arrangement (Fig. 5), the luminaires are mounted either on columns or in rows parallel to the pitch sideline.

A side arrangement is preferred because the lighting solution in this way offers good uniformity of the vertical illuminance. For pitches with limited spectator accommodation, the column version of the side arrangement is recommended. With this arrangement, an acceptable uniformity is possible using relatively low columns or masts: costs are thereby kept to a minimum. To avoid the columns being obtrusive they should be placed behind the spectator accommodation or constructed with the smallest cross sectional dimension compatible with safety requirements.

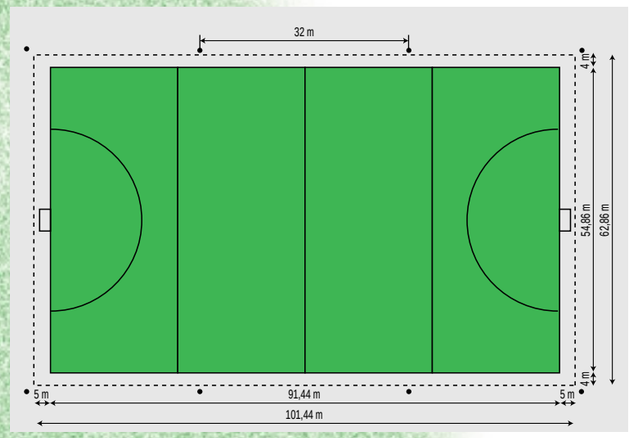

Figure 5:
Side arrangement

High-roofed stands may prohibit the use of column mounted side lighting. The alternative arrangement, with the luminaires mounted in rows on or above the stand roof, may then be employed. This arrangement offers both the best uniformity and the greatest freedom from shadow. The absence of costly masts may also lead to a more economic and attractive installation.

Four-corner arrangement. In this arrangement (Fig. 6), the luminaires are mounted on four columns or masts situated behind the four corners of the pitch.
The four-corner arrangement finds application in large stadiums where the a side arrangement solution is not feasible. Corner floodlighting, however, may give insufficient vertical illuminance in the centre areas of the sidelines. The need for supplementary lighting in these areas must, therefore, be considered.

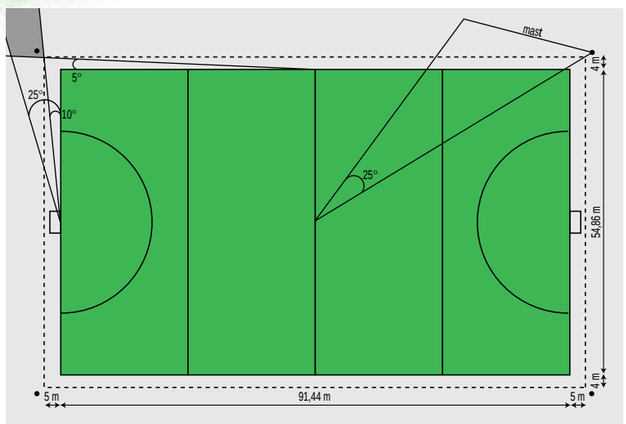

Figure 6:
Four-corner arrangement

To avoid intolerable glare for the players, the aiming angle of the luminaires from any one of the four masts should be limited. Therefore the height of the masts must be chosen to ensure that the angle from each of the four masts, measured from the top of the mast to the centre point of the field, should not be smaller then 25 degrees (see Figure 6).

A combination of the four-corner arrangement and the side arrangement can also be used to advantage. The floodlights used in the side arrangement are then used to create the vertical illuminance in the areas close to the sidelines, while the lesser number of floodlights now needed on the masts are used to create the vertical illuminances at the opposite areas of the field.
As the mounting height decreases so the danger of glare and the length of the shadows cast by the players increases. The cost of the columns, on the other hand, decreases with the decrease in mounting height, and low-column lighting gives a more favourable vertical illuminance.
High columns are not only expensive, they also give a less favourable relationship between the vertical and the horizontal illuminance. Advantages of using high columns are that they restrict glare and cast shorter shadows.
Whatever the type of floodlight used, it is desirable that the angles subtended at the lengthwise centreline of the pitch between the horizontal and the lowest point of each floodlight battery be at least 25 degrees (Fig. 4).

