

AS 2560.2:2021



Sports lighting

Part 2: Specific applications



AS 2560.2:2021

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- Australian Football League
- Baseball Australia
- Confederation of Australian Sport
- Cricket Australia
- Department of National Parks, Sport and Racing
- Hockey Australia
- IES: The Lighting Society
- Lighting Council Australia
- Parks and Leisure Australia
- Property Council of Australia
- Sports And Play Industry Association
- Sports and Recreation Victoria
- Tennis Australia

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Preface

This Standard was prepared by the Standards Australia Committee LG-009, Sports Lighting, to supersede and to integrate into a single document, the following:

AS 2560.2.1:2003, *Sports lighting, Part 2.1: Specific applications—Lighting for outdoor tennis*

AS 2560.2.2:1986, *Guide to sports lighting, Part 2.2: Lighting of multipurpose indoor sports centres*

AS 2560.2.3:2007, *Sports lighting, Part 2.3: Specific applications—Lighting for football (all codes)*

AS 2560.2.4:1986, *Guide to sports lighting, Part 2.4: Lighting for outdoor netball and basketball*

AS 2560.2.5:2007, *Sports lighting, Part 2.5: Specific applications—Swimming pools*

AS 2560.2.6:1994, *Guide to sports lighting, Part 2.6: Specific recommendations—Baseball and softball*

AS 2560.2.7:1994, *Guide to sports lighting, Part 2.7: Specific recommendations—Outdoor hockey*

AS 2560.2.8:2007, *Sports lighting, Part 2.8: Specific applications—Outdoor bowling greens*

Additional sports have also been included in this document. For example, cricket, squash, equestrian, aquatic sports (diving), and indoor where applicable. Uniformity gradient is applied more broadly.

It forms part of the AS 2560 series. The AS 2560 series is in two main parts. Part 1 deals with general principles and recommendations for places where sport is played. Part 2 is a collection of requirements, recommendations, and calculation methods for the lighting of specific sports or sporting venues.

When revision is completed, the series will consist of the following:

AS 2560.1, *Sports lighting, Part 1: General principles*

AS 2560.2, *Sports lighting, Part 2: Specific applications* (this document)

This document is intended to be applied in conjunction with the general principles and recommendations of AS 2560.1.

The AS 2560 series is not intended to apply to lighting systems for television coverage. Generally, specialist lighting requirements are needed for these installations; usually requiring relatively high vertical illuminance levels, and higher uniformity. However, the general principles of AS 2560 should be applied to such venues, specifically (but not limited to): the methods of calculation, glare limitation, and the measurement of the installation. For guidance on TV lighting requirements, refer to the following documents:

- (a) Free TV Australia Operation Practice OP-31, *Lighting Requirements for Television*.
- (b) CIE 083, *Guide for the lighting of sports events for colour television and film systems*, 3rd Edition, International Commission on Illumination (CIE), Vienna, 2019.
- (c) CIE 169, *Practical guidelines for the lighting of sport events for colour television and filming*, International Commission on Illumination (CIE), Vienna, 2005.

The various sporting organizations often publish their own technical recommendations.

The terms “normative” and “informative” are used in Standards to define the application of the appendices to which they apply. A “normative” appendix is an integral part of a Standard, whereas an “informative” appendix is only for information and guidance.

Contents

Preface	ii
Section 1 Scope and general	1
1.1 Scope	1
1.2 Application	1
1.3 Normative references	1
1.4 Terms and definitions	1
1.5 Levels of play (classes)	4
1.6 Luminaire mounting height	5
1.7 Luminaire aiming	5
1.7.1 Aiming angle	5
1.7.2 Reference direction	6
1.7.3 Rotation angle	6
1.7.4 Tilt angle	6
1.7.5 Uplift angle	6
1.7.6 Reference surface	6
1.8 Multipurpose sports areas	9
1.9 Glare and veiling reflections from windows and roof lights	9
1.9.1 General	9
1.9.2 Indoor sports venues	9
1.9.3 Outdoor sports venues — Reflected glare	9
1.10 Spectator areas	9
1.11 Basis of conformance	10
1.12 Measurements	11
Section 2 Specific sporting applications	12
2.1 Aquatic sports	12
2.1.1 General	12
2.1.2 Objectives	12
2.1.3 Light Technical Parameters (LTPs)	13
2.1.4 Calculation and measurement grids	14
2.1.5 Glare control and veiling reflections	16
2.1.6 Lighting systems for outdoor pools	21
2.1.7 Lighting systems for indoor pools	22
2.2 Baseball and softball	25
2.2.1 General	25
2.2.2 Light Technical Parameters (LTPs)	25
2.2.3 Calculation and measurement grids	26
2.2.4 Glare control	28
2.2.5 Batting cages and bullpens	30
2.3 Bowling greens	35
2.3.1 General	35
2.3.2 Outdoor (including covered) bowling greens	35
2.3.3 Indoor bowling greens	38
2.4 Cricket	39
2.4.1 Outdoor cricket	39
2.4.2 Outdoor practice pitches	45
2.4.3 Cricket training — Indoor	49
2.4.4 Indoor cricket — Competition	50
2.5 Equestrian	53
2.5.1 General	53
2.5.2 Objectives	53
2.5.3 Scope	54
2.5.4 Outdoor equestrian	54
2.5.5 Indoor equestrian	58
2.6 Football (all codes)	59

2.6.1	Outdoor football	59
2.6.2	Indoor football	67
2.7	Hockey	68
2.7.1	General	68
2.7.2	Outdoor hockey	68
2.7.3	Indoor hockey	71
2.8	Multipurpose indoor sports centres	72
2.8.1	General	72
2.8.2	Backgrounds	72
2.8.3	Light Technical Parameters (LTPs)	73
2.8.4	Calculation and measurement grids	74
2.8.5	Glare control	75
2.9	Netball and basketball	78
2.9.1	General	78
2.9.2	Outdoor netball and basketball	78
2.9.3	Indoor netball and basketball	84
2.10	Squash	85
2.10.1	General	85
2.10.2	Backgrounds	85
2.10.3	Light Technical Parameters (LTPs)	85
2.10.4	Calculation and measurement grids	86
2.10.5	Glare control	87
2.11	Tennis	88
2.11.1	General	88
2.11.2	Outdoor tennis	88
2.11.3	Indoor or covered tennis	96
Appendix A (informative) Safety lighting		99
Appendix B (normative) Uniformity gradient		100
Bibliography		102

Australian Standard®

Sports lighting

Part 2: Specific applications

Section 1 Scope and general

1.1 Scope

This document contains design and performance requirements and recommendations for the lighting of specific outdoor and indoor sports areas. It also provides recommendations for spectator areas and safety lighting.

This document does not include the special lighting requirements which will apply for television broadcasting.

This document does not include any requirements or recommendations with respect to indoor emergency lighting. Refer to AS/NZS 2293.

This document does not make recommendations or set requirements regarding obtrusive light effects from sports lighting installations. Refer to AS/NZS 4282.

1.2 Application

This document is intended to be read in conjunction with AS 2560.1. The specific requirements in this document shall take precedence over the general recommendations of AS 2560.1. The choice of which level of play is applicable rests with the client (usually the applicable owner and/or governing body). Level of play guidance may be found in recommendations produced by the relevant sporting authority.

1.3 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document:

NOTE Documents for informative purposes are listed in the Bibliography.

AS 2560.1, *Sports lighting, Part 1: General principles*

AS ISO/IEC 17025, *General requirements for the competence of testing and calibration laboratories*

1.4 Terms and definitions

The definitions given in AS 2560.1 and those below apply.

1.4.1

aiming

luminaire aiming

angles of rotation and tilt at which the reference direction of a luminaire (usually a floodlight) is directed

Note 1 to entry: See [Clause 1.7](#).

1.4.2**Baseball/Softball****1.4.2.1****infield**

<baseball> 29 m arc taken from the centre of the pitching plate

Note 1 to entry: A 27.4 m square “diamond” area lies within the infield, it is inclusive of the 4 bases — home, 1st, 2nd and 3rd.

Note 2 to entry: The calculation and measurement area for the LTPs are defined in [Figure 2.2.1](#).

1.4.2.2**infield**

<softball> 18.29 m arc taken from the centre of the pitching plate

Note 1 to entry: An 18.29 m square “diamond” area lies within the infield, it is inclusive of the 4 bases — home, 1st, 2nd and 3rd.

Note 2 to entry: The calculation and measurement area for the LTPs are defined in [Figure 2.2.1](#).

1.4.2.3**outfield**

area between the foul lines which extends from the infield to the perimeter fence

Note 1 to entry: The calculation and measurement area for the LTPs are defined in [Figure 2.2.1](#).

1.4.3**competent person**

person who has acquired, through education, training, qualification, or experience, or a combination of these, the knowledge and skill enabling that person to perform the task required

1.4.4**cricket****1.4.4.1****square**

<for the calculation and measurement of LTPs> area encompassing the pitch/pitches

Note 1 to entry: This is a square generally taken as 27.4 m × 27.4 m.

1.4.4.2**infield**

<for the calculation and measurement of LTPs> circle with a radius of 37.5 m, and excludes the square

1.4.4.3**outfield**

<for the calculation and measurement of LTPs> remainder of playing area, outside of the infield and square area, up to the outfield boundary

Note 1 to entry: The cricket outfield dimensions will vary dependent upon their location and primary use.

1.4.5**exclusion zone****no-go zone**

particular area around, or above the playing area where the location of luminaires may cause glare and diminished task visibility for participants

Note 1 to entry: This document also indicates recommended zones where luminaires should be located.

Note 2 to entry: For practical reasons, it may be necessary to locate luminaires in exclusion zones. If necessary, care needs to be taken that they do not cause glare in the relevant directions towards participants, officials, and spectators. In particular, the luminaire should be of a type, and aimed in a direction that, when operational, appears to be off to the observer(s), i.e. the luminance of the light emitting surface viewed by the observer should be substantially limited.

1.4.6 **field of play** **FOP**

official marked area where sport is played

Note 1 to entry: The infield and outfield together are known as the field of play.

1.4.7 **indoor sports**

sports activity where the total playing area (TPA) is completely covered by a permanent roof and is surrounded by walls that form a background against which the activity takes place

Note 1 to entry: Relatively small windows or openings, particularly those located near the roof may be discounted.

Note 2 to entry: Indoor facilities generally provide services for heating, cooling and ventilation.

Note 3 to entry: Sport specific classifications of “indoor” and “outdoor” should be sought from governing bodies, as applicable.

Note 4 to entry: Sports housed under a permanent structure (including “air halls”, fabric frame structures, rigid framed buildings) where there are no walls may be defined as indoor if the temperature, ventilation and humidity can be controlled.

