STUDIES ON OUTDOOR SPORTS LIGHTING – BADMINTON AND TENNIS COURT

A Dissertation submitted in partial fulfillment in the requirements for the degree of

Master of Engineering
in
Illumination Engineering

Submitted by

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CONTENT:

Abstract:

Effective lighting is essential for enhancing visibility and performance in indoor and outdoor sports such as tennis and badminton, where rapid movements and precise reactions are crucial. This paper explores the key principles and advancements in sports lighting technology tailored to these sports. It discusses the significance of uniform illumination, glare control, and color rendering for enabling athletes to accurately perceive ball or shuttlecock trajectories and player movements. The evolution of LED lighting has revolutionized sports lighting by offering benefits like energy efficiency, customizable lighting levels, and reduced maintenance costs. This thesis work also replicates the application of Dialux software for designing a proper LED lighting system as per standards for tennis and badminton. Practical guidelines for designing lighting systems specific to tennis and badminton courts are also provided, including considerations such as fixture placement, lighting angles, and recommended illuminance levels. The abstract concludes by emphasizing the importance of well-designed sports lighting in promoting fair competition, safety, and an optimal experience for both participants and spectators. This abstract summarizes the critical aspects of sports lighting for both tennis and badminton, highlighting technical considerations and practical guidelines essential for designing effective lighting systems.

CHAPTER 1 – Introduction:

I. Effective lighting is crucial for optimizing visibility and performance in sports environments, particularly in dynamic and fast-paced games like tennis and badminton. These sports require athletes to react quickly and accurately to the movement of a ball or shuttlecock, making clear visibility essential. Properly designed lighting systems not only enhance visibility but also contribute to player safety and the overall spectator experience.

II. Based on lighting requirement, sports can be classified into two types, aerial and ground level sports. Aerial level sports are those where the playing object stays may be in the air as well as in the ground, but in ground level sports the playing object stays in the ground most of the times. Different sports required different lighting standards as suggested by CIE, NLC, EN or different sports authority boards. CIE 042-1978 talks about the lighting experience in a tennis court, also about the selection of luminaires and overall lighting system.

III. In both tennis and badminton, the quality of lighting directly impacts gameplay. For tennis, players need to track the trajectory of the ball accurately, especially during fast serves and volleys. Similarly, in badminton, the shuttlecock moves swiftly across the court, demanding clear and consistent lighting to ensure players can anticipate its path and react accordingly.

IV. Advancements in lighting technology, particularly with the widespread adoption of LED systems, have significantly improved sports lighting capabilities. LED lights offer benefits such as energy efficiency, adjustable brightness levels, and improved color rendering, which are crucial for creating optimal playing conditions.

V. Designing effective lighting for tennis and badminton involves considerations such as lighting uniformity, minimizing glare, optimizing lighting angles, and ensuring adequate illuminance levels across the entire playing area. Proper placement and distribution of lighting fixtures are critical to achieving these goals while also adhering to specific standards and guidelines set forth for sports lighting.

VI. This thesis work explores the key principles and considerations involved in designing lighting systems tailored to tennis and badminton courts. It discusses the technological advancements shaping modern sports lighting, practical guidelines for implementation, and the overall impact of well-designed lighting on gameplay, safety, and the spectator experience.

VII. This introduction sets the stage for a deeper exploration into the nuances of sports lighting as it pertains specifically to tennis and badminton, highlighting the importance of visibility, technology, and design considerations in enhancing the sporting environment.

Objective:

The objectives of tennis and badminton sports lighting revolve around optimizing conditions for gameplay, safety, and spectator experience. Here are the key objectives:

I. **Enhanced Visibility:** The primary goal of sports lighting in tennis and badminton is to provide sufficient and uniform illumination across the playing area. This ensures that players can see the ball or shuttlecock clearly at all times, allowing them to react quickly and accurately during fast-paced exchanges.

II. **Minimization of Glare:** Effective lighting design aims to minimize glare, which can impair visibility and distract players. Glare reduction techniques such as proper fixture placement, shielded luminaires, and control of light distribution help maintain optimal visual conditions on the court.

III. **Accurate Color Rendering:** High-quality lighting systems are essential for accurate color rendering, enabling players to distinguish between different objects on the court, such as the ball, lines, and opponents' movements. This enhances the precision of gameplay decisions and movements.

IV. **Safety and Injury Prevention:** Lighting also plays a crucial role in ensuring the safety of players by illuminating potential hazards, such as uneven surfaces, obstacles, and court boundaries. Well-designed lighting helps minimize the risk of injuries during matches and practices.

V. **Energy Efficiency:** With advancements in LED technology, there is a focus on energy-efficient lighting solutions that reduce operational costs and environmental impact while maintaining high-quality illumination levels required for sports activities.

VI. **Flexibility and Adaptability:** Modern sports lighting systems are designed to be flexible and adaptable, allowing for adjustable lighting levels and configurations to accommodate different levels of play.

VII. **Enhanced Spectator Experience:** Beyond the players, good lighting enhances the viewing experience for spectators by ensuring clear visibility of the action on the court. This contributes to a more engaging and enjoyable experience for fans attending matches.

CHAPTER 2 – Fundamentals of sports lighting:

2.1 Sports lighting - an overview:

Sports lighting refers to the specialized illumination systems designed for outdoor and indoor sports facilities to ensure optimal visibility during sporting events, practices, and competitions. Here's an overview of key aspects of sports lighting:

I. **Purpose:** The primary goal of sports lighting is to provide adequate and uniform illumination across the playing area and total area to enhance visibility for players, officials, and spectators. This is crucial for safety, performance, and enjoyment of the sport.

II. **Design Considerations:**

Uniformity: Ensuring consistent and uniform light levels across the entire playing surface to minimize shadows and glare.

Brightness: Adequate illumination levels depending on the sport and level of play.

Color Rendering: The ability of the lighting to render colors accurately, which is important for players and spectators to distinguish between different elements on the field.

Glare Control: Minimizing glare to prevent discomfort or distraction for players, officials and spectators.

III. **Technologies Used:**

Metal Halide: Traditional source providing high-intensity light suitable for outdoor sports.

Fluorescent lamp and High pressure sodium vapour lamp: Earlier sodium vapour lamps and tubular fluorescent lamps were used for non – televised and indoor level sports lighting respectively.

LED: Increasingly popular due to its energy efficiency, durability, and ability to be dynamically controlled. LEDs are used both indoors and outdoors for various sports.

IV. **Control Systems:** Advanced lighting systems often include controls for adjusting light levels based on different events or requirements. This can include dimming for practice sessions versus full illumination for games.

V. **Environmental Considerations:** Modern sports lighting systems are designed to be energy-efficient, reducing operational costs and environmental impact. LED lighting, in particular, has significantly lower energy consumption and longer operational life compared to older technologies.

VI. **Maintenance:** Regular maintenance is essential to ensure optimal performance and longevity of sports lighting systems. This includes cleaning fixtures, replacing bulbs or LEDs, and adjusting aiming angles as needed.

VII. **Regulations and Standards:** Sports lighting designs must adhere to local regulations and international standards such as those set by the International Commission on Illumination (CIE) and sports governing bodies.

VIII. **Adaptability:** Lighting systems should be adaptable to different sports played on the same field, accommodating variations in required light levels and uniformity.

2.2 Necessity of sports lighting:

Sports lighting is necessary for several important reasons:

I. **Extended Playing Hours:** Many sports are played during evenings or at indoor facilities where natural light is insufficient or unavailable. Sports lighting allows for extended playing hours, enabling athletes to train and compete after sunset or in indoor environments.

II. **Visibility and Safety:** Adequate lighting ensures that players, officials, and spectators can see clearly during matches or training sessions. This visibility is

crucial for avoiding collisions, injuries, and for players to accurately judge the trajectory of the ball or other players.

III. **Broadcasting and Spectator Experience:** High-quality lighting is essential for broadcasting sports events, whether on television or live-streamed online. It ensures that cameras capture clear images, enhancing the viewing experience for spectators who cannot attend in person.

IV. **Regulatory Compliance:** Many sports associations and governing bodies have specific lighting requirements to ensure fair play and safety standards. These regulations often dictate minimum lighting levels, uniformity across the playing area, and glare control to maintain competitive integrity.

V. **Performance and Skill Development:** Good lighting conditions contribute to optimal performance by providing consistent visibility of the playing surface and other players. This is crucial for athletes to develop their skills during training sessions and to perform at their best during competitive matches.

VI. **Community Engagement and Economic Impact:** Well-lit sports facilities can host a variety of events, including tournaments and matches, attracting larger crowds and generating revenue from ticket sales, concessions, and local businesses. This contributes to the economic vitality of communities and fosters a sense of community pride and engagement through sports.

VII. **Technological Advancements:** Advances in lighting technology, such as LED (Light Emitting Diode) fixtures, have significantly improved energy efficiency, durability, and the quality of illumination in sports lighting. LED lighting also offers flexibility in adjusting light levels and reducing operational costs compared to traditional lighting sources.

In summary, sports lighting plays a critical role in facilitating safe and enjoyable sports activities, extending playing hours, supporting broadcast requirements, complying with regulations, enhancing performance, and contributing to the economic and social fabric of communities.

2.3 Terminologies of sports lighting:

There are some terms related to sports lighting:

I. **Lumens:** A measurement of the total quantity of visible light emitted by a source.

II. **Lux:** A measurement of illuminance, indicating how much light is present at a specific point on a surface. It's often used to determine the quality of light on playing surfaces.

III. **Uniformity of illuminance:**

In sports lighting refers to the consistency of light intensity across the playing surface. It ensures that there are minimal variations in brightness, which is crucial for maintaining visibility and safety during sports events. Here are some key aspects related to uniformity of illuminance:

Definition: Uniformity of illuminance specifically refers to how evenly the light is distributed across the playing area. It is measured by ratio between the minimum illuminance (lowest light level) to the average illuminance (overall light level) across the surface.

Measurement: Uniformity is quantified using a Uniformity Ratio (UR), often expressed as U1 min/max and U2 min/avg. These ratios indicate the relationship between the lowest light level (min) and the average light level (avg) at various points on the field or court.

Importance: Good uniformity ensures that players and officials have consistent visibility throughout the playing area. It reduces the risk of uneven lighting conditions that can affect depth perception, judgment of distances, and overall performance. Uniformity relates with the visual performance and visual comfort, useful to avoid adaptation problem for the players.

IV. **Factors Affecting Uniformity**:

Fixture Placement: Proper positioning of light fixtures ensures even coverage without creating excessively bright or dark areas.

Beam Angle and Spread: Choosing fixtures with appropriate beam angles and distribution patterns helps achieve uniformity.

Mounting Height: The height at which fixtures are mounted can influence how evenly light spreads across the playing surface.

Lighting Design: Effective lighting design considers these factors to optimize uniformity while meeting lighting level requirements for different sports.

V. **Gradient:**

In sports lighting, the horizontal illuminance gradient refers to the change in illuminance levels across the horizontal plane of a playing surface, such as a field or a court. This gradient is an important consideration in ensuring uniform lighting

conditions throughout the area where the sport is played. Here are key aspects related to the horizontal illuminance gradient in sports lighting:

Definition: The horizontal illuminance gradient specifically looks at how illuminance levels vary across the width and length of the playing surface. It indicates whether there are areas that are significantly brighter or darker than others.

Measurement: The gradient is typically measured by comparing illuminance levels at various points along a horizontal line on the field or court. It helps assess the evenness of light distribution from one side to the other and from the centre to the edges of the playing area. A gradient of horizontal illuminance of maximum 25% change per 5m is recommended as per field dimension.

Importance: A smooth horizontal illuminance gradient is essential for ensuring consistent visibility and performance for athletes. It reduces the risk of uneven lighting that can affect depth perception, accuracy in judgment, and overall playing conditions.

VI. **Glare restriction:**

Glare restriction in sports lighting is crucial for providing optimal visibility and safety for athletes, officials, and spectators. Glare occurs when there is excessive brightness or contrast that can cause discomfort, reduce visibility, and affect performance. Here are key considerations and methods for glare restriction in sports lighting:

Fixture Selection: Choose lighting fixtures with proper shielding and optics designed to minimize glare. Full cutoff fixtures are often preferred as they direct light downward onto the playing surface, reducing the potential for glare.

Lighting Design: Plan the layout and positioning of fixtures to avoid direct line-of-sight from players, officials, and spectators. This includes considering the angle and orientation of light beams to minimize glare and maximize uniform illumination.

Glare Ratings: Evaluate fixtures based on glare ratings provided by manufacturers. This helps ensure that fixtures meet recommended glare limits and provide comfortable lighting conditions. The assessment scale of GR ranges from 10 to 90 and lower the GR better is the glare restriction. For sports lighting acceptable GR values lies within 50.

Lighting Control: Use lighting control systems to adjust light levels as needed during different phases of sports events. Dimming or zoning controls can help reduce glare while maintaining adequate illumination levels for specific areas of the field or court.

Player and Spectator Comfort: Consider the viewing angles and positions of spectators when designing lighting layouts to minimize glare from their perspective as well.

Compliance with Standards: Follow lighting standards and guidelines that specify maximum permissible glare levels for different sports venues. Standards such as those from the Illuminating Engineering Society (IES) provide recommendations for glare control in sports lighting applications.

VII. **Flicker:**

Flicker in sports lighting refers to the rapid and repeated variations in light output that can occur due to the cycling of electric current powering the light source. This flickering is typically not visible to the naked eye but can affect athletes, spectators, and even broadcast quality in sports venues. Here are key aspects of flicker in sports lighting:

Causes: Flicker can be caused by various factors, including fluctuations in power supply, the type of lighting technology used (e.g., older fluorescent or HID lamps), and the modulation of light output by lighting control systems.

Effects on Vision: Even though flicker may not be perceived directly, it can lead to visual discomfort, eye strain, and even headaches for athletes and spectators. This can impact concentration and performance, especially in fast-paced sports where quick reactions and visual clarity are crucial.

Broadcasting Issues: Flicker can interfere with cameras and broadcasting equipment, causing visible flickering in video footage or photographs. This affects the quality of live broadcasts and recorded media from sports events.

Regulations and Standards: There are international standards and guidelines that address flicker in lighting systems (e.g., IEEE Std 1789-2015). These standards set limits on flicker frequency and amplitude to minimize its effects on human health and performance.

VIII. **Colour rendering index(CRI):**

The Colour Rendering Index (CRI) is an important consideration in sports lighting as it affects how accurately colours are perceived under artificial light compared to natural daylight. Here's how CRI relates to sports lighting:

Definition: CRI is a quantitative measure of a light source's ability to reveal the true colours of objects compared to a natural light source (like sunlight) of the same colour temperature. It is expressed on a scale from 0 to 100, with higher values indicating better colour rendering ability.

Importance in Sports Lighting:

a. Visual Clarity: High CRI lighting helps athletes, referees, and spectators discern details, such as team colours, markings on the field, and equipment colours, accurately.
b. Colour Contrast: Proper colour rendering enhances the contrast between different elements on the playing field, which is crucial for players to quickly distinguish between teammates, opponents, and the ball.
c. Broadcasting and Media: In venues where sports events are broadcasted or recorded, good colour rendering ensures that the colours appear natural and vibrant on cameras and screens.

IX. Co-related colour temperature(CCT):

"CCT" in sports lighting stands for "Correlated Colour Temperature." It is a specification that indicates the colour appearance of the light emitted by a source, measured in Kelvin (K). In the context of sports lighting, CCT is important because it affects how colours are perceived on the playing field and how well players can distinguish objects.

Here's how CCT relates to sports lighting:

Colour Appearance: The CCT value indicates whether the light appears warm (lower Kelvin, more yellowish-white) or cool (higher Kelvin, more bluish-white). Sports lighting typically uses cooler CCTs (5000K to 6500K) to enhance visibility and contrast.

Visual Acuity: Cooler CCTs are often preferred in sports lighting because they can improve visual acuity, making it easier for players to see details and movements on the field or court.

Broadcasting and Photography: CCT also affects how well sports events are captured on cameras. Lighting with a consistent CCT ensures that colours are accurately reproduced in broadcasts and photographs.

Player Comfort: The right CCT can contribute to player comfort by reducing eye strain and fatigue during games or practices.

Energy Efficiency: LED lights with cooler CCTs tend to be more energy-efficient, which is beneficial for large sports facilities that require substantial lighting.

X. Light pollution:

Light pollution in sports lighting refers to the unwanted and excessive artificial light that spills beyond the intended area of illumination, adversely affecting the surrounding environment. In case of sports lighting, Upward Light Ratio (ULR) should be kept within 7% to avoid excessive amount of light going towards upward. Here's how light pollution manifests in sports lighting and its impacts:

Types of Light Pollution:

a. Sky Glow: The brightening of the night sky over urban areas due to scattered light from poorly directed or excessive outdoor lighting, including sports facilities.
b. Glare: Excessive brightness that causes discomfort or reduces visibility for drivers, pedestrians, or nearby residents.
c. Light Trespass: Unwanted light that intrudes into areas where it is not needed or wanted, such as neighboring properties or natural habitats.
d. Clutter: Excessive grouping or overlapping of light sources, creating a confusing and visually intrusive environment.

Causes in Sports Lighting:

a. Over-illumination: Using more light than necessary to illuminate sports fields or facilities, leading to wasted energy and increased light pollution.
b. Improper Fixture Design: Fixtures that do not have proper shielding or optics can emit light in unintended directions, contributing to glare and light trespass.
c. Control Systems: Lack of or improper use of lighting controls, such as timers, dimmers, or motion sensors, can lead to unnecessary light spillage and prolonged operation.

Impacts:

a. Ecological Effects: Light pollution disrupts natural behaviors and habitats of wildlife, affecting nocturnal animals and migrating birds. It can also interfere with plant growth and ecological cycles.
b. Human Health: Excessive nighttime lighting can disrupt circadian rhythms and sleep patterns in humans, leading to potential health issues such as insomnia and fatigue.
c. Astronomy: Bright skies from light pollution can hinder astronomical observations and stargazing, limiting opportunities for scientific research and public enjoyment of the night sky.
d. Energy Waste: Wasted energy from unnecessary or misdirected lighting contributes to environmental pollution and increases operational costs.

2.4 Key factors of sports lighting:

Key factors to consider for sports lighting include:

I. **Brightness and Uniformity:** Ensuring sufficient illumination levels across the playing area without glare or dark spots. Uniform lighting enhances visibility and safety for players and spectators.

II. **Colour Rendering:** High Colour Rendering Index (CRI) ensures accurate color representation, crucial for distinguishing team uniforms, boundary lines, and other game elements.

III. **Glare Control:** Minimizing glare to prevent distraction and discomfort for athletes. Proper fixture placement and shielding techniques help achieve this.

IV. **Flicker-Free Operation:** Stable lighting without flicker ensures consistent visibility and prevents potential negative effects on performance and comfort.

V. **Energy Efficiency:** Opting for energy-efficient lighting technologies such as LEDs to reduce operational costs and environmental impact while maintaining performance.

VI. **Durability and Weather Resistance:** Choosing fixtures that can withstand outdoor conditions like rain, wind, and temperature fluctuations to minimize maintenance needs and ensure longevity.

VII. **Adaptability and Control:** Implementing lighting controls for adjusting light levels based on different activities, events, or broadcast requirements. Automated systems can enhance flexibility and efficiency.

VIII. **Compliance with Standards:** Adhering to relevant national and international standards for sports lighting ensures safety, performance, and energy efficiency requirements are met.

IX. **Maintenance Requirements:** Considering ease of maintenance and accessibility of fixtures to facilitate regular upkeep and ensure consistent performance over time.

X. **Cost-Effectiveness:** Balancing initial investment with long-term operational savings and benefits to achieve a cost-effective lighting solution.

By addressing these factors comprehensively, sports facilities can provide optimal lighting conditions that enhance gameplay, spectator experience, and overall safety.

2.5 Non- Televised sports lighting design:

Non-televised sports lighting refers to the lighting systems used in sports facilities where events are not broadcasted on television. These lighting systems are designed primarily to meet the needs of athletes, spectators, and officials present at the venue rather than for the specific requirements of TV broadcasting.

Non-televised sports lighting focuses on creating a safe and enjoyable environment for participants and spectators, tailored to the specific needs of the sport and the venue, rather than meeting the additional requirements imposed by television broadcasting.

2.6 Televised sports lighting design:

Televised sports lighting refers to the specialized lighting systems designed specifically for sports venues where events are broadcasted on television. These lighting systems have additional requirements beyond those of non-televised sports lighting, primarily to ensure high-quality visuals for TV broadcasts.

Overall, televised sports lighting is designed to enhance the viewing experience for television audiences while meeting the technical requirements of broadcasters and maintaining optimal conditions for athletes and officials on the field or court.

CHAPTER 3 – Sports lighting luminaire:

3.1 Luminaire and Sports lighting luminaire:

I. Luminaire:

A luminaire is a term used to describe a complete lighting unit that includes a light source (such as a bulb or LED), the housing or fixture that holds the light source, and any necessary components like reflectors, lenses, or diffusers. Essentially, it's the entire apparatus that provides illumination.

Luminaires come in various shapes, sizes, and styles, and they are designed for different purposes ranging from residential lighting to commercial and industrial applications. They can be ceiling-mounted, wall-mounted, freestanding, or integrated into furniture or architecture.

In technical and design contexts, "luminaire" is the term used to encompass all aspects of the lighting fixture itself, distinguishing it from just the light source or bulb.

Classification of luminaires:

Luminaires can be classified in several ways based on different criteria such as their function, design, light distribution, and application. Here are some common classifications of luminaires:

a. By Function:
- General Lighting Luminaires: These provide overall illumination to a space, typically through ceiling-mounted fixtures or recessed lights.
- Task Lighting Luminaires: Designed to provide focused illumination for specific tasks such as reading, cooking, or working. Examples include desk lamps and under-cabinet lights.
- Accent Lighting Luminaires: Used to highlight or accentuate architectural features, artwork, or specific objects. Track lights and adjustable spotlights are examples.

b. By Light Distribution:

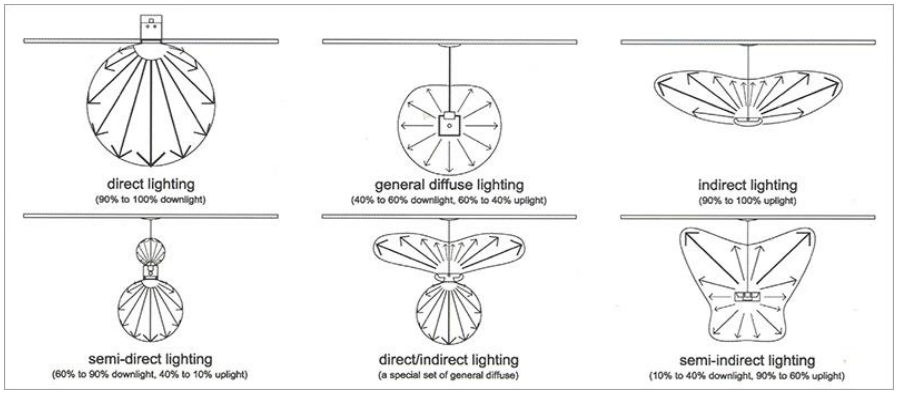


Fig1: Luminaires based on light distribution

From above the picture (fig1) represents the various type of luminaires based on light distribution which are briefly described given below.

- Direct Luminaires: These emit light in a specific direction, often downward, without significant diffusion or reflection.
- Semi – Direct Luminaires: It distributes 60 to 90 percent of the emitted light downward and the balance upward.
- Indirect Luminaires: Designed to reflect light off ceilings or walls to create diffuse, ambient illumination without direct glare.
- Semi – Indirect Luminaires: It distributes 60 to 90 percent of the emitted light upward and the balance downward.
- Direct-Indirect Luminaires: Provide a combination of direct and indirect lighting, distributing light both upwards and downwards to achieve a balanced illumination.

c. By Design and Form:

- Ceiling-Mounted Luminaires: Fixtures mounted on or recessed into ceilings, including flush mounts, chandeliers, and recessed lights.
- Wall-Mounted Luminaires: Sconces and wall lights that are mounted vertically on walls.
- Floor Luminaires: Free-standing fixtures placed on the floor, such as floor lamps and torchieres.
- Pendant Luminaires: Suspended from the ceiling by a cord, chain, or rod, including pendants and hanging lights.

d. By Application:

- Residential Luminaires: Designed for use in homes, including fixtures for living rooms, bedrooms, kitchens, and outdoor areas.
- Commercial Luminaires: Suitable for offices, retail stores, restaurants, and other commercial spaces, often emphasizing energy efficiency and functionality.
- Industrial Luminaires: Robust fixtures designed for use in factories, warehouses, and industrial facilities, capable of withstanding harsh conditions.

e. By Light Source:

- LED Luminaires: Utilizing light-emitting diodes (LEDs) for energy efficiency, long lifespan, and versatility in design.
- Incandescent Luminaires: Traditional fixtures using incandescent bulbs, known for warm colour rendering but lower energy efficiency.
- Fluorescent Luminaires: Incorporating fluorescent tubes or compact fluorescent lamps (CFLs), offering higher energy efficiency compared to incandescent bulbs.

f. By Mounting Type:

- Recessed Luminaires: Installed into ceilings, walls, or floors to be flush with the surface.
- Surface-Mounted Luminaires: Fixed directly onto the surface of ceilings, walls, or floors.

- Track Luminaires: Mounted on a track system to allow adjustable positioning and flexibility in lighting direction.

These classifications help categorize luminaires based on their intended use, design characteristics, and technological features, providing options suitable for various lighting requirements and preferences.