5.2 Examples

It is not possible to draw diagrams that can be used at all times and in all places for lighting installations. Stands and/or other obstacles can require adaptations of the lighting installation. Figures 3a, 3b, 4, 5 and 6 are only intended, therefore, as examples which in practice require adaptation according to the specific circumstances of the project. In view of continuing technological developments it is always advisable to consult recent technical documentation when designing installations.

General 6.1

To prove the indicated values of the supplied computer calculations used, illuminance measurements should be made upon completion of any artificial lighting installation. If a field-test to FIH standards is to be carried out by a FIH accredited laboratory officer, this will normally include an assessment of the lighting levels provided. The address of the laboratories accredited by the FIH can be obtained from FIH office in Brussels.

The basic document illustrating the artificial lighting needs for all levels of hockey activity is this “Guide to the artificial lighting of hockey pitches”, issued by the FIH in 2000 (fourth edition).

Measurements of the lighting levels should be carried out using an approved and recently calibrated luxmeter (available, for example, from L.M.T. Lichtmesstechnik GmbH in Berlin or Minolta Camera Co. Ltd. Japan). The procedures to be followed are those set down below, in Chapter 6.2, and should be carried out at least 30 minutes after switching on the floodlights. When measuring different switching steps, care should be taken that the measurement is made with the lamps at full output.

Voltage values, weather conditions, the accuracy of the measuring equipment, etc. can result in possible deviations between measured and calculated values.

If a field test has been authorised by the FIH or is undertaken to obtain an FIH certificate of compliance, it must be carried out by a FIH accredited test laboratory and reported on the appropriate FIH test report form. Alternatively, the test report form in Annex 2 may be used either to supplement the FIH form or to report upon an artificial lighting assessment carried out in other circumstances.

Measuring procedure 6.2

The first part of an assessment of the artificial lighting installation involves a description of the physical installation:

- **a:** The number, height and location of the masts;
- **b:** The number and type of floodlights on each mast, including their current state of efficiency;
- **c:** The sources and nature of the primary (and, if any, secondary) power supply;
- **d:** The connection and switching arrangements, including level and segment selections;
- **e:** The nature of any local lighting restrictions arising from power supply or neighbourhood disturbance; and
- **f:** The nature of the main (incoming) power supply in terms of voltage level and stability (i.e. at least before and after measurement of the illumination level) should be determined per phase.

The use of a 5 x 5 m measuring grid, as shown in Figure 7, is the preferred and the best method. These grid points have certainly to be used when the installation is designed to (Wide screen) TV requirements. For the other levels of activity, without any (Wide screen) TV requirements, a measuring grid of 10 x 10 m, as also shown in Figure 7, will be acceptable.

If the measured lighting results are not in conformity with the parameters of the above-mentioned FIH guide and the data received from the contractor, an additional voltage measurement both at each ballast and at each lamp should be carried out.

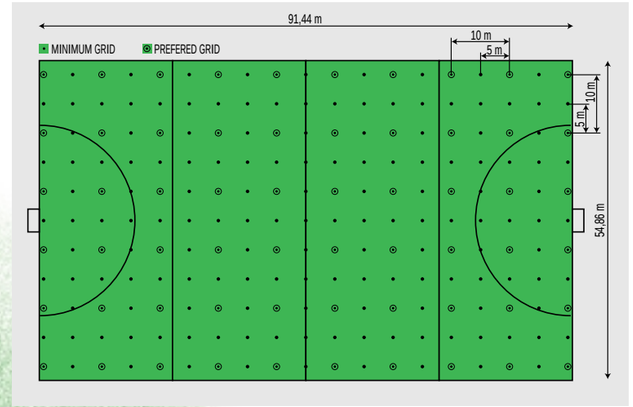

Figure 7:
The grid points for the preferred (•)
and the acceptable minimum number
of grid points (⊙)

Light depreciation and maintenance • • • • • • • • • • • • • • • • • • • 7.1

The electro-technical installation of a lighting system has to be consistent and in accordance with the electricity supply company's conditions with regard to connections. Regular maintenance is necessary to ensure that the installation continues to meet the design specifications as efficiently and economically as possible. Maintenance of lamps and luminaires should be carried out at least once a year and at the latest when the average illuminance has fallen to the average specified minimum illuminance.
Maintenance comprises the regular replacement of lamps and other components with a limited service life, as well as the timely replacement of worn or damaged parts. Maintenance contributes, moreover, to efficient energy consumption and prevents unnecessary costs. Lamps can be replaced individually or all the lamps in an installation can be replaced at the same time, i.e. group replacement. Apart from lamps which fail at an early stage, it is best to replace all the lamps at the same time. This prevents large differences in luminous flux between old and new lamps.
Individual lamp replacement is necessary if the contribution of the light source in question is indispensable. This applies to outdoor installations with a small number of lamps and to emergency and safety lighting.

