Lighting Standards

Iowa
High School
Athletic
Association

IOWA HIGH SCHOOL
ATHLETIC ASSOCIATION

Adopted September, 2017

TABLE OF CONTENTS

Lighting Guidelines

The Board of Control of the Iowa High School Athletic Association approved the development of lighting guidelines in the 2002-03 school year. The following standards have been updated and accepted by the Iowa High School Athletic Association and apply to the lighting of all high school athletic activities sponsored by the IHSAA or its member schools.

Lighting athletic fields provides more opportunities for participants and allows increased family and community attendance at evening events. These standards incorporate the most current data available regarding the desired performance, lighting, electrical and structural issues that apply to installation of a safe, effective lighting system. Lighting technologies currently available vary greatly in efficiency, with the most effective providing life-cycle savings equal to or greater than the initial cost of the system, depending on hours of usage.

The standards are divided into recommended minimums and desirable features. The minimums establish criteria important to safe conduct of IHSAA activities and include evaluation of operating costs over the expected life of the lighting system. Desirable features are established to give added values where appropriate for a school's needs.

With ever-increasing pressure on operating budgets, schools are encouraged to clearly establish the performance criteria they expect and to evaluate the life-cycle operating cost of the sports lighting system.

I. Recommended Minimum Standards

These minimum standards are recommended for all lighting installations after the date of adoptions of these standards. Any modification in existing lighting systems after this date should be done so as to result in a lighting system in compliance with these standards. To be in compliance, a system must meet all recommended minimum standards.

PART 1 – GENERAL

1.1 LIGHTING PERFORMANCE

A. Quantity

The IESNA "Recommended Practice for Sports and Recreational Area Lighting" RP-6-15 provides design criteria for sports facilities. Maintained average illuminance is defined as the average illuminance below which the light level should not fall throughout the system's life. Actual values are calculated from measurements taken on the specified surface at the time maintenance is to be carried out.

The preferred method of design should provide a constant light level over the light-level guarantee period. The acceptable alternative is to apply a recoverable light loss factor.

1. Preferred Technology

a. Metal Halide

By utilizing a series of power adjustments, a lighting system is able to provide "constant light levels" and greatly extend the life of the lamps. In addition, this generation of lighting has high performance optic characteristics that enable reductions in the quantities of luminaires needed to meet design targets, lowering installation and operating costs. Light levels are typically guaranteed for up to 25 years with this technology.

b. LED

LED light sources can have a much greater lifespan than metal halide light sources with significantly less lumen depreciation over typical sports lighting operating hours. For example, a metal halide light source may reach 70% lumen maintenance in as little as 2,100 – 3,000 hours while an LED light source may take 100,000 hours or more.

2. **Prior Technology – Metal Halide**

   For prior technology lighting systems, the specified light levels should be derived by applying Light Loss Factors to the Initial lighting designs in the manner shown in the IESNA Lighting Handbook Reference and Application, Tenth Edition, page 10.24.

   Initial light levels are to be based on footcandles as calculated from the photometric report of the luminaire (per the lamp manufacturer's 100 hour lamp lumens) x Ballast Factor x Voltage Factor x Ambient Temperature Factor x Lamp Tilt Factor.

   In determining the target average light values, a recoverable light loss factor of 0.7 is to be applied, in addition to the adjustment for the above mentioned non-recoverable Light Loss Factors.

   Target Light Levels = Initial Light Levels x Recoverable LLF

   Recoverable LLF = LLD x LDD = 0.70

   Quality manufacturers are willing to provide guarantees of lighting performance.

3. **Initial and Target/Constant Light Levels**

   The average initial light levels (for prior technology systems only) and target/constant light levels, should be as stated below:

   NOTE: For facilities that plan on hosting televised events, the facility should be lit according to the NCAA lighting standards for television broadcasts. To access these standards online, go to http://www.ncaa.org, then use the site's search feature to search for "Best Lighting Practices."

Average Light Levels (Initial and Target [maintained] Levels)		
Area of Lighting	**Initial Light Levels (Avg)**	**Target Light Levels (Avg)**
Baseball/Softball Infield Area	71.5 footcandles	50 footcandles
Baseball/Softball Outfield Area	43 footcandles	30 footcandles
Football/Soccer/Lacrosse/Field Hockey/Rugby (Practice Fields or facilities with less than 2000 spectator seating)	43 footcandles	30 footcandles
Football/Soccer/Lacrosse/Field Hockey/Rugby (Facilities with more than 2000 spectator seating)	71.5 footcandles	50 footcandles
Tennis	71.5 footcandles	50 footcandles
Gymnasiums (For practice or recreational purposes only)	71.5 footcandles	50 footcandles
Gymnasiums (For hosting events with spectators)	114.5 footcandles	80 footcandles
Track and Field (Track oval only)	29 footcandles	20 footcandles
Track and Field (For areas where field events will take place)	43 footcandles	30 footcandles
Note: Combination/Multipurpose areas must meet the highest average among the standards for activities played on the field.		

B. Quality

Uniformity is a measure of relationships of the illuminances over an area and helps to ensure the quality of the lighting on a project. This is particularly important for high-speed sports conducted on a playing field. To ensure the highest quality of light, three separate uniformities are defined. They are maximum to minimum illuminance uniformity ratio, uniformity gradient, and coefficient of variation. The quality of the lighting should be determined on a basis of these three measurements.

1. **Maximum to Minimum Uniformity Ratio**

   The uniformities of the playing field should be measured by comparing the maximum reading to the minimum reading. This ratio should not exceed the value given on the table below.

2. **Uniformity Gradient (UG)**

   The ratio of greater footcandles to lesser footcandle levels between any two adjacent points in the defined grid should not exceed the value given on the table below.

3. **Coefficient of Variation (CV)**

   The maximum ratio of the standard deviation for all of the footcandle values to the mean should not exceed the value given on the following table.

Uniformity			
Area of Lighting	**Max to Min Ratio**	**Uniformity Gradient**	**Coefficient of Variation**
Baseball/Softball Infield Area	2.0:1	1.5	0.17
Baseball/Softball Outfield Area	2.5:1	1.5	0.21
Football/Soccer/Lacrosse/Field Hockey/Rugby (Practice Fields or facilities with less than 2000 spectator seating)	3.0:1	1.5	0.25
Football/Soccer/Lacrosse/Field Hockey/Rugby (Facilities with more than 2000 spectator seating)	2.0:1	1.5	0.21
Tennis	2.0:1	1.5	0.17
Gymnasiums (For practice or recreational purposes only)	3.0:1	2.0	0.25
Gymnasiums (For hosting events with spectators)	2.5:1	1.5	0.21
Track and Field (Track oval only)	4.0:1	2.0	0.30
Track and Field (For areas where field events will take place)	3.0:1	2.0	0.30
Note: Combination/Multipurpose areas must meet the highest average among the standards for activities played on the field.			

C. Light Source

1. **Metal Halide**

   Metal halide lamps have long been used for sports lighting applications due to their ability to provide high luminous efficacy, good color rendering, and good optical control characteristics. In general, 1500-watt fixtures are the most economical solution for exterior facilities. Standard correlated color temperature (CCT) is about 4200 K.

2. **Light Emitting Diode (LED)**

   LEDs are becoming more prevalent in their use for sports lighting applications. Their efficacy continues to improve, the costs decrease, and the life of the diodes is much longer than metal halide.

   For the expected life of the LED it is recommended to obtain the lumen maintenance report per TM-21-11, of the fixture being proposed. Projected lumen maintenance hours should be reported (based on 6x testing) values and not calculated values. However, the long life of an LED is only as good as the system around it...starting with the heat sink, the luminaire design and protection from the elements, the driver, and the structure to which it is attached.

   LEDs can come in various color rendering and color temperature combinations, all of which affect efficacy. Currently, the most efficient LEDs for sports lighting are about 5700 K. This is acceptable per the IES position statement, PS-09-17.

LEDs provide for the ability to have better optical control. This is only as good as the overall optical design of the luminaire. Some metal halide luminaires have better optical control than some LED luminaires.

D. Light Level Documents

1. On-Field Performance

Lighting equipment manufacturers should provide drawings showing the horizontal footcandle quantity at each point of measurement on the field. The drawings should indicate both the initial and target average horizontal illuminance levels at each measurement point on the field. The drawings should contain any relevant light loss factors in determining the predicted illuminance levels. For designs where constant light is utilized, a single set of drawings showing target illuminance levels is sufficient.

An additional drawing may be necessary to evaluate the initial spill and glare values required to meet local ordinances.

2. Environmental Light Control

For areas of concern the glare, from any one fixture, should not exceed 5,000 candela (measured at 60 inches above ground level).

E. Measurement of Light Quantity

1. Area of Light Quantity

The areas for which measurements are to be taken and the points of measurement within that area are shown in the appendix. It is important that measurements be taken at all of the points to meaningfully establish that the standards for quantity and standards are being met for the facility.

2. Methods of Measuring Light Quantities

The light sensing surface of the light meter should be held 36 inches above the playing surface with the sensing surface horizontal so that it detects light coming downward to the sensing surface from all directions around the ball field. Testing equipment for measurement of light should be a cosine and color-corrected light meter regularly calibrated in footcandles.

3. Grid Spacing

Submitted computer models depicting the measurements of light should be generated on a grid of a specified number of points covering a stated area on an equally spaced grid. See the chart shown in the appendix for the exact specifications for the area to be lighted, grid spacing, and minimum number of grid points for each field.

F. Maintained Alignment

1. Luminaire Alignment

The sports lighting manufacturer’s warranty should include accurate alignment of the fixtures. The current technology of lighting equipment has precise intense beams — the misalignment of individual fixtures by a few degrees can significantly impact the appearance of the field. Misaligned fixtures can also result in undesirable glare for players, spectators, and neighbors.

2. Pole Alignment

Twisting or leaning of poles can also result in misalignment of fixtures, thereby altering the quantity and quality of light on the field. Wood poles should not be used due to the potential of the longitudinal fibers of the pole to twist. The foundation for the poles should also be designed with sufficient strength to prohibit the pole from leaning, which could likewise misalign the lights. Foundations should be certified by a Registered Professional Engineer licensed in the State of Iowa.

G. Pole Locations

Pole locations should be positioned, as established by the layouts shown in the appendix, to keep the lights out of glare zones as defined in the IESNA RP-6-15, thus enhancing playability. Wherever possible, poles should be located outside of fences to avoid causing an obstruction and safety hazard to the play of the game.

H. Vertical Aiming Angles

To enhance playability on the field, reduce glare, and minimize spill light, minimum pole heights should be defined in the project specifications based on site conditions to ensure proper vertical aiming angles. Refer to notes about minimum vertical aiming angles in the appendix. Certain sites may require steeper vertical angles due to enhanced spill and glare concerns.

I. Electrical Components

a. Ballast and Capacitor

The ballast, capacitor, and fusing for each lighting fixture should be mounted off the fixture or crossarm onto the pole at stepladder height. There are maintenance and long-term durability issues enhanced by placing these components lower on the pole. Pages 18 and 63 of the IESNA RP-6-15 "Recommended Practice for Sports and Recreational Area Lighting" discuss some of the benefits of remote ballasts.

b. Driver

For the same reasons mentioned above, when using LED lighting, the driver and associated electrical components should be mounted off the fixture or crossarm onto the pole at stepladder height.

J. Aiming Diagram

The manufacturer should supply a drawing showing the aiming alignment of each fixture with the measurement referencing the field and the pole locations.

1.2 ENVIRONMENTAL LIGHT CONTROL

Many facilities are located near residential properties or roadways, creating the possibility of spill and glare onto adjoining properties. They are also often located adjacent to other fields where the glare from lights on one field can affect playability on another. Consideration should be given to this issue during the initial lighting design stage to minimize this effect. Some communities are implementing ordinances designed to minimize light pollution. Contact your local planning committee or zoning board.

The lighting equipment manufacturer can assist in assessing this issue and provide drawings showing maximum footcandles at any points of concern on adjacent properties. Do not hesitate to investigate a manufacturer's reputation, abilities, and past experiences in working with local authorities and private property owners regarding glare and spill issues. See section 1.1.D.2 for standards.

1.3 LIFE-CYCLE COSTS

Because the efficiency of lighting systems currently available can vary greatly, a life-cycle operating cost analysis should be completed when evaluating lighting systems. Owners should expect a quality lighting system to last a minimum of 25 years.

These standards provide a Life-Cycle Operating Cost Evaluation form on page 13 to assist with the process. Items that should be included are energy consumption based upon the facility's expected usage, cost for group and spot lamp replacement and maintenance, and any additional savings in energy or labor cost provided by automated on/off control systems.

Contract price and life-cycle operating cost should both be considered in determining a lighting manufacturer for the project.

1.4 WARRANTY AND GUARANTEE

When comparing products, the manufacturers' warranty should also be evaluated. The quality of the warranty reflects a manufacturer's confidence in the long-term durability of their equipment. Considerations include the extent of the equipment covered, the duration of the warranty, and whether the warranty provides a guarantee of light levels during the warranty period. From the owner's perspective, the warranty offers the opportunity to reduce costs for equipment repair. Comprehensive warranties covering parts and labor are available for up to 25 years.