Type of luminaires:

Luminaires come in various types, each serving different purposes and applications. Here are some common types of luminaires categorized based on their design and usage:

a. Ceiling-Mounted Luminaires:
- Flush Mounts: Luminaires that are mounted flush with the ceiling, providing general ambient lighting without protruding.
- Semi-Flush Mounts: These extend slightly below the ceiling, offering a decorative element while providing ambient or task lighting.

b. Wall-Mounted Luminaires:
- Sconces: Fixtures that are mounted on walls, typically for accent or ambient lighting. They come in various designs and styles to complement interior decor.

c. Recessed Luminaires:
- Recessed Downlights: Installed into the ceiling or wall, these luminaires are flush with the surface, providing directional or diffused lighting. They are popular for ambient or accent lighting in residential and commercial spaces.

d. Track Luminaires:
- Track Heads: Mounted on a track system, track luminaires allow for adjustable positioning and directionality. They are used for highlighting artwork, merchandise displays in retail settings, or for flexible lighting in galleries and museums.

e. Floor Luminaires:
- Floor Lamps: Standalone fixtures placed on the floor, providing ambient or task lighting in living rooms, bedrooms, and offices. Floor lamps come in various heights and designs, offering flexibility in placement and function.

f. Specialty Luminaires:
- Sports Lighting Luminaires: Specialized fixtures designed for illuminating sports fields, stadiums, and arenas, ensuring high brightness, uniformity, and minimal glare.

- Emergency Lighting Luminaires: Fixtures designed to provide illumination during power outages or emergencies, ensuring safety and visibility in buildings and public spaces.

g. Outdoor Luminaires:
- Floodlights: Powerful luminaires designed to illuminate large outdoor areas such as building facades, parking lots, and sports fields.
- Wall Packs: Mounted on exterior walls, these luminaires provide security lighting for pathways, building perimeters, and outdoor spaces.

h. Decorative Luminaires:
- Decorative Fixtures: Luminaires designed primarily for aesthetic purposes, enhancing the visual appeal of interiors or exteriors with their design, materials, and finishes.

These types of luminaires vary in their design, mounting method, light distribution, and application, catering to a wide range of lighting needs in residential, commercial, industrial, and outdoor environments.

Fig2: LED indoor luminaire

Fig3: LED outdoor luminaire

From above the pictures, Fig2 represents the LED indoor luminaire and Fig3 represents the commercial LED outdoor lighting industrial luminaire.

II. Sports lighting luminaire:

A sports lighting luminaire is a specialized type of lighting fixture designed specifically for illuminating sports fields, stadiums, and arenas. These luminaires are engineered to meet the specific requirements of sports lighting, which include providing high levels of brightness, uniform light distribution, and minimal glare.

Key features and characteristics of sports lighting luminaires include:

a. High Output Light Sources: They typically utilize high-intensity light sources such as metal halide lamps, high-pressure sodium lamps, or more commonly nowadays, LED modules. These light sources are chosen for their ability to provide sufficient illumination over large areas.

b. Optics and Light Control: Sports luminaires are equipped with precision optics that control the direction and spread of light. This ensures uniform distribution of light across the playing field while minimizing spill light and glare. Different beam angles and light distribution patterns may be used to achieve specific lighting requirements.

c. Durability and Weather Resistance: Since sports luminaires are often installed outdoors, they are designed to withstand various weather conditions including rain, wind, and temperature fluctuations. They are constructed from durable materials that are corrosion-resistant and provide effective thermal management for the light sources.

d. Energy Efficiency: Modern sports lighting luminaires increasingly utilize LED technology due to its energy efficiency, long lifespan, and ability to provide instant lighting with precise control. LEDs also allow for dimming capabilities, which can further enhance energy savings.

e. Compliance with Standards: Sports lighting luminaires must comply with international and local standards and regulations that specify minimum lighting levels, uniformity ratios, glare limitations, and color rendering requirements for different types of sports and levels of competition.

f. Mounting Options: They can be mounted on poles, structures, or integrated into the architecture surrounding the sports field. This flexibility allows for precise aiming and positioning of the luminaires to achieve optimal lighting performance.

Sports lighting luminaires are essential for enabling nighttime sports activities, practices, competitions, and broadcasts by providing sufficient and high-quality illumination that meets the stringent demands of athletes, officials, spectators, and television broadcasts.

Classification of sports lighting luminaires:

Sports lighting luminaires can be classified based on several criteria, including their light source, design, and application. Here’s a detailed classification:

a. Based on Light Source:

- Incandescent Luminaires:
  - Description: Use a filament that heats up to produce light.
  - Characteristics: Warm light, poor efficiency, short lifespan.
  - Common Use: Rarely used in modern sports lighting due to inefficiency.

- Halogen Luminaires:
  - Description: A type of incandescent lighting with improved efficiency and lifespan.
  - Characteristics: Better color rendering, still relatively high energy consumption.
  - Common Use: Occasionally used for smaller or less critical applications.

- Metal Halide (MH) Luminaires:
  - Description: Use high-intensity discharge (HID) technology with a mix of gases.
  - Characteristics: High intensity, good colour rendering, longer warm-up times.
  - Common Use: Popular in large outdoor sports facilities due to high brightness.

- High-Pressure Sodium (HPS) Luminaires:
  - Description: Another type of HID lighting using sodium vapour.
  - Characteristics: Very efficient, long lifespan, but poor colour rendering.
  - Common Use: Often used for non – televised sports in large outdoor venues where efficiency is prioritized over colour quality.

- Fluorescent Luminaires:
  - Description: Use gas discharge and a phosphor coating.
  - Characteristics: Better efficiency than incandescent but not typically used for high-intensity sports lighting.
  - Common Use: More common in indoor applications or smaller facilities.

- Light Emitting Diode (LED) Luminaires:
  - Description: Use semiconductor technology to produce light.
  - Characteristics: High energy efficiency, long lifespan, adjustable colour temperature, low heat emission.
  - Common Use: Widely used in modern sports lighting for its efficiency and flexibility.

b. Based on Design and Mounting:

- Floodlights:
  - Description: Provide broad, high-intensity light over large areas.
  - Characteristics: High output, versatile mounting (poles, towers).
  - Common Use: Ideal for outdoor sports fields, stadiums, and courts.

- Downlights:
  - Description: Focus light directly downward.
  - Characteristics: Targeted illumination, typically mounted in ceilings.

- Common Use: Indoor sports facilities or specific task lighting.

- Wall-Mounted Lights:
- Description: Mounted on walls to provide side or accent lighting.
- Characteristics: Often used as supplemental lighting.
- Common Use: Outdoor courts or practice areas where pole mounting isn't feasible.

- Pole-Mounted Lights:
- Description: Mounted on tall poles or towers.
- Characteristics: Provides high-intensity, elevated illumination.
- Common Use: Tennis and badminton courts, large sports facilities.

c. Based on Light Distribution:
- Asymmetric Distribution:
- Description: Light is directed in one direction.
- Characteristics: Reduces light spill, focuses illumination on specific areas.
- Common Use: Courts where targeted lighting is needed.

- Symmetric Distribution:
- Description: Light is distributed evenly in all directions.
- Characteristics: Provides uniform illumination.
- Common Use: Areas requiring consistent lighting coverage.

d. Based on Application:
- General Lighting:
- Description: Provides overall illumination for large areas.
- Characteristics: Even light distribution, minimal shadows.
- Common Use: Outdoor sports fields, stadiums.

- Task Lighting:
- Description: Focused lighting for specific activities.
- Characteristics: High intensity, precise control.
- Common Use: Playing surfaces, practice areas.

- Emergency Lighting:
- Description: Provides illumination during power outages.
- Characteristics: Battery backup, automatic activation.
- Common Use: Ensures safety during emergencies.

- Accent Lighting:
- Description: Highlights specific features or areas.
- Characteristics: Adjustable beams, varied color temperatures.
- Common Use: Branding, visual effects.

e. Based on Control Systems:

- Manual Control:
  - Description: Operated with physical switches or dimmers.
  - Characteristics: Basic control over lighting levels.
  - Common Use: Simple or smaller installations.

- Automatic Control:
  - Description: Uses timers, sensors, or programmable controls.
  - Characteristics: Adjusts lighting based on conditions or schedules.
  - Common Use: Enhances functionality and energy efficiency.

- Smart Control:
  - Description: Integrated with IoT for advanced management.
  - Characteristics: Remote control, real-time adjustments.
  - Common Use: Complex installations requiring detailed management.

These classifications help in selecting the appropriate lighting solutions based on the specific needs of the sports facility, ensuring optimal performance, efficiency, and safety.

Type of sports lighting luminaires:

Sports lighting luminaires come in several types, each designed to cater to different lighting needs and environments. Here's a summary of the primary types:

a. Floodlights:
- Description: Provide high-intensity, wide-angle illumination.
- Features: High output, adjustable beams, mounted on poles or towers.
- Common Use: Outdoor fields, stadiums, tennis and badminton courts.
- Types:
  - LED Floodlights: Energy-efficient, long-lasting, and offer excellent colour rendering.
  - Metal Halide Floodlights: High intensity, good colour rendering but less efficient.
  - High-Pressure Sodium Floodlights: Highly efficient but with poor colour quality.

b. Downlights:
- Description: Direct light downward for focused illumination.
- Features: Mounted in ceilings or overhead fixtures.
- Common Use: Indoor sports facilities or specific lighting tasks.
- Types:
  - Recessed Downlights: Sleek and integrated into ceilings.
  - Surface-Mounted Downlights: Attached to the surface of ceilings.

c. Wall-Mounted Lights:

- Description: Mounted on walls for side lighting or accent lighting.
- Features: Often used as supplementary lighting.
- Common Use: Outdoor practice areas or where pole mounting is impractical.
- Types:
  - Wall Pack Lights: Durable, used for exterior lighting and security.
  - Architectural Wall Lights: Designed for aesthetic and functional purposes.

d. Pole-Mounted Lights:
- Description: Mounted on tall poles or towers to provide high-level illumination.
- Features: High elevation, adjustable for optimal coverage.
- Common Use: Large outdoor sports facilities, tennis courts, and badminton courts.
- Types:
  - LED Pole: Mounted Lights: High efficiency, long lifespan.
  - Metal Halide Pole: Mounted Lights: High intensity but less efficient than LEDs.

e. Integrated Lighting Systems:
- Description: Combine different types of luminaires and technologies.
- Features: Customizable for specific performance and control needs.
- Common Use: Complex sports venues or multi-use facilities.
- Types:
  - Hybrid Systems: Combine LEDs with other lighting technologies.
  - Smart Lighting Systems: IoT-enabled for advanced control and management.

f. Emergency and Backup Lighting:
- Description: Provides illumination during power failures or emergencies.
- Features: Battery backup or generator-powered.
- Common Use: Ensures safety during power outages.

g. Accent and Decorative Lighting:
- Description: Highlights specific features or creates visual effects.
- Features: Adjustable beams, various colour temperatures.
- Common Use: Branding, visual effects, and enhancing player zones.

h. High-Mast Lighting:
- Description: Extremely high poles for large area illumination.
- Features: Wide coverage for extensive areas.
- Common Use: Large sports complexes and stadiums.

Each type of luminaire is chosen based on factors such as the sport being played, the size of the facility, and the desired lighting performance.

Fig4: Indoor sports lighting

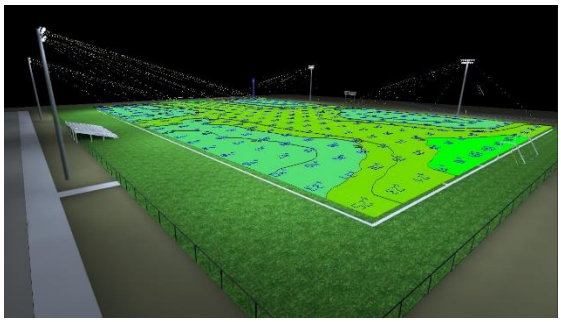


Fig5: Outdoor sports lighting

From above the pictures, Fig4 represents The indoor sports lighting luminaire and Fig5 represents The outdoor sports lighting luminaire.

3.2 Components of a luminaire:

A luminaire typically consists of several components that work together to provide lighting. Here are the main components commonly found in a luminaire:

a. Housing: The outer casing or body of the luminaire that encloses and protects the internal components. The housing can be made from various materials such as metal, plastic, or glass, and it often includes design features to enhance aesthetics and functionality.

b. Light Source: The light-emitting element of the luminaire, which can be an incandescent bulb, fluorescent tube, LED module, or other light sources. The type of light source determines factors such as energy efficiency, color rendering, and lifespan.

c. Socket or LED Module: The socket holds and connects the light source to the electrical wiring inside the luminaire. In the case of LED luminaires, an LED module is often integrated directly into the luminaire housing.

d. Optical System: This includes components such as reflectors, lenses, diffusers, and optics designed to control and distribute light emitted by the light source. The optical system influences factors such as beam angle, light distribution pattern, and glare control.

e. Driver or Ballast: In luminaires that use LED or fluorescent light sources, a driver or ballast is required to regulate the electrical current supplied to the light source. The driver ensures proper operation and efficiency of the luminaire.

f. Heat Sink: In LED luminaires, a heat sink is often included to dissipate heat generated by the LEDs. Proper thermal management helps maintain the longevity and performance of the LEDs.

g. Mounting Hardware: Components such as brackets, arms, or clips used to mount the luminaire to ceilings, walls, poles, or other structures. The mounting hardware ensures secure installation and proper alignment of the luminaire.

h. Electrical Wiring: Internal wiring that connects the light source, driver, and other electrical components to the power supply. It includes insulation and connectors to ensure safe and reliable electrical connections.

i. Control Mechanisms: Some luminaires may include controls such as switches, dimmers, motion sensors, or smart lighting controls. These mechanisms allow users to adjust lighting levels, automate operation, or integrate with building management systems.

j. Decorative Elements: Depending on the design and application, luminaires may feature decorative elements such as shades, covers, or finishes that enhance the visual appeal and integration with interior or exterior decor.

Each component plays a crucial role in the overall function, performance, and appearance of the luminaire, ensuring it meets lighting requirements while offering durability, efficiency, and aesthetic appeal in various settings.

3.3 IP and IK ratings of a luminaire:

I. IP Ratings:

IP ratings, or Ingress Protection ratings, are standards that define the level of protection a luminaire (or any electronic device) has against intrusion from foreign objects (like dust) and moisture (such as water). The IP rating system is defined by the International Electrotechnical Commission (IEC).

Here's how IP ratings work:

a. First Digit (Protection against solid objects):
    - 0: No special protection.
    - 1: Protected against solid objects greater than 50mm (e.g., accidental touch by hands).
    - 2: Protected against solid objects greater than 12.5mm (e.g., fingers).
    - 3: Protected against solid objects greater than 2.5mm (e.g., tools and wires).

- 4: Protected against solid objects greater than 1.0mm (e.g., small tools and wires).
- 5: Dust protected (limited ingress of dust, but not entirely prevented).
- 6: Dust tight (complete protection against dust).

b. Second Digit (Protection against liquids):
   - 0: No protection.
   - 1: Protected against vertically falling drops of water (e.g., condensation).
   - 2: Protected against direct sprays of water up to 15° from vertical.
   - 3: Protected against sprays from all directions, up to 60° from vertical.
   - 4: Protected against water splashes from all directions.
   - 5: Protected against low-pressure jets of water from all directions.
   - 6: Protected against powerful jets of water (e.g., heavy seas).
   - 7: Protected against temporary immersion in water (up to 1 meter for 30 minutes).
   - 8: Protected against continuous immersion in water beyond 1 meter (specific depths specified by manufacturer).

For example, an IP65-rated luminaire would be dust tight (6) and protected against water jets (5), making it suitable for outdoor use where it might encounter rain and dust.

It's essential to check the specific IP rating of a luminaire to ensure it meets the environmental conditions where it will be installed. This helps in ensuring longevity and safety of the luminaire in various operating environments.

II. IK Ratings:

It seems like you might be referring to "IK ratings" rather than "IP ratings." IK ratings are another set of standardized ratings that indicate the degree of protection provided by an enclosure or luminaire against mechanical impacts, particularly relating to the impact resistance of the housing and its ability to withstand physical shocks.

Here's how IK ratings work:

a. IK00: No protection against impact.
b. IK01: Protection against 0.14 joules impact (equivalent to impact of 0.25 kg mass dropped from 56 mm height).

c. IK02: Protection against 0.2 joules impact.
d. IK03: Protection against 0.35 joules impact.
e. IK04: Protection against 0.5 joules impact.
f. IK05: Protection against 0.7 joules impact.
g. IK06: Protection against 1 joule impact.
h. IK07: Protection against 2 joules impact.
i. IK08: Protection against 5 joules impact.
j. IK09: Protection against 10 joules impact.
k. IK10: Protection against 20 joules impact.

The IK rating system is particularly important for luminaires installed in environments where they might be subject to accidental impacts, vandalism, or other mechanical stresses. Higher IK ratings indicate greater resistance to impact, ensuring the luminaire remains functional and safe even after accidental collisions.

When choosing a luminaire, both IP ratings (for protection against ingress of dust and water) and IK ratings (for protection against mechanical impacts) should be considered based on the specific installation environment and potential hazards.

3.4 Photometric and Electrical parameters:

I. Photometric parameters:

Photometric parameters of a luminaire refers to the various measurements and characteristics that describe how the luminaire distributes light. These parameters are crucial for understanding the performance of a light fixture and its suitability for different applications. Here are some common photometric parameters:

a. Intensity Distribution: Describes how light is distributed in different directions around the luminaire. It can be represented in various ways such as polar diagrams showing intensity at different angles.

b. Light Distribution Curve: Shows how the light intensity varies across different planes (horizontal and vertical) around the luminaire.

c. Luminous Intensity: The amount of light emitted in a particular direction, measured in candelas (cd).

d. Beam Angle: The angle over which the light is emitted from the luminaire, usually defined where the intensity drops to a certain percentage of the maximum intensity.

e. Colour Characteristics: Parameters such as correlated colour temperature (CCT) and colour rendering index (CRI) describe the colour appearance and quality of the light emitted by the luminaire.

f. Luminous Flux: Total amount of light emitted by the luminaire, measured in lumens (lm).

g. Efficiency: How efficiently the luminaire converts electrical power into light output, often expressed as lumens per watt (lm/W).

h. Uniformity: Measures how evenly light is distributed over a given area, important for avoiding glare and achieving consistent illumination.

i. Glare Rating: Quantifies the potential discomfort or visibility impairment caused by excessive brightness contrasts within the field of view.

j. Light Distribution Types: Specifies whether the luminaire provides direct, indirect, or semi-direct lighting, influencing its application suitability and visual comfort.

These parameters are typically provided in photometric reports or data sheets by manufacturers and are essential for lighting designers, architects, and engineers when selecting luminaires for specific projects to ensure appropriate lighting quality and efficiency.

II. Electrical parameters:

Electrical parameters of a luminaire refer to the characteristics related to how the luminaire consumes electrical power and operates within an electrical system. These parameters are crucial for understanding the electrical requirements, compatibility, and efficiency of the luminaire. Here are some common electrical parameters:

a. Voltage: The nominal operating voltage required for the luminaire to function properly, typically specified in volts (V).

b. Power Consumption: The amount of electrical power consumed by the luminaire when operating at its full capacity, measured in watts (W).

c. Current Draw: The amount of electrical current drawn by the luminaire from the power supply, measured in amperes (A).

d. Power Factor: A measure of how efficiently the luminaire uses the electricity supplied to it. It is dimensionless and usually expressed as a decimal or percentage.

e. Operating Frequency: The frequency at which the luminaire operates, especially relevant for fluorescent or LED luminaires that require specific electronic ballasts or drivers.

f. Input Voltage Range: The range of voltages over which the luminaire can operate safely and effectively, which is particularly important in regions where voltage fluctuations are common.

g. Electrical Safety Ratings: Standards such as IP (Ingress Protection) ratings, which indicate the luminaire's protection against dust and water ingress, and IK (Impact Protection) ratings, which indicate its resistance to mechanical impacts.

h. Electrical Connections: Specifications regarding the type and method of electrical connections required for installation, including terminals, connectors, and wiring requirements.

i. Dimming Compatibility: Information on whether the luminaire is compatible with dimming systems, and if so, the type of dimming protocol (e.g., 0-10V, DALI).

j. Start-up Characteristics: Information about any start-up surge currents or time delays when the luminaire is powered on.

These electrical parameters are typically detailed in the luminaire's product datasheet or specifications provided by the manufacturer. They are crucial for electricians, facility managers, and installers to ensure proper installation, operation, and maintenance of the luminaires within an electrical system.

CHAPTER 4 – Sports lighting design and standards:

4.1 Design consideration of a sports lighting:

Designing sports lighting involves several key considerations to ensure optimal visibility, performance, and safety. Here are the main factors to consider:

I. Illumination Levels:

a. General Lighting Levels: Different sports require varying levels of illumination. For example, professional-level sports like football or basketball require higher lux levels compared to recreational or amateur sports.
b. Uniformity: Achieve even light distribution to minimize shadows and prevent glare. Uneven lighting can affect player performance and viewer experience.

II. Lighting Distribution:

a. Spotlights and Floodlights: Use a combination of spotlights and floodlights to cover the entire playing area effectively. Positioning and angling are crucial to avoid direct glare at players and spectators.
b. Angle and Height: Position lights at appropriate angles and heights to ensure comprehensive coverage. Typically, lights are mounted on high poles or structures around the field or court.

III. Colour Temperature:

a. White Light: Choose lights with a colour temperature that replicates natural daylight (around 4000K to 6000K). This helps in reducing eye strain and improving visual clarity.
b. Colour Rendering Index (CRI): A high CRI is beneficial as it enhances the clarity and accuracy of colours, which is important for both players and viewers.

IV. Glare Control:

a. Shielding: Use shields or louvers to minimize glare for players and spectators. Proper shielding helps direct light where it's needed and prevents light spill into unwanted areas.
b. Light Fixtures: Opt for fixtures designed to reduce glare, which can impact players' performance and viewer comfort.

V. Energy Efficiency:

a. LED Technology: Consider using LED lights, which are energy-efficient and have a longer lifespan compared to traditional lighting solutions. They also offer better control over light distribution and dimming.
b. Smart Controls: Implement controls like dimming, scheduling, and motion sensors to optimize energy usage and adapt to different needs and conditions.

VI. Maintenance and Durability:

a. Weather Resistance: Ensure that lighting fixtures are rated for outdoor use and can withstand environmental conditions like rain, wind, and extreme temperatures.
b. Ease of Maintenance: Design the lighting system for easy access and maintenance. Regular upkeep is essential to ensure consistent performance and safety.

VII. Regulations and Standards:

a. Compliance: Adhere to local and international standards for sports lighting, such as those provided by organizations like the Illuminating Engineering Society (IES) or the International Lighting Commission (CIE).
b. Event-Specific Requirements: Consider specific requirements for televised or high-profile events, which may have stricter lighting standards.

VIII. Aesthetic Considerations:

a. Integration: Design the lighting system to complement the aesthetics of the venue and blend with the surrounding environment.

b. Spectator Experience: Ensure that the lighting enhances the spectator experience, providing a clear and engaging view of the event.

IX. Safety and Security:

a. Emergency Lighting: Incorporate emergency lighting to ensure safety during power outages or other emergencies.
b. Surveillance: Adequate lighting can enhance security around the venue by improving visibility for surveillance cameras and reducing the risk of accidents.

By addressing these considerations, you can design a sports lighting system that enhances the playing experience, meets regulatory requirements, and provides a safe and enjoyable environment for both players and spectators.

4.2 Approach to design sports lighting:

Designing sports lighting involves a systematic approach to ensure the lighting system meets the specific needs of the sport, venue, and users. Here's a step-by-step guide:

I. Understand Requirements:

a. Sport-Specific Needs: Identify the sport and its requirements, such as field size, type of play, and standard lighting levels. For example, football requires higher illumination levels than tennis.
b. Venue Details: Consider the type of venue (stadium, indoor arena, etc.), its dimensions, and any existing infrastructure.

II. Conduct Site Assessment:

a. Survey the Location: Measure the area to be illuminated, note existing structures that might affect lighting (e.g., stands, trees), and identify any potential obstacles.
b. Evaluate Environmental Conditions: Assess factors like weather conditions, potential for light pollution, and surrounding landscape.

III. Determine Lighting Levels and Uniformity:

a. Illumination Levels: Refer to industry standards (such as those from the Illuminating Engineering Society or sport-specific organizations) to determine the required lux levels for different types of play.
b. Uniformity: Aim for uniform light distribution to minimize shadows and ensure even lighting across the field or court.

IV. Select Lighting Technology:

a. Fixture Type: Choose the type of lighting fixtures (LED, metal halide, etc.) based on their efficiency, longevity, and light quality.

b. Colour Temperature and CRI: Opt for a colour temperature that mimics daylight (around 4000K to 6000K) and a high Colour Rendering Index (CRI) to enhance visibility and colour accuracy.

V. Design the Lighting Layout:

a. Fixture Placement: Plan the arrangement of lights to ensure comprehensive coverage. Use tools like photometric software to simulate light distribution and optimize placement.
b. Height and Angle: Determine the appropriate mounting height and angle to avoid glare and ensure proper coverage.

VI. Implement Control Systems:

a. Dimming and Scheduling: Incorporate control systems to adjust lighting levels based on specific needs, such as varying game times or different events.
b. Smart Controls: Use advanced controls for energy efficiency, including motion sensors and automated scheduling.

VII. Ensure Compliance with Standards:

a. Regulatory Compliance: Follow local and international lighting standards and regulations to ensure safety and performance.
b. Event-Specific Standards: For televised or high-profile events, meet additional requirements for light intensity and uniformity.

VIII. Plan for Maintenance:

a. Accessibility: Design the lighting system for easy maintenance access to reduce downtime and costs.
b. Durability: Choose fixtures that can withstand environmental conditions and require minimal maintenance.

IX. Test and Validate:

a. Installation Testing: After installation, test the system to ensure it meets the design specifications and performance criteria.
b. Adjustments: Make necessary adjustments based on test results to achieve optimal lighting conditions.