1.4.8 **Light Technical Parameter** **LTP**

quantitative parameter based on SI units of measurement (base and derived), and other special units that represent the effectiveness of sports lighting systems

EXAMPLE Maintained illuminance, distribution of illuminance (uniformity), glare control, and colour quality.

Note 1 to entry: Conformance with this document will be achieved by meeting all the required LTP values.

1.4.9 **may**

indicates the existence of an option

1.4.10 **minimum vertical maintained illuminance**

E_{vmin}

minimum of only those vertical maintained illuminance values determined for all of the points in either the calculation or measurement grid as applicable to the method of determination

1.4.11 **multipurpose sports area**

facility with dimensions and markings to accommodate more than one sport

EXAMPLE Multipurpose sports halls; a building or part of a building in which sports are played, or Multi Use Games Area (MUGA); usually outdoor.

Note 1 to entry: Floor surfaces may be natural grass, artificial sports surfaces, tarmac, concrete, or wood.

Note 2 to entry: Applicable line markings are provided for each sport, often lined in different coloured paints.

1.4.12 **officials**

all officials, both on and off the field, court or similar, required to view and make judgements on the play

EXAMPLE Umpires (including plate umpire), coaches, linesman, off-field referees, judges.

1.4.13

outdoor sports

sports activity where the total playing area (TPA) is completely uncovered by a permanent roof or where the TPA is completely, or partially covered by a roof and is not substantially surrounded by walls that form a background against which the activity takes place

EXAMPLE An outdoor swimming pool or a bowling green with shade structures.

Note 1 to entry: Sport specific classifications of indoor and outdoor should be sought from governing bodies as applicable.

1.4.14

participant

any person taking part in the applicable game, activity or sport

1.4.15

safety lighting

lighting other than emergency evacuation lighting which is used in the event of a failure of the normal sports lighting system

Note 1 to entry: For sports activities, safety lighting is used to facilitate the safe stopping of an activity. It is not for the continuation of an activity.

Note 2 to entry: Normal sports lighting is all installed electric lighting used for the sports activity supplied from the normal power supply.

Note 3 to entry: The provision of safety lighting is at the discretion of the applicable owner and/or governing body. See [Appendix A](#).

Note 4 to entry: For emergency evacuation lighting refer to AS/NZS 2293.

1.4.16

shall

indicates that a statement is mandatory

1.4.17

should

indicates a recommendation

1.4.18

spectator

any person viewing the applicable game, activity or sport

1.4.19

uniformity gradient

rate of change of illuminance over a defined area

Note 1 to entry: For the method of calculation of the uniformity gradient, see [Appendix B](#).

1.5 Levels of play (classes)

This document defines various levels of play that take into account the visual requirements of players, officials and spectators, e.g. training, recreational, and competition. The choice of which level of play is applicable rests with the client (usually the applicable owner and/or governing body).

Where the lighting installation is suitable for physical training or lower levels of competition is to be provided, consideration should be given to the likelihood of the lighting system being upgraded so that provision can be made at the time of installation to minimize the cost of the future upgrading.

Where an area is used for warming up held at a venue with higher illuminance levels, e.g. for broadcasting, then that higher level should be considered to acclimatize the participant, e.g. a practice pitch for cricket.

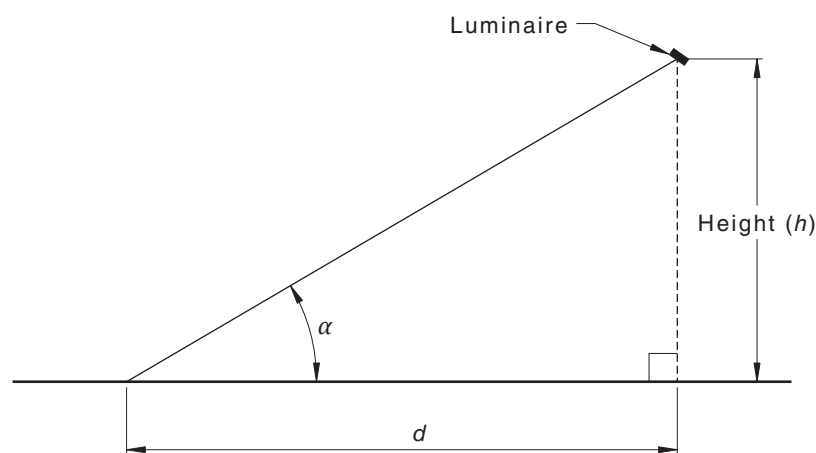
1.6 Luminaire mounting height

Luminaires should be installed at a height such that a line from the lowest luminaire is at an angle to the horizontal that is not less than required for the specific sport, see [Figure 1.3](#).

The minimum mounting height (h) to achieve this angle is calculated by the following equation:

$$h = \tan \alpha \times d$$

where



- α = minimum elevation angle ($^{\circ}$); $\tan \alpha$ may be expressed as a ratio
- d = horizontal distance from a reference point immediately below the applicable luminaire(s) under consideration to a point required for the specific sport

Figure 1.3 — Minimum mounting height for luminaires

In determining the luminaire height, the reference height of the playing surface may be taken as the centre of the PPA or FOP, or the part of the surface at which the luminaires are generally aimed. For outdoor sports it will be necessary to take into account the difference in height between the base of the pole and the playing surface, and also the distance between the lowest and highest luminaire on that pole or tower.

If lighting suitable for a lower level of play is to be provided initially and there is a likelihood that the lighting system will be upgraded in the future to provide a higher level of play, then consideration should be given to installing luminaires at the height recommended for the higher level.

Generally, for a given lighting layout and luminaire aiming, glare to players and spectators will be reduced by adopting mounting heights above the minimum values recommended.

1.7 Luminaire aiming

1.7.1 Aiming angle

Aiming angle has a specific meaning for lighting calculations, in particular, rotation, tilt, and uplift. For the purposes of general directionality, and glare control, the term “aiming angle” may be used to mean the direction of maximum intensity.

1.7.2 Reference direction

Luminaires that are aimed are usually a floodlight, viz. a luminaire that has a concentrated beam designed to be adjusted so that the beam can be directed/projected to a specific point. The luminaire reference direction is that which is used as the nadir direction (the downward vertical axis directly beneath) in photometric files used for lighting calculations. It is the reference direction that is rotated and tilted to determine luminaire aiming in lighting calculations, see [Figure 1.7.1](#).

Conventionally, the luminaire reference direction is the direction of the maximum intensity (or close to it), or a similar main part of the light beam. However, it may not be where the maximum intensity lies; it may be taken as a direction normal to a reference surface, e.g. a physical feature of the luminaire such as the light emitting surface, or housing, see [Clause 1.7.5](#).

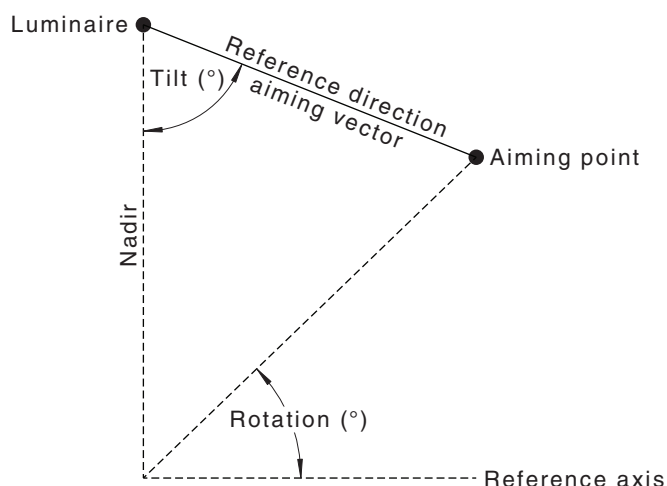


Figure 1.7.1 — Luminaire aiming angles

1.7.3 Rotation angle

The angle in the horizontal plane from a reference axis, e.g. positive x-axis, to the vector that the luminaire reference direction is aimed, see [Figure 1.7.1](#).

1.7.4 Tilt angle

The angle in the vertical plane from nadir (the downward vertical axis directly beneath) to the vector that the luminaire reference direction is aimed, see [Figure 1.7.1](#).

1.7.5 Uplift angle

The angle of the reference surface of the luminaire (usually the light emitting surface or housing) with respect to the horizon, see [Figures 1.7.2](#), [1.7.3](#), and [1.7.4](#).

NOTE The uplift angle may be positive or negative.

1.7.6 Reference surface

A reference surface is a physical feature of the luminaire such as the light emitting surface, or housing. It is generally used to assist with the aiming of luminaires as it relates to the photometric file used in calculations.

In the case of floodlights with a symmetrical intensity distribution, e.g. a Type A or B floodlight, the maximum intensity is typically at or close to the reference direction, such that the reference surface is horizontal, see [Figure 1.7.2](#).

In the case of floodlights with a pronounced asymmetric intensity distribution e.g. a Type C, C cut-off or D floodlight, the photometric file may be structured either —

- (a) where the reference surface is horizontal and the maximum intensity is elevated by some degree, see [Figure 1.7.3](#); or
- (b) where the maximum intensity is at, or close to the reference direction. The reference direction may not be normal to the reference surface of the luminaire, the difference is known as the B-angle offset, see [Figure 1.7.4](#).

NOTE The choice of structure is at the discretion of the originator of the photometric file. Also, refer to AS 2560.1 Appendix B.