Maintenance of the lighting installation must be taken into account as early as the design stage. Provisions should be made to ensure that the luminaires are easily and cheaply accessible for maintenance and lamp replacement.
Outside it is often difficult to approach the lighting masts with mobile equipment because, often, they are fenced off or surrounded by trees and/or shrubs. It is therefore recommended that means should be provided on the masts themselves, in the form of rungs, to make the luminaires easily accessible for the necessary maintenance.

Care should be taken when replacing lamps that the luminaires are fitted with the right type of lamp The electrical installation should be checked and any parts which are missing or damaged should be replaced with new materials. The luminaires should be checked for correct alignment.

7.2 • Initial and operating costs

Both the quantity and the quality of the lighting are decisive factors in choosing a lighting system. When, however, systems are compared which are equivalent in lighting engineering terms, a cost analysis may make the choice considerably easier. In making such an analysis it is necessary to assess not only the initial cost but also the anticipated operating costs, among other reasons because energy costs usually play an important role in the economics of a hockey pitch installation.

The following data are required for making a cost analysis:

- the number and type of luminaires required;
- the price of the luminaire;
- the number and type of the lamps required;
- the price of the lamp;
- the power consumption per luminaire, including power losses in the ballast;
- the electricity rates;
- the anticipated service life or useful life of the lamp;
- the number of operating hours per year of the lighting;
- financing in connection with depreciation;
- the price of the lighting system.

Annex 1

Summary of recommended minimum lighting parameters for hoc-key pitches:

Activity	E_h init. lux	E_h maint. lux	E_v init. lux	E_v maint. lux	horizontal		vertical		GR max.	R_a min	T_k
					U_1	U_2	U_1	U_1			
Non-competitive including physical training	250	200	-	-	0.5	0.7	-	-	50	20	2000
Ball training, as xell as junior and low grade clubs competitions	375	300	-	-	0.5	0.7	-	-	50	65	4000
Hight grade national club and international competition	625	500	-	-	0.5	0.7	-	-	50	65	4000
CTV ≥ 75 m	-	-	1250	1000	0.5	0.7	0.4	0.6	50	65(90)	4000/5000
CTV ≥ 150 m	-	-	1700	1400	0.5	0.7	0.4	0.6	50	65(90)	4000/5000
Wide screen TV	-	-	2500	2000	0.7	0.8	0.6	0.7	50	90	5000

E_h init. : The minimum average specified horizontal illuminance at ground level for a new installation.

E_h maint.: The minimum average horizontal illuminance at ground level during the life of an installation.

E_v init. : The minimum average specified vertical illuminance at a height of 1.5 meters above the playing surface, into the direction of the camera position for a new installation.

E_v maint.: The minimum average vertical illuminance at a height of 1.5 meter above the playing surface, into the direction of the camera position, during the life of an installation.

U_1: Uniformity: E_{mjn}/E_{max}

U_2: Uniformity: $E_{min}/E_{average}$

GR: Glare rating

R_a: Colour rendering index

T_k: Colour temperature in degrees Kelvin

Annex 2

Official test report form (page 1 of 2)

In order to keep the lighting installation classified, it is advised to carry out once a year, the following activities:

- inspection of the masts;
- inspection of the electrical installation, especially the switching part, the electrical gear, the earth connection and the various other electrical connections;
- cleaning of the front glass of the floodlight;
- checking of the number of burning hours (if a counter for the burning hours is available);
- inspection of the illuminance level;
- replacing lamps (optional);
- inspection of the alignment of the floodlights;
- reporting of the inspection, inclusive of recommendations for corrective and preventive maintenance.

For optimal maintenance, we advise concluding a maintenance contract with the original electrical contractor of your installation or with a local electrical contractor.