X. Monitor and Optimize:

a. Ongoing Evaluation: Regularly monitor the lighting system's performance and make adjustments as needed to maintain high-quality illumination.
b. Feedback: Gather feedback from users and stakeholders to continuously improve the lighting design.

By following these steps, you can design a sports lighting system that enhances performance, improves the spectator experience, and meets safety and regulatory requirements.

CHAPTER 5 – Sports lighting design of a Badminton and Tennis playground:

- ## Case study-1:

I. Overview of a Badminton court:

Dimension of the court:

- Total area (TA) : 16m x 9m
- Playing area (PA) : 14m x 7m

Estimation of grid dimension

$p \leq 0.2 \times 5^{logd}$

$= 0.93m$

p = Grid size

d = The longer dimension of the reference area

Using this formula for grid calculation, the value of p is 0.93m. But in Dialux design the value of p taken as 1m as per NLC 2010.

So, p = 1m

$D = \sqrt{4^2 + 4.5^2}$

$= 6.02m$

$H = D \times tan\ \theta$ ($\theta = 20° - 25°$)

$= 6.02 \times tan\ 25°$

$= 2.80m$

$\approx 3m$

H = average mounting height

D = distance between mast base and centre point of the field

$\theta = 20° - 25°$

From above the calculation, the value of mounting height of the pole is 3m. But in Dialux design the mounting height taken as 8m.

So, H = 8m

A thumb rule estimation using Lumen method to determine the approximate number of luminaires can be performed:

Lumen Method:

Cu = 0.4

LLF = 0.8

$$E_{avg} = \frac{N \times \Phi \times Cu \times LLF}{A}$$

$$N = \frac{E_{avg} \times A}{\Phi \times Cu \times LLF}$$

$= \frac{2000 \times 16 \times 9}{72987 \times 0.4 \times 0.8}$ = 12.33 ≈ 12

N = number of luminaires required

E_{avg} = required average maintained horizontal illuminance (Lux)

A = playing area size (length × width) in sq.mtr.

Φ = lumen output per lamp

Cu = co-efficient of utilization factor

LLF = light loss factor

After the theoretical calculation, the number of luminaires is 12. But in case of dialux design the number of luminaires taken as 32. Because, with the help of 12 luminaires, all the values as per NLC 2010 can't be achieved.

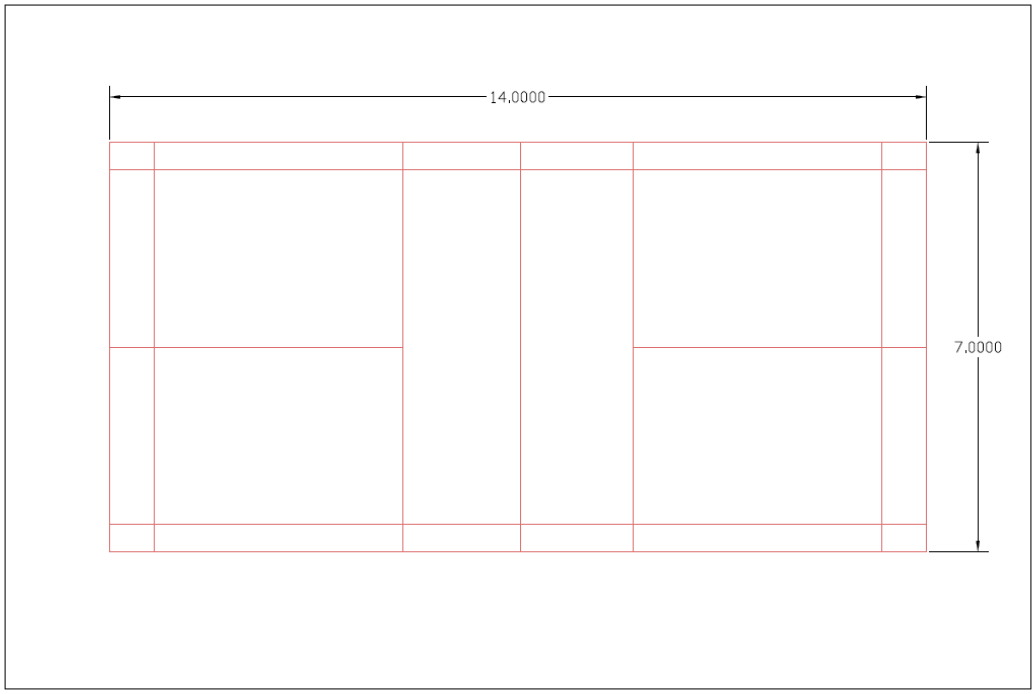
So, N = 32

Luminaire details = Thorn lighting, wide beam, double asymmetric, 483 watts

Following the table represents the Achieved values from Dialux design and NLC 2010 recommended values.

	Achieved Values			Recommended Values		
Parameters	International	National	Practice	International	National	Practice
E_{avg}	2188	1230	541	1500-3000	2200	500
E_v	2643	1486	653	2200	1000	-
E_{min}	1702	901	422	-	-	-
E_{max}	2571	1461	642	-	-	-
$U_1(E_{min/max})$	0.66	0.62	0.66	0.7	0.5	0.5
$U_2(E_{min/avg})$	0.78	0.73	0.78	0.8	0.7	0.7

II. Layout of the playing area of a Badminton court:



- **Case study-2**

I. Overview of a Tennis court:

Dimension of the court:

Total area (TA) = 24m x 11m

Estimation of grid dimension

$P \leq 0.2 \times 5^{logd}$

= 1.069m

p = Grid size

d = The longer dimension of the reference area

Using this formula for grid calculation, the value of p is 1.069m. But in Dialux design the value of p taken as 1m as per NLC 2010.

So, p = 1m

$D = \sqrt{6^2 + 5.5^2}$

= 8.13m

$H = D \times tan\ \theta$ (θ = 20° - 25°)

= 8.13 × *tan* 25°

= 3.79m

≈ 4m

H = average mounting height

D = distance between mast base and centre point of the field

θ = 20° - 25°

From above the calculation, the value of mounting height of the pole is 4m. But in Dialux design the mounting height taken as 8m.

So, H = 8m

A thumb rule estimation using Lumen method to determine the approximate number of luminaires can be performed:

Lumen Method:

Cu = 0.4

LLF = 0.8

$$E_{avg} = \frac{N \times \Phi \times Cu \times LLF}{A}$$

$$N = \frac{E_{avg} \times A}{\Phi \times Cu \times LLF}$$

$= \frac{2000 \times 24 \times 11}{72987 \times 0.4 \times 0.8}$ = 22.60 ≈ 23

N = number of luminaires required

E_{avg} = required average maintained horizontal illuminance (Lux)

A = playing area size (length × width) in sq.mtr.

Φ = lumen output per lamp

Cu = co-efficient of utilization factor

LLF = light loss factor

After the theoretical calculation, the number of luminaires is 23. But in case of dialux design the number of luminaires taken as 36. Because, with the help of 12 luminaires, all the values as per NLC 2010 can't be achieved. Also to maintain the proper ULR appropriate number of luminaires needed.

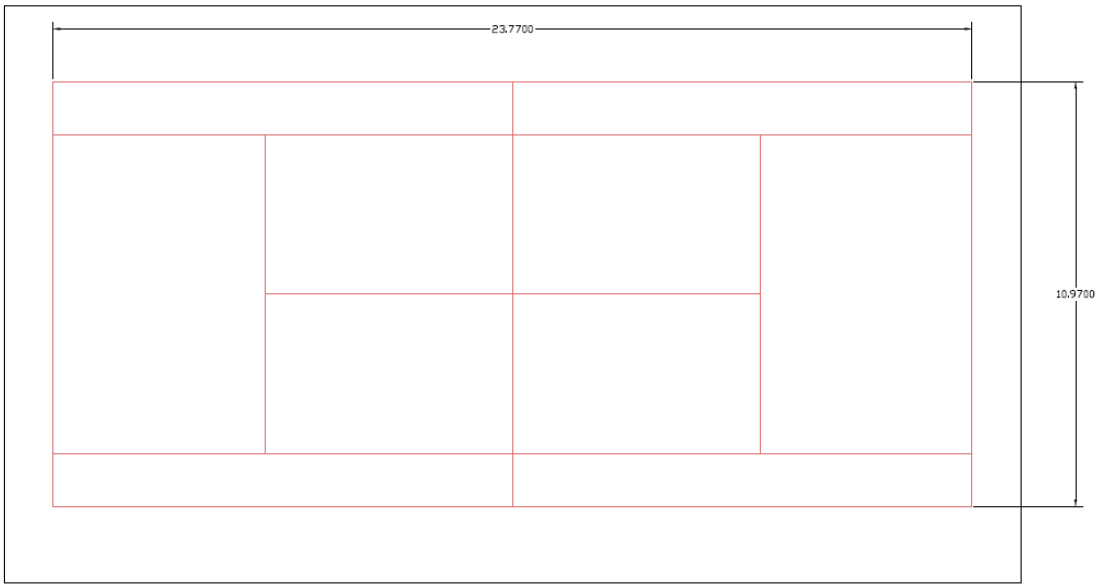
So, N = 36

Luminaire details = Thorn lighting, wide beam, double asymmetric, 483 watts

Following the table represents the Achieved values from Dialux design and NLC 2010 recommended values.

	Achieved Values			**Recommended Values**		
Parameters	International	National	Practice	International	National	Practice
E_{avg}	2000	1500	600	1500-3000	1000-2000	500
E_v	2392	1794	718	2200	1000	-
E_{min}	1610	1208	483	-	-	-
E_{max}	2164	1623	649	-	-	-
$U_1(E_{min/max})$	0.74	0.74	0.74	0.7	0.5	0.5
$U_2(E_{min/avg})$	0.81	0.81	0.80	0.8	0.7	0.7

II. Layout of The playing area of a Tennis court:



CHAPTER 6 – Sports lighting design Methodology:

Designing outdoor sports lighting involves a methodical approach to ensure optimal illumination for player performance, safety, and viewer experience. Here's a detailed methodology for designing outdoor sports lighting:

I. Define Project Scope and Requirements:

a. Sport-Specific Requirements: Understand the specific lighting needs for the sport (e.g., soccer, badminton, tennis), including the level of play (amateur, professional).
b. Field Dimensions: Measure the dimensions of the sports field or court.
c. Lighting Standards: Research and adhere to relevant lighting standards and regulations (e.g., standards from organizations like the International Tennis Federation or local governing bodies).

II. Site Analysis:

a. Survey the Site: Assess the site for any existing features or obstacles (e.g., trees, buildings) that might affect lighting.

b. Environmental Conditions: Consider local weather patterns, average daylight hours, and potential for light pollution.

III. Select Lighting Fixtures:

a. Fixture Types: Choose appropriate fixtures such as floodlights, high-intensity discharge (HID) lamps, or LEDs. Factors to consider include:
   - Luminaire Efficiency: Brightness and energy consumption.
   - Beam Angle: Wide, narrow or medium beams depending on coverage needs.
   - Durability: Weather resistance and maintenance requirements.

b. Photometric Data: Obtain and use photometric data files (e.g., IES or LDT files) for accurate modeling.

IV. Design the Lighting Layout:

a. Create a Model: Use lighting design software (e.g., DIALux, Dialux Evo, AGi32) to create a 3D model of the sports field.

b. Position Luminaires: Place fixtures to ensure uniform coverage and adequate illuminance. Common layouts include:
   - Corner Placement: Fixtures at each corner of the field.
   - Perimeter Placement: Fixtures along the perimeter or sides of the field.
   - Overhead or Mast Placement: For larger fields, fixtures mounted on tall poles or structures.

V. Configure Lighting Parameters:

a. Set Heights and Angles: Adjust fixture height, tilt, and orientation to achieve the desired light distribution and minimize shadows.

b. Illuminance Levels: Set illuminance levels based on the sport's requirements:
   - Recreational Play: Typically 200-300 lux.
   - Competitive Play: 500-1000 lux or more, depending on the level of competition.

VI. Run Simulations and Analyze Results:

a. Generate Simulations: Use the software to create simulations of the lighting layout.

b. Evaluate Metrics: Analyze metrics such as:
   - Average Illuminance: Ensures overall brightness.
   - Uniformity Ratio: Measures the consistency of lighting across the field (target is generally 0.6 or higher).
   - Glare: Ensure minimal glare for players and spectators.

VII. Optimize Design:

a. Adjust Design: Based on simulation results, refine the fixture placement, type, or settings to improve performance.

b. Re-Simulate: Validate changes through additional simulations to confirm improvements.

VIII. Generate Documentation:

a. Prepare Reports: Create detailed reports including:
- Lighting Plans: Diagrams showing fixture placement and coverage.
- Illuminance Levels: Data on average illuminance and uniformity.
- Compliance: Verification that the design meets standards and regulations.

b. Review: Ensure all documentation aligns with project requirements and specifications.

IX. Plan for Installation:

a. Prepare Specifications: Detail the requirements for the installation, including fixture types, mounting heights, and electrical considerations.

b. Oversee Installation: Supervise the installation process to ensure it adheres to the design specifications.

X. Post-Installation Evaluation:

a. Performance Verification: Check the installed system to confirm it meets design specifications and performance criteria.

b. Adjustments: Make necessary adjustments based on real-world performance, including fine-tuning fixture angles or heights.

XI. Maintenance and Upkeep:

a. Maintenance Plan: Develop a maintenance plan to ensure the longevity and optimal performance of the lighting system.

b. issues and ensure continued compliance with lighting standards.

By following this comprehensive methodology, you can design an effective and efficient outdoor sports lighting system that enhances the experience for players and spectators while meeting all relevant standards and requirements.

CHAPTER 7 – Result and Analysis:

7.1 Comparing and Analysis the data:

Proper lighting is very important for both tennis and badminton, lighting design should satisfy the requirements of players, officials and spectators. Above table shows the comparison between lighting requirements as per standard and achieved results for both the sports. The comparison table consists of lighting parameters for International, National and Practice matches.

Firstly in case of Badminton, for international matches average illuminance value 2289 lux and 2188 lux has been achieved for playing area(PA) and total area(TA) respectively, which satisfy the standard requirement and also sufficient uniformity has been achieved for both the areas. Also for national and practice matches, proper illuminance values and uniformity has been achieved for both playing and total area. In all three cases, the illuminance values under camera vertical has been achieved as per standard. For international, national and practice matches maximum glare value achieved as 25, 24 and 23 respectively which is suitable for proper playing condition and also satisfy the visibility purposes for the players and officials. ULR(Upward light ratio) for international, national and practice matches are 1%, 0.5% and 1.5% respectively, so ULR is less than 7% which implies that the amount of excessive light going towards upward is so less. All the achieved values for international, national and practice matches replicates that the lighting design is very much suitable for the glare free vision and proper playing conditions.

Now in case of Tennis, for international matches average illuminance 2000 lux has been achieved in the playing area and also the uniformity is 0.81, which is suitable for the playing conditions as per the standards. For national and practice matches average illuminance values 1500 lux and 600 lux has been achieved. For international and national matches illuminance values under camera vertical satisfy the conditions for telecasting. Maximum glare values for international, national and practice matches are 36, 35, and 34 respectively, glare value below 50 suits the condition of glare free vision. ULR is also less than 7% in all the three cases.

7.2 Observed sports lighting design challenges:

Designing outdoor sports lighting in DIALux 4.13 involves several challenges:

I. Accurate Field Representation:

a. Challenge: Creating a precise 3D model of the sports field with accurate dimensions and features.
b. Solution: Use detailed field measurements and CAD files. Ensure all relevant environmental elements (e.g., trees, buildings) are included.

II. Uniform Light Distribution:

a. Challenge: Achieving even light coverage across the entire field while minimizing shadows and dark spots.
b. Solution: Experiment with different fixture placements and heights. Use DIALux's simulation tools to assess light distribution and make necessary adjustments.

III. Illuminance Levels:

a. Challenge: Meeting the required illuminance levels for different types of sports and ensuring they are uniformly distributed.
b. Solution: Input accurate photometric data for chosen fixtures and adjust placement based on simulated results. Reference sports lighting standards for target illuminance levels.

IV. Glare Management:

a. Challenge: Reducing glare for players and spectators to avoid discomfort and distraction.
b. Solution: Use fixtures with glare control features and adjust angles and shielding in the design. Simulate glare in DIALux and make necessary refinements.

V. Light Pollution Control:

a. Challenge: Minimizing light spill and controlling light pollution to avoid affecting surrounding areas.
b. Solution: Incorporate cutoff or shielded fixtures. Model the surrounding environment to analyze potential light spill and adjust the design accordingly.

VI. Fixture and Cable Integration:

a. Challenge: Integrating lighting fixtures with existing infrastructure and managing cables and power sources.
b. Solution: Coordinate with installation teams to ensure fixtures are compatible with existing structures and infrastructure. Plan cable routes carefully within the design model.

VII. Realistic Simulation:

a. Challenge: Ensuring that simulations accurately reflect real-world conditions.
b. Solution: Validate design by comparing simulated results with actual field conditions and adjust as necessary.

VIII. Software Limitations:

a. Challenge: DIALux 4.13 may have limitations in handling complex environments or advanced lighting scenarios.
b. Solution: Supplement DIALux with additional tools if needed and stay updated on software updates or newer versions.

By addressing these challenges, you can create a robust and effective outdoor sports lighting design that meets performance standards and practical requirements.

Conclusions:

The studies on outdoor sports lighting design for badminton and tennis courts emphasize the importance of achieving proper illuminance, uniform light distribution, and glare control. Addressing design challenges through effective fixture placement, managing light pollution, and utilizing simulation tools are crucial for creating optimal lighting systems. Adhering to standards and staying updated on technological advancements will ensure that lighting designs meet the needs of players, spectators, and the environment.

Effective outdoor sports lighting design for badminton and tennis courts requires careful consideration of illuminance levels, uniformity, glare control, and light pollution. By leveraging simulation tools, adhering to standards, and addressing design challenges, it is possible to create a lighting system that enhances player performance, spectator experience, and environmental sustainability. Regular updates and advancements in technology should be integrated into future designs to maintain optimal performance and efficiency.

Future scopes:

The future scope for outdoor tennis and badminton sports lighting using Thron LED lights will likely see several key advancements:

I. **Precision and Performance:**
a. Advanced Optics: Thron LEDs will feature cutting-edge optics for precise light control, minimizing glare and shadows, which is crucial for high-performance sports.
b. Dynamic Adjustment: Integration with sensors and smart controls will allow real-time adjustments in lighting based on game conditions, ensuring optimal visibility.

II. **Energy Efficiency:**
   a. Enhanced Efficiency: Thron LEDs will offer high lumen output per watt, reducing overall energy consumption while delivering bright, uniform light.
   b. Sustainable Solutions: Innovations will include options for solar-assisted lighting or other eco-friendly technologies to further reduce energy use and environmental impact.

III. **Durability and Reliability:**
   a. Rugged Construction: Designed to withstand extreme weather conditions and physical impacts, Thron LEDs will require less frequent maintenance and have a longer lifespan.
   b. Low Maintenance: With their durability and longevity, these LEDs will significantly lower maintenance costs and effort.

IV. **Customization and User Control:**
   a. Programmable Features: Users will have the ability to set and adjust lighting scenarios for different types of play or events through advanced control systems.
   b. Remote Operation: Thron LEDs will support remote management and scheduling via apps or control panels, enhancing convenience for facility operators.

V. **Integration with Other Technologies:**
   a. Performance Monitoring: Integration with performance analytics tools will allow lighting adjustments based on player movements and game dynamics.
   b. Broadcast Quality: Lighting will be optimized for high-definition broadcasting, ensuring clear and consistent illumination for TV and streaming.

VI. **Environmental Considerations:**
   a. Reduced Light Pollution: Advanced shielding and directional control will minimize light spill and reduce light pollution, making Thron LEDs suitable for urban or residential areas.
   b. Eco-Friendly Materials: Future designs will incorporate recyclable materials and energy-efficient technologies, aligning with sustainability goals.

VII. **Health and Safety:**
   a. Circadian-Optimized Lighting: Features supporting circadian rhythms will enhance player well-being and performance by mimicking natural daylight patterns.
   b. Safety Features: Built-in emergency lighting and automatic adjustments for power failures will improve safety during unexpected situations.

Overall, Thron LED lights will lead the way in outdoor sports lighting with innovations in efficiency, control, and durability, enhancing both player performance and spectator experience while addressing environmental and safety concerns.

References:

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x. X-H Lee, J-T Yang et al. 'An LED-based luminaire for badminton court illumination', Lighting Res. Technol. 2015; 0: 1-11

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xxi. https://www.manufacturer.lighting/club/15/

ANNEXURE – I

SPORTS LIGHTING DESIGN FOR BADMINTON PAYGROUND

Sports lighting design for Badminton court

LIGHTING DESIGNED FOR:

INTERNATIONAL LEVEL
NATIONAL LEVEL
TRAINING LEVEL

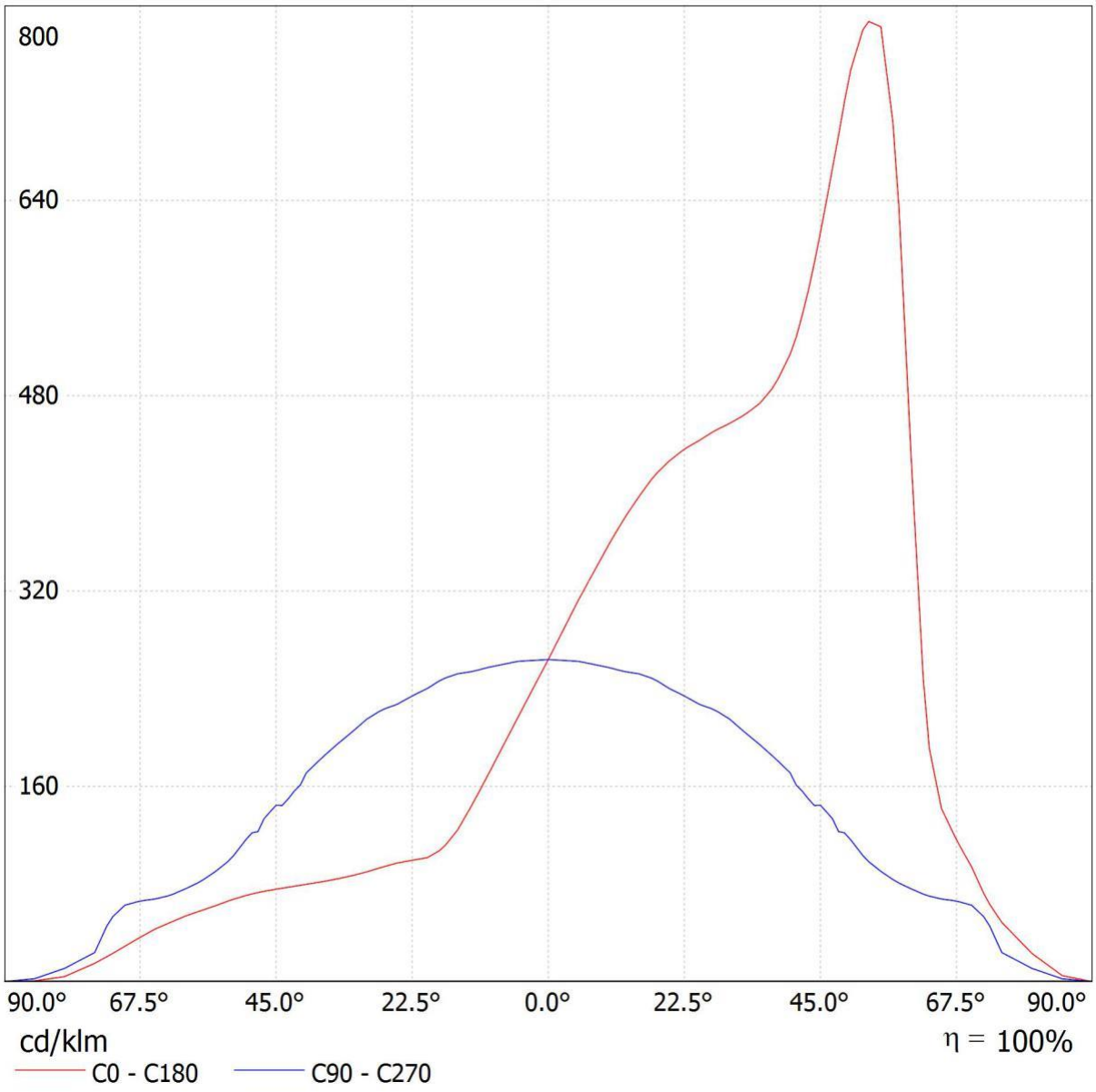
Partner for Contact:
Order No.:
Company:
Customer No.:

Date: 23.08.2024
Operator: Triprna Mondal

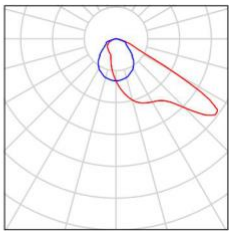
Table of contents

Thorn 96635929 AFP2 2M 192L85-740 A4 CL1 GY [STD] / LDC (Linear)

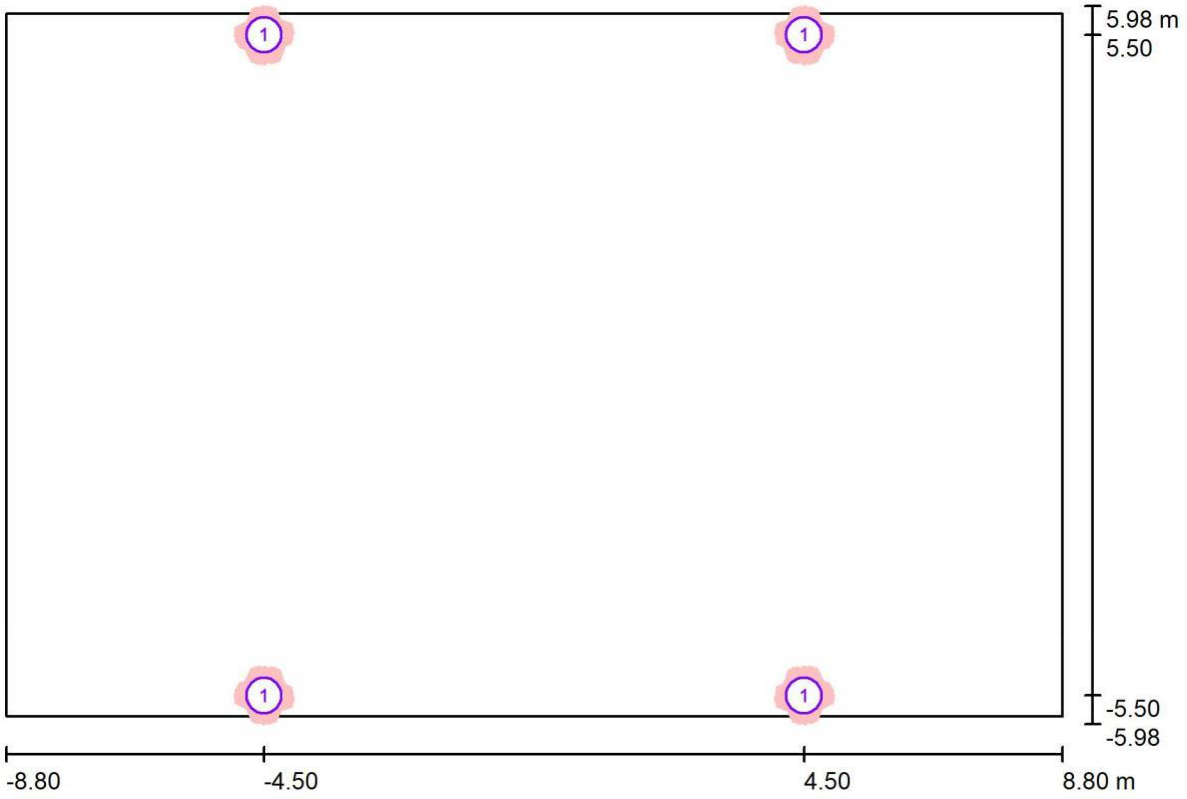
Luminaire: Thorn 96635929 AFP2 2M 192L85-740 A4 CL1 GY [STD]
Lamps: 1 x LED 483 W



32 Pieces **Thorn 96635929 AFP2 2M 192L85-740 A4 CL1 GY [STD]**
Article No.: 96635929
Luminous flux (Luminaire): 72987 lm
Luminous flux (Lamps): 72987 lm
Luminaire Wattage: 483.0 W
Luminaire classification according to CIE: 100
CIE flux code: 39 83 98 100 100
Fitting: 1 x LED 483 W (Correction Factor 1.000).