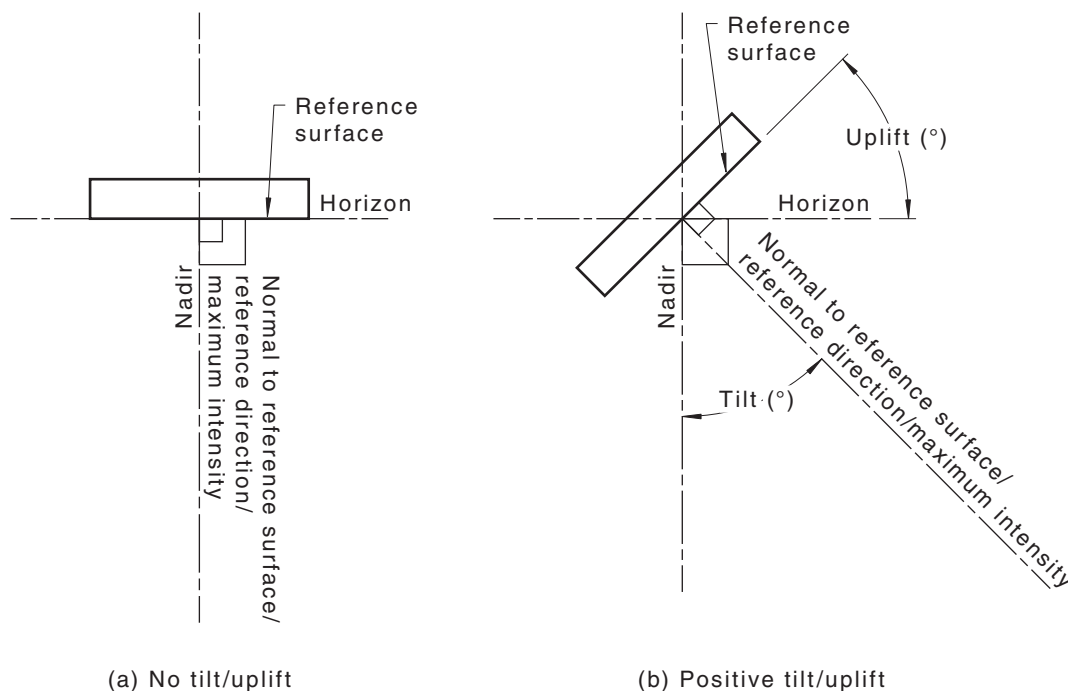


Figure 1.7.2 — Luminaire tilt/uplift where the reference direction and maximum intensity is normal to the reference surface (uplift = tilt)

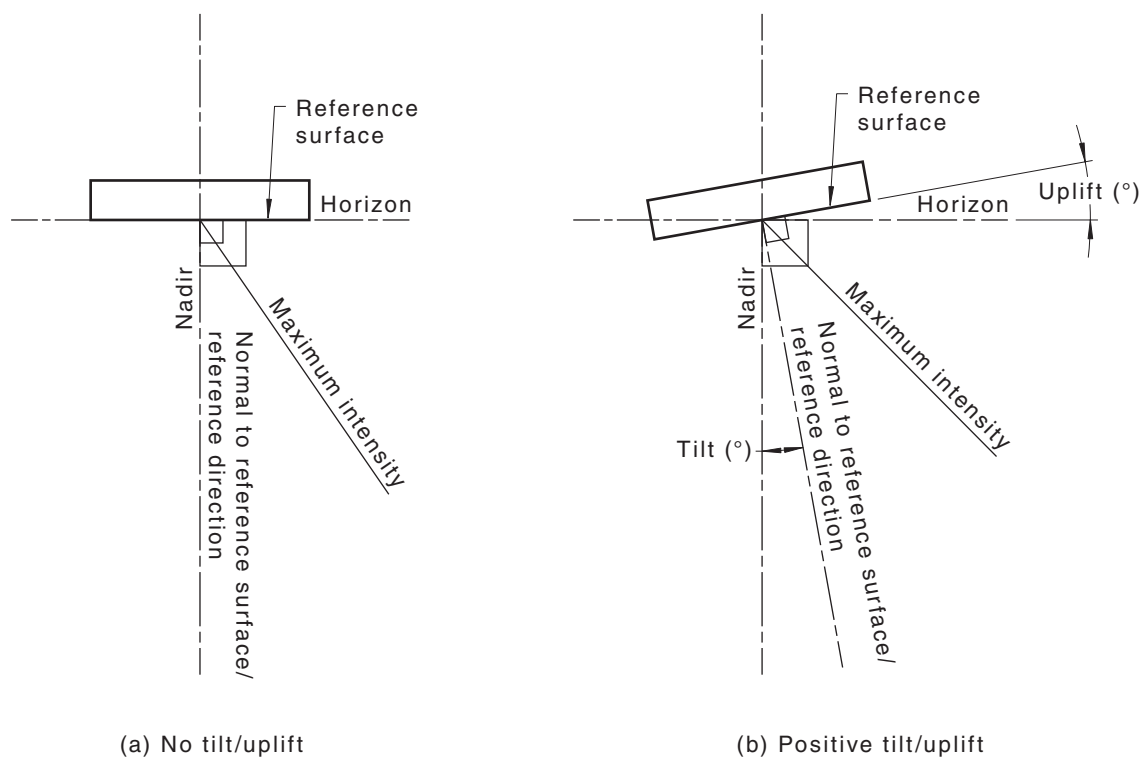


Figure 1.7.3 — Luminaire tilt/uplift where the reference direction is normal to the reference surface and the maximum intensity is elevated (uplift = tilt)

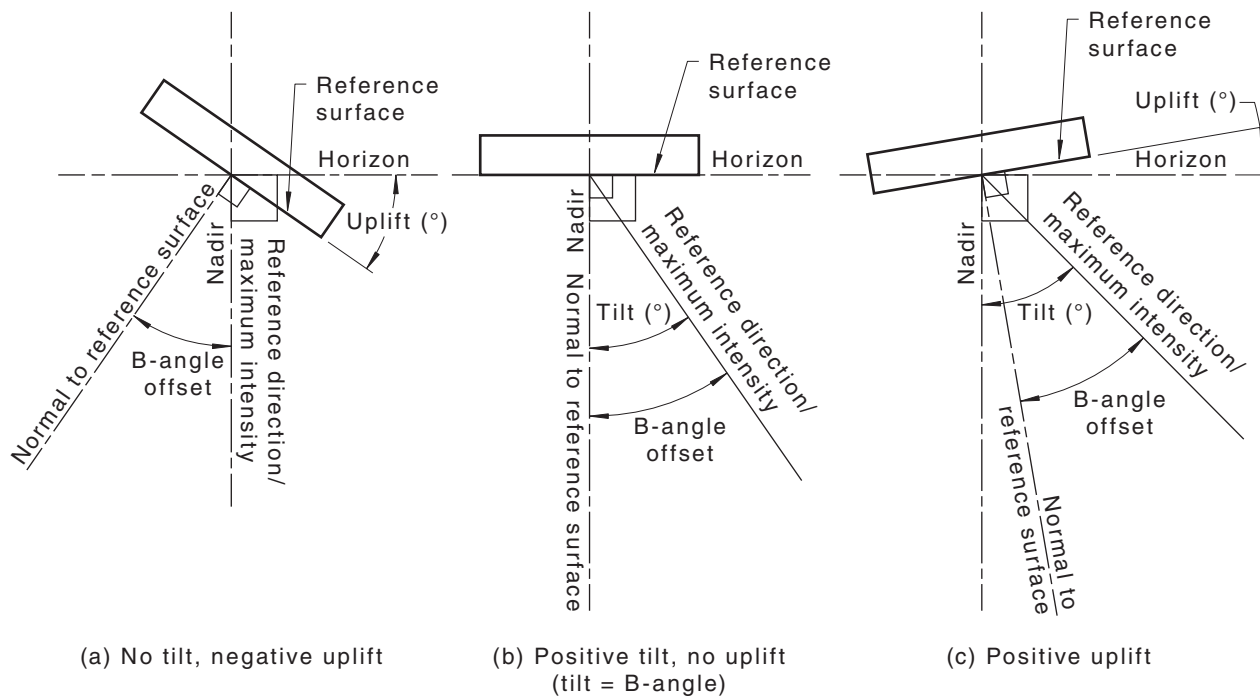


Figure 1.7.4 — Luminaire tilt/uplift where the reference direction is not normal to the reference surface (uplift = tilt - B-angle)

1.8 Multipurpose sports areas

When planning the lighting scheme, the sport with the highest lighting levels and/or level of play shall be taken into account when determining the Light Technical Parameters. Dimming and/or switching of lighting should be provided as necessary to suit the requirements of the various activities. The luminaires should be placed to suit each activity avoiding any exclusion zones.

Individual principal playing areas (PPA) and total playing areas (TPA) shall satisfy their particular Light Technical Parameter (LTP) requirements.

1.9 Glare and veiling reflections from windows and roof lights

1.9.1 General

Glare and veiling reflections from windows and roof lights, within the range of participants' normal viewing directions and, where applicable, of officials and spectators should be taken into account and minimized.

1.9.2 Indoor sports venues

1.9.2.1 Daylight

Where windows and roof lights are provided for the admission of daylight, they should be located or arranged to minimize sky glare and direct sunlight penetration, refer to AS 1680.1.

1.9.2.2 Reflected glare from luminaires

Reflected glare from luminaires should be mitigated by the following measures:

- (a) Windows and roof lights should be located or arranged to minimize reflections from the luminaires.
- (b) Luminaire distribution types should be chosen to control unwanted intensities which may reflect off glazed surfaces; and the secondary reflections off specular sport surfaces.
- (c) Luminaire aiming angles should be per recommendations herein.

1.9.3 Outdoor sports venues — Reflected glare

To prevent reflected glare, the size, location and orientation of windows, window walls and glazed curtain walls in the vicinity of the sporting area should consider:

- (a) The sun path: North-facing glazed elements located on the south side of the sporting area, depending on size, may cause unacceptable glare to the participants. Sun path modelling is advised to ascertain both the direct reflected glare off the glazed elements and the secondary reflections off specular sport surfaces,
- (b) Luminaire distribution types: they should be chosen to control unwanted intensities which may reflect off glazed surfaces; and the secondary reflections off specular sport surfaces,
- (c) Luminaire aiming angles: they should be per recommendations herein.

1.10 Spectator areas

Spectator areas may be illuminated by spill light from the PPA and/or the TPA. Where additional lighting is required, for example, for the purposes of safe movement, the following apply:

- (a) *For indoor sports* — refer to AS 1680.0.

- (b) *For outdoor sports* — a minimum point horizontal maintained illuminance of 2 lx.

Where required, for example, for the purposes of amenity, the following apply:

- (i) *For indoor sports* — have an average horizontal maintained illuminance of 80 lx.
- (ii) *For outdoor sports* — have an average horizontal maintained illuminance that is 10 % of the PPA but not less than 7 lx, and a uniformity ratio (maximum/average) of not more than 8.

1.11 Basis of conformance

Design calculations form the basis for conformance. They should be provided by a competent person with access to luminaire photometric data and design aids. Calculations should account for accuracies and tolerances in accordance with the AS/NZS 3827 series of Standards.

NOTE 1 It is good practice to achieve design values for illuminance and uniformity that are 5 % to 10 % higher than the target LTPs.

Luminaire photometric data testing shall be performed by a laboratory that meets the requirements of AS ISO/IEC 17025.

NOTE 2 By way of example, accreditation bodies which are signatories to the International Laboratory Accreditation Cooperation (ILAC) Mutual Recognition Arrangement (MRA) for testing laboratories may be able to offer accreditation against the requirements of AS ISO/IEC 17025. A listing of ILAC signatories is available from the ILAC website (www.ilac.org). In Australia and New Zealand, the National Association of Testing Authorities (NATA), Joint Accreditation System of Australia and New Zealand (JAS-ANZ) and International Accreditation New Zealand (IANZ) are signatories to the ILAC MRA.