PART 2 – PRODUCT

2.1 LIGHTING SYSTEM CONSTRUCTION

A. Electrical

1. Electrical System

Electrical system shall consist of main service entrance panel, contactor cabinet for safe on/off operation, and electrical circuits feeding luminaire circuits. System design should conform to National Electric Code.

2. Fusing

Each lighting fixture should be individually fused with UL Listed fused equipment rated for use with the system. Fusing shall be located in the remote electrical enclosure located at ground servicing height on the pole.

3. Disconnects

There should be provided at each pole a disconnect means located at the minimum height required by code to allow disconnecting of electrical power of the pole. This disconnect should be in addition to overcurrent protection provided at the distribution panel for the each individual circuit.

4. Grounding

All poles, fixtures, and distribution panels should be grounded according to National Electric Code recommendations. It is important to verify the ground and grounding connections.

If lightning grounding is not integrated into the structure, it may be necessary to supplement with grounding electrodes, copper down conductors, and exothermic weld kits.

5. Lightning Protection

Each pole or structure supporting lighting equipment should be equipped with lightning protection as established by NFPA 780 (National Fire Protection Association).

6. Surge Protection

Surge protection should be provided at each pole equal to or greater than 40 kA for each line to ground (Common Mode) as recommended by IEEE C62.41.2 - 2002

7. Enclosed Rigid Cover

All conductors above grade should be enclosed in rigid metallic or liquid type flex conduit unless they are in the interior of the pole.

8. Lockable Hinged Enclosures

All enclosures of electrical conductors that are hinged and designed to be opened should be lockable and should be kept locked except during times of access for operation or service. Access should be by means of lock or special tool.

9. Electrical Conductor Wires

All electrical conductor wires for distribution of power around the playing field should be buried underground at depths as required by NEC or by applicable local code that may supersede NEC. Conductor wires should be copper. No shared neutral is allowed.

10. Drawings of the Electrical System of the Lighting Structure

The lighting equipment manufacturer should provide a drawing of the entire electrical system from the light fixtures at the top of the pole to the base of the pole that shows compliance with these standards and provides sufficient information for maintenance personnel.

11. **Drawings of Electrical Distribution**

    The electrical designer should provide electrical drawings certified by a Registered Professional Engineer licensed in the State of Iowa. These drawings should illustrate the electrical system from the base of the pole to the transformer provided by the utility company. These drawings should be in compliance with and/or be approved by the local authority regulating electrical systems and should incorporate the lighting system designs provided by the lighting manufacturer.

12. **Underwriter Laboratory Listing**

    The lighting and electrical equipment on ballfield and court lighting structures should have a UL Listing to confirm that the equipment has passed the safety tests of Underwriters Laboratory, not only as to the individual components, but also as to the use of the components in the configuration of the lighting system on the field.

13. **Non-Compliance with the Standards**

    Deviation from these standards for electrical systems may occur only after approval of written documentation signed by an electrical engineer licensed in the state. The documentation should state the reason why it is necessary to deviate from the standards and state how a safe electrical system will be achieved using the alternate standards.

14. **Wire Harness**

    Wire harnesses should be provided for each pole structure complete with an abrasion protection sleeve, strain relief support, and plug-in connections for fast, trouble-free installation.

15. **Strain Relief**

    The wiring harness should be supported at the top of the pole by a stainless steel wire mesh grip matched to the size and number of conductors within the harness. There should not be more than 13 conductors supported by a single wire mesh grip. If the pole height is greater than 80 feet, an interim wire mesh grip support should be located approximately half way down the pole.

16. **Voltage Drop**

    The installing contractor should verify that voltage drop does not exceed 3% of nominal voltage.

B. Manufacturing Requirements

All components should be designed and manufactured as a system. All luminaires, wire harnesses, and ballast and other enclosures should be factory assembled, aimed, wired, and tested for reduced installation time and trouble-free operation.

C. Durability

All exposed components shall be constructed of corrosion-resistant material and/or coated to help prevent corrosion. All exposed carbon steel shall be hot-dip galvanized per ASTM A123. All exposed hardware and fasteners shall be stainless steel of 18-8 grade or better, passivated and coated for protection against corrosion and stress-corrosion cracking. All exposed aluminum shall be powder coated with high performance polyester paint or anodized. All exterior reflective inserts shall be anodized, coated with a clear, high gloss, durable fluorocarbon, and protected from direct environmental exposure to prevent reflective degradation or corrosion. All wiring shall be enclosed within the crossarms, conduit, pole, or electrical components enclosure.

D. Lightning Protection

All outdoor structures shall be equipped with lightning protection meeting NFPA 780 standards.

E. Safety

All system components shall be UL Listed for the appropriate application.

2.2 STRUCTURAL PARAMETERS

A. Strength of Foundation

There should be calculations and documentation certified by a Registered Professional Engineer licensed in the State of Iowa, illustrating that the foundation design is adequate to withstand the forces imposed from the pole, lighting fixtures, and other attachments to prevent the structure from leaning or failing.

1. Foundations should be made of reinforced concrete and should provide for pole attachment at a minimum of 18 inches above the ground to avoid corrosive deterioration.

   For a foundation using a pre-stressed concrete base embedded in concrete backfill the concrete shall be air-entrained and have a minimum compressive design strength at 28 days of 3,000 PSI. 3,000 PSI concrete specified for early pole erection, actual required minimum allowable concrete strength is 1,000 PSI. All piers and concrete backfill must bear on and against firm undisturbed soil.
2. Poles and other support structures, brackets, arms, bases, anchorages, and foundations shall be determined based on the 50-year mean recurrent isotach wind maps for the appropriate county per the Iowa State Building Code, which uses the International Building Code (IBC) as a basis for the building code standard. Luminaire, visor, and crossarm shall withstand 150 mph winds and maintain luminaire aiming alignment.
3. Any backfill of excavated soil should be replaced with concrete to ensure adequate compressive strength, which will avoid leaning and misalignment of the pole.
4. The design criteria for these specifications are based on soil design parameters as outlined in the geotechnical report. If a geotechnical report is not provided by the school, the foundation design shall be based on soils of a Class 5 material as defined by 2015 IBC, Table 1806.2.

B. Strength of Pole

The stress analysis and safety factor of the poles shall conform to AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals.

1. Hot-dip galvanized steel poles are recommended. Wood poles are undesirable for sports lighting applications because the twisting of poles often causes electrical safety problems. Wood poles would not meet standards if this document was regulatory in nature.
2. Recommended foundation types include: direct buried prestressed concrete poles, direct buried prestressed concrete base with a slip fit steel pole shaft, or a poured-in-place concrete foundation with anchor bolts and a base plate galvanized steel pole. It is recommended that all pole bases be of concrete construction in the ground and to a point 18 inches above the ground to avoid corrosive deterioration. Foundations designed with direct embedment steel components are not recommended.
3. If direct burial steel poles are used, the supplier should furnish stamped foundation drawings from a structural engineer licensed in Iowa. A soil analysis should be conducted by a geotechnical engineering firm and appropriately analyzed to assess the interaction between the galvanized pole and the surrounding soil for compatibility. The embedded portion of the steel should be sealed inside and out with a moisture-impervious coating to help resist corrosion. If the coating is damaged in transit or during installation, it should be repaired using the manufacturer's recommended procedures and permitted to cure an appropriate length of time before final installation.

C. Retrofits

Modifications to any existing poles require permitting from the local building official. Should the local building official determine that a permit is not required the building code still requires the work to be done in a manner that meets code. As such, structural calculations should be furnished to demonstrate compliance with the building code requirements for alterations to existing structures.

D. Lightning

All structures should meet the NFPA 780 lightning protection code as referenced in section 2.1.A.5.

PART 3 – EXECUTION

3.1 FIELD QUALITY CONTROL

A. Field observation of the foundations should be made by the Lead Architect and/or the structural/geotechnical design consultant to ensure proper installation.

B. Upon completion of the installation of the lighting system, it is in the best interest of the school system that the light levels be tested in order to ensure compliance to these lighting standards by the manufacturer supplying the system and the contractor who has installed the system. A formal light test, using a calibrated light meter, should be conducted in the presence of the contractor, owner, lighting design team or associated consultants, and lighting manufacturer's representative, to verify initial light levels. The light meter should be held in a horizontal position at the locations determined by the computer light scan originally supplied by the manufacturer. The readings should be recorded and compared to the original initial light level predictions. If the uniformities and overall footcandle average of the readings do not meet or exceed the specified levels, the contractor/manufacturer of the system should be required to bring the system into compliance. Final testing should be conducted in accordance with IESNA publications LM-5-04 and IESNA RP-6-15.

C. To help ensure the safety of the players and spectators, it is recommended that each school or school district develop a regularly scheduled maintenance program. Regardless of source technology, the basics of lighting maintenance remain the same: relamping (metal halide), cleaning, monitoring, aiming alignment, and troubleshooting. At a minimum, the following items should be addressed:

1. Visual Testing

Should be performed annually prior to the start of a season on lamps, lenses, conduit, pole, fuses, ballasts, drivers, grounding connections, and breaker boxes to ensure integrity and performance of the system. (Refer to Maintenance Checklist provided in the Appendix)

2. Performance Audits

Audits should be performed annually prior to the start of a season on light levels. (Refer to the Lighting Performance sections provided in the Appendix)

D. Group relamping (metal halide) should occur according to the manufacturer's recommended time frame such that the required maintained average light level is sustained.

E. Facilities with existing wood poles should conduct an annual inspection of aiming, alignment, and external electrical components. Additionally, core tests of the wood poles should be performed as recommended by the testing company or local utility.

II. Desirable Features

The following practices are recommended for increasing the lighting system performance.

4.1 TV QUALITY LIGHTING

Lighting for televised events involves considerations in addition to spectators and participants. It is recommended that schools wishing to light facilities for television broadcast use consultants and lighting manufacturers with experience and knowledge in that area.

NOTE: For facilities that plan on hosting televised events, the facility should be lit according to the NCAA lighting standards for television broadcasts. To access these standards online, go to http://www.ncaa.org, then use the site's search feature to search for "Best Lighting Practices."

4.2 AUXILIARY BRACKETS

Sports-lighting manufacturers can provide accommodations for mounting auxiliary equipment such as speakers on sport lighting poles. This ensures poles will be sized to accommodate the weight, dimensions, and EPA of the additional equipment. Brackets shall be welded to the pole and fabricated from hot-dip galvanized steel with a covered hand hole access and internal wiring in the pole.

4.3 FIELD PERIMETER LIGHTING

There should be sufficient lighting in and around athletic facilities to prevent unsafe and inappropriate actions. The parking areas, major areas utilized for passage, and areas immediately bordering the facilities should be lighted to the minimum levels required to meet local codes and the recommendations found in the IESNA publications RP-20-14 "Lighting for Parking Facilities."

4.4 EMERGENCY LIGHTING FOR SPECTATOR SEATING AREA

Consideration should be given to providing emergency lighting for spectator seating areas in case of loss of power at indoor and outdoor facilities. Refer to local codes for specific requirements as they apply to athletic facilities.

4.5 MULTI-LEVEL LIGHTING

Additional energy savings can be obtained through the use of multi-level lighting. The multi-level lighting will allow the system to operate at the light level that is most appropriate to the activity taking place at any given time. For example, a facility may only be used for competitive play a few hours a day, with the remainder being used for practice or recreational use. The multi-level lighting would allow for the lights to be operated in the high mode for competition events, while operating on a medium, or low light level during the remainder of the time, thus conserving energy.

4.6 CONTROL AND MONITORING SYSTEM

A remote control and monitoring system will provide ease of operation and management for your facility. Manufacturers providing systems with a 25-year warranty will use this system to ensure your lighting performs as required.

A. Remote Monitoring

The system should monitor lighting performance and notify manufacturer if individual luminaire outage is detected so that appropriate maintenance can be scheduled. The manufacturer should notify the owner of outages within 24 hours, or the next business day. The controller should determine switch position (Manual or Auto) and contactor status (open or closed).

B. Remote Lighting Control

The system should allow owner and users with a security code to schedule on/off system operation via a web site, phone, fax, or email up to 10 years in advance. Manufacturer should provide and maintain a two-way TCP/IP communication link. Trained staff should be available 24/7 to provide scheduling support and assist with reporting needs.

The owner may assign various security levels to schedulers by function and/or fields. This function must be flexible to allow a range of privileges, from full scheduling capabilities for all fields to only having permission to execute "early off" commands by phone.

Control unit should accept and store 7-day schedules, be protected against memory loss during power outages, and should reboot once power is regained and execute any commands that would have occurred during outage.

C. Management Tools

Manufacturers should provide a web-based database of actual field usage and provide reports by facility and user group.

D. Communication Costs

Manufacturers should include communication costs for operating the controls and monitoring system for a period of 25 years.

E. Cabinet Construction

Controls and Monitoring Cabinet should be constructed of aluminum and rated NEMA Type 4. Cabinet shall contain contactors, labeled to match field diagrams and electrical design. Manual Off-On-Auto selector switches should be provided.