Badminton court area / Luminaires (layout plan)

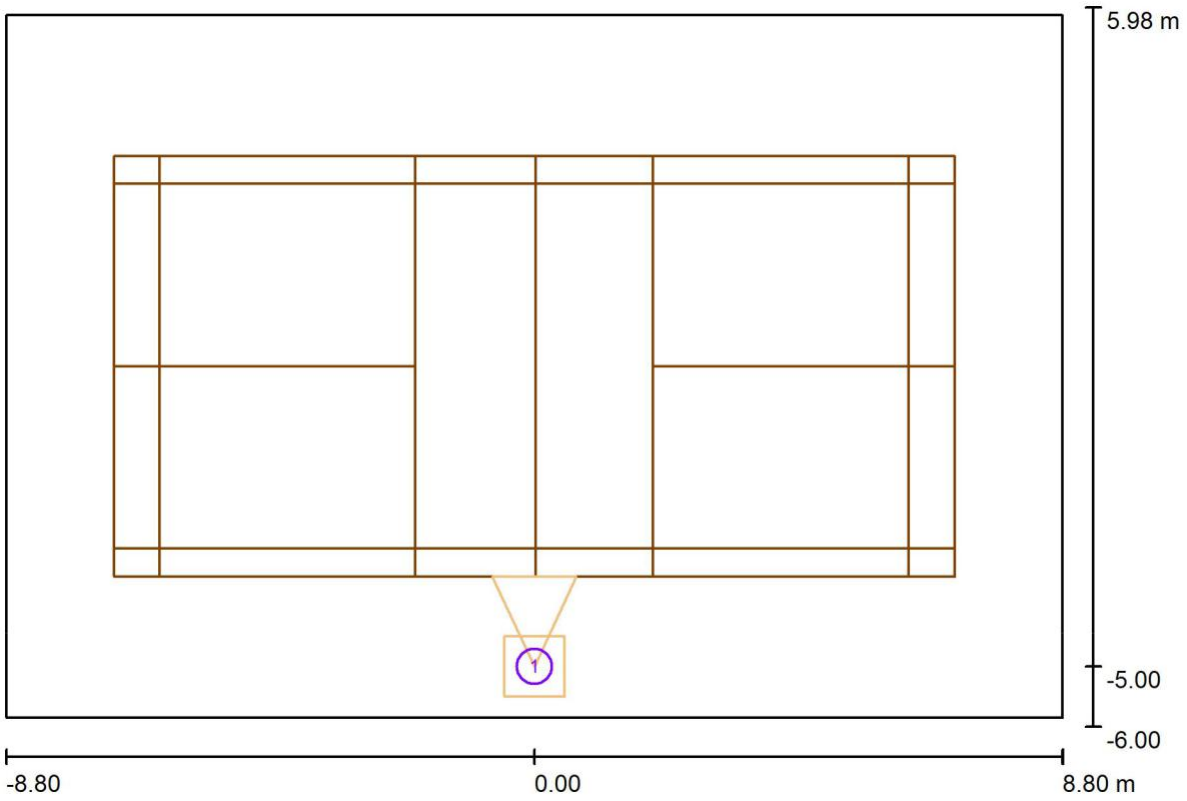


Scale 1 : 126

Luminaire Parts List

No.	Pieces	Designation
1	32	Thorn 96635929 AFP2 2M 192L85-740 A4 CL1 GY [STD]

Badminton court area / TV Cameras (Coordinates List)

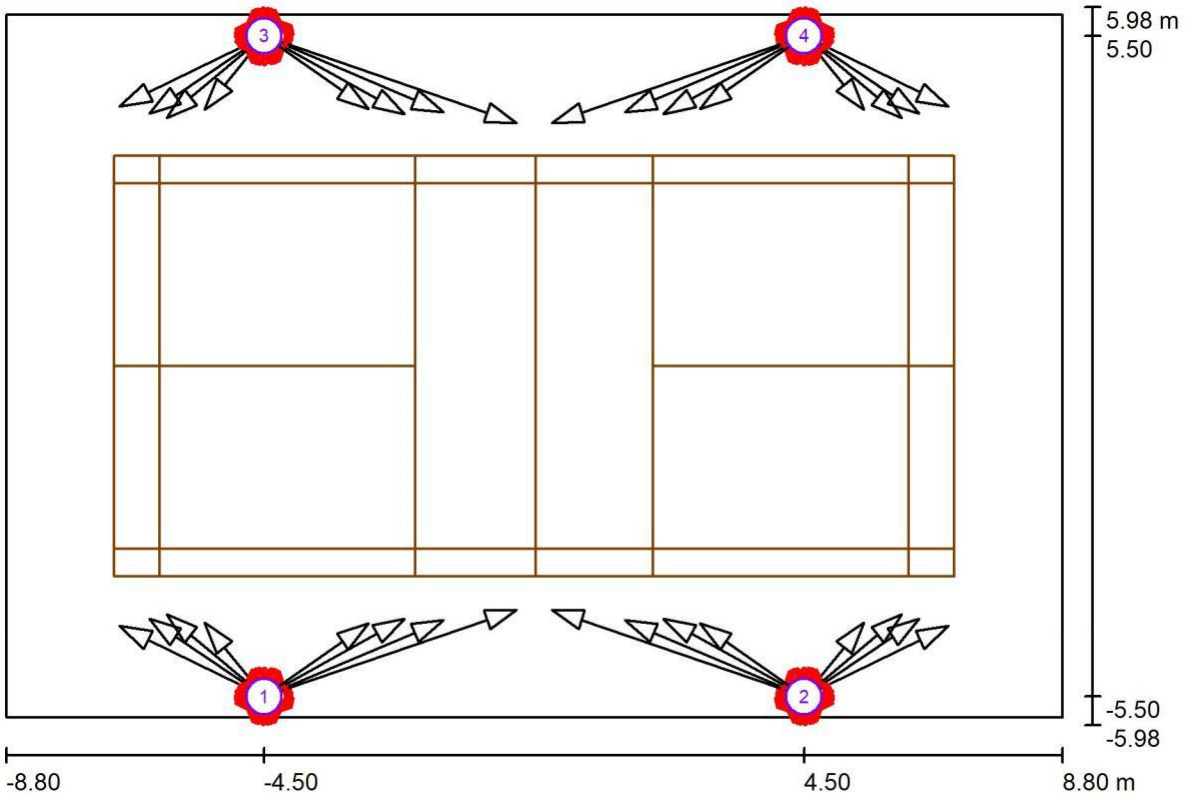


Scale 1 : 126

List of the TV Cameras

No.	Designation	Position [m]		
		X	Y	Z
1	TV Camera	0.000	-5.000	4.000

Badminton court area / Sport Luminaires (Coordinates List)



Scale 1 : 126

List of the Sport Luminaires

Luminaire	Index	Position [m]			Aiming Point [m]			Angle [°]	Alignment	Pole
		X	Y	Z	X	Y	Z			
Thorn 96635929 AFP2 2M 192L85-740 A4 CL1 GY [STD]	1	-4.500	-5.500	10.000	-5.497	-4.269	0.000	81.0	(C0,G0)	/
Thorn 96635929 AFP2 2M 192L85-740 A4 CL1 GY [STD]	2	4.500	-5.500	10.000	5.497	-4.269	0.000	81.0	(C0,G0)	/
Thorn 96635929 AFP2 2M 192L85-740 A4 CL1 GY [STD]	3	-4.500	5.500	10.000	-5.497	4.269	0.000	81.0	(C0,G0)	/
Thorn 96635929 AFP2 2M 192L85-740 A4 CL1 GY [STD]	4	4.500	5.500	10.000	5.497	4.269	0.000	81.0	(C0,G0)	/

List of the Sport Luminaires

Luminaire	Index	Position [m] X	Y	Z	Aiming Point [m] X	Y	Z	Angle [°]	Alignment	Pole
Thorn 96635929 AFP2 2M 192L85-740 A4 CL1 GY [STD]	1	-4.500	-5.500	10.000	-1.509	-4.230	0.000	72.0	(C0,G0)	/
Thorn 96635929 AFP2 2M 192L85-740 A4 CL1 GY [STD]	2	4.500	-5.500	10.000	1.509	-4.230	0.000	72.0	(C0,G0)	/
Thorn 96635929 AFP2 2M 192L85-740 A4 CL1 GY [STD]	3	-4.500	5.500	10.000	-1.509	4.230	0.000	72.0	(C0,G0)	/
Thorn 96635929 AFP2 2M 192L85-740 A4 CL1 GY [STD]	4	4.500	5.500	10.000	1.509	4.230	0.000	72.0	(C0,G0)	/
Thorn 96635929 AFP2 2M 192L85-740 A4 CL1 GY [STD]	1	-4.500	-5.500	10.000	-6.908	-4.325	0.000	75.0	(C0,G0)	/
Thorn 96635929 AFP2 2M 192L85-740 A4 CL1 GY [STD]	2	4.500	-5.500	10.000	6.908	-4.325	0.000	75.0	(C0,G0)	/
Thorn 96635929 AFP2 2M 192L85-740 A4 CL1 GY [STD]	3	-4.500	5.500	10.000	-6.908	4.325	0.000	75.0	(C0,G0)	/
Thorn 96635929 AFP2 2M 192L85-740 A4 CL1 GY [STD]	4	4.500	5.500	10.000	6.908	4.325	0.000	75.0	(C0,G0)	/
Thorn 96635929 AFP2 2M 192L85-740 A4 CL1 GY [STD]	1	-4.500	-5.500	10.000	-6.414	-4.209	0.000	77.0	(C0,G0)	/
Thorn 96635929 AFP2 2M 192L85-740 A4 CL1 GY [STD]	2	4.500	-5.500	10.000	6.414	-4.209	0.000	77.0	(C0,G0)	/
Thorn 96635929 AFP2 2M 192L85-740 A4 CL1 GY [STD]	3	-4.500	5.500	10.000	-6.414	4.209	0.000	77.0	(C0,G0)	/
Thorn 96635929 AFP2 2M 192L85-740 A4 CL1 GY [STD]	4	4.500	5.500	10.000	6.414	4.209	0.000	77.0	(C0,G0)	/
Thorn 96635929 AFP2 2M 192L85-740 A4 CL1 GY [STD]	1	-4.500	-5.500	10.000	-2.156	-4.201	0.000	75.0	(C0,G0)	/
Thorn 96635929 AFP2 2M 192L85-740 A4 CL1 GY [STD]	2	4.500	-5.500	10.000	2.156	-4.201	0.000	75.0	(C0,G0)	/
Thorn 96635929 AFP2 2M 192L85-740 A4 CL1 GY [STD]	3	-4.500	5.500	10.000	-2.156	4.201	0.000	75.0	(C0,G0)	/
Thorn 96635929 AFP2 2M 192L85-740 A4 CL1 GY [STD]	4	4.500	5.500	10.000	2.156	4.201	0.000	75.0	(C0,G0)	/
Thorn 96635929 AFP2 2M 192L85-740 A4 CL1 GY [STD]	1	-4.500	-5.500	10.000	-6.128	-4.134	0.000	78.0	(C0,G0)	/
Thorn 96635929 AFP2 2M 192L85-740 A4 CL1 GY [STD]	2	4.500	-5.500	10.000	6.128	-4.134	0.000	78.0	(C0,G0)	/
Thorn 96635929 AFP2 2M 192L85-740 A4 CL1 GY [STD]	3	-4.500	5.500	10.000	-6.128	4.134	0.000	78.0	(C0,G0)	/
Thorn 96635929 AFP2 2M 192L85-740 A4 CL1 GY [STD]	4	4.500	5.500	10.000	6.128	4.134	0.000	78.0	(C0,G0)	/
Thorn 96635929 AFP2 2M 192L85-740 A4 CL1 GY [STD]	1	-4.500	-5.500	10.000	-0.290	-4.050	0.000	66.0	(C0,G0)	/
Thorn 96635929 AFP2 2M 192L85-740 A4 CL1 GY [STD]	2	4.500	-5.500	10.000	0.290	-4.050	0.000	66.0	(C0,G0)	/
Thorn 96635929 AFP2 2M 192L85-740 A4 CL1 GY [STD]	3	-4.500	5.500	10.000	-0.290	4.050	0.000	66.0	(C0,G0)	/
Thorn 96635929 AFP2 2M 192L85-740 A4 CL1 GY [STD]	4	4.500	5.500	10.000	0.290	4.050	0.000	66.0	(C0,G0)	/
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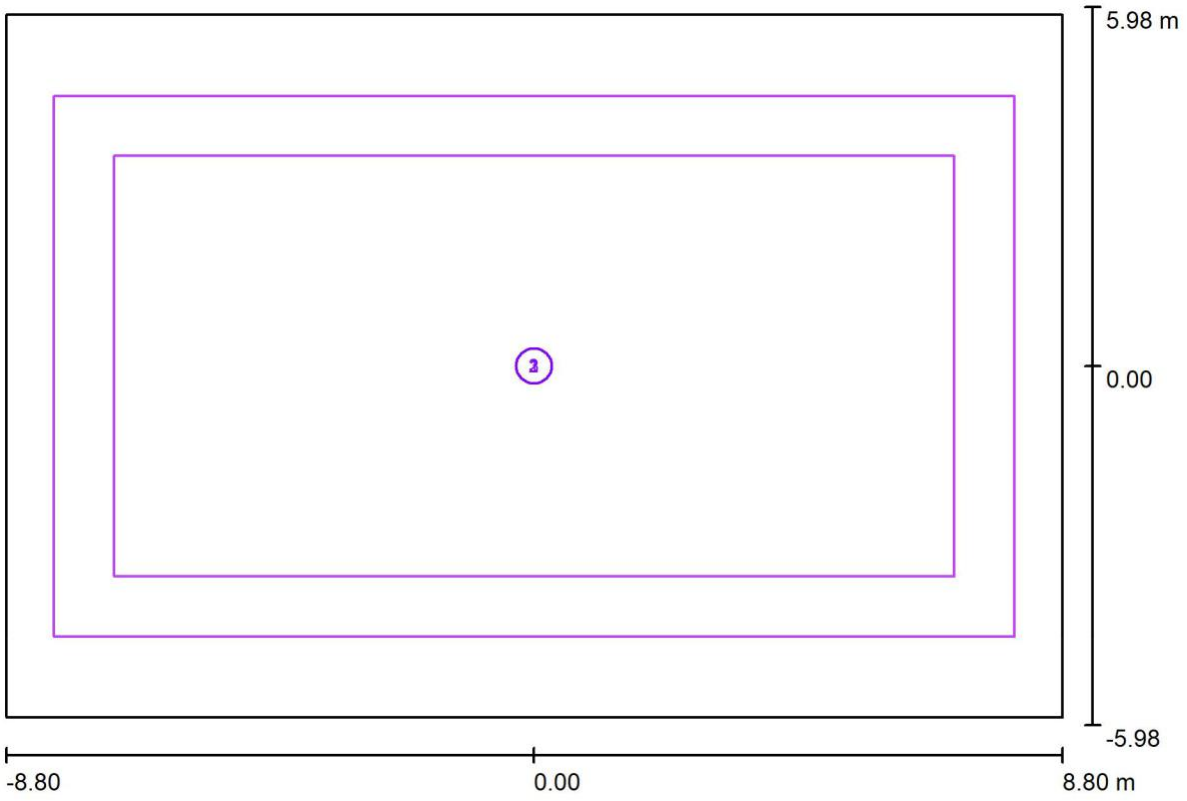
Thorn 96635929 AFP2 2M 192L85-740 A4 CL1 GY [STD]	2	4.500	-5.500	10.000	2.759	-4.281	0.000	78.0	(C0,G0)	/
Thorn 96635929 AFP2 2M 192L85-740 A4 CL1 GY [STD]	3	-4.500	5.500	10.000	-2.759	4.281	0.000	78.0	(C0,G0)	/
Thorn 96635929 AFP2 2M 192L85-740 A4 CL1 GY [STD]	4	4.500	5.500	10.000	2.759	4.281	0.000	78.0	(C0,G0)	/



Scale 1 : 126

List of the Calculation Grids

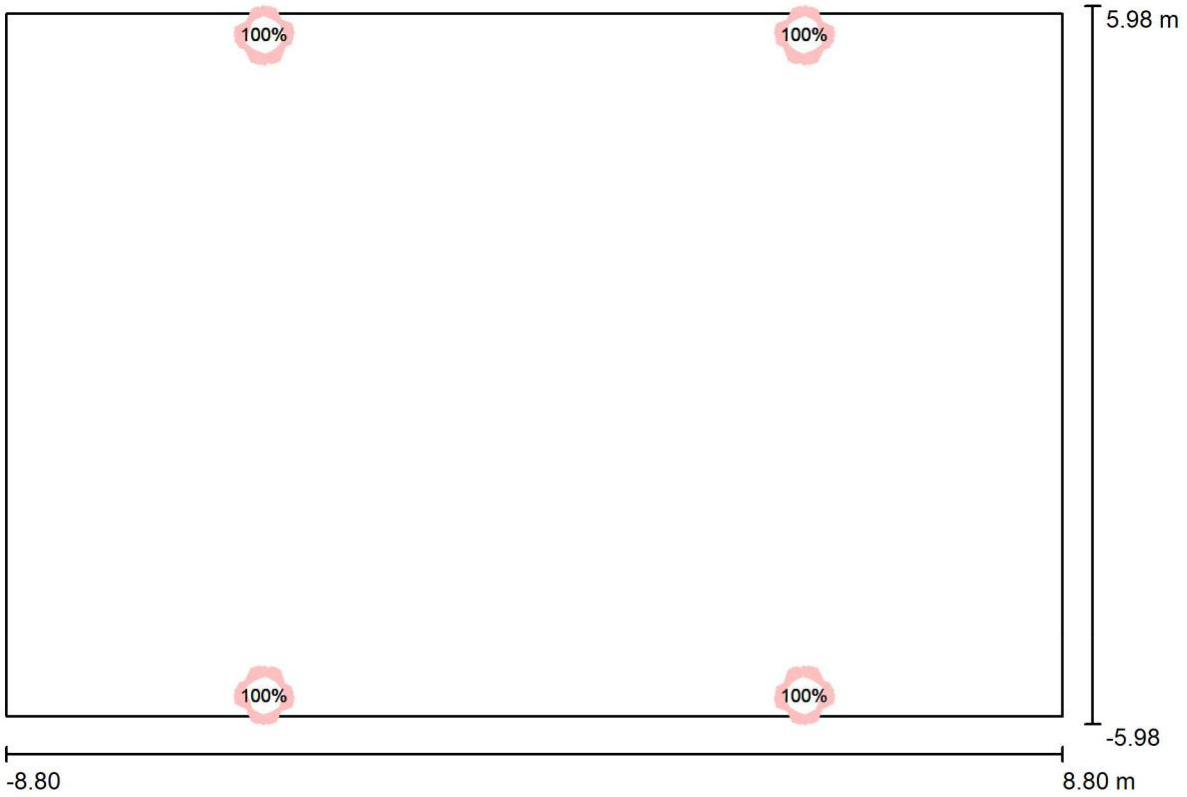
No.	Designation	Position [m]			Size [m]		Rotation [°]		
		X	Y	Z	L	W	X	Y	Z
1	Badminton court Calculation Grid (PA)	0.000	0.000	0.000	14.000	7.000	0.0	0.0	0.0
2	Badminton court Calculation Grid (TA)	0.000	0.000	0.000	16.000	9.000	0.0	0.0	0.0
3	Camera Vertical	0.000	0.000	1.500	16.000	9.000	0.0	0.0	0.0

Badminton court area / control group commissioning

	1	2	3	4
I	100 %	/	/	0 %
II		/ 100%	/	0 %
III		// 100%	0%	

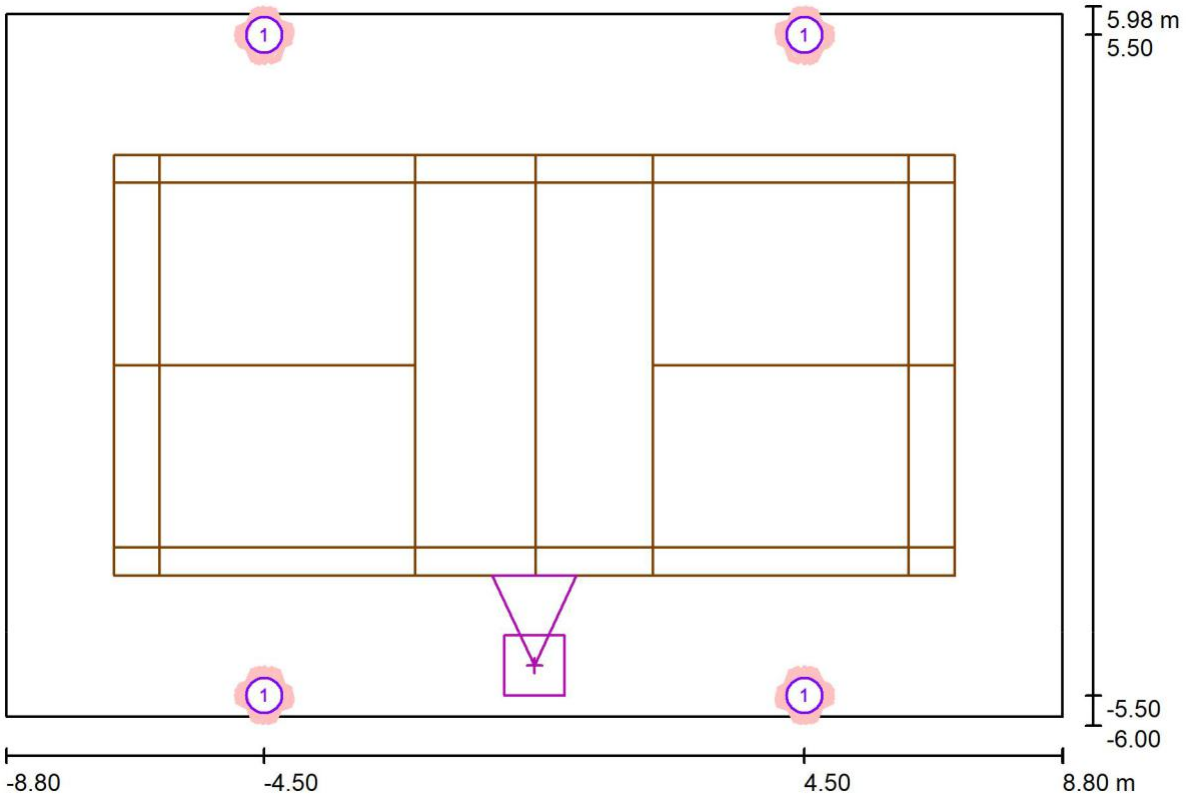
No.	Light scene
I	INTERNATIONAL
II	NATIONAL
III	TRANING

No.	Control group
1	LUMINAIRE FOR INTERNATIONAL
2	LUMINAIRE FOR NATIONAL
3	LUMNAIRE FOR TRANING
4	All other luminaires



Scale 1 : 126

No.	Control group (Luminaire)	Dimming values (Total) [%]
1	LUMINAIRE FOR INTERNATIONAL (Thorn 96635929 AFP2 2M 192L85-740 A4 CL1 GY [STD])	100
	All other luminaires	0