The following information should be recorded:

- (a) A statement prepared by a competent person that either —
- (i) states that the design satisfies the LTPs at all times throughout its projected life when considered together with the maintenance assumptions; and
 - (ii) identifies, and justifies any aspects of the design that do not satisfy the Light Technical Parameters, and/or other recommendations, e.g. luminaire locations and heights.
- (b) The essential details of all elements to be illuminated.
- (c) A scaled plan showing significant features and the proposed lighting scheme with luminaire locations, mounting height, and relevant aiming information.
- (d) The levels of play or LTPs.
- (e) Calculations that indicate that the design would satisfy the LTPs and any assumptions, e.g. reflectance factor used for determining the glare rating (GR).
- (f) For outdoor sports, calculations in accordance with AS/NZS 4282.
- (g) State any switching/dimming options, and show conformance on each area for each switching/dimming option.
- (h) Details of the luminaires and light sources to be used, e.g. luminaire identification details, light source type/colour, luminous flux, power.
- (i) The photometric data substantiated by reference to a test report/s (e.g. a test number).
- (j) The maintenance factor used in the design and its basis, including the following:
- (i) Luminaire dirt depreciation (LDD) factor, and cleaning cycle.

- (ii) Light source lumen depreciation factor (LLD).
- (iii) Light source life expectancy.

1.12 Measurements

Where required, measurements of illuminance shall be made by a competent person with a light meter that is calibrated, and colour and cosine-corrected. Software applications for mobile devices are not suitable and shall not be used. Refer to AS 2560.1.

Measurements shall only be made for illuminance at a series of points for the determination of minimum, maximum, average and the ratios of U_1 and U_2 . Other LTPs, such as GR, G/UG, and R_a , are not required for measurements.

Section 2 Specific sporting applications

2.1 Aquatic sports

2.1.1 General

This section applies to the following activities:

- (a) Swimming.
- (b) Artistic swimming.
- (c) Water polo.
- (d) Diving.
- (e) Leisure pools, children's pools.

The lighting should provide a safe environment in the water, and around the sides of the pool. The following visual tasks also need to be taken into account:

- (i) In competitive swimming, it is important that officials and spectators are able to determine accurately when swimmers touch the pool wall and, if applicable, that turns and strokes are correctly executed.
- (ii) In recreational pools, safety attendants need to be able to see swimmers or other participants who may be in distress in any part of the pool, especially under the surface.
- (iii) In water polo, it is important that the participants, officials and spectators are able to see the fast movements involved.
- (iv) For diving, it is important that officials and spectators are able to see the diver through the run-up, contact, and aerial phase for each springboard and/or platform. Therefore, vertical illuminance is required within the space where the dives are performed. It is essential that divers are able to see the water surface.

Underwater visual tasks, e.g. seeing swimmers in difficulty and water polo participants, may be assisted by underwater lighting.

A further difficulty that requires consideration is that spectators may be viewing important details from considerable distances from the pool.

2.1.2 Objectives

The main objectives of the lighting installation is that it provides the following:

- (a) A level of illuminance to cater for the visual requirements of the participants, officials and spectators, and to ensure safety (see [Clause 2.1.3](#)).
- (b) Uniformity of illuminance over the total water area and the pool surrounds (see [Clause 2.1.4](#)).
- (c) Control of glare and veiling reflections from luminaires and windows, within the range of normal viewing directions of participants and, where applicable, of officials and spectators (see [Clause 2.1.5](#)).
- (d) Use of light sources with colour properties that will ensure a satisfactory appearance of people and the surroundings (see [Table 2.1.1](#)).
- (e) Selection of lighting equipment that is of suitable construction that will be safe and durable in the environment of swimming pools which may have a corrosive or saline atmospheres, a

high humidity and ambient temperature (lower maintenance factors are expected), refer to the following:

- (i) ISO 9227.
 - (ii) AS 60598.2.18. This Standard specifies requirements for fixed luminaires intended for use in the water, or in contact with the water, e.g. in the basins of swimming pools.
- (f) Selection of lighting equipment of suitable type and the location and arrangement of such equipment in a manner that will facilitate necessary maintenance during the life of the installation.

2.1.3 Light Technical Parameters (LTPs)

The LTPs shall be in accordance with the applicable values in [Table 2.1.1](#) and for diving [Table 2.1.2](#).

For outdoor pools that are partially covered by shade structures the applicable values in [Table 2.1.1](#) shall apply to pool area that is not shaded. For the shaded portion the minimum illuminance (E_{hmin}) shall not be less than the following values. Minimum horizontal uniformity U_1 and U_2 limits shall apply in the shaded portion. Separate calculation grids shall be used for each portion for the assessment of illuminance and uniformity:

- (a) 50 lx for recreation or training, and low-level local competition.
- (b) 100 lx for club, interclub or district competition.

Table 2.1.1 — LTPs for aquatic sports

Level of play	Average horizontal maintained illuminance ($\bar{E}_h$)	Minimum horizontal uniformity		Maximum glare rating (GR)		Minimum colour rendering index (R_a)
		$(E_{hmin}/\bar{E}_h)$ (U_1)	(E_{hmin}/E_{hmax}) (U_2)	Outdoor	Indoor	
Recreation or training, and low-level local competition	150	0.50	0.30	50	40	65
Club, interclub or district competition	300	0.60	0.40	50	40	65
National or state competition	600	0.70	0.50	50	40	80

NOTE Refer to particular requirements of *FINA Facilities Rules* should they be deemed applicable and to [Clause 2.1.4.2](#) for specific requirements for competition diving.

Table 2.1.2 — LTPs for diving

Level of play	Average vertical maintained illuminance ($\bar{E}_v$)	Minimum vertical uniformity (E_{vmin}/E_{vmax}) (U_2) ^a
Recreation or training, and low-level local competition	$0.5 \times \bar{E}_h$	0.30
Club, interclub or district competition	$0.5 \times \bar{E}_h$	0.30
National or state competition	$0.8 \times \bar{E}_h$	0.30

^a The uniformity U_2 (E_{vmin}/E_{vmax}) of vertical illuminance should not be less than 0.3 in any separate field, see [Figure 2.1.2](#)

2.1.4 Calculation and measurement grids

2.1.4.1 Aquatic sports other than diving

Due to the difficulty involved in performing measurements, only calculations and analysis of design methods are used to determine values required by this document, refer to AS 2560.1.

Calculations of horizontal illuminance and uniformity shall be made at the level of the surface of the water in the pool. Calculations may be made at the level of the immediate surrounding area (i.e. the deck) if the level of the water is not lower than 0.5 m.

Calculations shall use a regular grid of points spaced not more than 2.5 m × 2.5 m fitted evenly within the perimeter of an area that is not less than 2 m beyond the water's edge in all directions, see the example in [Figure 2.1.1](#).