For additional information, contact the IHSAA office at:

P.O. Box 10
Boone, Iowa 50036-0010
Phone: 515/432-2011
Fax: 515/432-2961
www.iahsaa.org

SPORTS LIGHTING LIFE-CYCLE OPERATING COST EVALUATION

This form will assist you in comparing 25-year life-cycle operating costs from multiple manufacturers. Bid proposals will be evaluated based upon compliance with the specifications, contract price and the following life cycle operating cost evaluation.

BID ALTERNATE A:

A.	**Energy consumption** ____ Number of luminaires x ____ kW demand per luminaire x ____ kW rate x ____ annual usage hours x 25 years		
B.	**Demand charges, if applicable** ____ demand rate x ____ max kW consumption x ____ 12 months x 25 years	+	
C.	**Spot relamping and maintenance over 25 years (replamping not applicable for LED)** Assume ____ repairs at $ ____ each if not included	+	
D.	**Group relamps during 25 years (replamping not applicable for LED)** ____ annual usage hours x 25 years / lamp replacement hours x $125 lamp & labor x number of fixtures	+	
E.	**Extra energy used without control system** ____% x Energy Consumption in item A.	+	
F.	**Extra labor without control system** $____ per hour x ____ hours per on/off cycle x ____ cycles over 25 years	+	
G.	**TOTAL 25-Year Life Cycle Operating Cost**		

BID ALTERNATE B:

A.	**Energy consumption** ____ Number of luminaires x ____ kW demand per luminaire x ____ kW rate x ____ annual usage hours x 25 years		
B.	**Demand charges, if applicable** ____ demand rate x ____ max kW consumption x ____ 12 months x 25 years	+	
C.	**Spot relamping and maintenance over 25 years (replamping not applicable for LED)** Assume ____ repairs at $ ____ each if not included	+	
D.	**Group relamps during 25 years (replamping not applicable for LED)** ____ annual usage hours x 25 years / lamp replacement hours x $125 lamp & labor x number of fixtures	+	
E.	**Extra energy used without control system** ____% x Energy Consumption in item A.	+	
F.	**Extra labor without control system** $____ per hour x ____ hours per on/off cycle x ____ cycles over 25 years	+	
G.	**TOTAL 25-Year Life Cycle Operating Cost**		

SPORTS LIGHTING SUBMITTAL INFORMATION
Design Submittal Data Checklist and Certification

This form will assist you in comparing proposals from various lighting manufacturers. All items listed below are mandatory, shall comply with the specification, and must be submitted according to your pre-bid submittal requirements.

Included	Tab	Item	Description
	A	Letter/Checklist	Listing of all information being submitted must be included on the table of contents. List the name of the manufacturer's local representative and his/her phone number. Signed submittal checklist to be included.
	B	On Field Lighting Design	Lighting design drawing(s) showing: a. Field Name, date, file number, prepared by b. Outline of field(s) being lighted, as well as pole locations referenced to the center of the field (x & y), Illuminance levels at grid spacing specified c. Pole height, number of fixtures per pole, horizontal and vertical aiming angles, as well as luminaire information including wattage, lumens and optics d. Height of light meter above field surface e. Summary table showing the number and spacing of grid points; average, minimum and maximum illuminance levels in foot candles (fc); uniformity including maximum to minimum ratio, coefficient of variance (CV), coefficient of utilization (CU) uniformity gradient; number of luminaries, total kilowatts, average tilt factor; light loss factor. f. Manufacturers shall provide constant light level or provide both initial and maintained light scans using a maximum 0.70 Light Loss Factor to calculate maintained values.
	C	Off Field Lighting Design	Lighting design drawings showing initial spill light levels along the boundary line (defined on bid drawings) in footcandles. Light levels shall be taken at 30-foot intervals along the boundary line. Readings shall be taken with the meter orientation at both horizontal and aimed towards the most intense bank of lights.
	D	Photometric Report	Provide photometric report for a typical luminaire used showing candela tabulations as defined by IESNA Publication LM-35-02, (LM-79-08, for LED). Photometric data shall be certified by laboratory with current National Voluntary Laboratory Accreditation Program or an independent testing facility with over 5 years experience.
	E	Life Cycle Cost calculation	Document life cycle cost calculations as defined on the Life Cycle Operating Cost Evaluation. Identify energy costs for operating the luminaires, maintenance cost for the system including spot lamp replacement, and group relamping costs. All costs should be based on 25 Years.
	F	Environmental Light Control Design	Environmental glare impact scans must be submitted showing the maximum candela from the field edge on a map of the surrounding area until 500 candela or less is achieved.
	G	Structural Calculations (if required)	Pole structural calculations and foundation design showing foundation shape, depth backfill requirements, rebar, and anchor bolts (if required). Pole base reaction forces shall be shown on the foundation drawing along with soil bearing pressures. Design must be stamped by a structural engineer in the state of Iowa.
	H	Control and Monitoring	Manufacturer shall provide written definition and schematics for automated control system to include monitoring. They will also provide examples of system reporting and access for numbers for personal contact to operate the system.
	I	Electrical distribution plans	If bidding an alternate system, manufacturer must include a revised electrical distribution plan including changes to service entrance, panels and wire sizing, signed by a licensed Electrical Engineer in the state of Iowa.
	J	Performance Guarantee	Provide performance guarantee including a written commitment to undertake all corrections required to meet the performance requirements noted in these specifications at no expense to the owner. Light levels must be guaranteed per the number of years specified.
	K	Warranty	Provide written warranty information including all terms and conditions.
	L	Project References	Manufacturer to provide a list of project references of similar products completed within the past three years.
	M	Product Information	Complete set of product brochures for all components, including a complete parts list and UL Listings.
	N	Non-Compliance	Manufacturer shall list all items that do not comply with the specifications.
	O	Compliance	Manufacturer shall sign off that all requirements of the specifications have been met at that the manufacturer will be responsible for any future costs incurred to bring their equipment into compliance for all items not meeting specifications and not listed in item N – Non-Compliance.

Manufacturer: ______________________ **Signature:** ______________________

Contact Name: ______________________ **Date:** _____/_____/_____

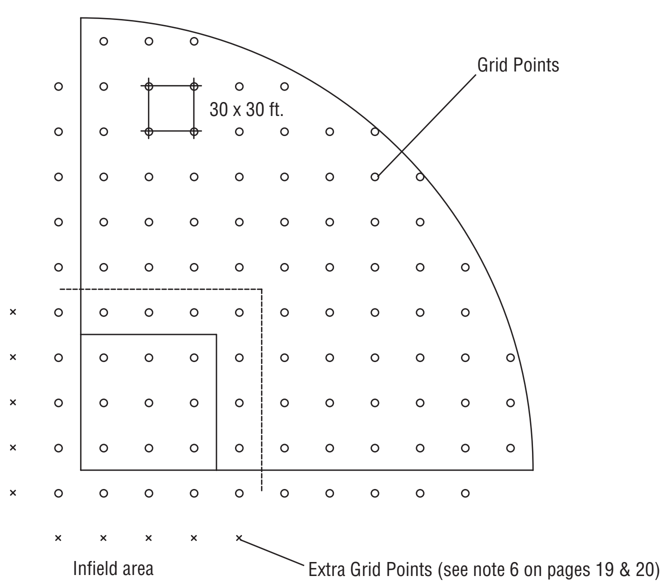
APPENDIX

Field Dimensions, Grid Spacing, and Grid Points of Typical Facilities

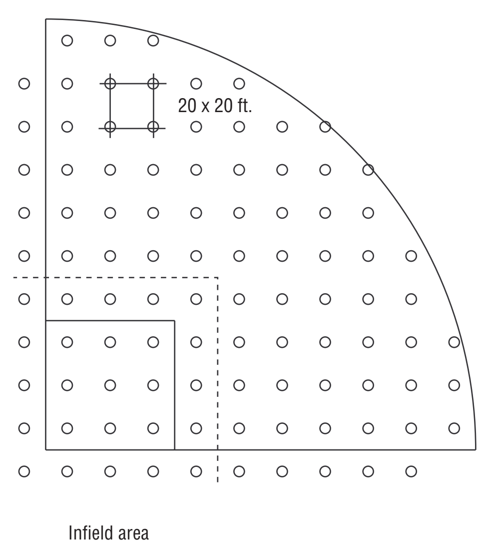
Typical Facilities			
Area of Lighting	**Playing Dimensions (feet)**	**Grid Spacing (feet)**	**Minimum # of Grids**
Baseball, Infield	90’ x 90’	30’ x 30’	25
Baseball, Outfield	Dimensions Vary	30’ x 30’	Varies
Softball, Infield	60’ x 60’	20’ x 20’	25
Softball, Outfield	Dimensions Vary	20’ x 20’	Varies
Football	360’ x 160’	30’ x 30’	72
Soccer	360’ x 180’	30’ x 30’	72
Lacrosse	330’ x 180’	30’ x 30’	66
Field Hockey	300’ x 180’	30’ x 30’	60
Rugby	330’ x 180’	30’ x 30’	66
Tennis	78’ x 36’	20’ x 20’	15
Gymnasiums	94’ x 50’	10’ x 10’	50
Track and Field	Dimensions Vary	30’ x 30’	Varies