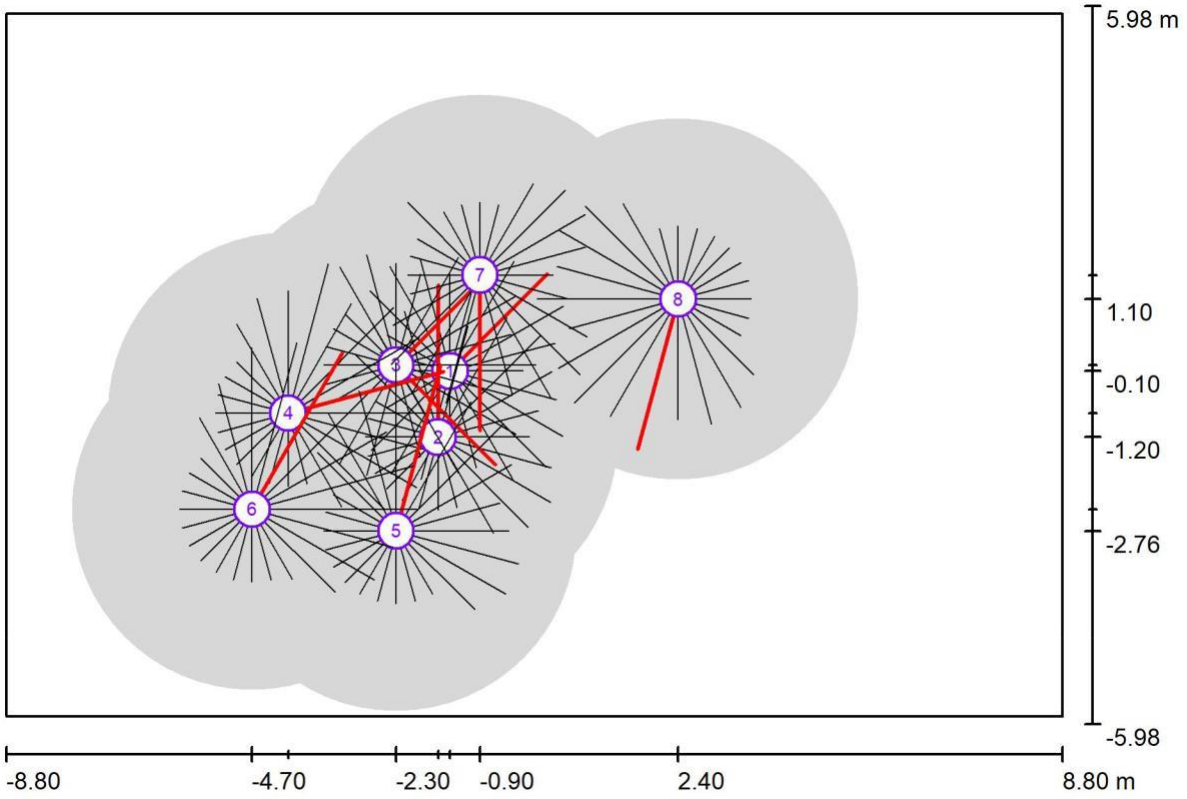


Light loss factor: 0.80, ULR (Upward Light Ratio): 1.0% **Scale 1:126**

Luminaire Parts List

No.	Pieces	Designation (Correction Factor)	F (Luminaire) [lm]	F (Lamps) [lm]	P [W]
1	32	Thorn 96635929 AFP2 2M 192L85-740 A4 CL1 GY [STD] (1.000)	72987	72987	483.0
			Total: 2335584	Total: 2335584	15456.0

Badminton court area / INTERNATIONAL / GR Observer (Results Overview)



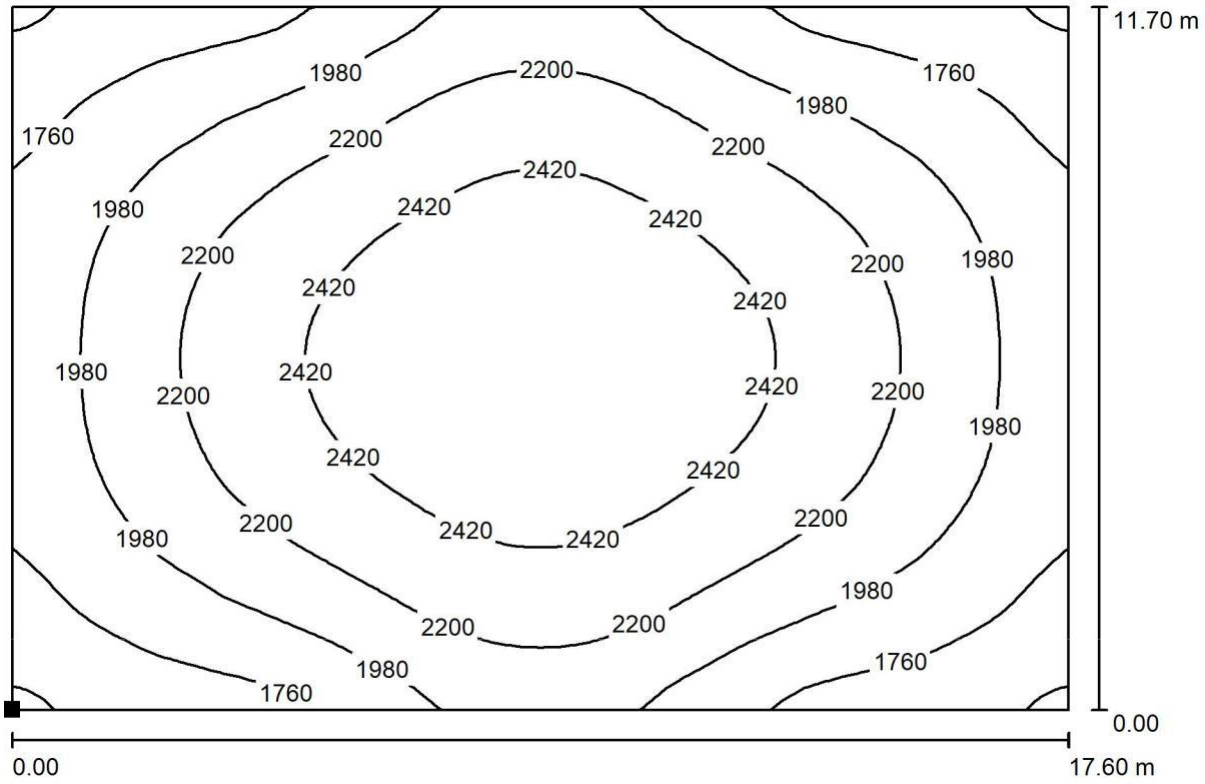
Scale 1 : 126

GR Observerlist

No.	Designation	Position [m]			Viewing sector [°]				Max
		X	Y	Z	Start	End	Increment	Slope angle	
1	GR Observer 1	-1.400	-0.100	1.500	0.0	360.0	15.0	-2.0	19 2)
2	GR Observer 2	-1.600	-1.200	1.500	0.0	360.0	15.0	-2.0	21 2)
3	GR Observer 3	-2.300	0.000	1.500	0.0	360.0	15.0	-2.0	19 2)
4	GR Observer 4	-4.100	-0.800	1.500	0.0	360.0	15.0	-2.0	22 2)
5	GR Observer 5	-2.300	-2.759	1.500	0.0	360.0	15.0	-2.0	24 2)
6	GR Observer 6	-4.700	-2.400	1.500	0.0	360.0	15.0	-2.0	25 2)
7	GR Observer 7	-0.900	1.500	1.500	0.0	360.0	15.0	-2.0	21 2)
8	GR Observer 8	2.400	1.100	1.500	0.0	360.0	15.0	-2.0	21 2)

2)The calculated equivalent veil luminance of the environment is based on the assumption of a complete diffuse reflection behavior of the environment (acc. EN 12464-2).

Badminton court area / INTERNATIONAL / Playing area / Surface 1 / Isolines (E)



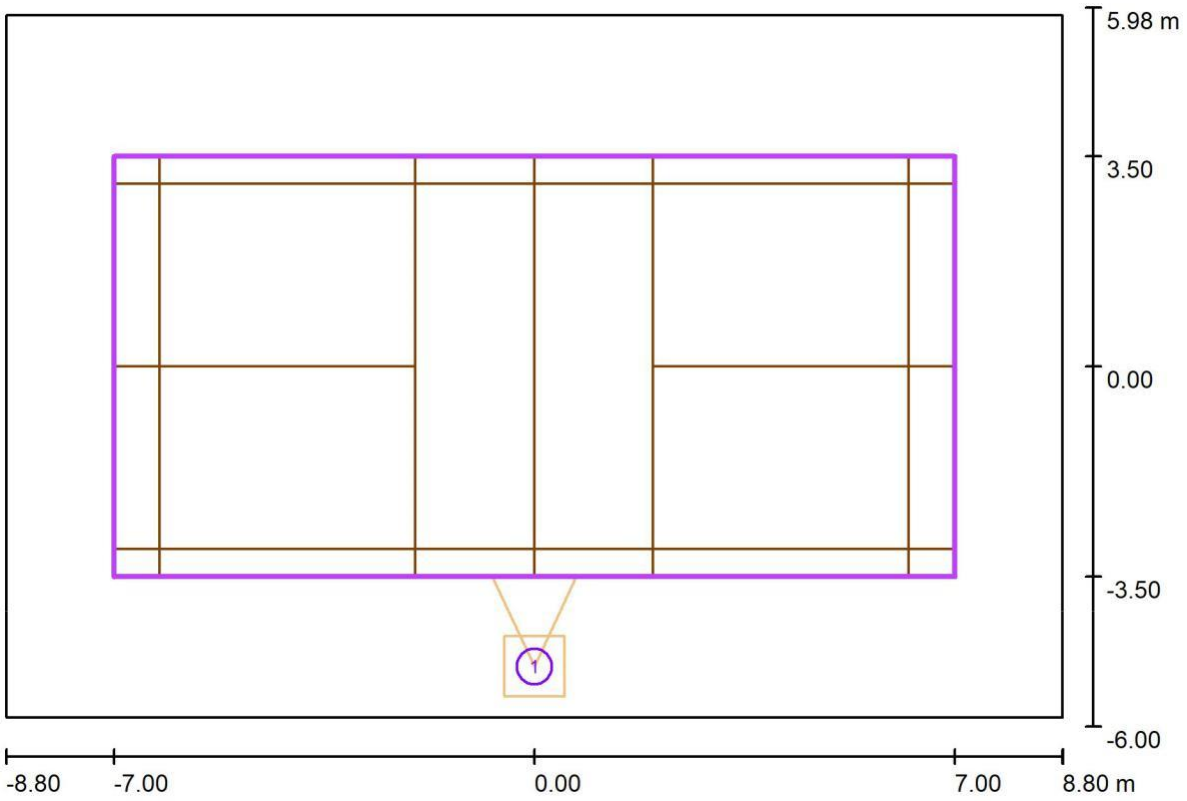
Values in Lux, Scale 1 : 126

Position of surface in external scene:
Marked point:
(-8.800 m, -5.850 m, 0.000 m)

Grid: 64 x 64 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
2119	1511	2574	0.713	0.587

Badminton court area / INTERNATIONAL / Badminton court Calculation Grid (PA) / Summary



Scale 1 : 126

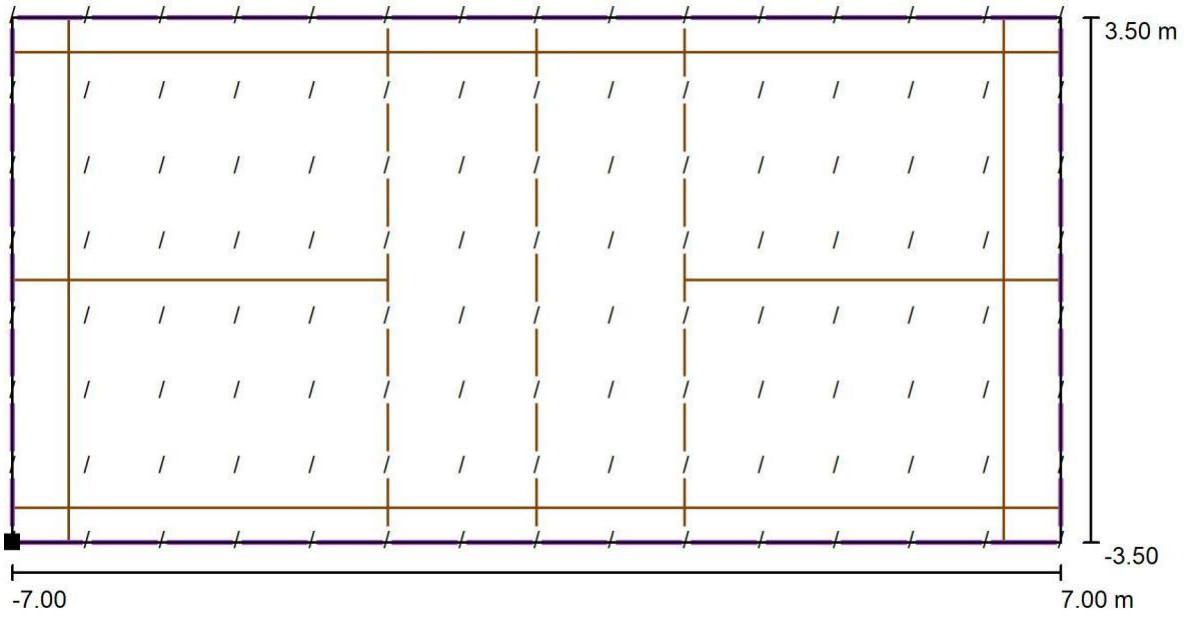
Position: (0.000 m, 0.000 m, 0.000 m)
Size: (14.000 m, 7.000 m)
Rotation: (0.0°, 0.0°, 0.0°)
Type: Normal, Grid: 15 x 8 Points
Belongs to the following sport arena: Badminton court

Results overview

No.	Type	E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}	$E_{h\,m}/E_m$	H [m]	Camera
1	horizontal	2289	1900	2571	0.83	0.74	/	0.000	/
2	Camera	2112	1870	2544	0.89	0.73	1.08	1.500	1

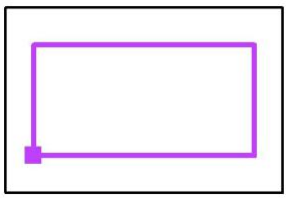
Eh m/Em = Relationship between middle horizontal and vertical illuminance, H = Measuring Height

Badminton court area / INTERNATIONAL / Badminton court Calculation Grid (PA) / Gradient Graphics (E, Horizontal)



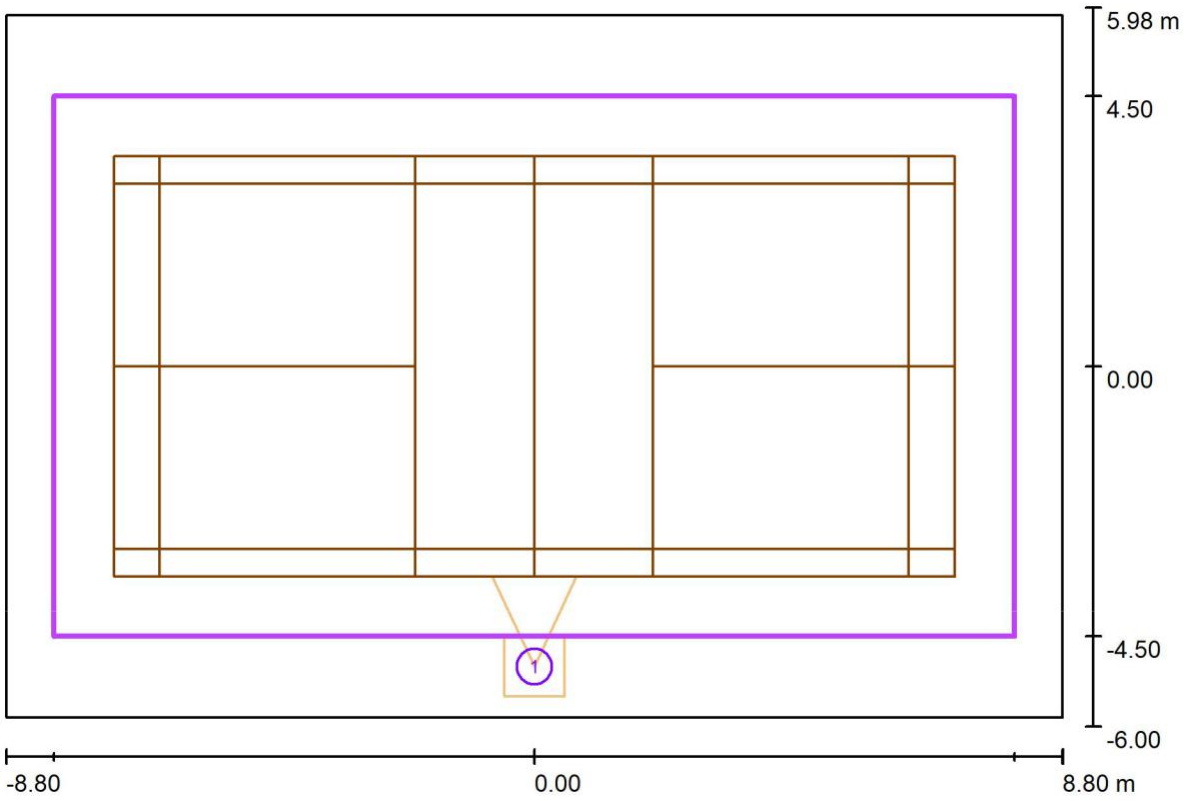
Values in %, Scale 1 : 101

Position of surface in external scene: Marked point: (-7.000 m, -3.500 m, 0.000 m)



Maximum Change: 12%
Selected Limit Value: 25% (Values below this limit value are not output.)
Distance for the Gradient Grid: 2.000 m

Badminton court area / INTERNATIONAL / Badminton court Calculation Grid (TA) / Summary



Scale 1 : 126

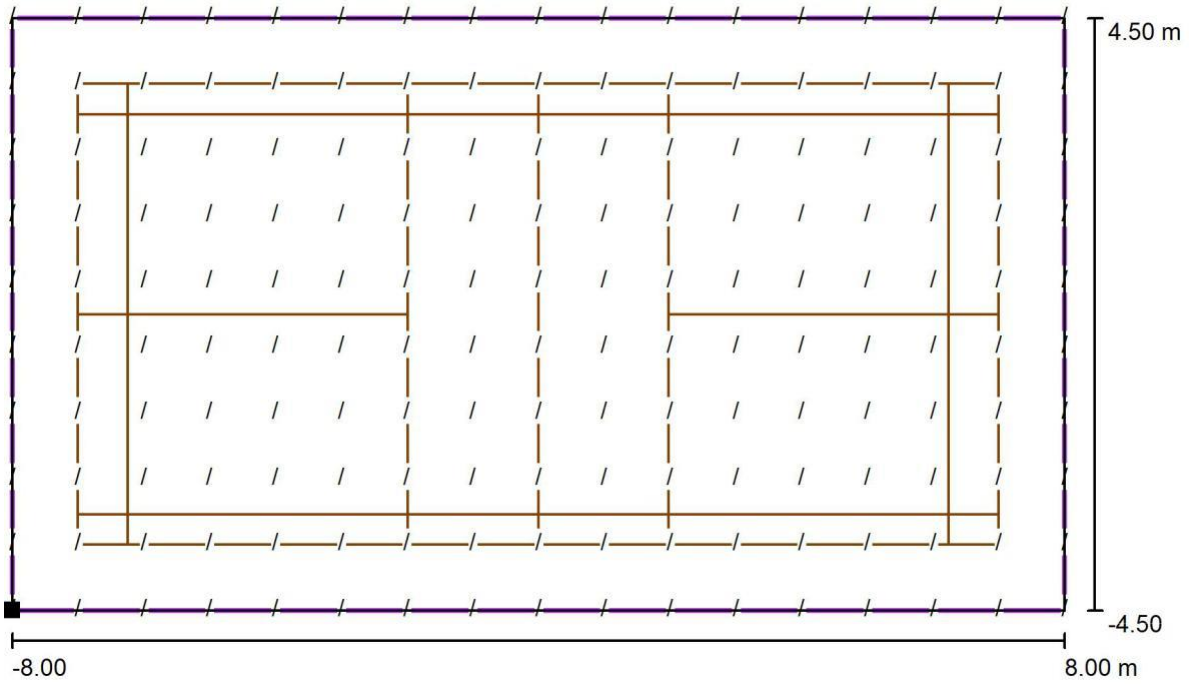
Position: (0.000 m, 0.000 m, 0.000 m)
Size: (16.000 m, 9.000 m)
Rotation: (0.0°, 0.0°, 0.0°)
Type: Normal, Grid: 17 x 10 Points
Belongs to the following sport arena: Badminton court

Results overview

No.	Type	E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}	$E_{h\,m}/E_m$	H [m]	Camera
1	horizontal	2188	1702	2571	0.78	0.66	/	0.000	/
2	Camera	2133	1870	2683	0.88	0.70	1.03	1.500	1

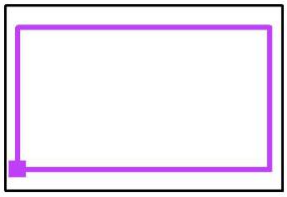
Eh m/Em = Relationship between middle horizontal and vertical illuminance, H = Measuring Height

Badminton court area / INTERNATIONAL / Badminton court Calculation Grid (TA) / Gradient Graphics (E, Horizontal)



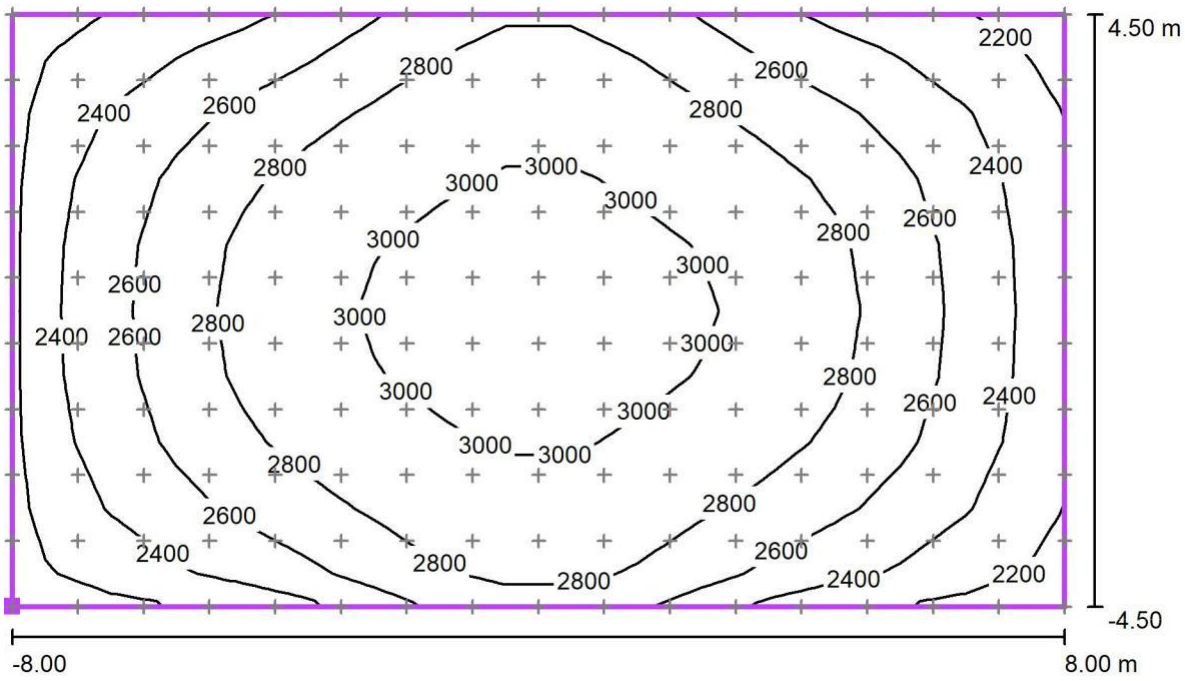
Values in %, Scale 1 : 115

Position of surface in external scene: Marked point: (-8.000 m, -4.500 m, 0.000 m)



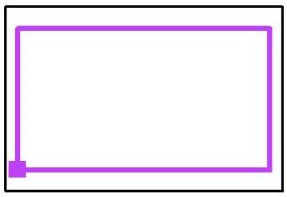
Maximum Change: 17%
Selected Limit Value: 25% (Values below this limit value are not output.)
Distance for the Gradient Grid: 2.000 m

Badminton court area / INTERNATIONAL / Camera Vertical / Isolines (E, Horizontal)