Dimensions in metres

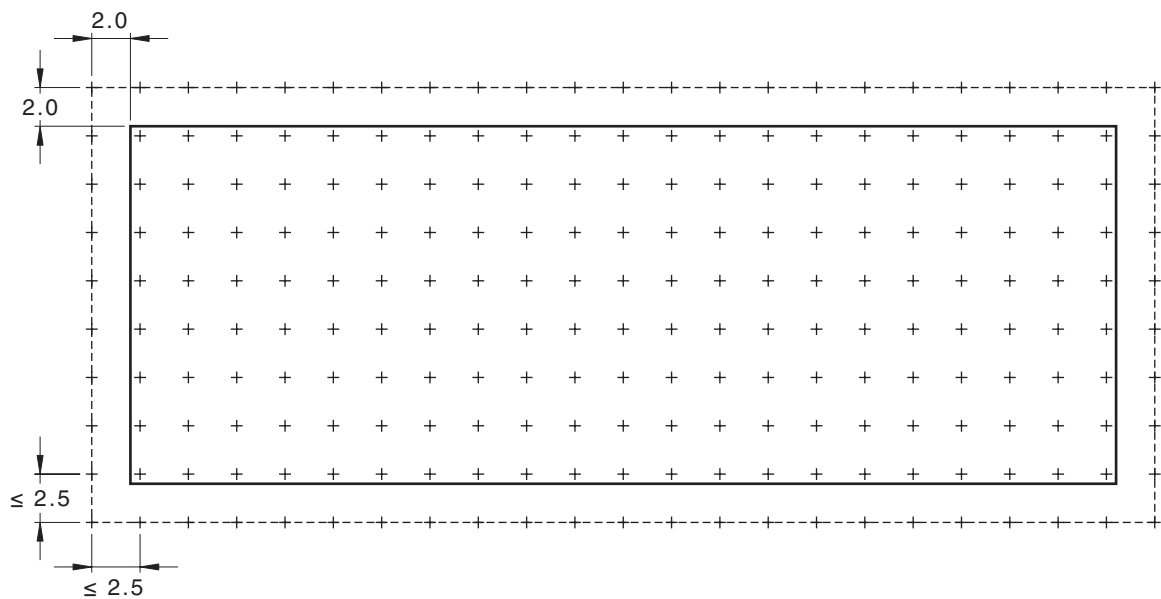


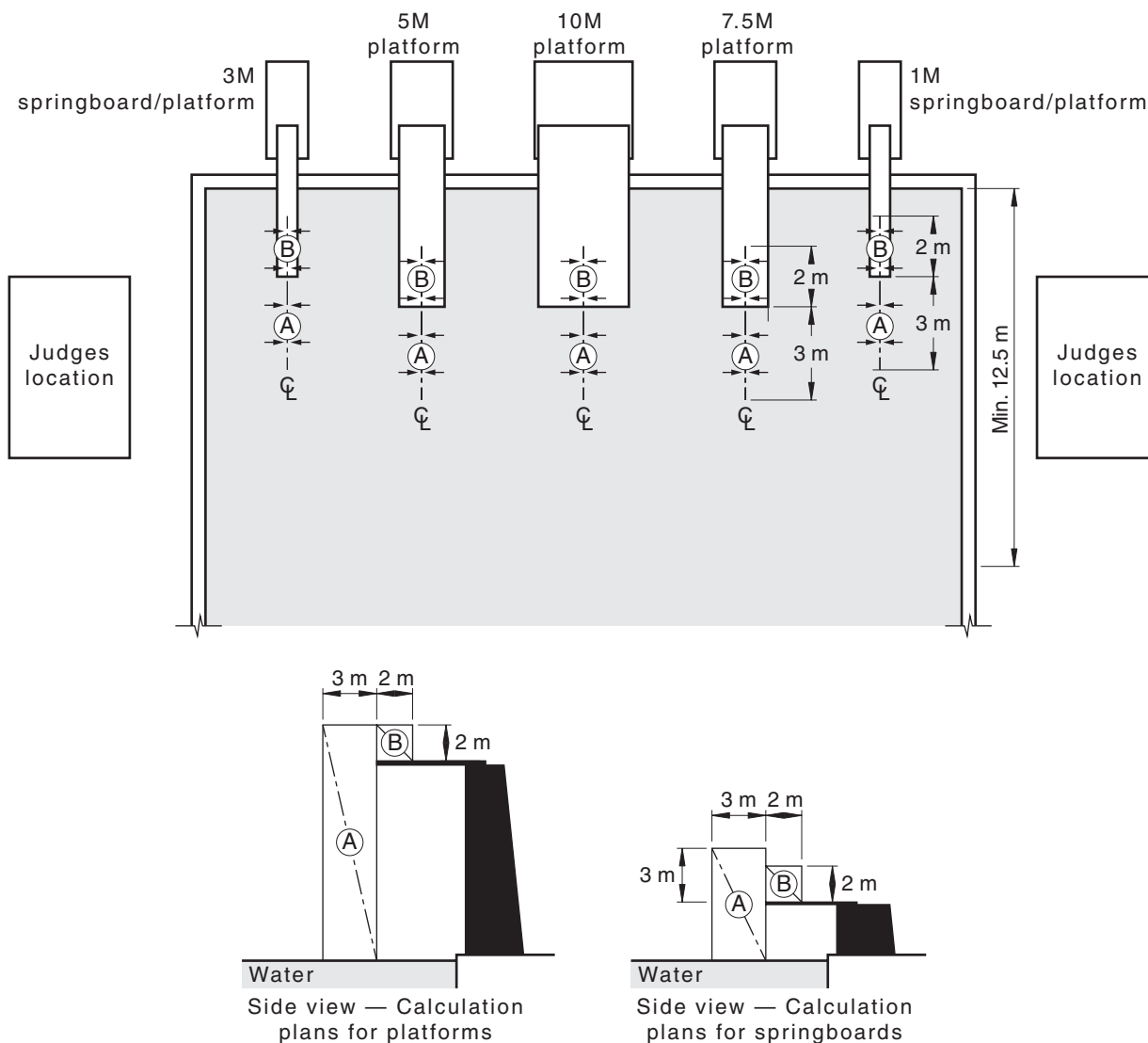
Figure 2.1.1 — Example calculation grid for aquatic sports

2.1.4.2 Diving

Due to the difficulty involved in performing measurements, only calculations and analysis of design methods are used to determine values required by this document, refer to AS 2560.1.

Horizontal calculations shall be in accordance with Clause [2.1.4.1](#). If the diving area is illuminated to a higher level than the pool, then the calculation area ahead of the springboards/platforms may be limited to 12.5 m from the edge of the pool as shown in [Figure 2.1.2](#).

To check the vertical illuminance conformance of the lighting design by means of calculation, the levels shall be calculated at points located on planes as shown in [Figure 2.1.2](#). Both sides of the vertical plane shall be calculated. A 1 m × 1 m grid shall be fitted within the perimeter of each applicable field shown in [Figure 2.1.2](#) such that all points immediately inside that perimeter are within 0.5 m (i.e. half a grid space) of the boundary.



The two vertical calculation plans are:

- (A) Vertical in front of the diving board, 3 m along from the edge of the board centre
 1. 2 m above the board, all the way down to the water surface for platforms
 2. 3 m above the board, all the way down to the water surface for springboards
- (B) Vertical in the centre of the diving board, 2 m along from the edge of the board, 2 m above the board

Figure 2.1.2 — Calculation fields for diving

2.1.5 Glare control and veiling reflections

2.1.5.1 General

The most difficult problem associated with the lighting of swimming pools is the control of reflections from the water surface. Swimmers are generally not bothered by such reflections but they can be a nuisance to divers and participants in water polo. Also, reflected images on the water surface can obscure or “veil” the view of officials and spectators of activities below the surface of the water, including swimmers in difficulties.

Limiting the veiling reflections in accordance with this document will generally limit discomfort glare for participants, including officials. However, glare rating (GR) is also used to limit discomfort glare.

Windows, roof lights, window walls and glazed curtain walls can be a major glare source either directly or indirectly, see [Clause 1.9](#).

2.1.5.2 Luminaire locations

To avoid veiling reflections, and ensure acceptable visibility into the water, the average luminance of the water surface needs to be not appreciably higher than that of the pool lining, as seen by the observer.

This is achieved by controlling three factors as follows:

- (a) The percentage of incident light reflected from the surface of the water should be kept low.
- (b) The percentage of incident light that penetrates the surface of the water should be kept high.
- (c) The reflectance factor of the (underwater) pool lining should be above 0.7.

[Figure 2.1.3](#) shows that if light reaches the water at angles of incidence of less than 60° (relative to the surface normal), little will be reflected from the water surface and maximum light penetration will be achieved, thus satisfying conditions (a) and (b). This is practically independent of the water surface conditions, i.e. still or turbulent.

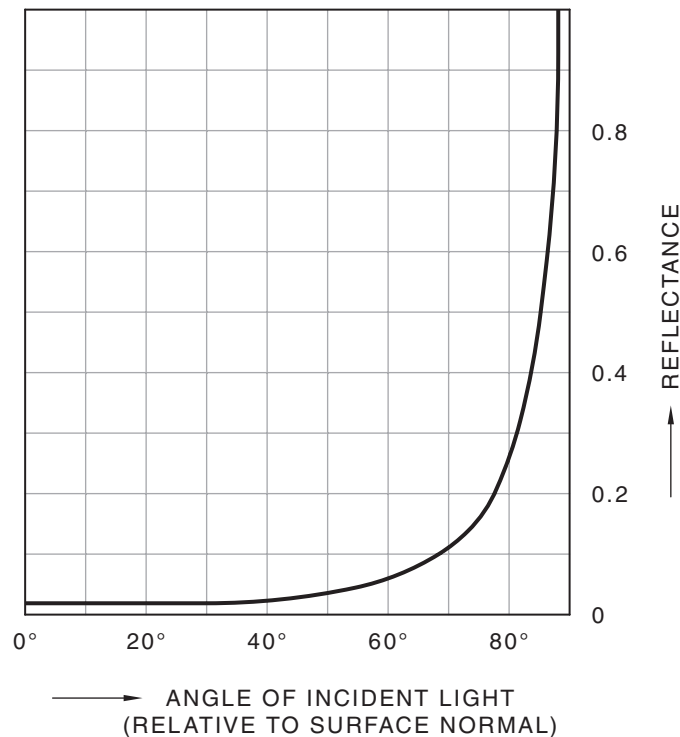


Figure 2.1.3 — Reflectance of water as a function of the angle of the incident light

Therefore, each luminaire should be located, in plan and mounting height so that the angle of incidence of the light reaching the opposite side of the pool, from any given luminaire, should be not more than 60° , see [Figure 2.1.4](#). This should ensure that only low luminance images of any luminaires are visible to those on the pool deck.

Although introducing underwater lighting will effectively increase the average luminance of the pool lining, it will do little to reduce veiling reflections if significant light is incident at greater than 60° to the normal.

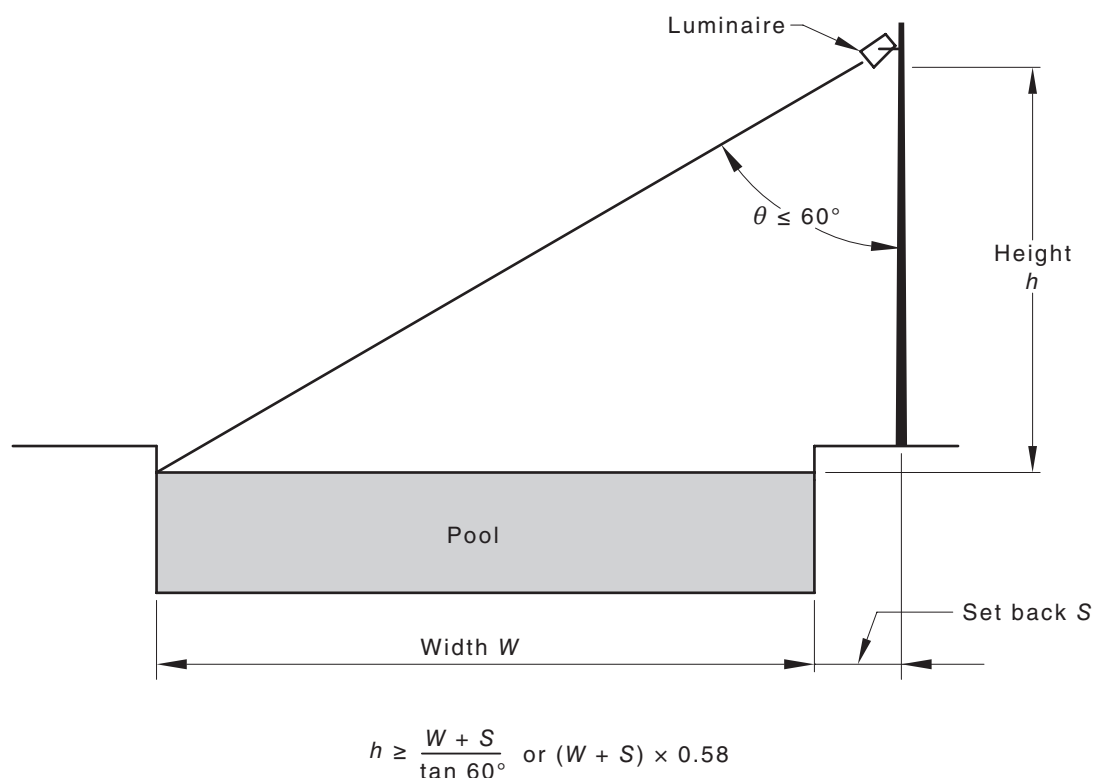
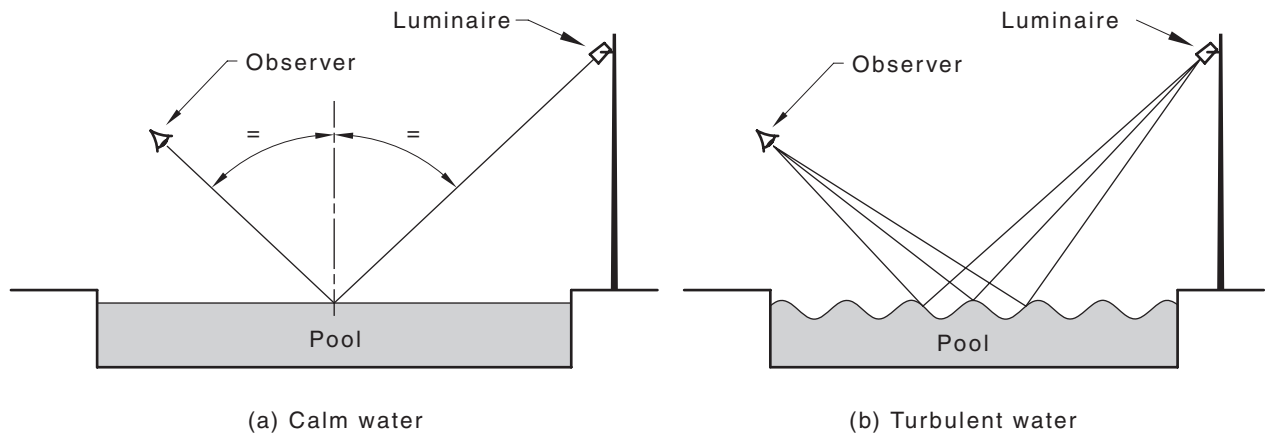