Light Level Grid Point Layouts

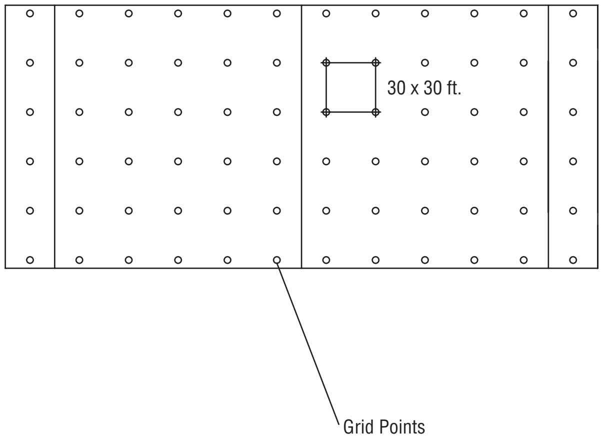
Baseball
300' radius field shown



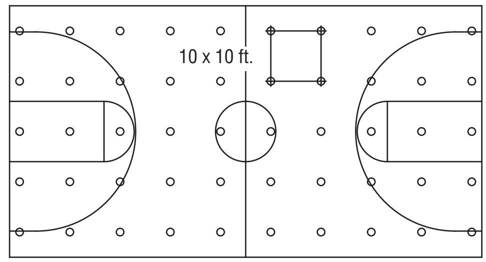
Softball
200' radius field shown



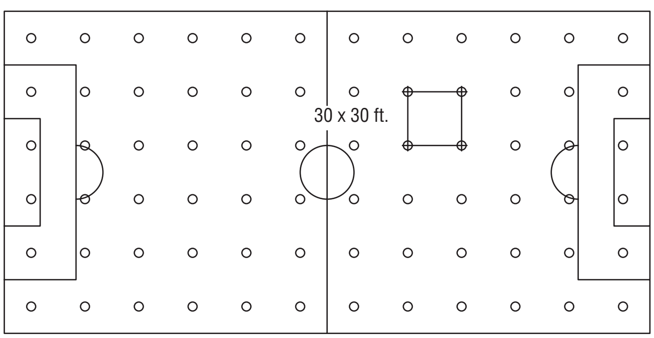
Football
360' x 160' field shown



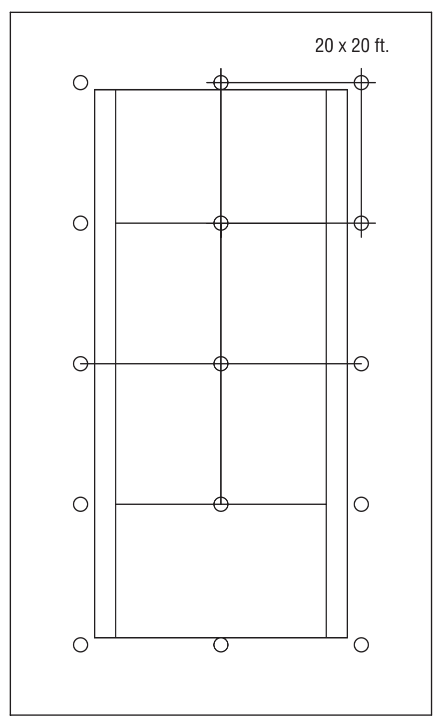
Gymnasium
94' x 50' court shown



Soccer
360' x 180' field shown

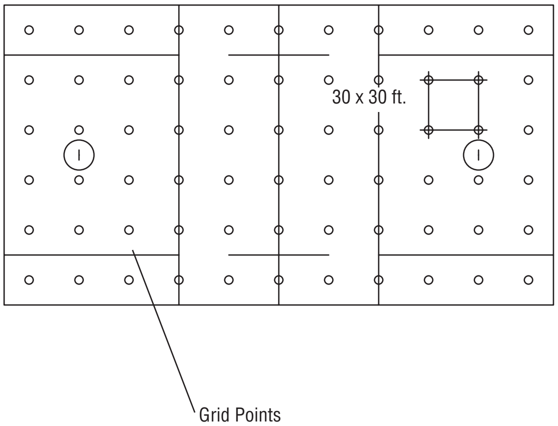


Tennis
78' x 36' court shown



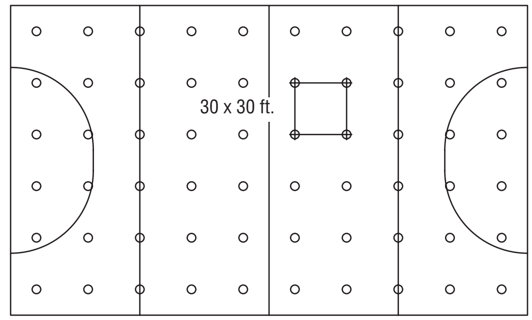
Lacrosse

330' x 180' field shown



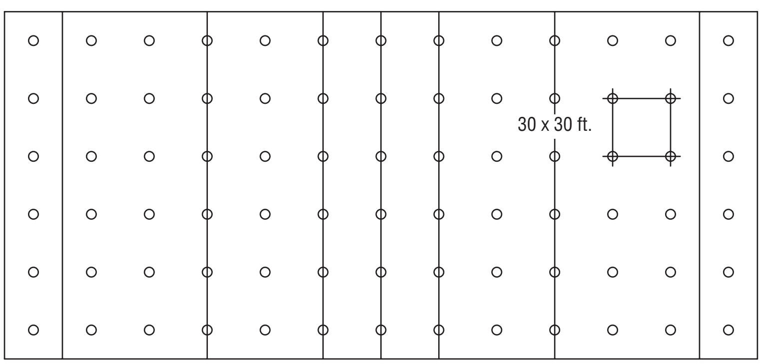
Field Hockey

300' x 180' field shown



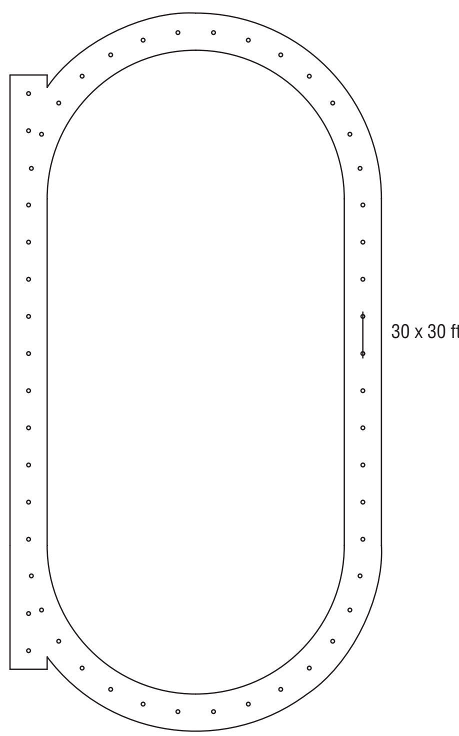
Rugby

330' x 180' field shown (not including end zones)

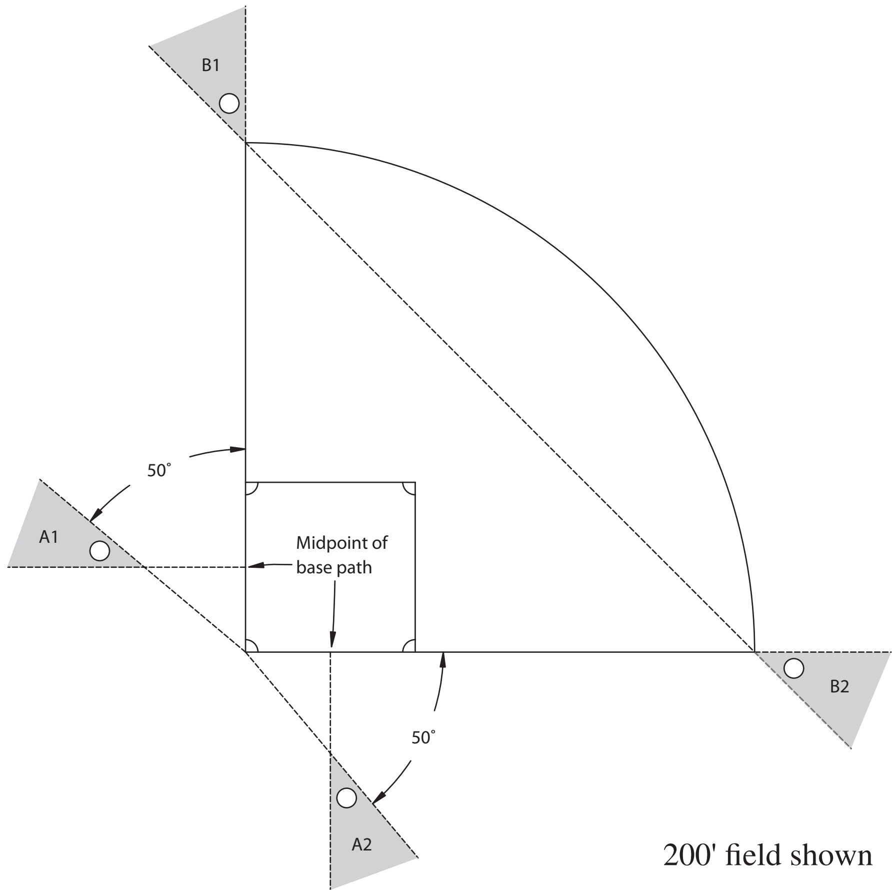


Track

400 meter, 8 lane track shown



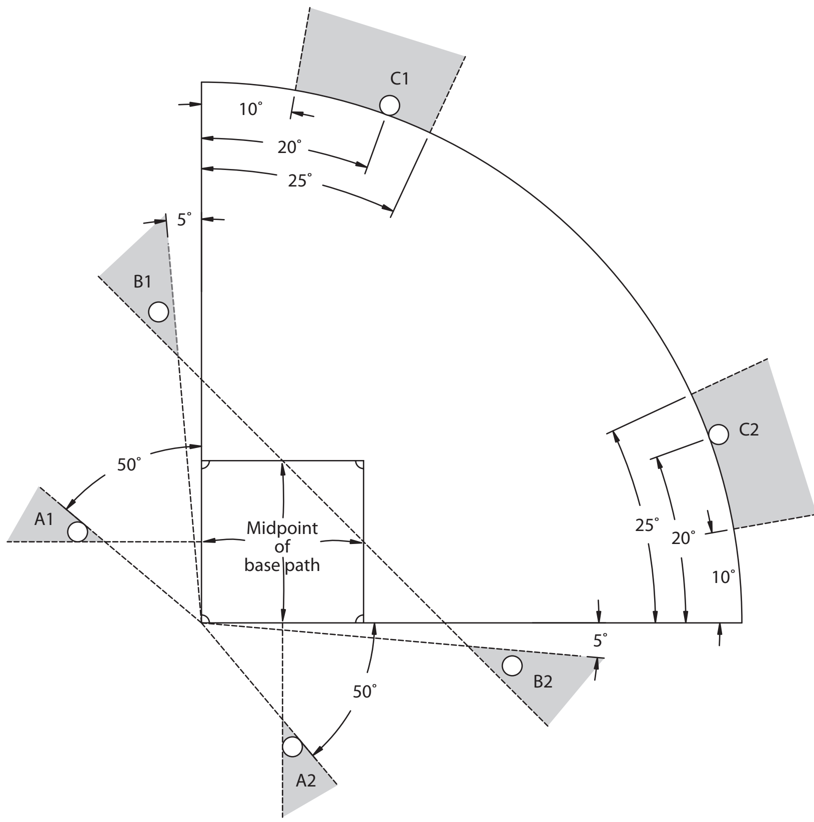
Pole Location Diagrams



4-Pole Softball Field

1. Poles are shown in optimal locations. Other permissible pole locations are indicated by the shaded areas.
2. For fields with a radius of 250 feet or greater, a 6-pole design is recommended.
3. Line drawn through the two "A" pole locations should be behind home plate to ensure lighting the portion of the ball the batter sees as it crosses home plate.
4. Vertical aiming angle should be 25 degrees minimum on fixtures aimed to the infield and 21 degrees minimum on fixtures aimed to the outfield. The angles are measured from below a horizontal plane at fixture height.

Note:
IES standards have not addressed issues for 4-pole design on softball fields. Design criteria are based upon actual practices used on 250' and smaller fields and standards adopted by Little League Baseball® and ASA Softball based upon testing done on their facilities.

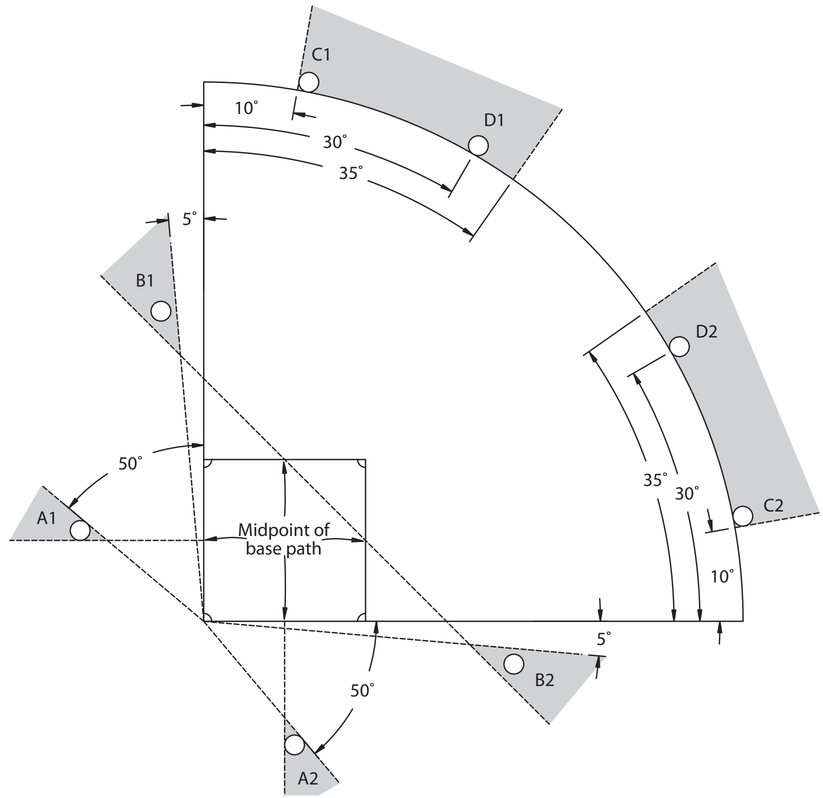


300' field shown

5*/6-Pole Baseball/Softball Field

1. Poles are shown in optimal locations. Other permissible pole locations are indicated by the shaded areas.
2. For fields with a radius of 320 feet or greater, an 8-pole design is recommended.
3. Line drawn through the two "A" pole locations should be behind home plate to ensure lighting the portion of the ball the batter sees as it crosses home plate.
4. Consideration should be given to locating "B" poles further toward the outfield locations. This positioning towards the outfield foul pole allows the ball to be lighted in a more constant perpendicular illuminance as it travels from the infield to the outfield.
5. Vertical aiming angle should be 25 degrees minimum on fixtures aimed to the infield, and 21 degrees minimum on fixtures aimed to the outfield. The angles are measured from below a horizontal plane at fixture height.
6. If the distance between home plate and the backstop is greater than 40 feet, an additional grid should be created to include 10 additional grid points. The average light level for this additional grid should meet or exceed the design criteria for the outfield points.

* If the lighting designer can demonstrate that glare from a pole in center field would be less than 1000 candela (as measured at home plate, 5' above the field surface) then the more economical 5-pole design would be acceptable.