Voltmeter: Type	**No**	**Calib. Date:**	
Voltage	hr	hr	hr	hr
Mast No	V	V	V	V
Mast No	V	V	V	V
Mast No	V	V	V	V
Mast No	V	V	V	V
Mast No	V	V	V	V
Mast No	V	V	V	V
Mast No	V	V	V	V
Mast No	V	V	V	V
Mast No	V	V	V	V

Luxmeter
Brand:

Type:	Date:
Number:	Time start:
Calibration date:	Time end:
Correction factor:	Weather conditions:

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Annex 2

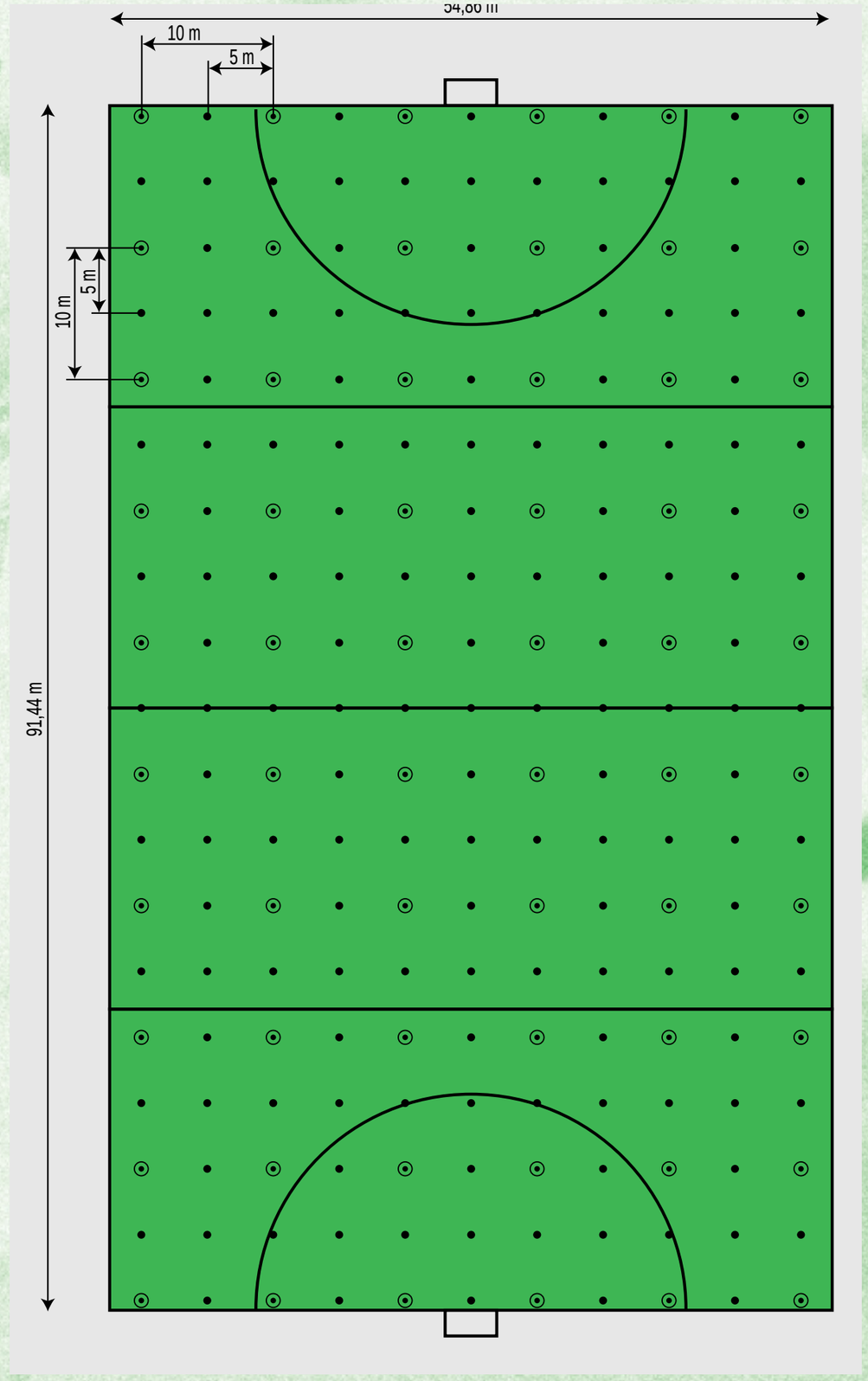
Official test report form (page 2 of 2)

Measurement:
Hor./Vert illuminance

			Camera Location		
E_{av} Hor.		Grid:	E_{av} Vert.		Grid :
min./max		Distance 10 m Level 0 m	min./max		Distance 5 m Level 1.5 m
min./av.			min./av.		

Signatures:

Consult:	Contract:	Supplier:



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