Figure 2.1.4 — Determination of minimum height of luminaires

Even if the above conditions are satisfied, veiling reflections can still occur when the reflected image of a luminaire, as viewed by the observer, has a relatively high luminance. [Figure 2.1.5 \(a\)](#) shows the reflection of a luminaire in still water and [Figure 2.1.5 \(b\)](#) in turbulent water. Note that the angle of the reflected light equals that of the incident light. From [Figure 2.1.3](#), if the angle of incident/reflected light that reaches an observer from a given luminaire is kept to less than 60° (relative to the pool surface normal) the luminance of the reflected image and hence the veiling effect of the reflected image will be minimized.

If a distributed array of luminaires of relatively low output is mounted such that the incident rays from each luminaire are at less than 60° to the surface normal, and the array is viewed against a generally dark background such as the night sky or a ceiling of relatively low luminance, an acceptably low average surface luminance and a low patch luminance from any specific reflected luminaire images should be achieved.



NOTE 1 Both diagrams show a relatively high viewing angle which might apply to an observer's position in the spectator stand. Diagram (a) illustrates that, from a given position, a single reflection of the luminaire will be seen in the surface of the water, as in a mirror.

NOTE 2 Diagram (b) shows that, for turbulent conditions, there will be multiple reflections of the luminaire in the form of constantly moving patches of different luminance reflected randomly from various ripples.

Figure 2.1.5 — Reflections of a luminaire in the pool surface

2.1.5.3 Diving

Lighting of the diving area requires special consideration. In particular, the following can be problematic for divers, and officials:

- (a) Light reflected from a turbulent water surface has an angular spread of about $\pm 20^\circ$. This means that reflected images on the water surface of luminaires mounted overhead may mask swimmers in the diving area from the view of a dive. Luminaires should be located outside of the zone shown in [Figure 2.1.6 \(a\)](#).
- (b) Luminaires may be a source of discomfort glare for divers. Luminaires should be located outside of the zone shown in [Figure 2.1.6 \(b\)](#).
- (c) When present, the view of officials may suffer due to disabling glare caused by bright luminaires near to their lines of sight. Luminaires should be located outside of the zone shown in [Figure 2.1.6 \(c\)](#).

The luminaire type, location, and aiming needs to be carefully considered, as does luminaire intensity control. Louvres, shields, etc. may ameliorate the light source brightness. For practical reasons it may be necessary to locate luminaires in the exclusion zones. If necessary, care needs to be taken that they do not cause glare in the relevant directions towards divers and judges. In particular, the luminaire should be of a type, and aimed in a direction that, when operational, appears to be off to the appropriate observer(s), i.e. the luminance of light emitting surface viewed by the observer should be substantially limited.

A switching or dimming system would allow individual luminaires to be controlled as necessary to suit a particular activity.

A competent lighting designer should be consulted.

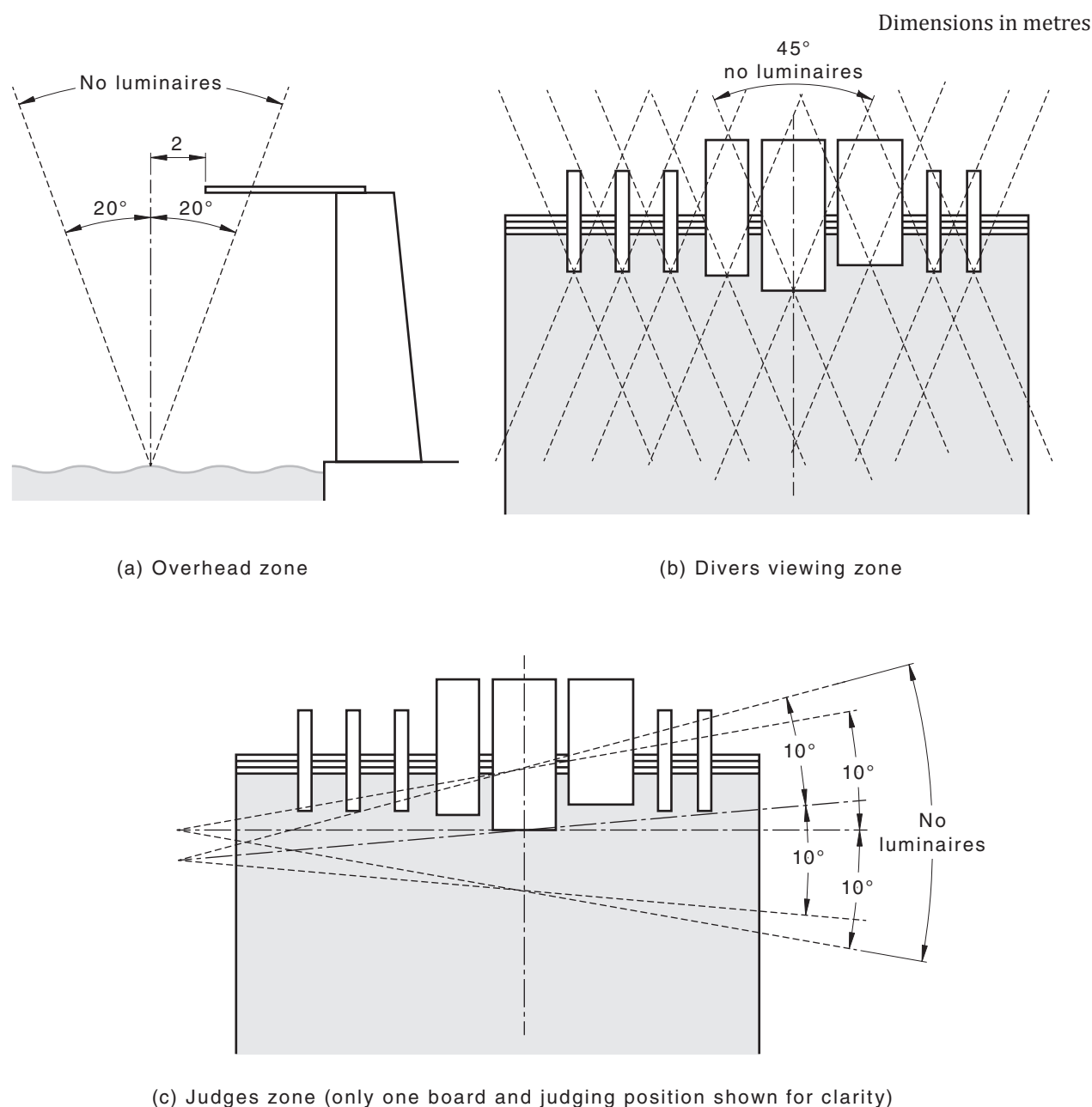


Figure 2.1.6 — Veiling reflection and glare control for diving

2.1.5.4 Spectator comfort

Where the spectator areas are on one side only of the pool, the luminaires should be located on that side and aimed across the pool and away from the spectators, if this is practicable.

2.1.5.5 Glare rating (GR)

For typical pools a diffuse reflectance factor of 0.5 usually applies. The maximum GR is applicable to each observer position. Observers should be located at 2 m back from the edge of the pool, and spaced around the perimeter at no more than 7.5 m, see the example in [Figure 2.1.7](#). Care should be used for irregular shaped pools to ensure that observers are located where lifeguards are likely to be positioned.

If the lighting system is symmetrical, then the number of observer points may be reduced. Observers shall be at a height of 1.5 m above the PPA. Each observer shall either —

- (a) view all of the calculation points specified by the calculation grid of [Figure 2.1.1](#); or
- (b) have a viewing angle of 2° below horizontal, and viewing directions in azimuth of equal angular steps of 15° (the viewing directions may be limited to those that lie within the extents of the calculation grid of [Figure 2.1.1](#)).

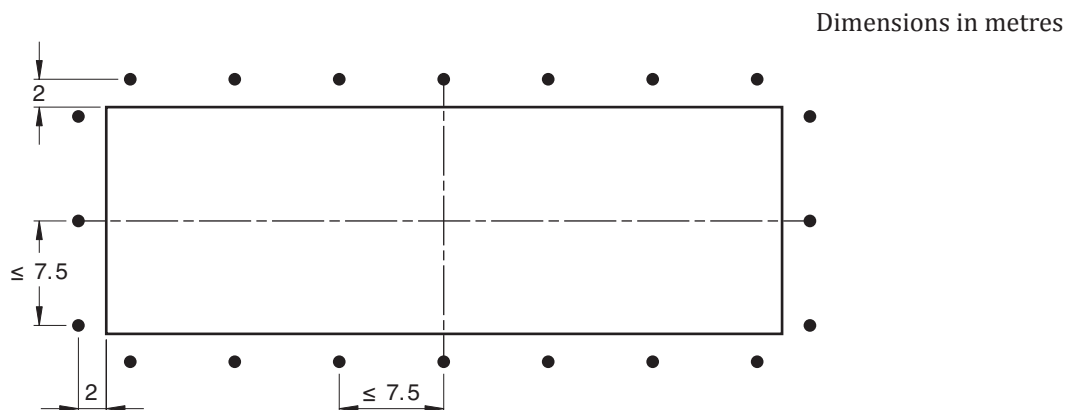


Figure 2.1.7 — Example of GR observer positions for aquatic sports

2.1.6 Lighting systems for outdoor pools

Generally, a side lighting system should be used for outdoor pools, whether for single or multi-pool complexes.