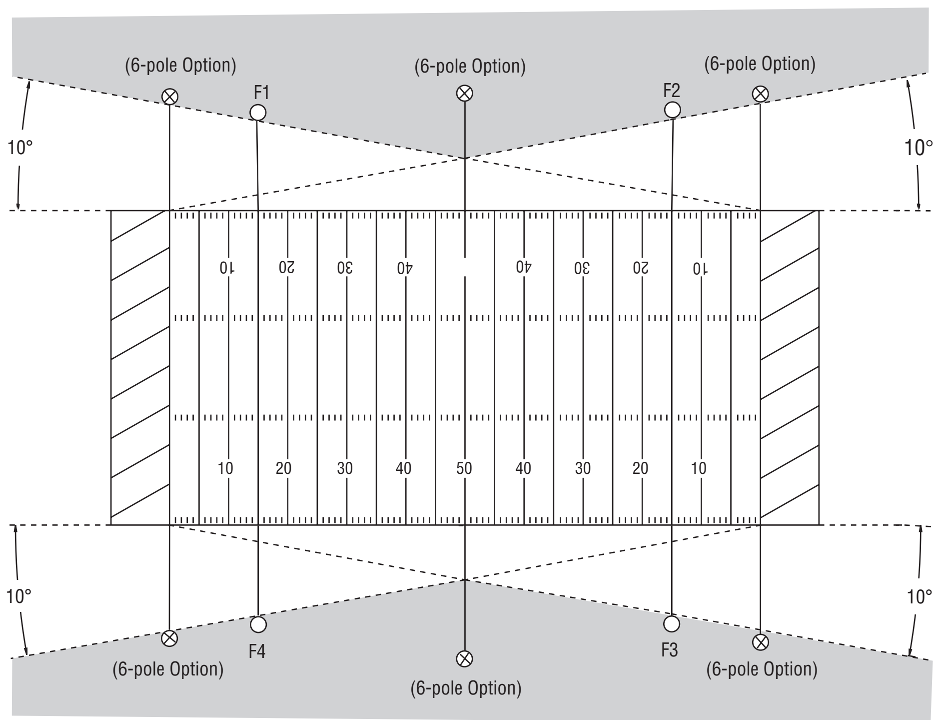


325' field shown

7*/8-Pole Baseball/Softball Field

1. Poles are shown in optimal locations. Other permissible pole locations are indicated by the shaded areas.
2. Line drawn through the two "A" pole locations should be behind home plate to ensure lighting the portion of the ball the batter sees as it crosses home plate.
3. Consideration should be given to locating "B" poles further towards outfield locations. This positioning towards the outfield foul pole allows the ball to be lighted in a more constant perpendicular illuminance as it travels from the infield to the outfield.
4. "B" poles may be located 10 feet closer to the infield as long as they maintain a position outside the 5 degree arc. The shaded area is preferable.
5. Vertical aiming angle should be 25 degrees minimum on fixture aimed to the infield, and 21 degrees minimum on fixtures aimed to the outfield. The angles are measured from below a horizontal plane at fixture height.
6. If the distance between home plate and the backstop is greater than 40 feet, an additional grid should be created to include 10 additional grid points. The average light level for this additional grid should meet or exceed the design criteria for the outfield points.

* If the lighting designer can demonstrate that glare from a pole in center field would be less than 1000 candela (as measured at home plate, 5' above the field surface) then the more economical 7-pole design would be acceptable.



Football Field

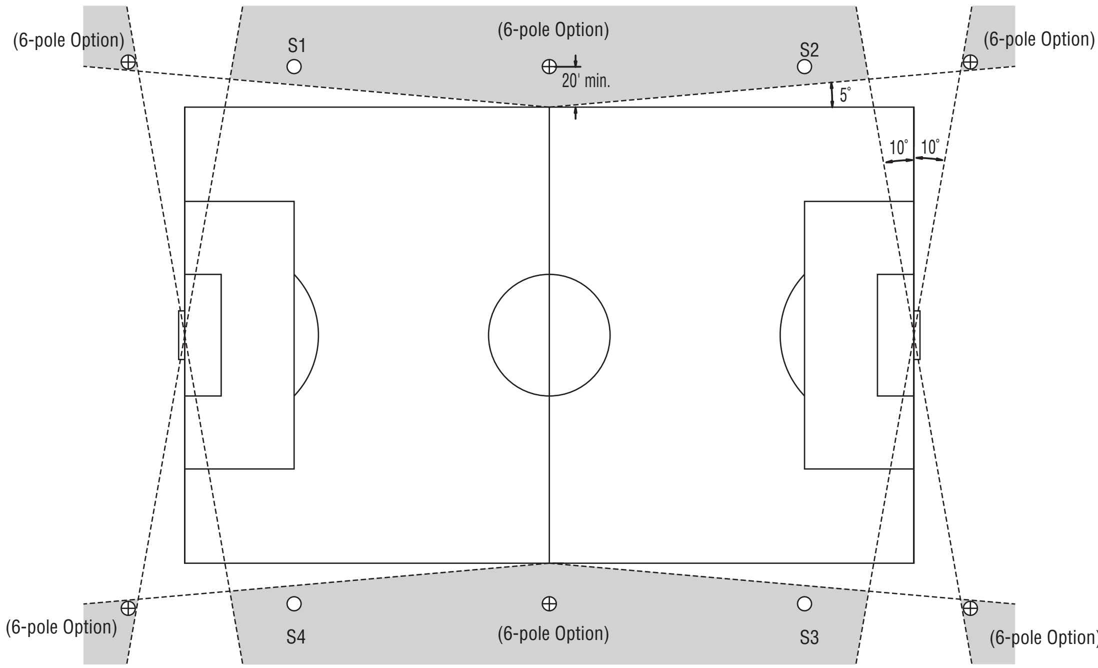
1. Poles are shown in optimal locations. Other permissible pole locations are indicated by the shaded areas. All poles should be at least 30 feet from the sideline.

2. On a 4-pole design, the optimum location is on the 15 yard line.

3. For the 6-pole option, the setback of middle poles will depend on the presence of bleachers. The optimum location for the corner poles is between the goal line and the corner of the field.

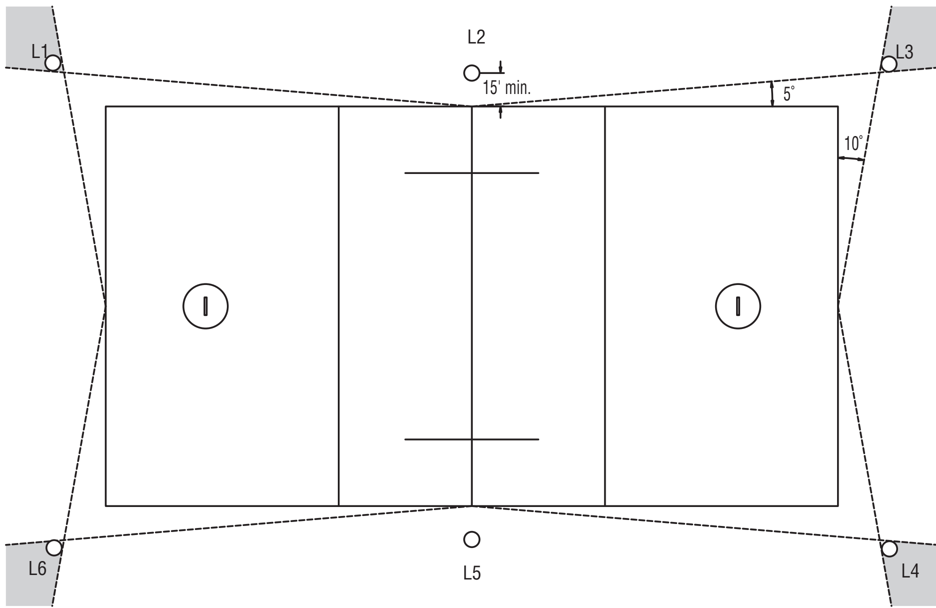
4. Poles should be positioned so as not to pose a potential injury hazard.

5. Vertical aiming angle should be 21 degrees minimum. The angles are measured from below a horizontal plane at fixture height.



Soccer Field

1. Poles are shown in optimal locations. Other permissible pole locations are indicated by the shaded areas. All poles should be at least 20 feet from the sideline.
2. On a 4-pole design, the optimum pole locations are (.35 x field length) from center of field.
3. In general, football lighting standards apply to soccer with the following considerations:
   a. A corner kick is a specific visual task and general consideration should be given to facility design specifically for soccer.
   b. The corner grid point shall be lit to no less than 90% of the average light level.
4. For combination football and soccer facilities, soccer should take precedence.
5. Vertical aiming angles should be 21 degrees minimum. The angles are measured from below a horizontal plane at fixture height.

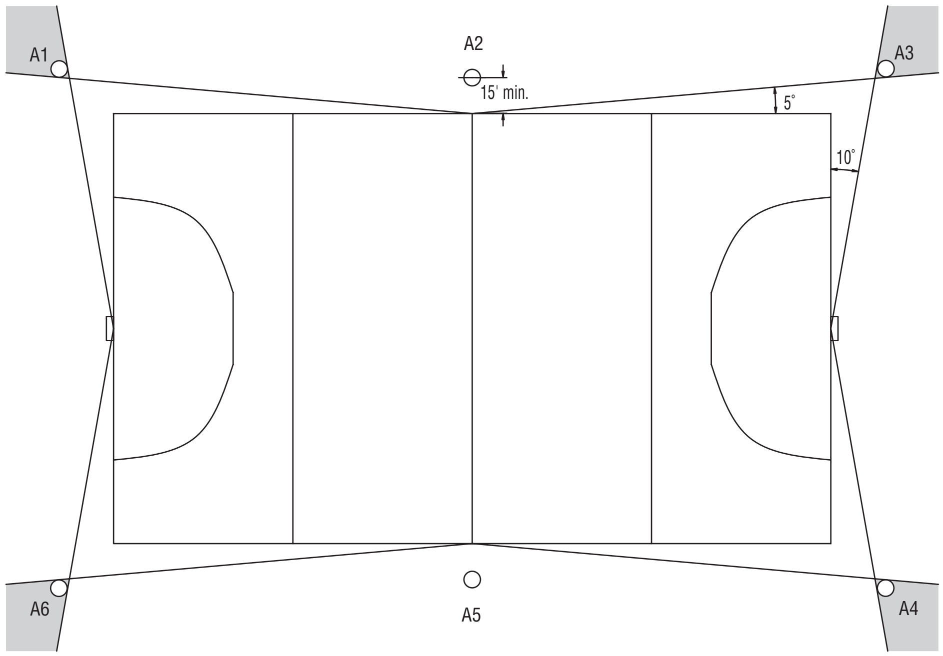


Lacrosse Field

1. Poles are shown in optimal locations. Other permissible pole locations are indicated by the shaded areas. All poles should be at least 15 feet from the sideline.

2. Vertical aiming angle should be 21 degrees minimum. The angles are measured from below a horizontal plane at fixture height.

3. A 4-pole design utilizing corner location is permissible providing minimum aiming angles can be achieved.

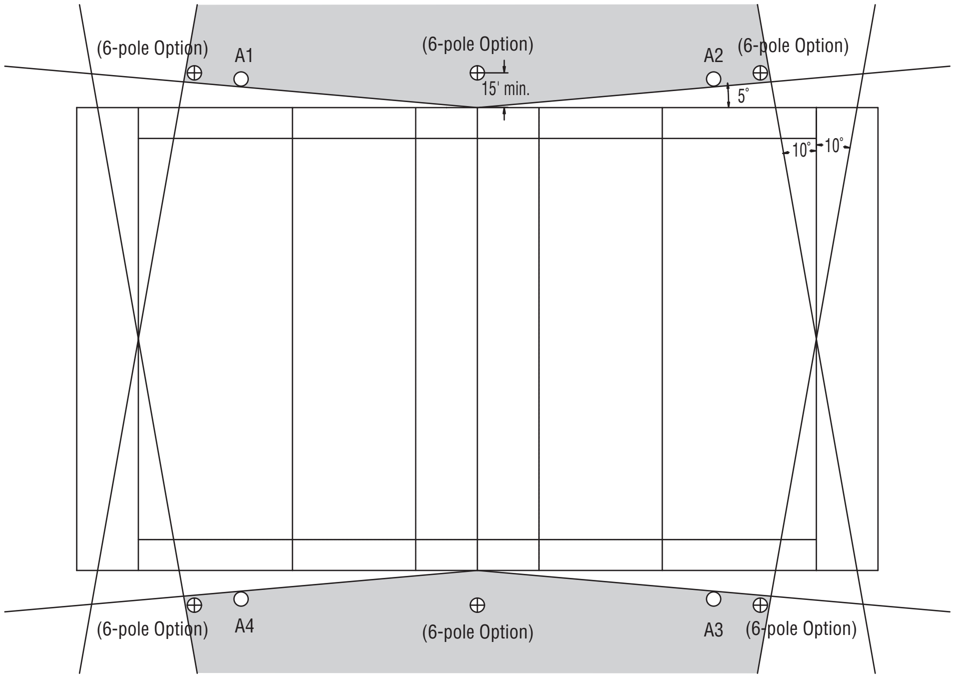


Field Hockey Field

1. Poles are shown in optimal locations. Other permissible pole locations are indicated by the shaded areas. All poles should be at least 15 feet from the sideline.

2. Vertical aiming angle should be 21 degrees minimum. The angles are measured from below a horizontal plane at fixture height.

3. A 4-pole design utilizing corner location is permissible providing minimum aiming angles can be achieved.



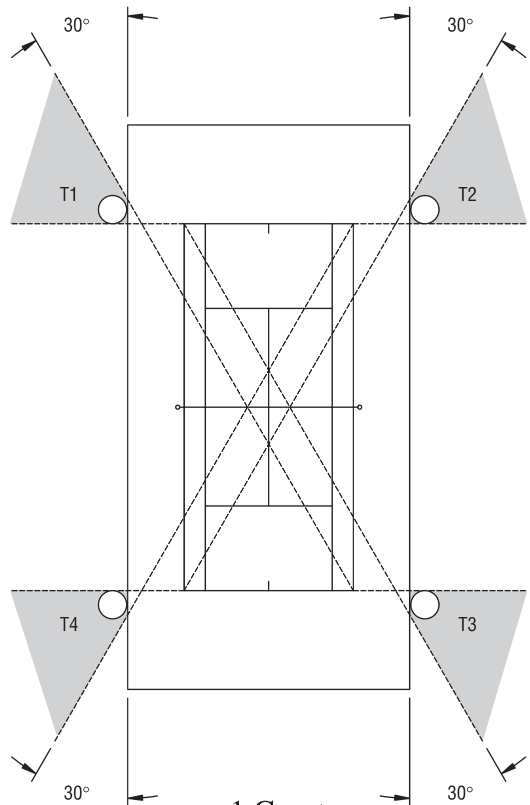
Rugby Field

1. Poles are shown in optimal locations. Other permissible pole locations are indicated by the shaded areas. All poles should be at least 15 feet from the sideline.