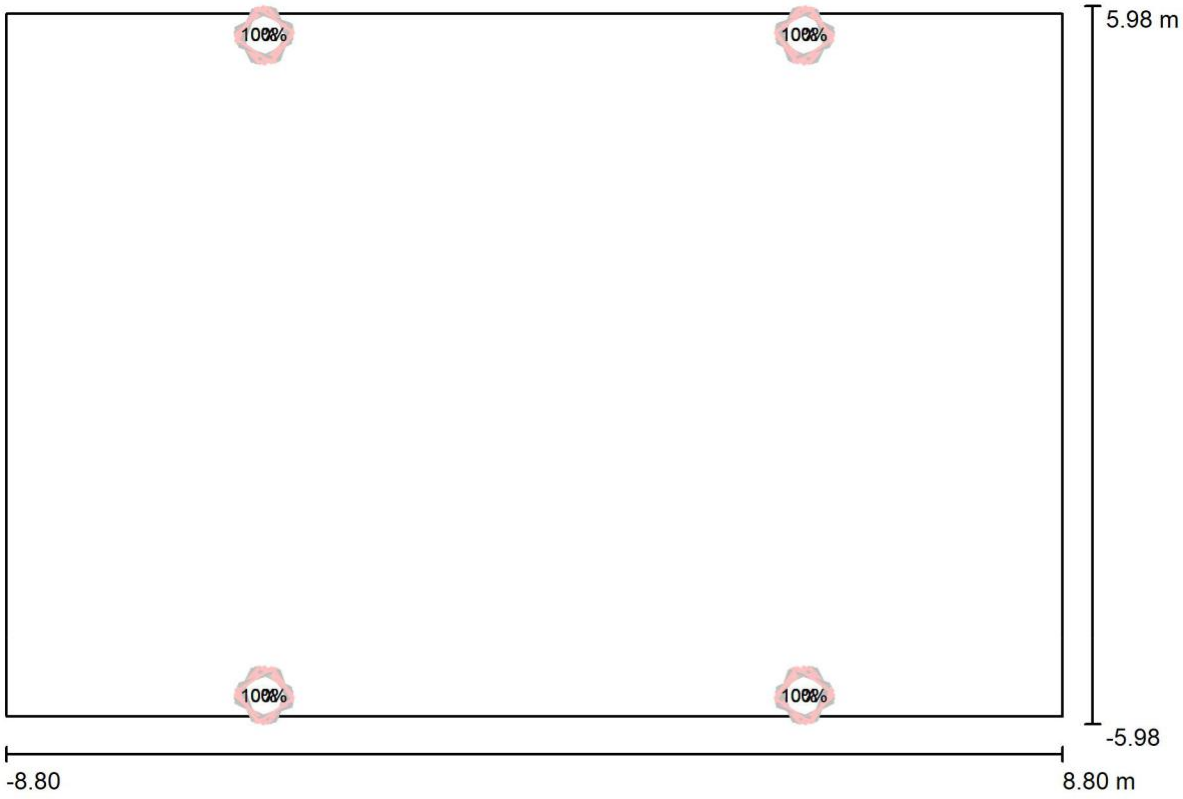
Values in Lux, Scale 1 : 115

Position of surface in external scene: Marked point: (-8.000 m, -4.500 m, 1.500 m)



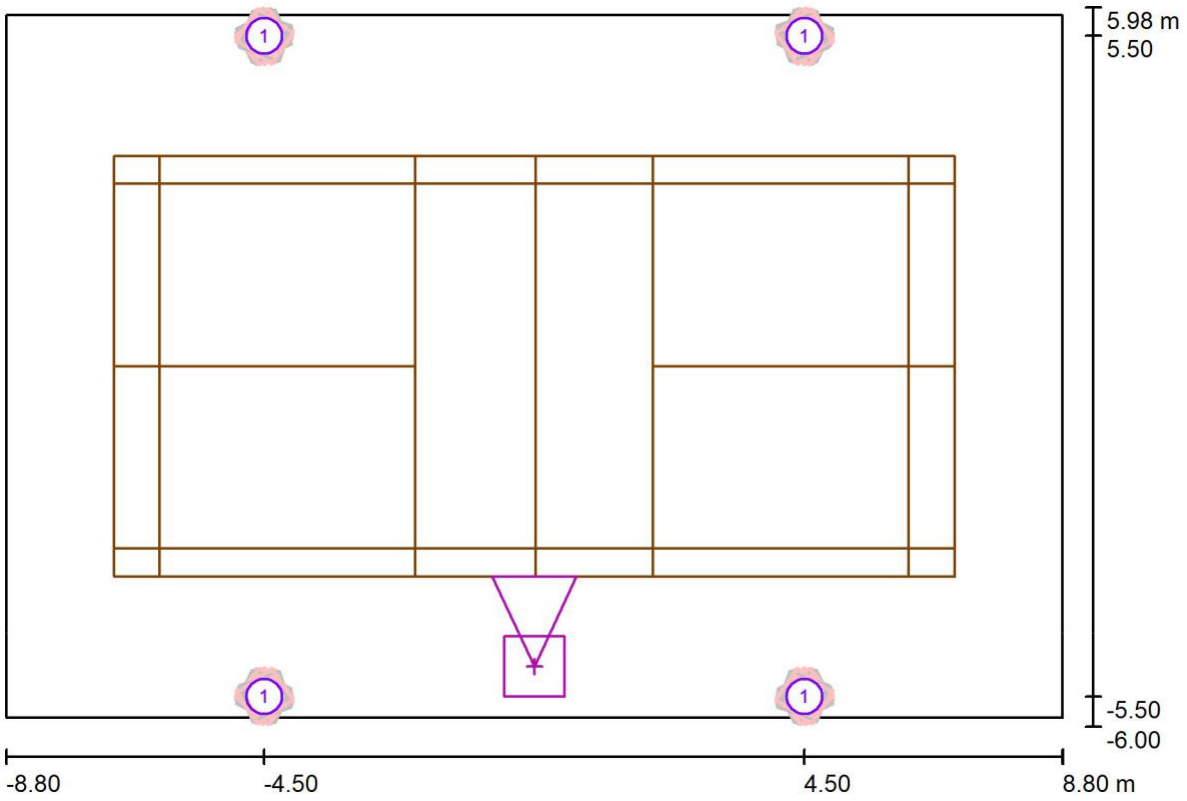
Grid: 17 x 10 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
2643	2061	3052	0.78	0.68



Scale 1 : 126

No.	Control group (Luminaire)	Dimming values (Total) [%]
1	LUMINAIRE FOR NATIONAL (Thorn 96635929 AFP2 2M 192L85-740 A4 CL1 GY [STD])	100
	All other luminaires	0

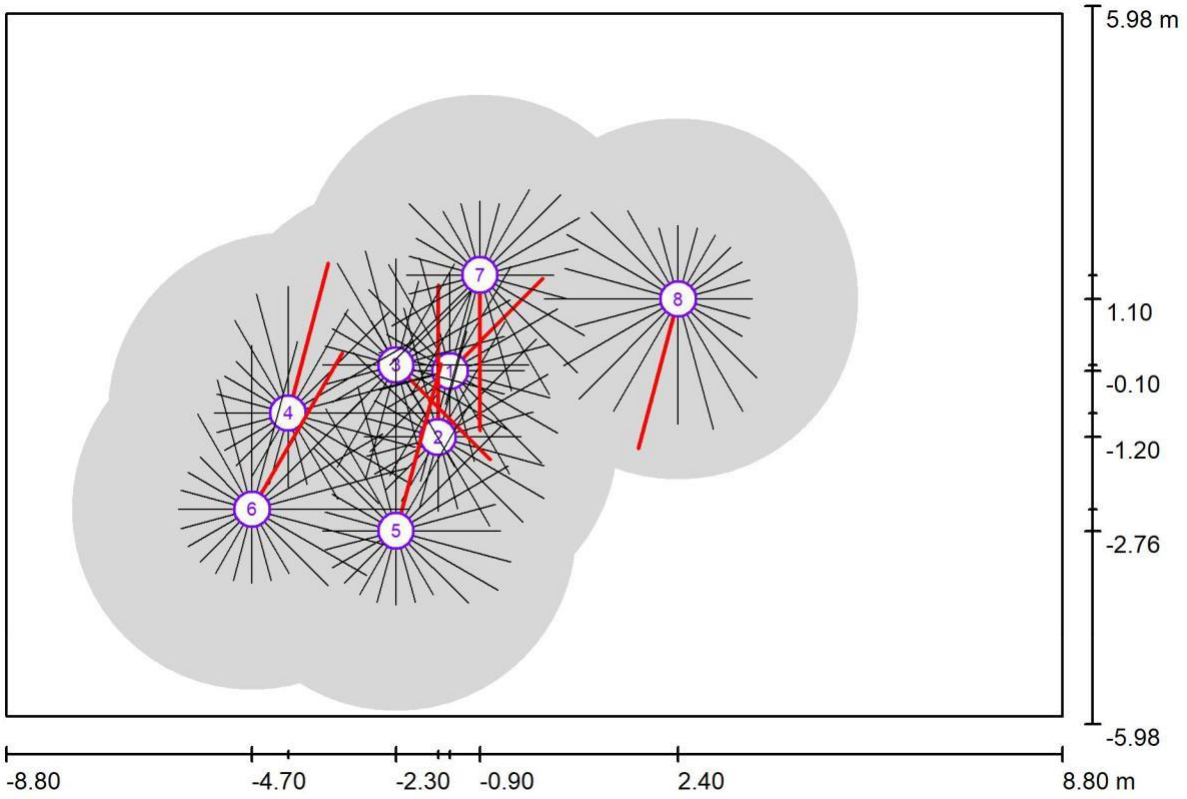


Light loss factor: 0.80, ULR (Upward Light Ratio): 0.5% **Scale 1:126**

Luminaire Parts List

No.	Pieces	Designation (Correction Factor)	F (Luminaire) [lm]	F (Lamps) [lm]	P [W]
1	16	Thorn 96635929 AFP2 2M 192L85-740 A4 CL1 GY [STD] (1.000)	72987	72987	483.0
			Total: 1167792	Total: 1167792	7728.0

Badminton court area / NATIONAL / GR Observer (Results Overview)



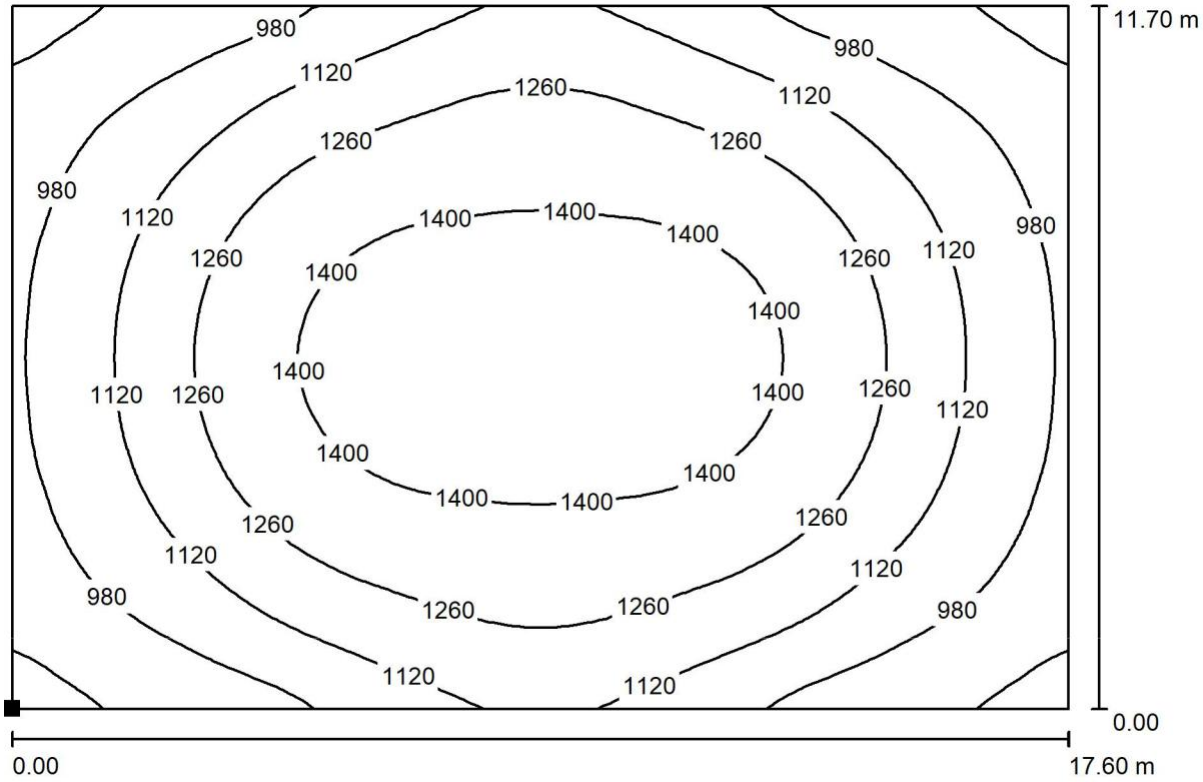
Scale 1 : 126

GR Observerlist

No.	Designation	Position [m]			Viewing sector [°]				Max
		X	Y	Z	Start	End	Increment	Slope angle	
1	GR Observer 1	-1.400	-0.100	1.500	0.0	360.0	15.0	-2.0	18 2)
2	GR Observer 2	-1.600	-1.200	1.500	0.0	360.0	15.0	-2.0	21 2)
3	GR Observer 3	-2.300	0.000	1.500	0.0	360.0	15.0	-2.0	18 2)
4	GR Observer 4	-4.100	-0.800	1.500	0.0	360.0	15.0	-2.0	21 2)
5	GR Observer 5	-2.300	-2.759	1.500	0.0	360.0	15.0	-2.0	23 2)
6	GR Observer 6	-4.700	-2.400	1.500	0.0	360.0	15.0	-2.0	24 2)
7	GR Observer 7	-0.900	1.500	1.500	0.0	360.0	15.0	-2.0	21 2)
8	GR Observer 8	2.400	1.100	1.500	0.0	360.0	15.0	-2.0	21 2)

2) The calculated equivalent veil luminance of the environment is based on the assumption of a complete diffuse reflection behavior of the environment (acc. EN 12464-2).

Badminton court area / NATIONAL / Playing area / Surface 1 / Isolines (E)



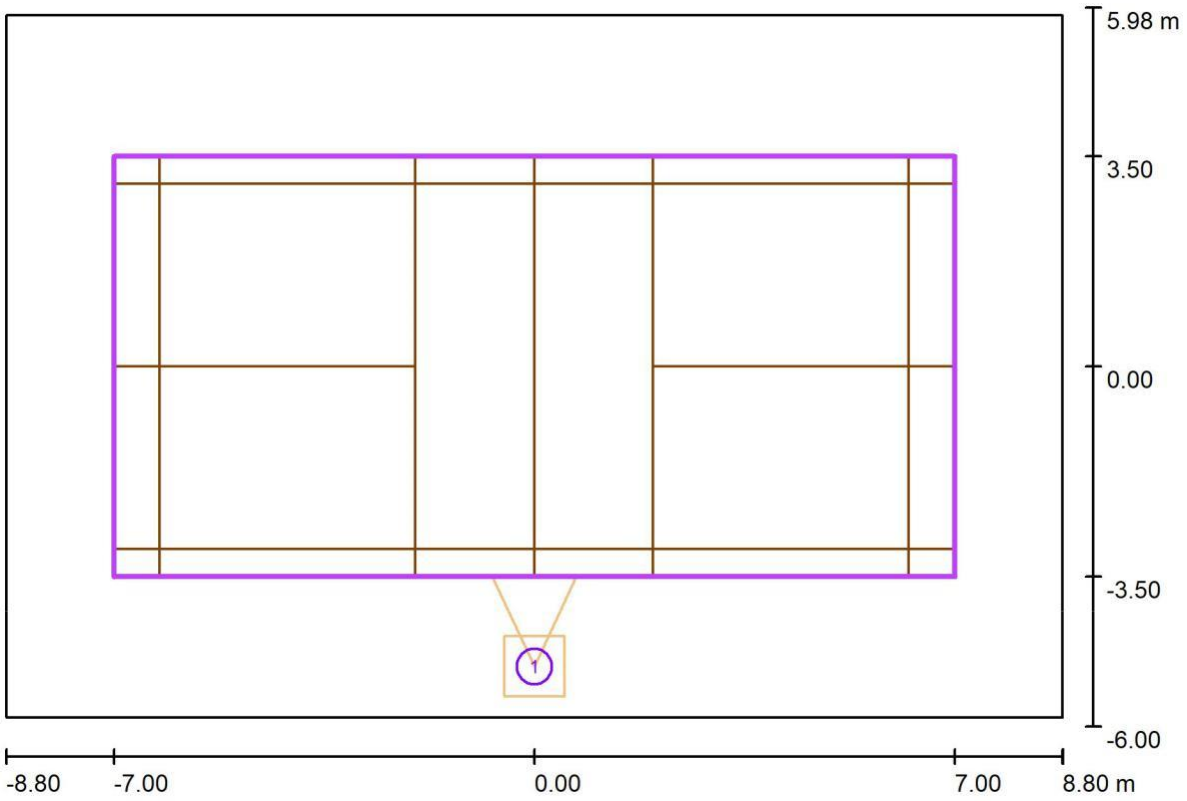
Values in Lux, Scale 1 : 126

Position of surface in external scene:
Marked point:
(-8.800 m, -5.850 m, 0.000 m)

Grid: 64 x 64 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
1186	785	1467	0.662	0.535

Summary



Scale 1 : 126

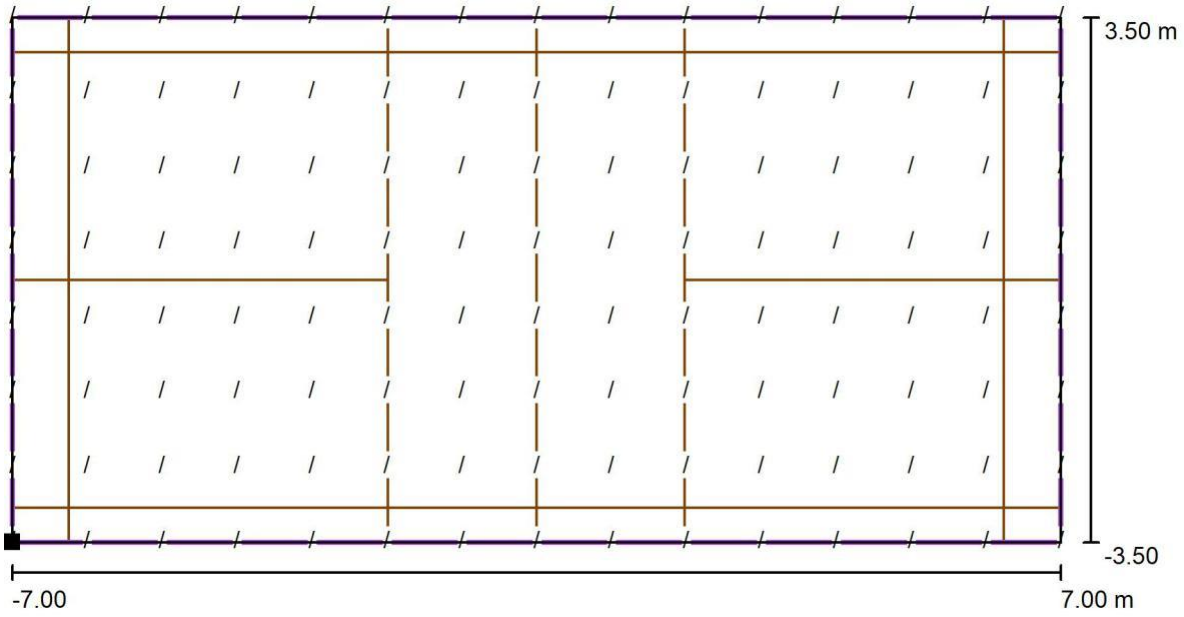
Position: (0.000 m, 0.000 m, 0.000 m)
Size: (14.000 m, 7.000 m)
Rotation: (0.0°, 0.0°, 0.0°)
Type: Normal, Grid: 15 x 8 Points
Belongs to the following sport arena: Badminton court

Results overview

No.	Type	E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}	$E_{h\,m}/E_m$	H [m]	Camera
1	horizontal	1298	1023	1461	0.79	0.70	/	0.000	/
2	Camera	1185	1066	1393	0.90	0.77	1.10	1.500	1

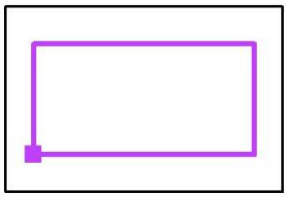
Eh m/Em = Relationship between middle horizontal and vertical illuminance, H = Measuring Height

Badminton court area / NATIONAL / Badminton court Calculation Grid (PA) / Gradient Graphics (E, Horizontal)

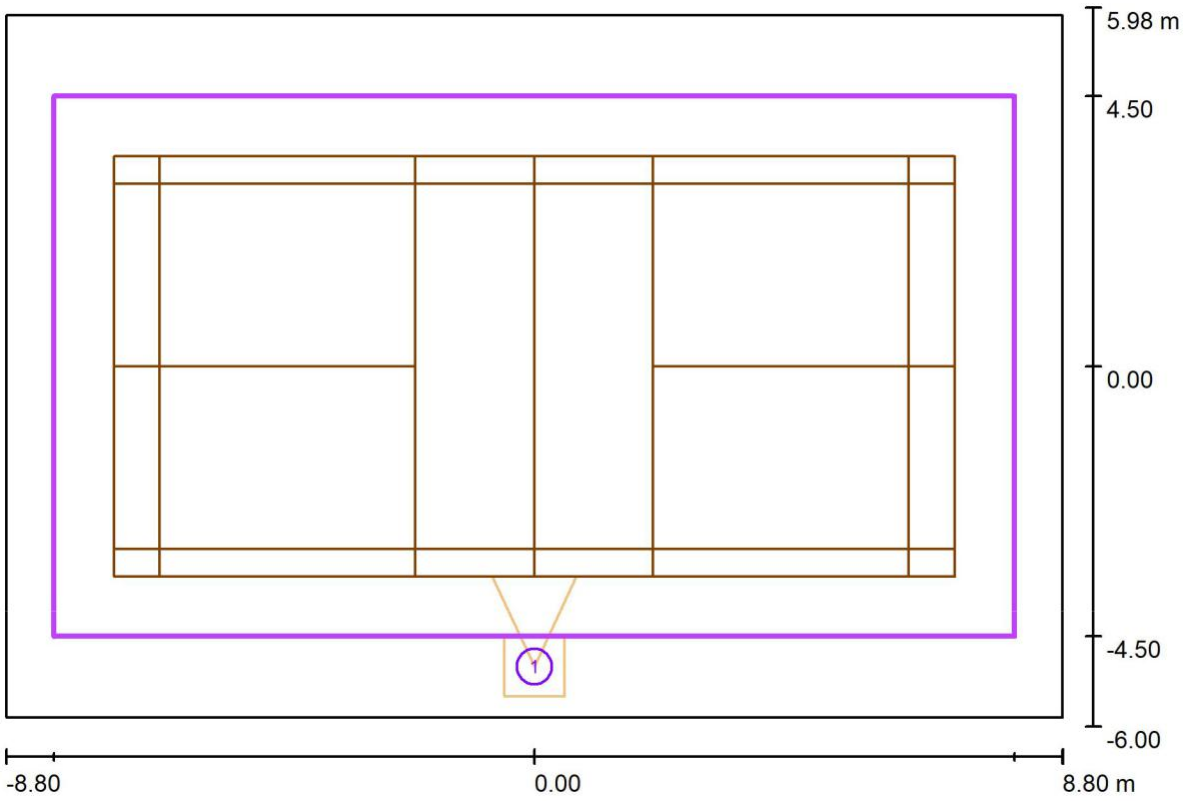


Values in %, Scale 1 : 101

Position of surface in external scene: Marked point: (-7.000 m, -3.500 m, 0.000 m)



Maximum Change: 19%
Selected Limit Value: 25% (Values below this limit value are not output.)
Distance for the Gradient Grid: 2.000 m



Scale 1 : 126

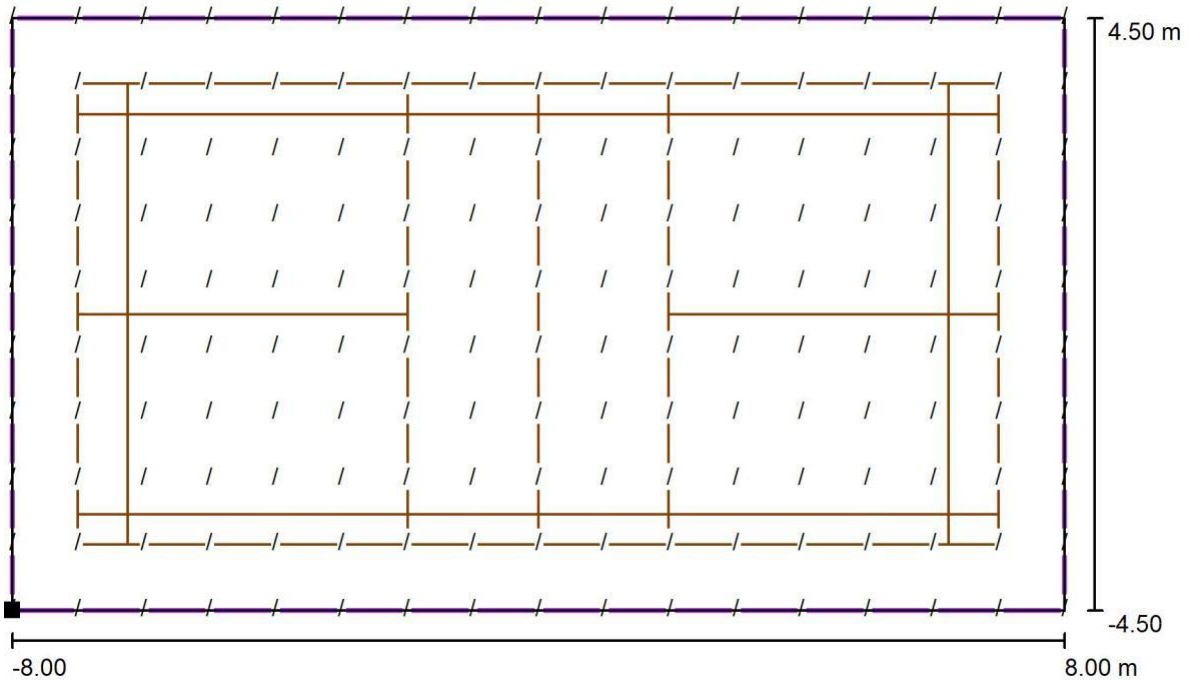
Position: (0.000 m, 0.000 m, 0.000 m)
Size: (16.000 m, 9.000 m)
Rotation: (0.0°, 0.0°, 0.0°)
Type: Normal, Grid: 17 x 10 Points
Belongs to the following sport arena: Badminton court