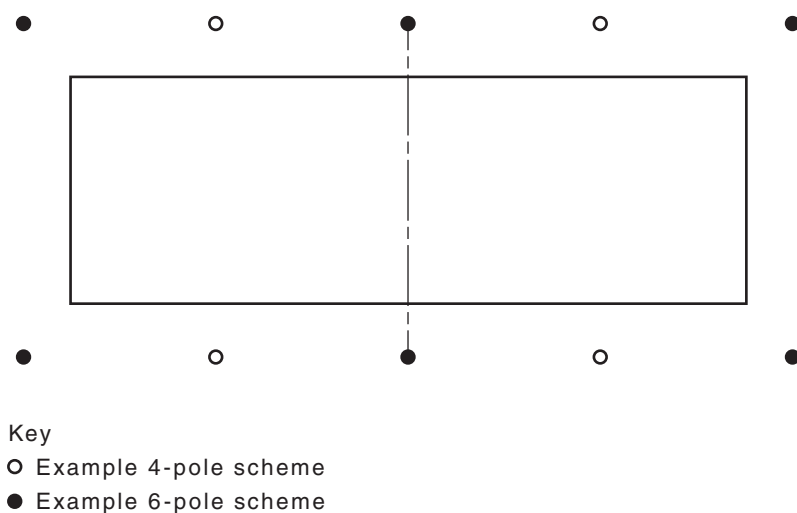
Luminaires located only at the corners or ends are not recommended because the shadows produced on the end walls will cause difficulty for swimmers judging the position of these walls for the purpose of correctly executing turns and finishes.

General area lighting is a suitable method for a single or multiple-pool installation where all, or a majority of, the pools are likely to be in use at the same time.

Underwater lighting contributes little to visibility if the overhead lighting is good. Underwater lighting is not recommended for competition pools but may be used for aesthetic or decorative purposes in recreational or free-form pools.

The standard method is to mount luminaires on poles located around the pool surrounds, see [Figure 2.1.8](#). The mounting height is governed by the maximum recommended incident angle, and so depends on the distance at which the luminaires are set back from the sides of the pool, see [Figure 2.1.4](#).

In selecting locations for lighting poles, care should be taken to minimize possible obstruction of views of the pool from spectator positions. Consideration should be given to the possibility of mounting luminaires on the front edge of roofed spectator stands, to avoid obstruction of views caused by lighting poles. Suitable provision should be made for access for maintenance.



NOTE Single-sided arrangements of either 2-pole or 3-pole schemes are acceptable provided they are in accordance with this section.

Figure 2.1.8 — Typical lighting layouts for outdoor aquatic sports

2.1.7 Lighting systems for indoor pools

2.1.7.1 General

The choice of lighting system for an indoor pool is largely dictated by the design and structure of the building. The electric lighting can only supplement deficiencies in daylight illuminance; it cannot counteract excessive sky glare or reflections of glazing in the water.

The design objective of electric lighting is to —

- (a) provide favourable conditions to see for participants and officials when insufficient light or no daylight is present;
- (b) be durable in withstanding the environmental conditions; and
- (c) be serviceable and facilitate maintenance throughout the life of the installation.

Luminaires not located above the pool will reduce maintenance cost associated with the draining of the pool to access luminaires and the consequent wastage of water and chemicals. This wastage has economic and environmental impacts.

2.1.7.2 Direct lighting

2.1.7.2.1 General

The direct lighting systems in this [Clause 2.1.7.2](#) are typically suitable for the lighting of indoor swimming pools.

2.1.7.2.2 Overhead near-point source luminaires

Overhead near-point source luminaires can provide a narrow intensity distribution where the luminance is strictly controlled above 50° from the vertical. Similar light control can also be provided with these lamps used in luminaires with louvres or prismatic panels. To provide an efficient installation, these units need to provide very high intensities at angles close to the downward vertical to achieve good water penetration and consequently luminance of the pool basin lining.

A feature of this type of installation is that the image reflected on the surface of the water is small in area and of low luminance. These installations are sometimes criticized for the high-downward light intensities which may cause glare to backstroke swimmers and participants in water polo and synchronized swimming. However, these criticisms can be largely overcome by careful design, particularly where the luminaires are integrated with acoustic baffles which also serve to screen views of the luminaires.

The reflectance factor of the ceiling should be at least 0.6 in order to reduce the contrast between the luminaires and their immediate surrounds when viewed by the swimmer.

Due to the narrow distribution of these luminaires, the luminance of the walls is usually satisfactory. Nevertheless, to prevent a gloomy effect the wall reflectance factor should be not less than 0.4.

Where there are large areas of glazing up to ceiling level, blinds or curtains should be used; firstly, to increase the effective wall reflectance at night and second to prevent disturbing reflections of the luminaires from the windows. In this type of installation underwater lighting will not improve viewing into the water.

It is recommended that glazing not extend more than 3 m above the pool concourse, to minimize the necessity for the blinds or curtains described above. Also, it should be noted that the life of most fabrics is severely affected by chlorine vapour.

2.1.7.2.3 Overhead large-area luminaires

Overhead large-area luminaires arranged separately, or in rows, are usually linear sources. Their luminance is much lower than that described in [Clause 2.1.7.2.2](#) but it is still important that the intensity at angles above 50° should be controlled. This means the light penetration is still of a high order and the reflected images, although much larger in area, are of a low luminance. If these requirements are met then additional underwater lighting is not necessary. If, however, luminaires with less control above 50° (which is sometimes unavoidable) are used in small halls with low ceilings, an underwater lighting system can improve viewing conditions into the water. Glare to swimmers is not usually a problem so long as wall and ceiling reflectance factor of at least 0.6 are used. The recommendations in [Clause 2.1.7.2.2](#) concerning the use of blinds or curtains at night also apply.

2.1.7.2.4 Side lighting

Side lighting, although offering reduced initial and maintenance costs, is the least effective lighting system due to excessive direct glare from the luminaires, and the difficulty of achieving incident lighting angles below the recommended maximum. For wall-mounted or ceiling-mounted (outside pool basin extremities) luminaires, used where the recommended mounting heights are practicable, good results can be achieved. In these cases, to reduce excessive contrast between the luminaires and their background, wall and ceiling reflectance factor should be at least 0.6.

2.1.7.3 Indirect lighting

Indirect lighting is generally not recommended on the grounds of inefficiency (high operating costs). However, in certain circumstances, such as pools covered in winter by airborne structures (air houses), it may be impractical to mount luminaires over the pool or at acceptable heights along the sides of the pool to allow direct lighting. In these situations, the covering membrane may be uniformly illuminated by side-mounted luminaires to provide pool lighting. The luminaires should be so aimed as to avoid high luminance adjacent to the luminaires and to avoid direct glare to spectators or officials in areas or seating around the pool, in that instance it may not be possible to achieve competition levels. The covering membrane should have a reflectance factor of at least 0.7, if possible.

2.1.7.4 Lighting from central and side catwalks

Catwalks provided for maintenance of building services (air conditioning or lighting) may be used to facilitate maintenance of lighting systems described above. If central or side catwalks are available,

direct or side lighting systems may be modified to suit, provided that the general guidelines given above are observed.

2.1.7.5 Underwater lighting

Underwater lighting may be considered for community recreational pools or free-form pools to provide decorative or aesthetic features rather than functional lighting. The functional lighting system should be provided in accordance with this [Clause 2.1.7](#).

2.2 Baseball and softball

2.2.1 General

Baseball and softball are high-speed outdoor sports in which the ball may travel at speeds in excess of 60 m/s. There is potential danger arising from the possibility of collision and contact between players and between players and the ball. At higher levels of play, the main difference is not the absolute ball velocity, but the increased level of pitching skill, e.g. curve balls, and velocity variation. Therefore, higher lighting levels are appropriate.

In addition to the major direction of ball travel between the pitcher and the batter, there is considerable ball travel between the other three bases and the pitcher. Commonly employed luminaires may be so bright as to cause disability glare to players and spectators alike, consequently suitable pole heights, locations, and luminaire aiming are therefore essential for sufficient visual performance for participants, officials, and spectators.

It is important that good contrast be provided between the ball and its background, especially in the pitcher and batter zones. This is facilitated by the provision of vertical illuminance. In addition, the provision of illumination over the whole of the field, and in the space above is important to facilitate the judgement of ball flight.

2.2.2 Light Technical Parameters (LTPs)

The LTPs shall be in accordance with the applicable values in [Table 2.2.1](#).

Table 2.2.1 — LTPs for baseball and softball

Level of play ^a	Grid	Average horizontal maintained illuminance ($\bar{E}_h$)	Minimum horizontal uniformity		Minimum vertical maintained illuminance (E_{vmin}) ^b	Max. glare rating (GR)	Minimum colour rendering index (R_a)
			$(E_{hmin}/\bar{E}_h)$ (U_1)	(E_{hmin}/E_{hmax}) (U_2)			
Training (non-competition)	Infield	300	0.50	0.30	n/a	n/a	65
	Outfield	200	0.30	0.20	n/a	n/a	65
Softball — Recreational, club/local competition	Infield	300	0.60	0.40	100	50	65
	Outfield	200	0.50	0.30	60	50	65
Baseball — Club/local competition	Infield	500	0.60	0.40	150	50	65
	Outfield	300	0.50	0.30	100	50	65
Baseball and Softball — State/major competition	Infield	750	0.70	0.50	300	50	65
	Outfield	500	0.60	0.40	200	50	65
Softball — National	Infield	750	0.70	0.50	300	50	80
	Outfield	500	0.60	0.40	200	50	80
Baseball — National	Infield	1 500	0.80	0.70	500	45	80
	Outfield	1 000	0.60	0.50	300	50	80

^a For international competitions refer to specific sport governing body requirements.

^b The ratio of the vertical illuminance at points H and P should be between 0.5 and 2, it is recommended that it should be between 0.75 and 1.5.

2.2.3 Calculation and measurement grids

Calculations and measurements of horizontal illuminance shall be made at ground level for a grid of points covering both the infield and outfield areas in accordance with [Figures 2.2.1](#) and [2.2.2](#).

Calculations and measurements of vertical illuminance shall be made parallel to the ground, and 1 m above ground level for the following positions and directions (see [Figure 2.2.3](#)):

- (a) *Infield area* — At home base (H) facing towards the pitcher's mound/plate (P), and at the pitcher's mound/plate (P) facing towards home base (H);
- (b) *Outfield area* — At each of the six outfield points (RF1/2, CF1/2, LF1/2) facing as shown.