2. On a 4-pole design, the optimum pole locations are (.35 x field length) from center of field.

3. Poles should be positioned so as not to pose a potential injury hazard.

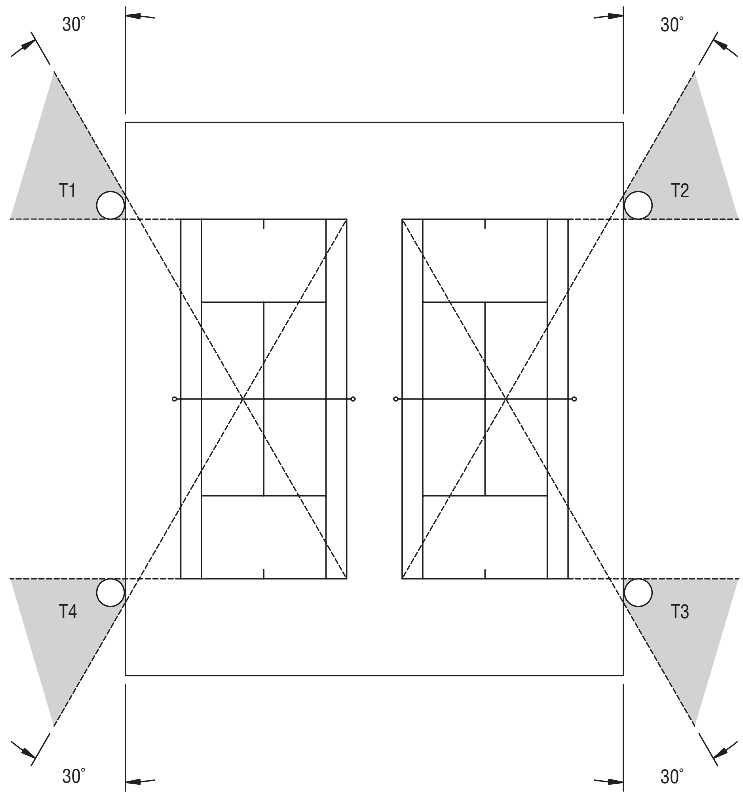
4. Vertical aiming angle should be 21 degrees minimum. The angles are measured from below a horizontal plane at fixture height.



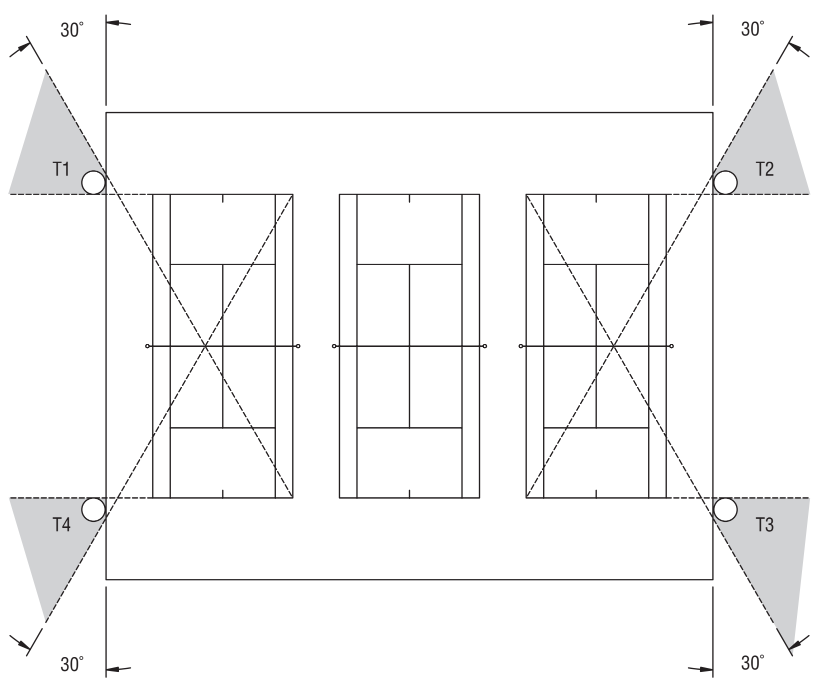
1 Court

Tennis Courts

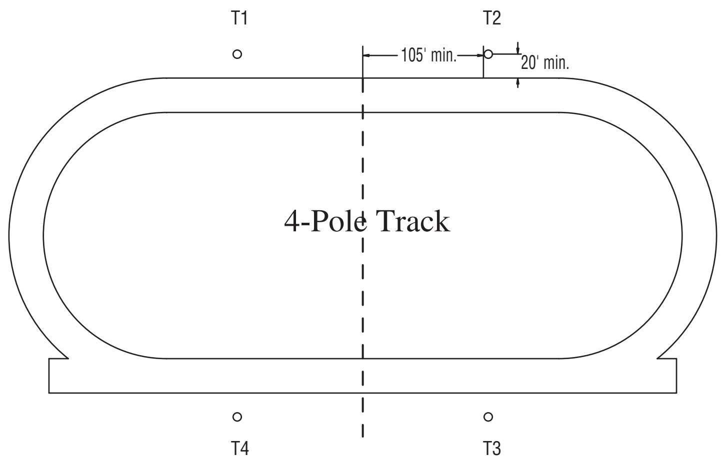
1. Poles are shown in optimal locations. Other permissible pole locations are indicated by the shaded areas.
2. It is not generally recommended to use a 6-pole layout with poles located at net lines. This position may be directly in the server's sight line with toss when the ball is served.
3. Vertical aiming angles should be 25 degrees minimum. The angles are measured from below a horizontal plane at fixture height.

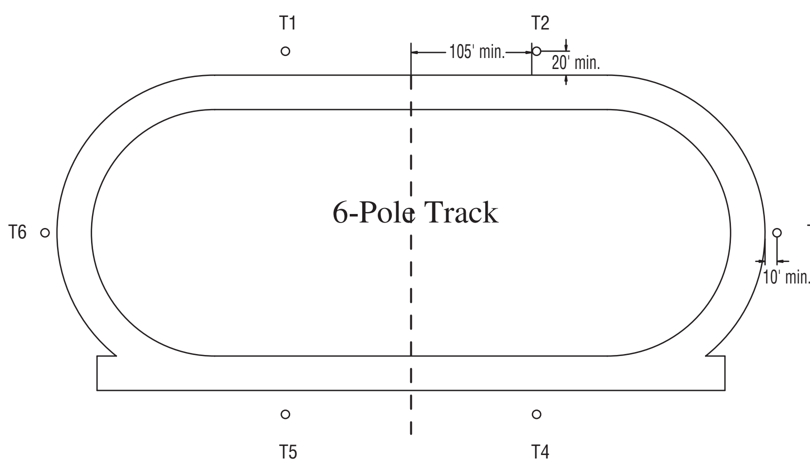


2 Courts



3 Courts





400 Meter, 8 Lane Track

1. These pole locations are for typical stand-alone tracks.
2. For tracks built in conjunction with a football or soccer field, use the standard pole locations on the football design (page 20) or soccer design (page 21).
3. Vertical aiming angles should be 21 degrees minimum. The angles are measured from below a horizontal plane at fixture height.

ANNUAL SYSTEM OPERATION & MAINTENANCE CHECKLIST

School Name____ Field Name____________________________________

Date of Inspection______________ Voltage/Phase___________________________ Date Installed__________________

Type of Pole___________________________ Type/# of Luminaires____

Inspected By____ Contact Number__________________________

WARNING!! Turn off electricity at power source and at safety disconnect on the pole.

	OK	Needs Repair	Notes
Service Entrance & Pole Distribution Boxes			
Check service panel for proper markings. • Emergency information should be visible.			
• Warning stickers, wiring diagrams, circuit labels, and other servicing information signs should be posted and clearly legible			
Test reset action on all service breakers. • Snap all breakers on and off to ensure firm contact.			
Check the wiring.* • Insulation around wiring should show no signs of deterioration.			
• Wiring should show no heat discoloration.			
Check all taped connections.* • Signs of wear should be replaced.			
Make sure no live parts are exposed. • Bare wires and exposed connections should be wrapped with insulated covering.*			
Padlocks for service entrance & distribution boxes should be in place and operational.			
Poles			
Check that poles aren't leaning.			
Check wood poles for decay or twisting. Twisted pole may require re-aiming of fixtures. • Effective Sept. 1, 1994, wood poles are no longer approved on new installations.			
Check base-plate of steel poles for signs of deterioration. • Check anchor bolt for signs of corrosion.			
• Check grouting under pole to make sure proper drainage exists.			
Check bolts and fittings for tightness. • Check all metal parts for signs of corrosion.			
Check to see that wiring covers are in place.			
Check all cables and conduits. • Pull on conduit to check for looseness.			
• Check for loose fittings and damaged conduit.			
• All cables should be straight and properly strapped.*			
• If cables are exposed to the elements, make sure the insulation has the proper rating.*			
Check overhead wiring. • Wiring should be properly secured*			
• Check that new growth on tree branches and limbs won't obstruct or interfere with overhead wiring.			
Check pole climbing equipment (if provided) • Check inspection cards on climbing harness and pole equipment. Are inspections up to date?			
• Check for proper cable tension. Cable should not be loose.			
Luminaires			
Check fixture housings. • Housings should show no sign of cracking, large dents, and/or water leakage.			
Check lenses. • Clean lenses.			
• Replace broken lenses.			
Replace burned-out lamps.			
Check luminaire fuses. • Fuses should be the correct size.			
• All fuses should be operational.			
Insulation covering on wiring should show no signs of wear or cracking.			
Ground wire connections must be secure.			
Check around ballasts for signs of blackening. (metal halide)			
Check that capacitors aren't bulging. (metal halide)			
Check aiming alignment of all fixtures. • On wooden poles, see if crossarms are still aligned with the field and horizontal.			
Ground			
Check grounding connections.*			
Check nearby metal objects. • Make sure metal bleachers and other metal objects are located at least 6' from the electrical components.			
• Metal objects, such as bleachers, must have their own individual grounding system.			

Lighting Performance Testing

To verify that your field meets the IHSAA recommended standards, complete the performance testing information below. The inspection must be done using a light meter calibrated within the last 12 months. The light meter should be held horizontally 36 inches above the middle point of each square in the grid.

Baseball/Softball

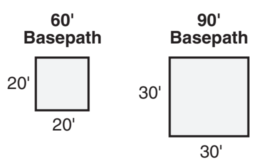
To obtain average footcandle value:
Record light readings within each square.

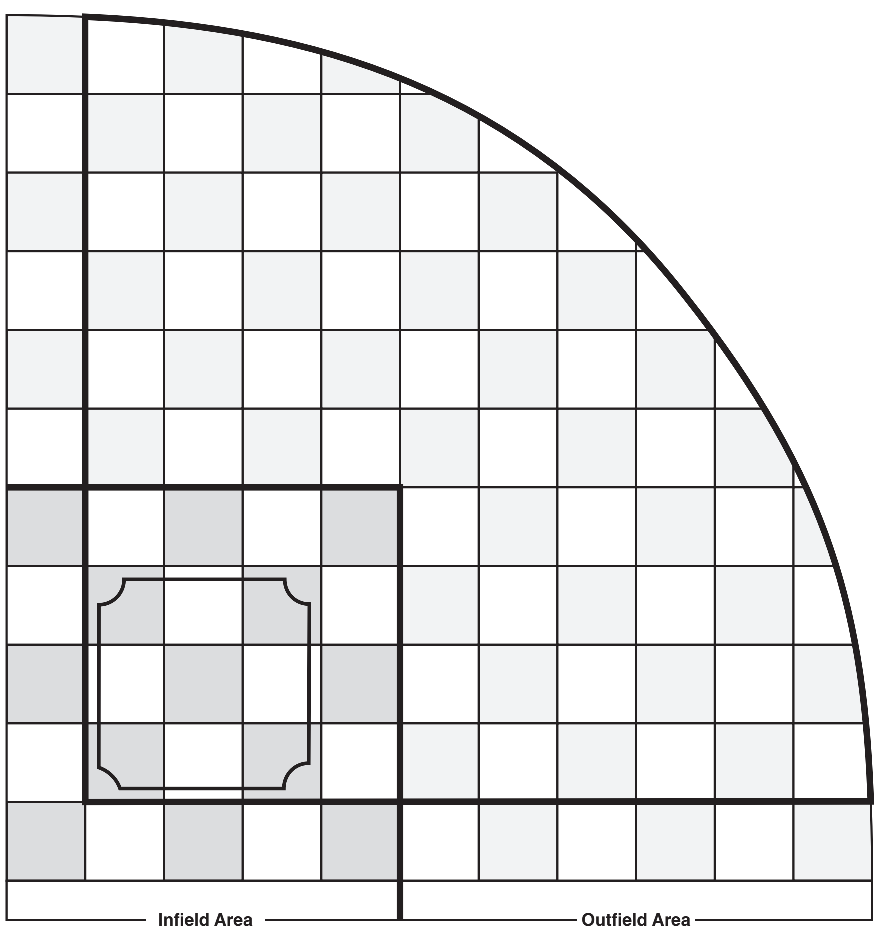
Infield = Total of infield readings ÷ 25

Outfield = Total of outfield readings ÷ number of readings.