Results overview

No.	Type	E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}	$E_{h\,m}/E_m$	H [m]	Camera
1	horizontal	1230	901	1461	0.73	0.62	/	0.000	/
2	Camera	1190	1066	1475	0.90	0.72	1.03	1.500	1

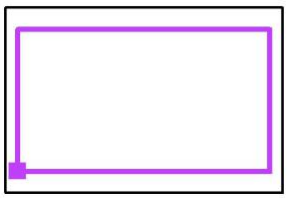
Eh m/Em = Relationship between middle horizontal and vertical illuminance, H = Measuring Height

Badminton court area / NATIONAL / Badminton court Calculation Grid (TA) / Gradient Graphics (E, Horizontal)



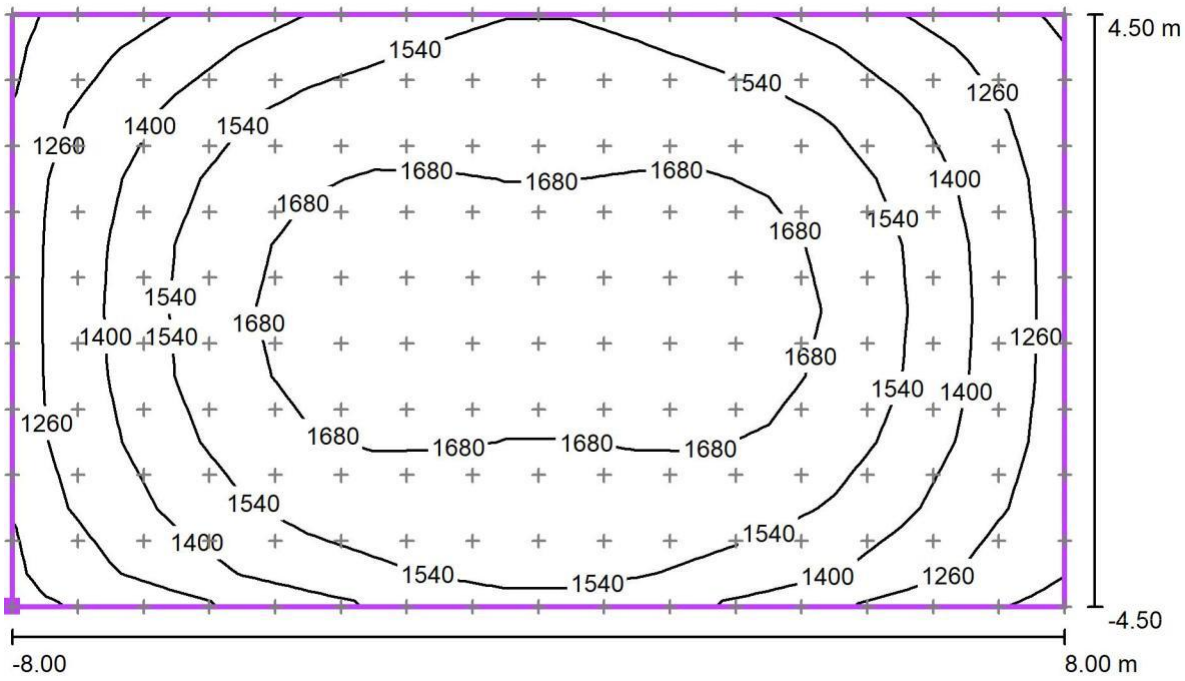
Values in %, Scale 1 : 115

Position of surface in external scene: Marked point: (-8.000 m, -4.500 m, 0.000 m)



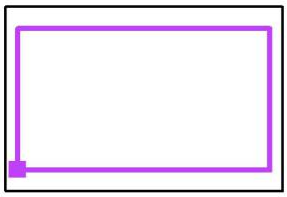
Maximum Change: 20%
Selected Limit Value: 25% (Values below this limit value are not output.)
Distance for the Gradient Grid: 2.000 m

Badminton court area / NATIONAL / Camera Vertical / Isolines (E, Horizontal)



Values in Lux, Scale 1 : 115

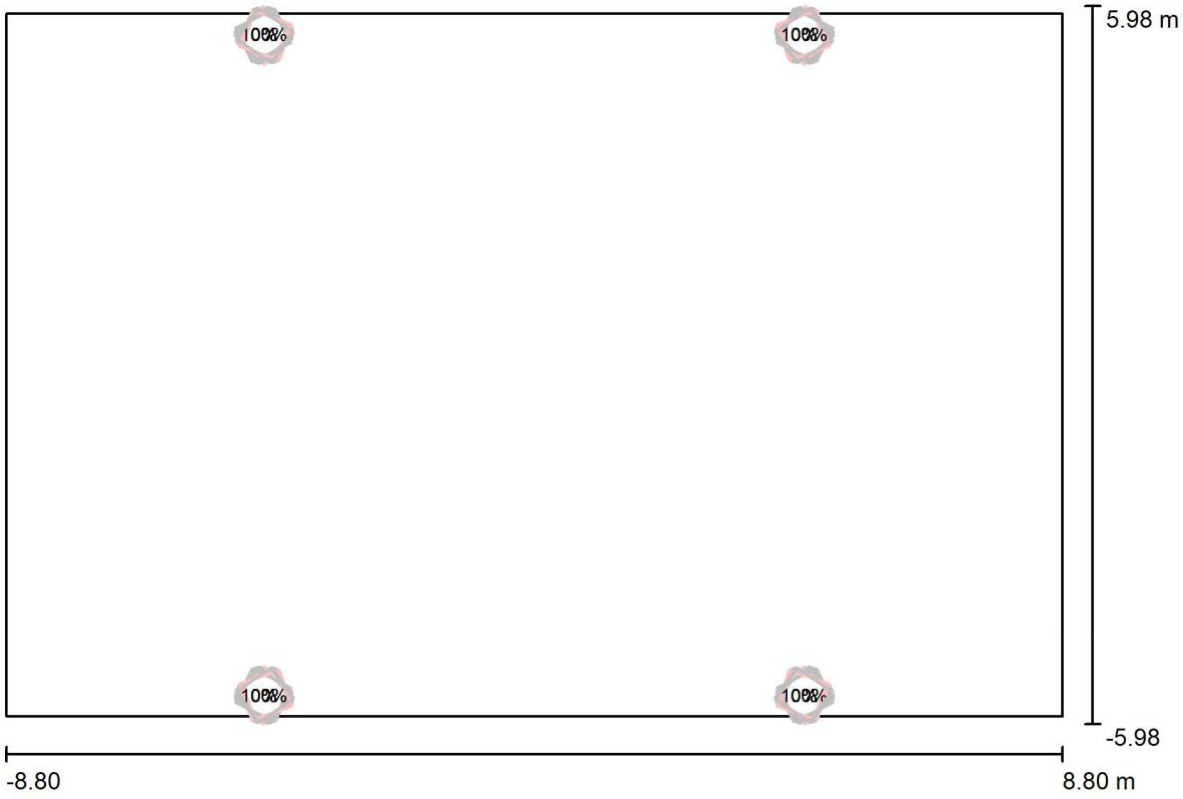
Position of surface in external scene: Marked point: (-8.000 m, -4.500 m, 1.500 m)



Grid: 17 x 10 Points

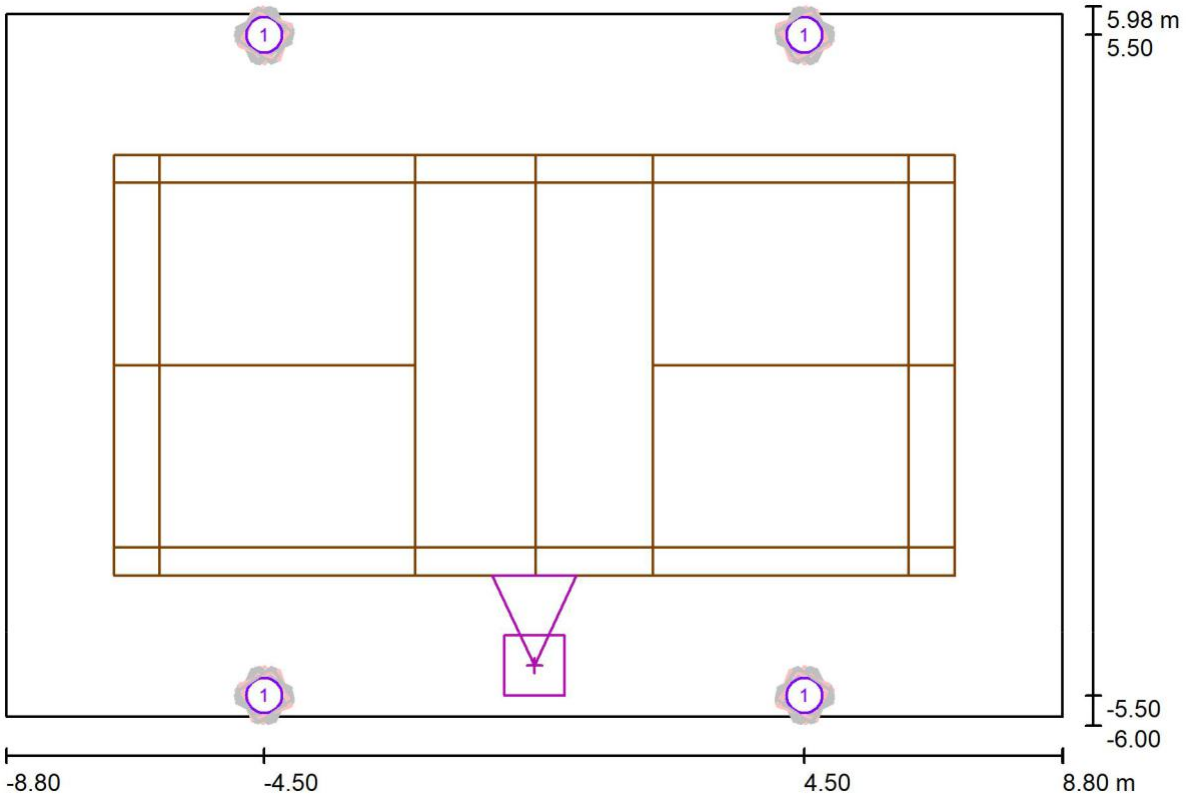
E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
1486	1093	1749	0.74	0.63

Badminton court area / TRANING / Planning data



Scale 1 : 126

No.	Control group (Luminaire)	Dimming values (Total) [%]
1	LUMNAIRE FOR TRANING (Thorn 96635929 AFP2 2M 192L85-740 A4 CL1 GY [STD])	100
	All other luminaires	0

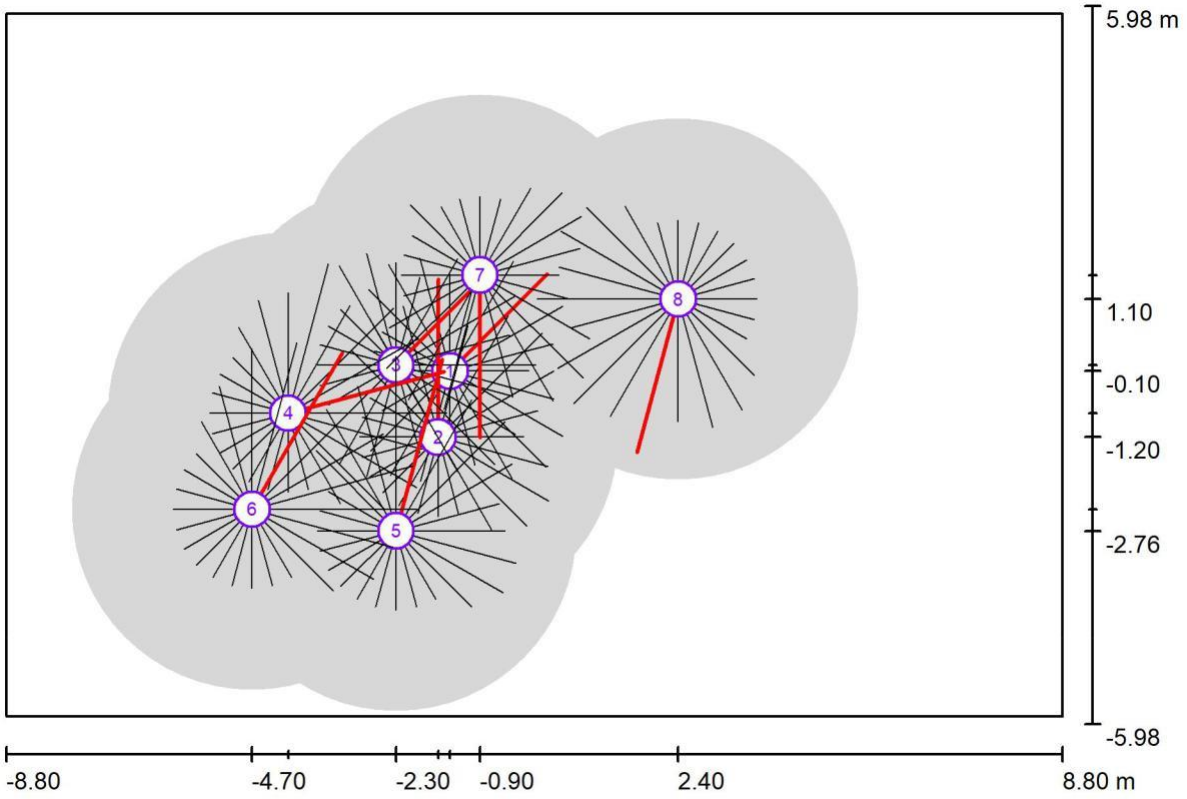


Light loss factor: 0.80, ULR (Upward Light Ratio): 1.5% **Scale 1:126**

Luminaire Parts List

No.	Pieces	Designation (Correction Factor)	F (Luminaire) [lm]	F (Lamps) [lm]	P [W]
1	8	Thorn 96635929 AFP2 2M 192L85-740 A4 CL1 GY [STD] (1.000)	72987	72987	483.0
			Total: 583896	Total: 583896	3864.0

Badminton court area / TRANING / GR Observer (Results Overview)



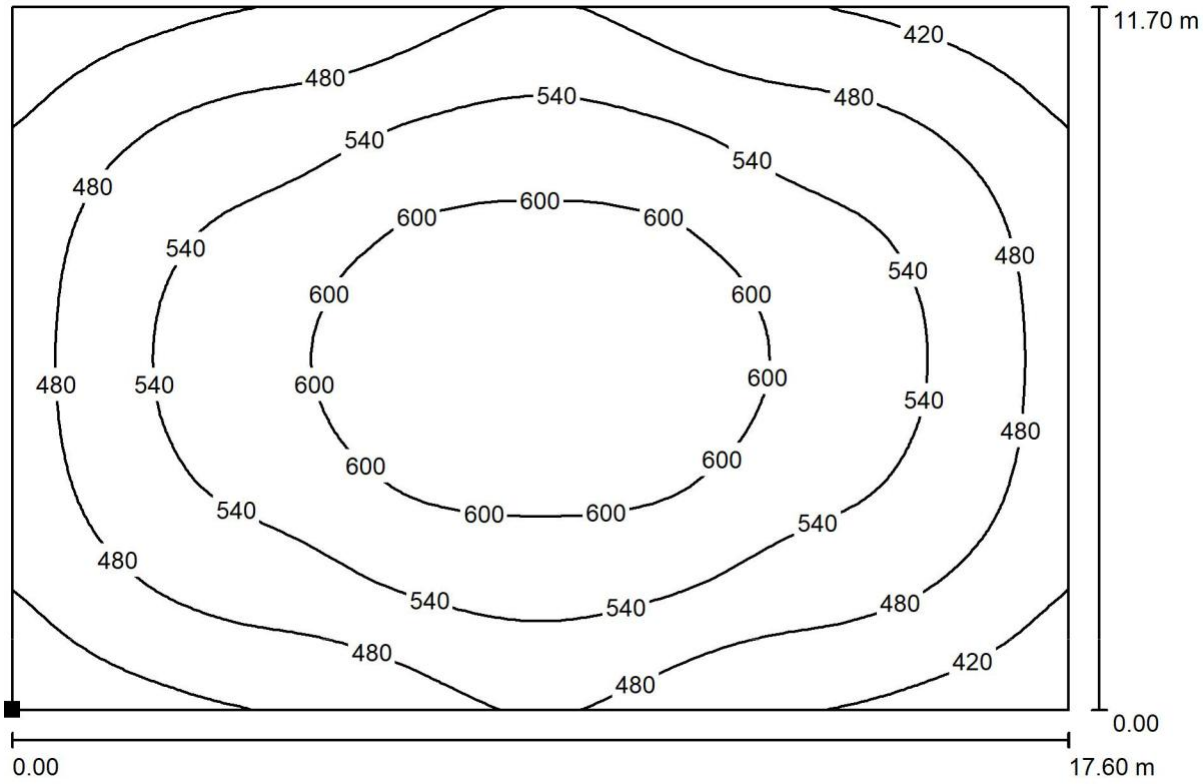
Scale 1 : 126

GR Observerlist

No.	Designation	Position [m]			Viewing sector [°]				Max
		X	Y	Z	Start	End	Increment	Slope angle	
1	GR Observer 1	-1.400	-0.100	1.500	0.0	360.0	15.0	-2.0	17 2)
2	GR Observer 2	-1.600	-1.200	1.500	0.0	360.0	15.0	-2.0	20 2)
3	GR Observer 3	-2.300	0.000	1.500	0.0	360.0	15.0	-2.0	18 2)
4	GR Observer 4	-4.100	-0.800	1.500	0.0	360.0	15.0	-2.0	21 2)
5	GR Observer 5	-2.300	-2.759	1.500	0.0	360.0	15.0	-2.0	22 2)
6	GR Observer 6	-4.700	-2.400	1.500	0.0	360.0	15.0	-2.0	23 2)
7	GR Observer 7	-0.900	1.500	1.500	0.0	360.0	15.0	-2.0	21 2)
8	GR Observer 8	2.400	1.100	1.500	0.0	360.0	15.0	-2.0	20 2)

2) The calculated equivalent veil luminance of the environment is based on the assumption of a complete diffuse reflection behavior of the environment (acc. EN 12464-2).

Badminton court area / TRANING / Playing area / Surface 1 / Isolines (E)



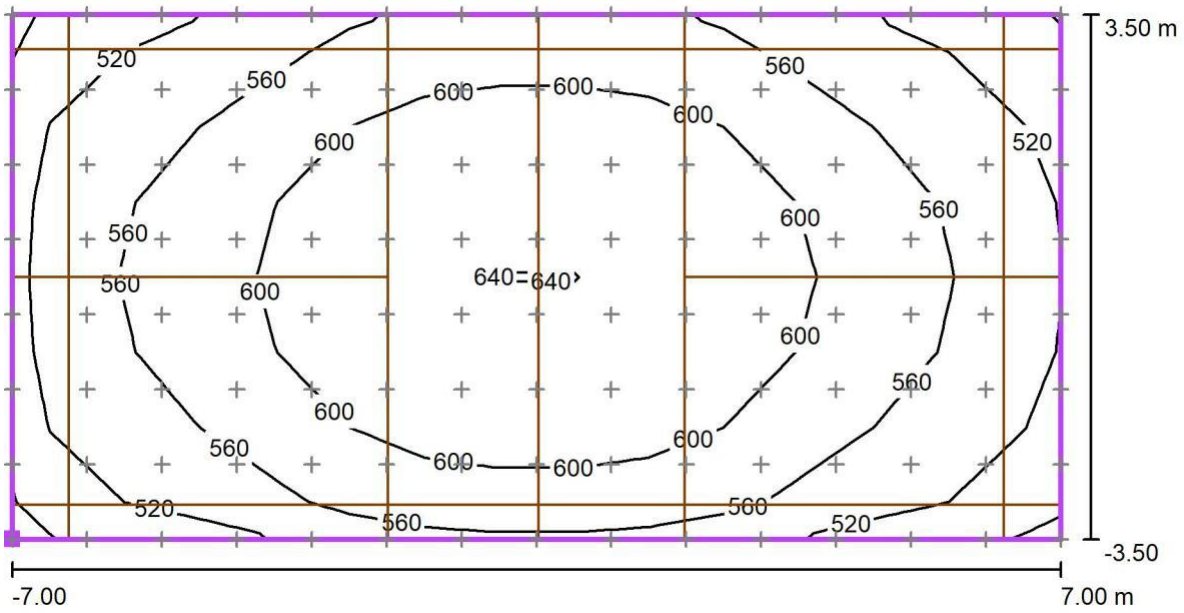
Values in Lux, Scale 1 : 126

Position of surface in external scene:
Marked point:
(-8.800 m, -5.850 m, 0.000 m)

Grid: 64 x 64 Points

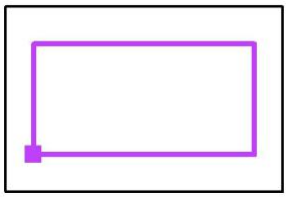
E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
522	363	644	0.696	0.564

Badminton court area / TRANING / Badminton court Calculation Grid (PA) / Isolines (E, Horizontal)



Values in Lux, Scale 1 : 101

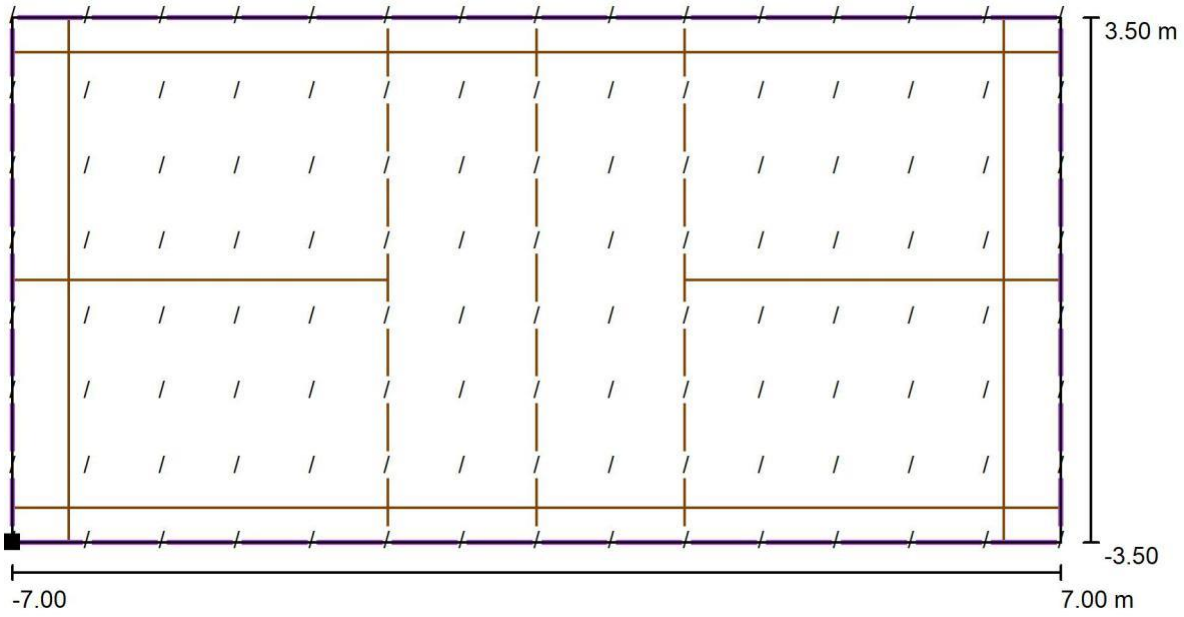
Position of surface in external scene: Marked point: (-7.000 m, -3.500 m, 0.000 m)



Grid: 15 x 8 Points

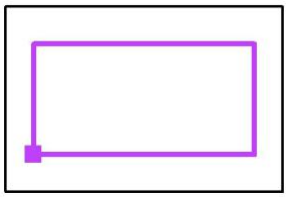
E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
566	478	642	0.84	0.74

Badminton court area / TRANING / Badminton court Calculation Grid (PA) / Gradient Graphics (E, Horizontal)



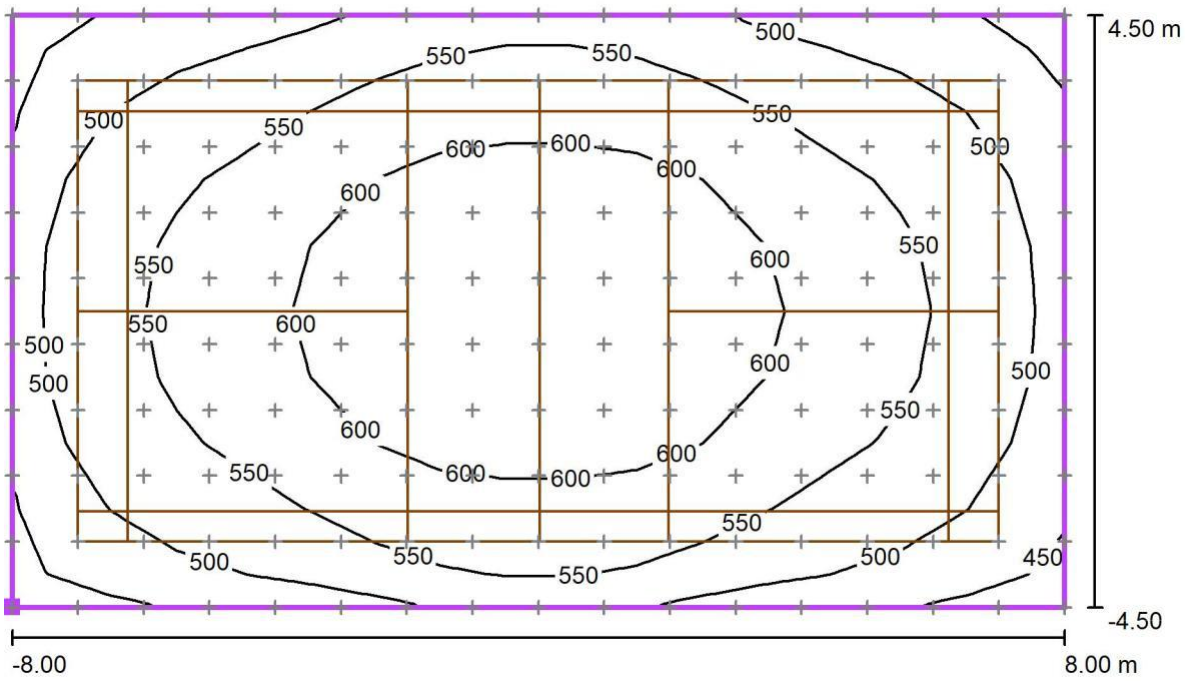
Values in %, Scale 1 : 101

Position of surface in external scene: Marked point: (-7.000 m, -3.500 m, 0.000 m)