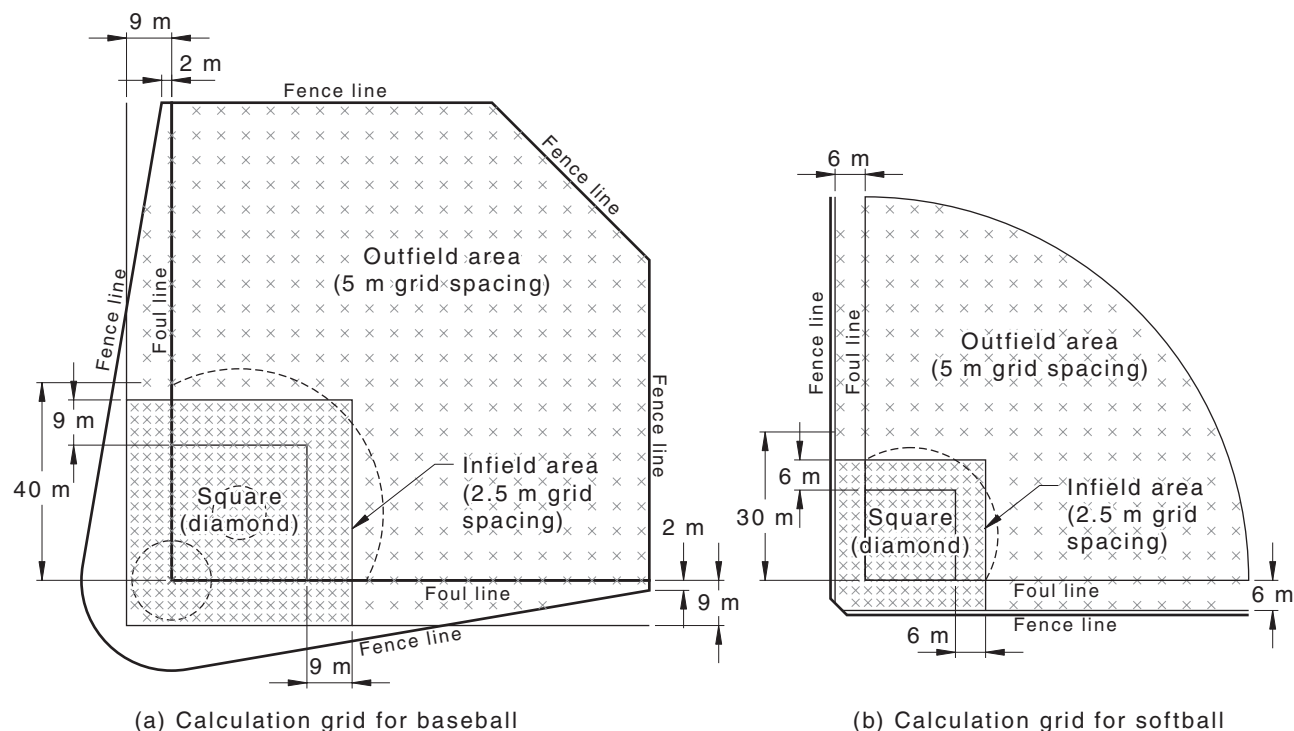


Figure 2.2.1 — Calculation grids for horizontal illuminance for baseball and softball

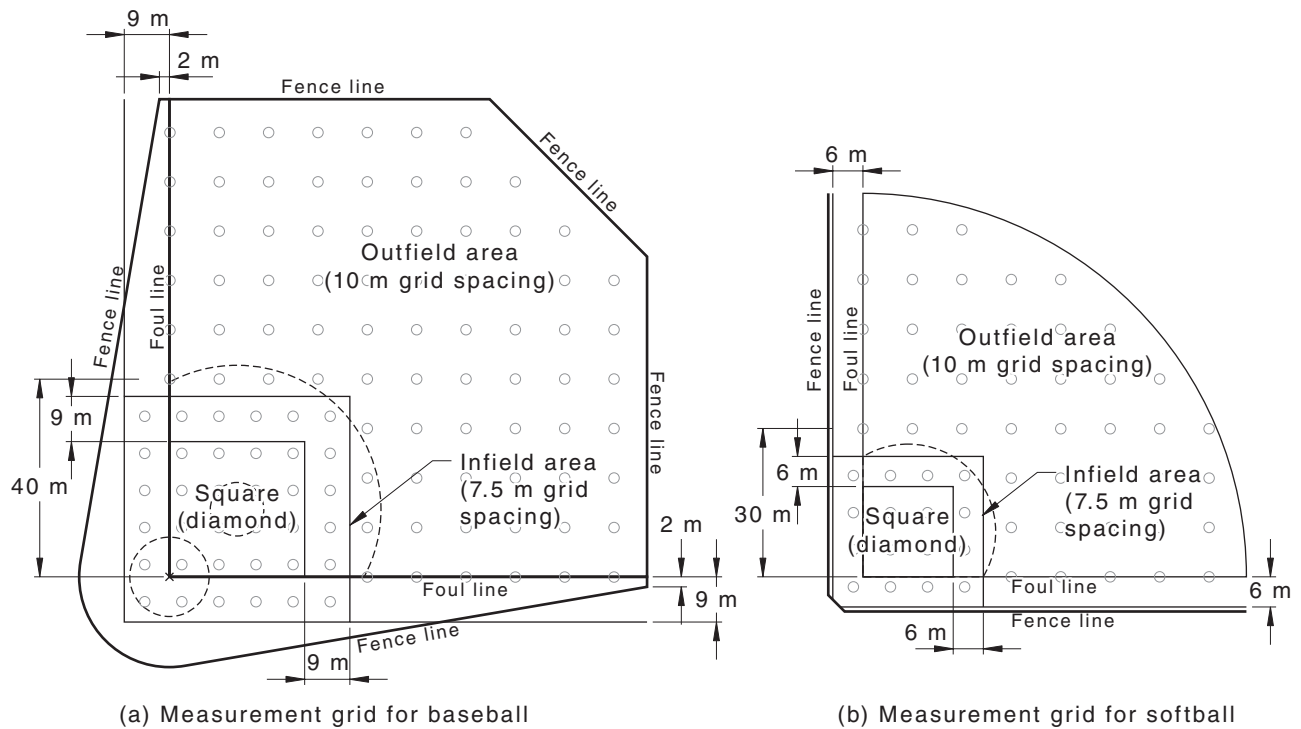
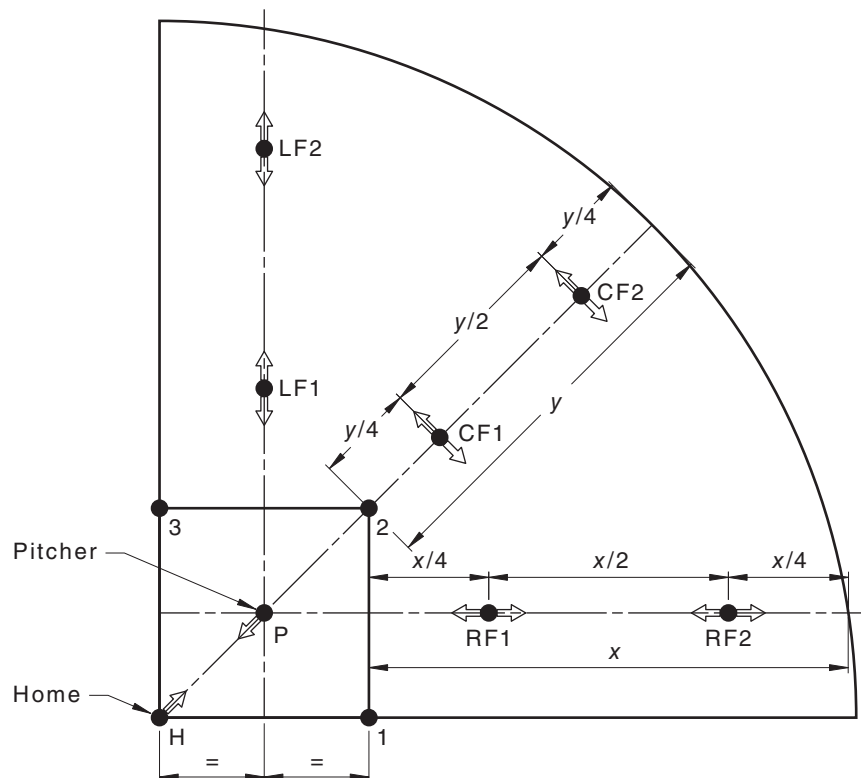


Figure 2.2.2 — Measurement grids for horizontal illuminance for baseball and softball



The arrow ($\Rightarrow$) indicates the direction of the surface normal of the plane for the calculation of vertical illuminance, viz. the orientation of the light meter. Points 1, 2, and 3 are exclusively for GR observers for baseball state/major competition and national level of play.

Figure 2.2.3 — Locations and directions for vertical illuminance points, and GR observer positions for baseball and softball

2.2.4 Glare control

2.2.4.1 General

The restriction of disability glare is an important safety consideration because the visibility of a ball approaching at high speed may be reduced, giving an increased risk of injury. Discomfort glare should also be limited for participants, officials, and spectators.

The principal means of controlling glare involves a combination of the following measures:

- (a) The luminaire mounting height should be in accordance with [Clause 2.2.4.2](#).
- (b) Poles should be located in accordance with [Clause 2.2.4.3](#).
- (c) Luminaires should be aimed in accordance with [Clause 2.2.4.4](#).
- (d) Glare rating shall be calculated in accordance with [Clause 2.2.4.5](#).

2.2.4.2 Luminaire mounting height

The minimum luminaire mounting height to the lowest luminaire should be in accordance with [Table 2.2.2](#).

Table 2.2.2 — Minimum mounting height for luminaires

Level of play	Minimum height of the lowest luminaire (<i>h</i>)
Baseball	
Club/Local/State/Major competition	25 m
National	30 m or <i>h</i> whichever is higher
Softball	
Recreational/Club/Local competition	20 m
State/Major competition/National	25 m or <i>h</i> whichever is higher

If applicable, the minimum mounting *h* should be determined in accordance with [Clause 1.6](#), where *h* is calculated by the following equation:

$$h = 0.6 \times d$$

where

d = the horizontal distance from the pole(s) under consideration to the applicable point on the FOP specified below (see [Figure 2.2.4](#)):

- (a) For A and B poles—the pitcher's plate;
- (b) For C poles—the nearest point on the field that is —
 - (i) for baseball—65 m from the home plate; and
 - (ii) for softball—45 m from the home plate.

The above relationship is intended to ensure that an angle of at least 30° will be provided between the horizontal and a line from the specified point on the FOP to the lowest luminaire.