To obtain uniformity ratio for infield or outfield:
Divide highest (maximum) light level reading by the lowest (minimum) light level reading.

For example:
61 footcandles ÷ 31 footcandles = 2.1



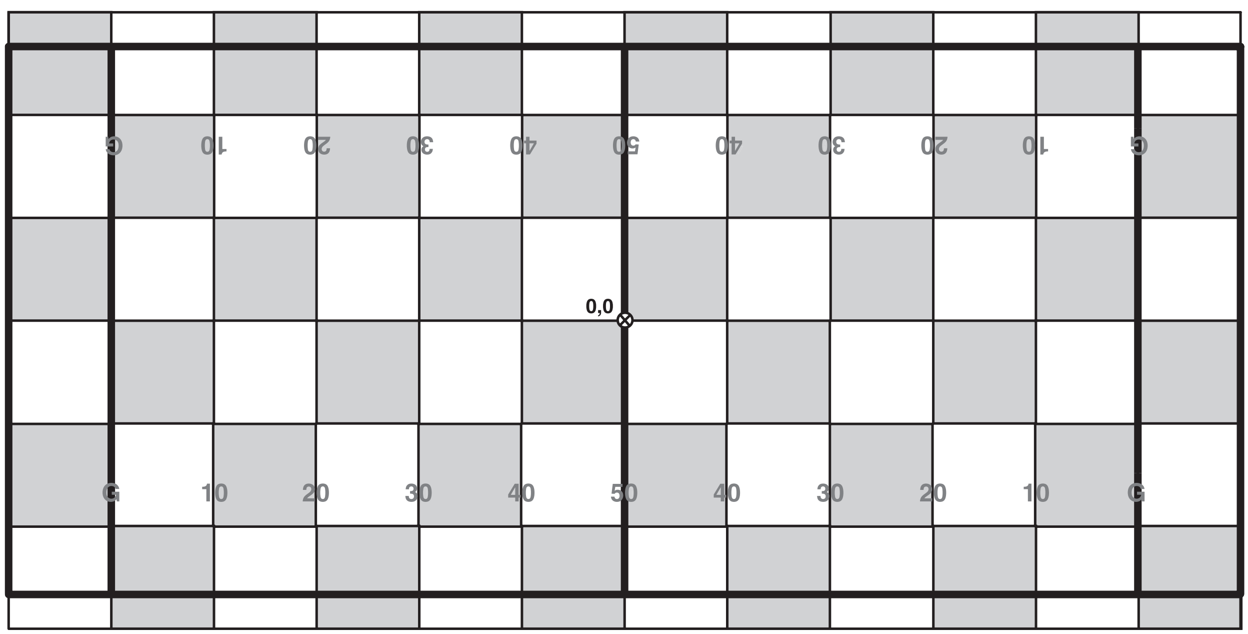


Football

To obtain average footcandle value:
Record light readings within each square.
Total all readings, divide by total number of readings taken.

To obtain uniformity ratio:
Divide highest (maximum) light level reading by the lowest (minimum) light level reading.

30' x 30' grid

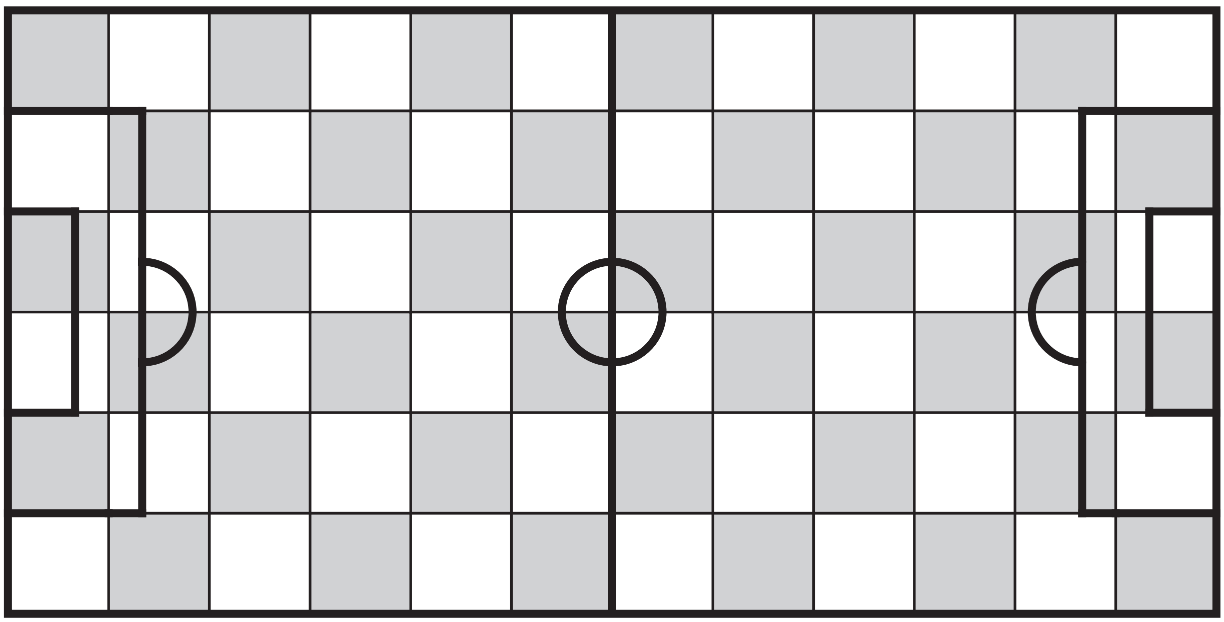


Soccer

To obtain average footcandle value:
Record light readings within each square.
Total all readings, divide by total number of readings taken.

To obtain uniformity ratio:
Divide highest (maximum) light level reading by the lowest (minimum) light level reading.

30' x 30' grid

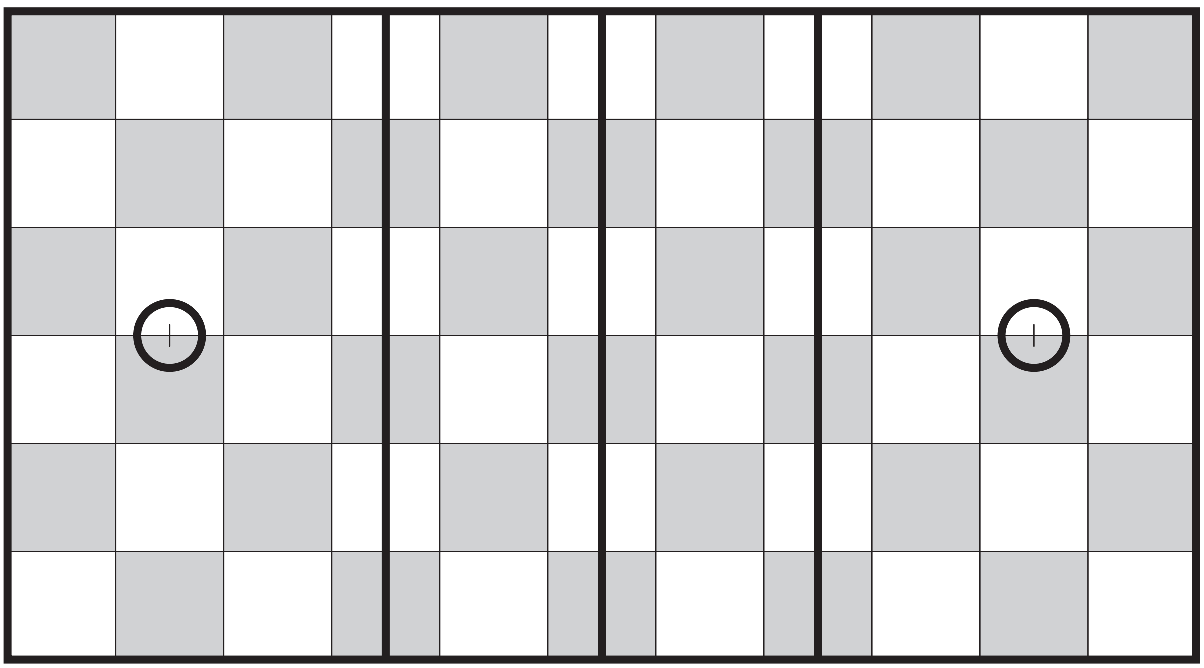


Lacrosse

To obtain average footcandle value:
Record light readings within each square.
Total all readings, divide by total number of readings taken.

To obtain uniformity ratio:
Divide highest (maximum) light level reading by the lowest (minimum) light level reading.

30' x 30' grid

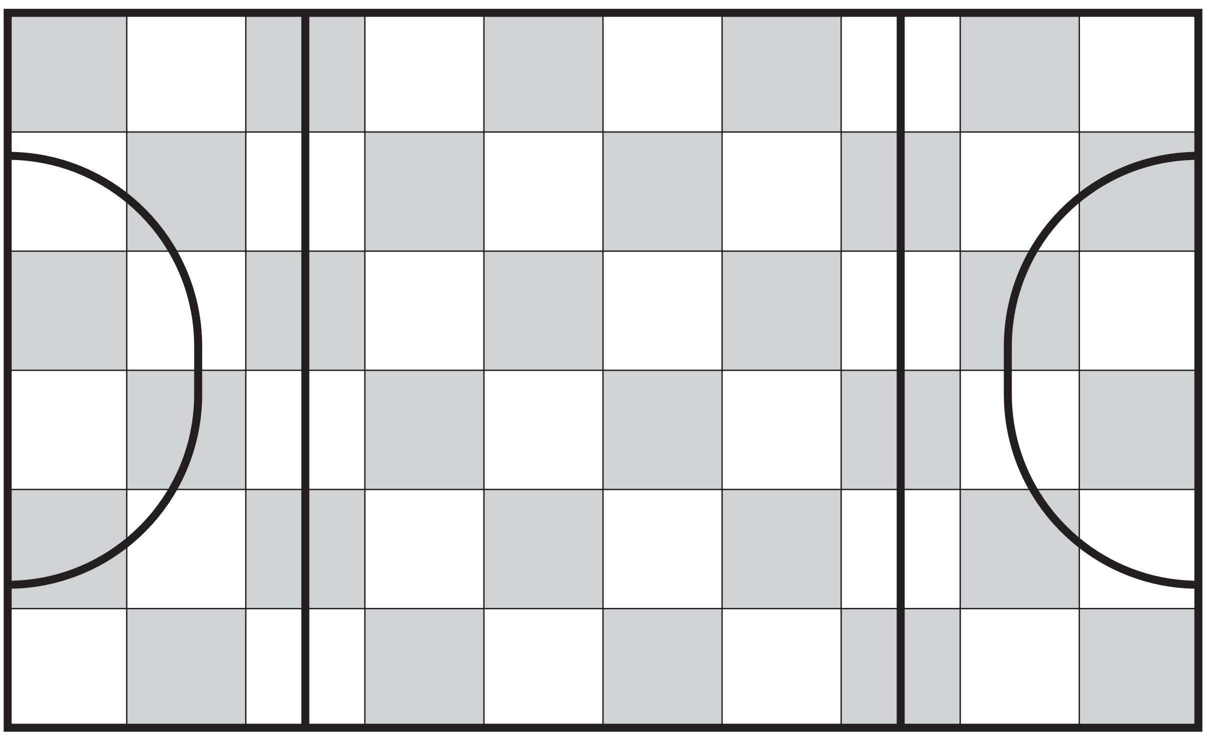


Field Hockey

To obtain average footcandle value:
Record light readings within each square.
Total all readings, divide by total number of readings taken.

To obtain uniformity ratio:
Divide highest (maximum) light level reading by the lowest (minimum) light level reading.

30' x 30' grid

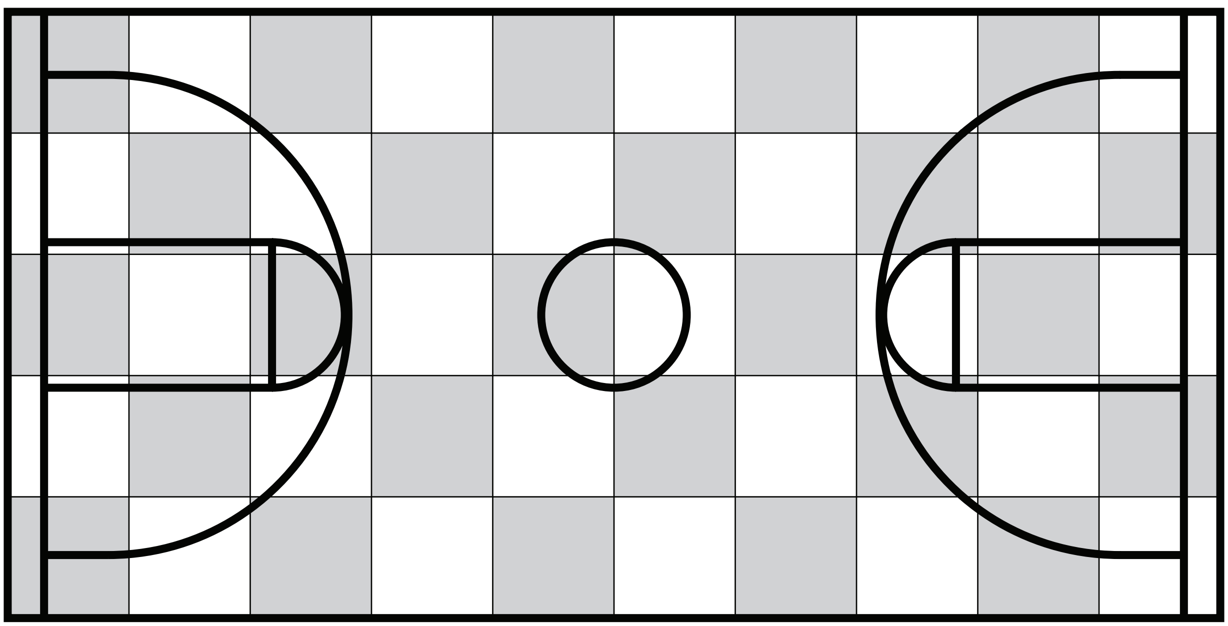


Basketball

To obtain average footcandle value:
Record light readings within each square.
Total all readings, divide by total number of readings taken.

To obtain uniformity ratio:
Divide highest (maximum) light level reading by the lowest (minimum) light level reading.

10' x 10' grid

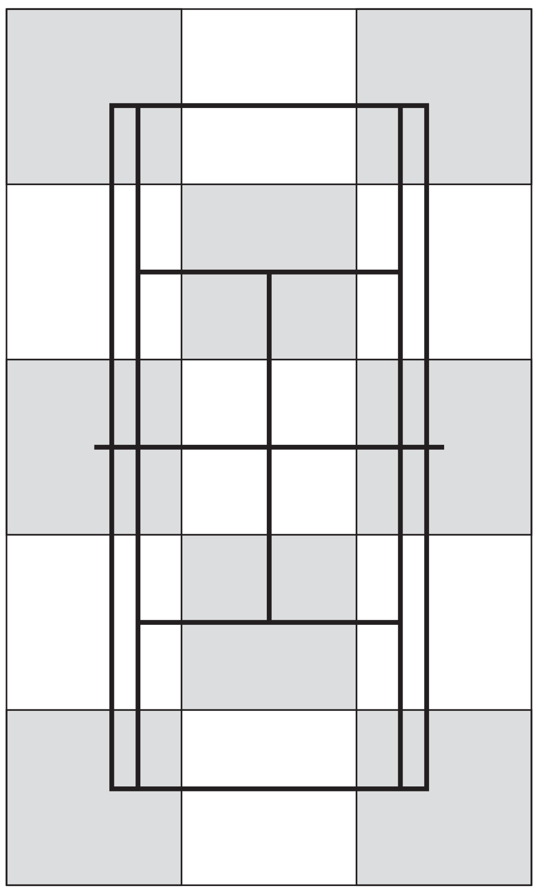


Tennis

To obtain average footcandle value:
Record light readings within each square.
Total all readings, divide by total number of readings taken.

To obtain uniformity ratio:
Divide highest (maximum) light level reading by the lowest (minimum) light level reading.

20' x 20' grid

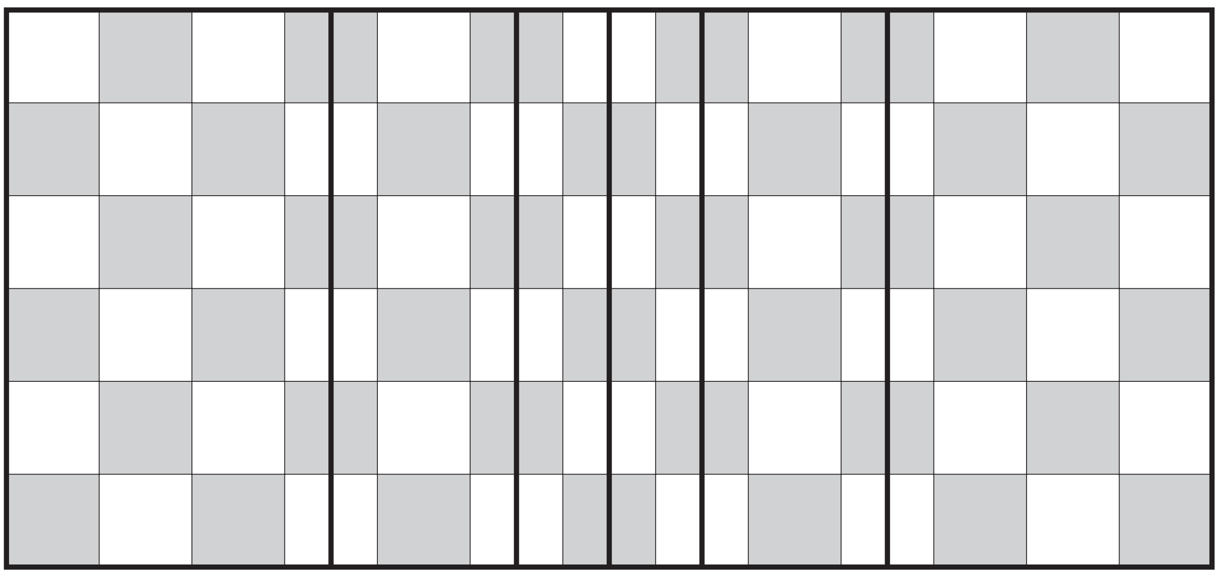


Rugby

To obtain average footcandle value:
Record light readings within each square.
Total all readings, divide by total number of readings taken.

To obtain uniformity ratio:
Divide highest (maximum) light level reading by the lowest (minimum) light level reading.

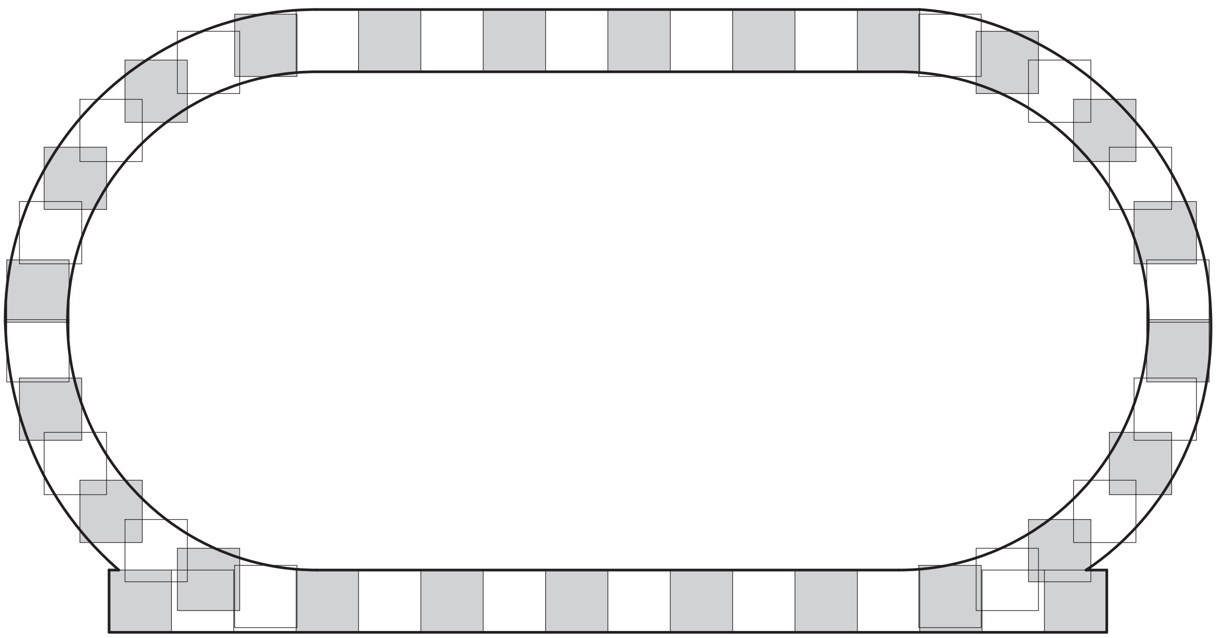
30' x 30' grid



Track

To obtain average footcandle value:
Record light readings within each square.
Total all readings, divide by total number of readings taken.

To obtain uniformity ratio:
Divide highest (maximum) light level reading by the lowest (minimum) light level reading.



GLOSSARY

Ballast A transformer that delivers the proper operating voltage for high intensity discharge type lamps including metal halide lamps.

Candlepower (CP) Measurement of light intensity expressed in candelas. The directional characteristic of a light source is described by the candlepower in specific directions.

Coefficient of Variation (CV) A measurement of illuminance uniformity. The standard deviation of a set of grid values divided by the average.

Constant Light Levels The amount of light you can expect on the field at any given time over the extended life of the system.

Driver The device used to power the LEDs. It provides sufficient current to light the LEDs to the required brightness and also limits the current to prevent damage to the LEDs.

Footcandle The measurement of light on a surface. One footcandle equals one lumen spread over one square foot.

Glare The sensation we experience when looking into an excessively bright light source that causes discomfort or a reduction in the ability to see. Glare can reduce the participant's ability to perform at their optimal level and/or cause discomfort to the spectators or surrounding neighbors.

IESNA Illuminating Engineering Society of North America. An organization that develops recommendations for sports lighting.

Initial Light Levels The average light levels when your lamps are new. Measuring initial light levels assures that you receive a system that meets your specifications. Your designer should provide scans showing what these levels will be.

LED (Light Emitting Diode) Small semiconductor device that creates light when electricity passes through it.

Light Loss Factor (LLF) Formerly called maintenance factor, Light Loss Factor is a factor used in calculating illuminance over a given period of time and under given conditions. It accounts for light loss due to temperature and voltage variations, dirt accumulation on luminaire, lamp depreciation, maintenance procedures and atmosphere conditions. Light loss factors are divided into two groups, "Recoverable" and "Non-Recoverable." Recoverable light loss factors, such as lamp lumen depreciation, can be recovered by relamping, and Non-Recoverable light loss factors, such as tilt factor, cannot be recovered by the general maintenance processes.

Lumen A quantity measurement of light, used mostly in measuring the amount of light a lamp produces.

Maintained Light Levels The average illuminance below which the light level is not supposed to fall throughout system life. Actual values are calculated from measurements taken on the specified surface at the time maintenance is to be carried out. This process would typically use a lamp lumen value at 70 percent of rated lamp life). In order to achieve the desired “maintained” light level as the system ages, the maintenance interval must become shorter and shorter due to non-recoverable light loss factors. This maintenance interval is dependent on local environmental conditions and the installation’s operational characteristics.

Max. to Min. Uniformity Ratio A design criteria to assure that light is distributed evenly across the entire field. A max/min uniformity ratio of 2:1 means that the brightest point is no more than double any other point.

Metal Halide Lamp A lamp that generates light by passing electrical current through metallic gases. The first choice for sports facilities because of efficiency and color.

NEC National Electric Code. A national safety code for electrical systems, which is the basis for most local codes.

NEMA Type A classification of reflectors. For example, a NEMA 2 reflector directs light in a narrow, focused beam allowing it to be projected a long distance. A NEMA 5 projects light a relatively short distance in a very wide beam. Most lighting designs use various combinations of NEMA types to get the desired results.

NFPA National Fire Protection Association. An organization that establishes and publishes various codes such as the Lightning Protection Code and the National Electric Code.

Reflector Key element of lighting optics. It surrounds the lamp and directs light to the field. The efficiency of the reflector determines how many light fixtures you have to buy and maintain.

Remote Electrical Enclosure A weatherproof enclosure that allows the heavy electrical gear to be moved from the top of lighting structures to a lower point where it can be serviced easily.

Spill Light Wasted light that falls off the field or is projected into the sky. Systems that can redirect spill light back onto the field save dollars and keep neighbors content.

Target Light Levels The average illuminance below which the light level is not suppose to fail throughout system life.

Tilt Factor This factor is a function of the lamp position for each fixture and directly affects the lamp performance in that specific floodlight. It is part of the non-recoverable light loss factor. The lamp tilt factor should be used in computer calculations and appear on any output documentation. A tilt factor of 1.0 should not be used, unless the lamp data provided shows testing in the installed position.

Underwriters Laboratories (UL) Independent, not-for-profit product safety testing and certification organization. Visit www.ul.org for additional information.

Uniformity Gradient (UG) Rate of change of illuminance between adjacent (grid) values.

Vertical Aiming Angles The degrees below horizontal that light fixtures are aimed at the field. Angles are measured from a horizontal plane at fixture height. Critical in safe, playable lighting design.

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