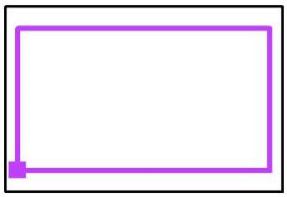
Maximum Change: 13%
Selected Limit Value: 25% (Values below this limit value are not output.)
Distance for the Gradient Grid: 2.000 m

Badminton court area / TRANING / Badminton court Calculation Grid (TA) / Isolines (E, Horizontal)



Values in Lux, Scale 1 : 115

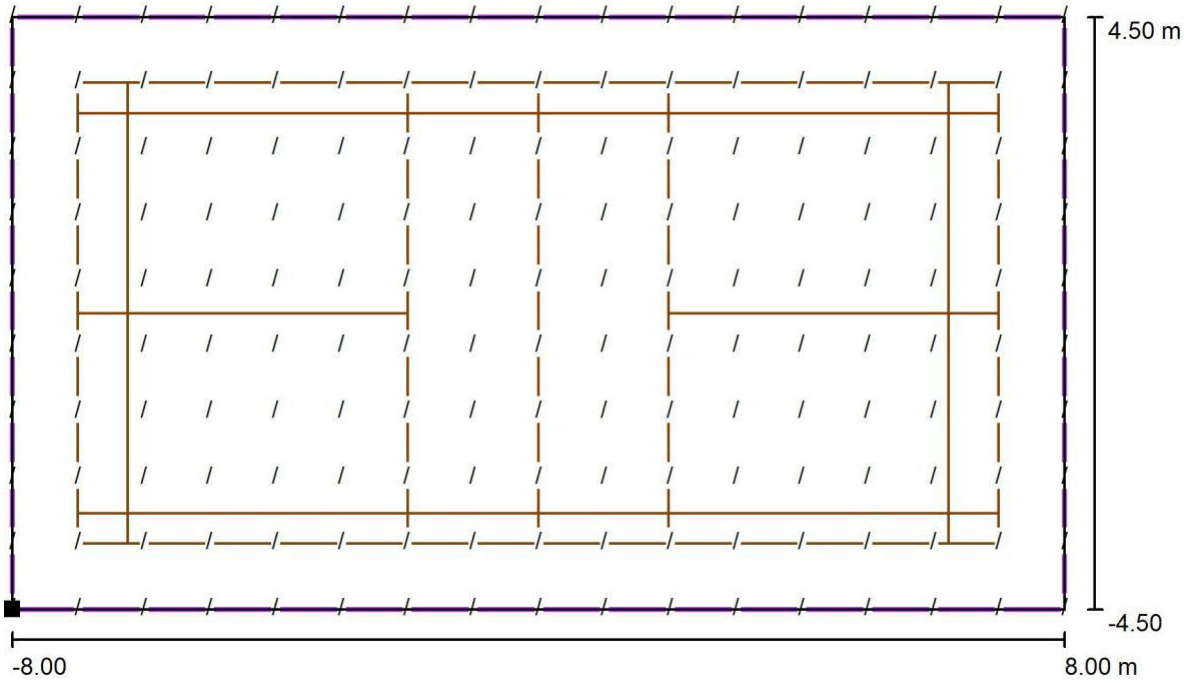
Position of surface in external scene: Marked point: (-8.000 m, -4.500 m, 0.000 m)



Grid: 17 x 10 Points

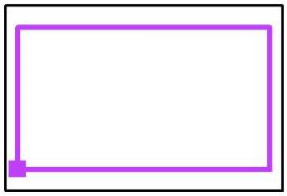
E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
541	422	642	0.78	0.66

Badminton court area / TRANING / Badminton court Calculation Grid (TA) / Gradient Graphics (E, Horizontal)



Values in %, Scale 1 : 115

Position of surface in external scene: Marked point: (-8.000 m, -4.500 m, 0.000 m)



Maximum Change: 19%
Selected Limit Value: 25% (Values below this limit value are not output.)
Distance for the Gradient Grid: 2.000 m

ANNEXURE – II

SPORTS LIGHTING DESIGN FOR A TENNIS PLAYGROUND

Sports lighting design for Tennis court

LIGHTING DESIGN FOR:

INTERNATIONAL LEVEL
NATIONAL LEVEL
TRAINING LEVEL

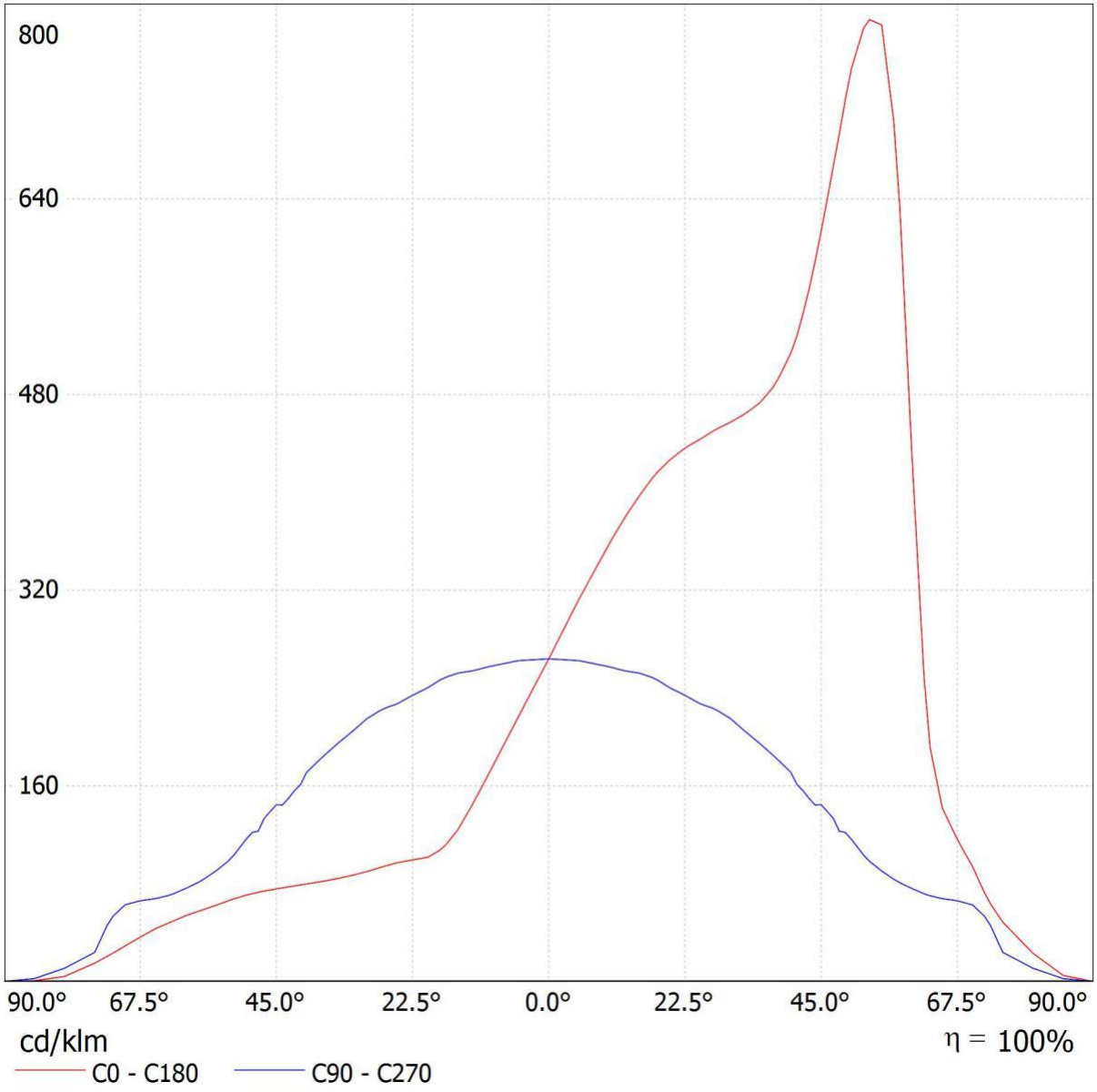
Partner for Contact:
Order No.:
Company:
Customer No.:

Date: 23.08.2024
Operator: Triparna Mondal

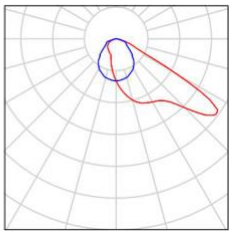
Table of contents

Thorn 96635929 AFP2 2M 192L85-740 A4 CL1 GY [STD] / LDC (Linear)

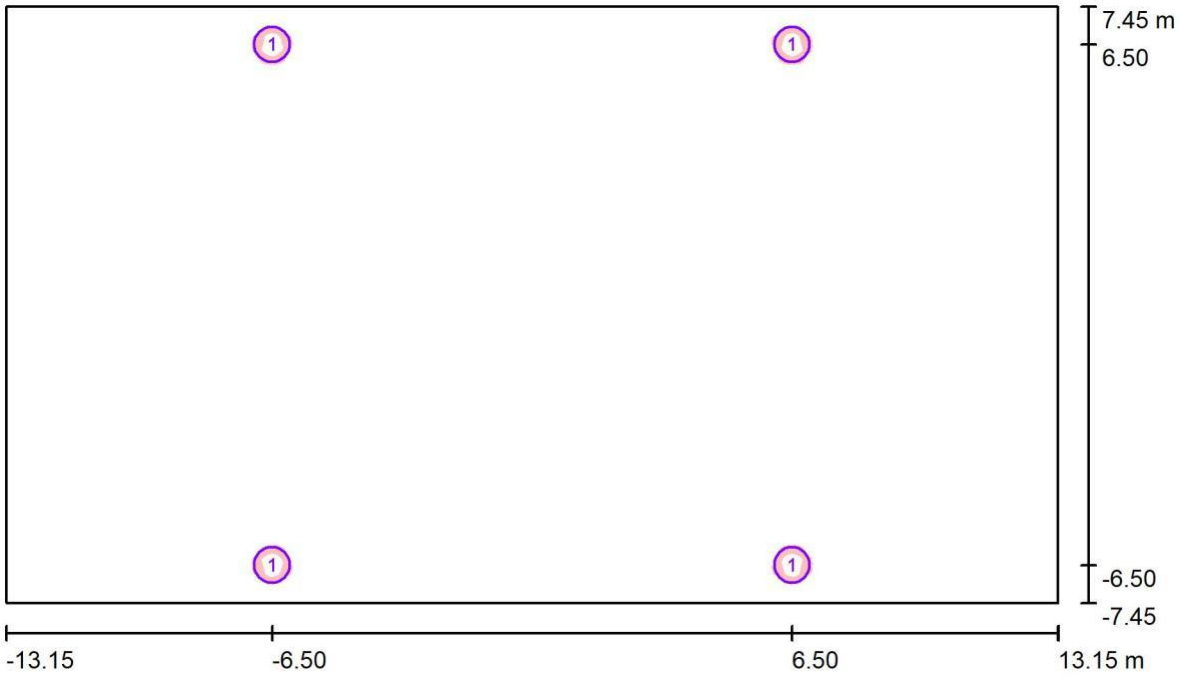
Luminaire: Thorn 96635929 AFP2 2M 192L85-740 A4 CL1 GY [STD]
Lamps: 1 x LED 483 W



36 Pieces **Thorn 96635929 AFP2 2M 192L85-740 A4 CL1 GY [STD]**
Article No.: 96635929
Luminous flux (Luminaire): 72987 lm
Luminous flux (Lamps): 72987 lm
Luminaire Wattage: 483.0 W
Luminaire classification according to CIE: 100
CIE flux code: 39 83 98 100 100
Fitting: 1 x LED 483 W (Correction Factor 1.000).



Tennis Court Area / Luminaires (layout plan)

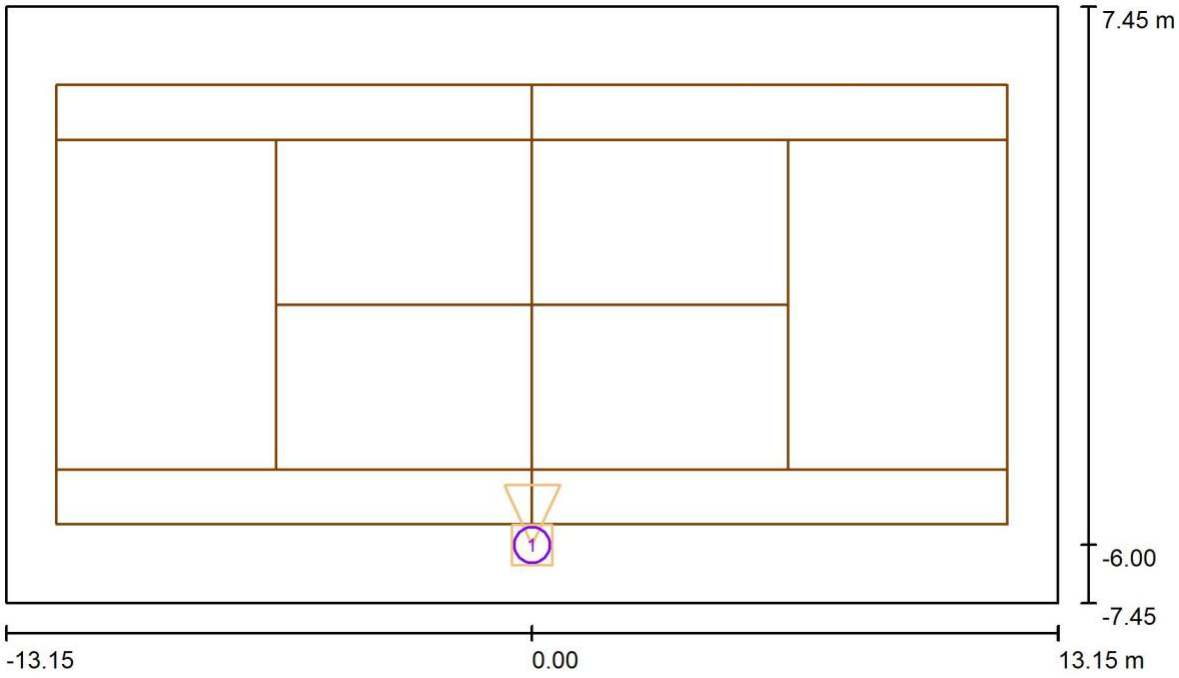


Scale 1 : 189

Luminaire Parts List

No.	Pieces	Designation
1	**36**	**Thorn 96635929 AFP2 2M 192L85-740 A4 CL1 GY [STD]**

Tennis Court Area / TV Cameras (Coordinates List)

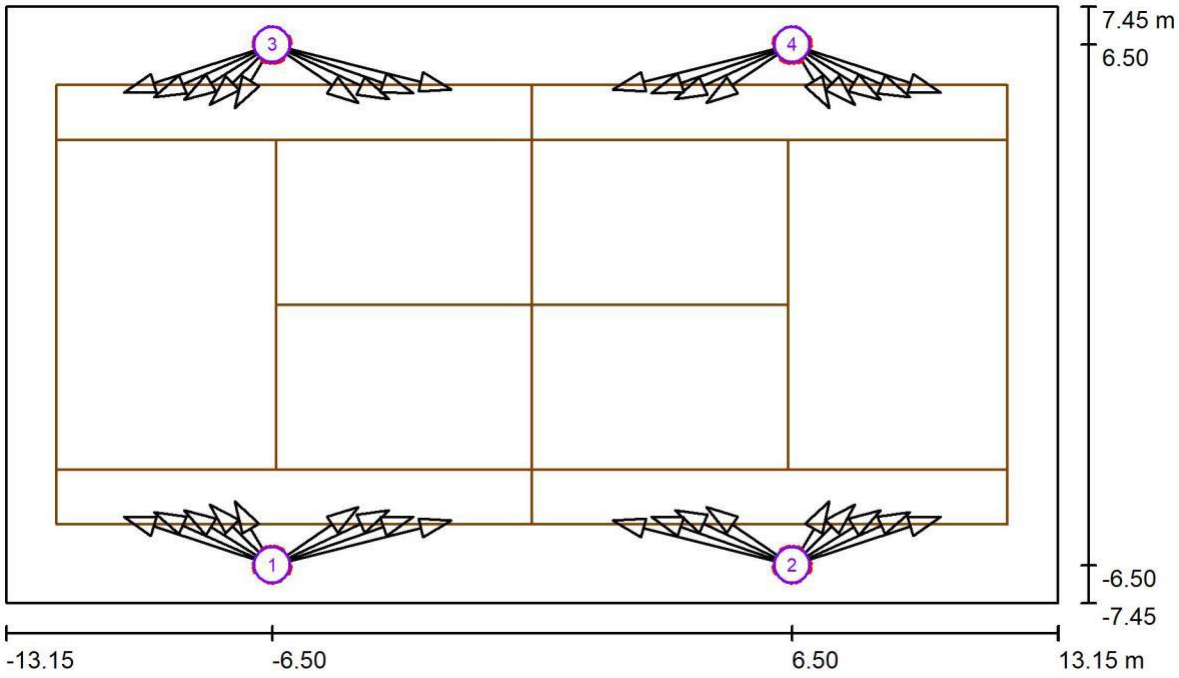


Scale 1 : 189

List of the TV Cameras

No.	Designation	Position [m]		
		X	Y	Z
1	TV Camera	0.000	-6.000	4.000

Tennis Court Area / Sport Luminaires (Coordinates List)



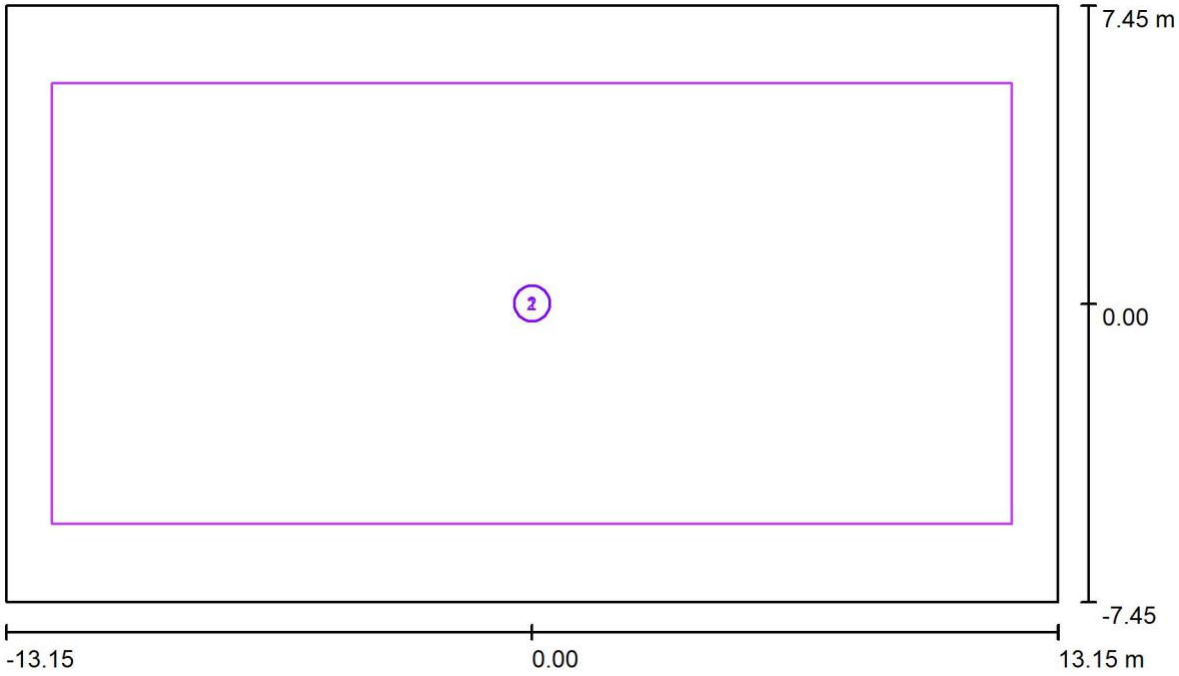
Scale 1 : 189

List of the Sport Luminaires

Luminaire	Index	Position [m]			Aiming Point [m]			Angle [°]	Alignment	Pole
		X	Y	Z	X	Y	Z			
Thorn 96635929 AFP2 2M 192L85-740 A4 CL1 GY [STD]	1	-6.500	-6.500	8.000	-7.438	-4.909	0.000	77.0	(C0,G0)	/
Thorn 96635929 AFP2 2M 192L85-740 A4 CL1 GY [STD]	1	-6.500	-6.500	8.000	-2.018	-5.383	0.000	60.0	(C0,G0)	/
Thorn 96635929 AFP2 2M 192L85-740 A4 CL1 GY [STD]	1	-6.500	-6.500	8.000	-2.973	-5.285	0.000	65.0	(C0,G0)	/
Thorn 96635929 AFP2 2M 192L85-740 A4 CL1 GY [STD]	1	-6.500	-6.500	8.000	-9.453	-5.185	0.000	68.0	(C0,G0)	/

List of the Sport Luminaires

Luminaire	Index	Position [m]			Aiming Point [m]			Angle [°]	Alignment	Pole
		X	Y	Z	X	Y	Z			
Thorn 96635929 AFP2 2M 192L85-740 A4 CL1 GY [STD]	1	-6.500	-6.500	8.000	-3.571	-5.134	0.000	68.0	(C0,G0)	/
Thorn 96635929 AFP2 2M 192L85-740 A4 CL1 GY [STD]	1	-6.500	-6.500	8.000	-8.704	-5.123	0.000	72.0	(C0,G0)	/
Thorn 96635929 AFP2 2M 192L85-740 A4 CL1 GY [STD]	1	-6.500	-6.500	8.000	-4.345	-5.046	0.000	72.0	(C0,G0)	/
Thorn 96635929 AFP2 2M 192L85-740 A4 CL1 GY [STD]	1	-6.500	-6.500	8.000	-10.211	-5.294	0.000	64.0	(C0,G0)	/
Thorn 96635929 AFP2 2M 192L85-740 A4 CL1 GY [STD]	1	-6.500	-6.500	8.000	-8.065	-4.989	0.000	74.8	(C0,G0)	/
Thorn 96635929 AFP2 2M 192L85-740 A4 CL1 GY [STD]	2	6.500	-6.500	8.000	7.438	-4.909	0.000	77.0	(C0,G0)	/
Thorn 96635929 AFP2 2M 192L85-740 A4 CL1 GY [STD]	2	6.500	-6.500	8.000	2.018	-5.383	0.000	60.0	(C0,G0)	/
Thorn 96635929 AFP2 2M 192L85-740 A4 CL1 GY [STD]	2	6.500	-6.500	8.000	2.973	-5.285	0.000	65.0	(C0,G0)	/
Thorn 96635929 AFP2 2M 192L85-740 A4 CL1 GY [STD]	2	6.500	-6.500	8.000	9.453	-5.185	0.000	68.0	(C0,G0)	/
Thorn 96635929 AFP2 2M 192L85-740 A4 CL1 GY [STD]	2	6.500	-6.500	8.000	3.571	-5.134	0.000	68.0	(C0,G0)	/
Thorn 96635929 AFP2 2M 192L85-740 A4 CL1 GY [STD]	2	6.500	-6.500	8.000	8.704	-5.123	0.000	72.0	(C0,G0)	/
Thorn 96635929 AFP2 2M 192L85-740 A4 CL1 GY [STD]	2	6.500	-6.500	8.000	4.345	-5.046	0.000	72.0	(C0,G0)	/
Thorn 96635929 AFP2 2M 192L85-740 A4 CL1 GY [STD]	2	6.500	-6.500	8.000	10.211	-5.294	0.000	64.0	(C0,G0)	/
Thorn 96635929 AFP2 2M 192L85-740 A4 CL1 GY [STD]	2	6.500	-6.500	8.000	8.065	-4.989	0.000	74.8	(C0,G0)	/
Thorn 96635929 AFP2 2M 192L85-740 A4 CL1 GY [STD]	3	-6.500	6.500	8.000	-7.438	4.909	0.000	77.0	(C0,G0)	/
Thorn 96635929 AFP2 2M 192L85-740 A4 CL1 GY [STD]	3	-6.500	6.500	8.000	-2.018	5.383	0.000	60.0	(C0,G0)	/
Thorn 96635929 AFP2 2M 192L85-740 A4 CL1 GY [STD]	3	-6.500	6.500	8.000	-2.973	5.285	0.000	65.0	(C0,G0)	/
Thorn 96635929 AFP2 2M 192L85-740 A4 CL1 GY [STD]	3	-6.500	6.500	8.000	-9.453	5.185	0.000	68.0	(C0,G0)	/
Thorn 96635929 AFP2 2M 192L85-740 A4 CL1 GY [STD]	3	-6.500	6.500	8.000	-3.571	5.134	0.000	68.0	(C0,G0)	/
Thorn 96635929 AFP2 2M 192L85-740 A4 CL1 GY [STD]	3	-6.500	6.500	8.000	-8.704	5.123	0.000	72.0	(C0,G0)	/
Thorn 96635929 AFP2 2M 192L85-740 A4 CL1 GY [STD]	3	-6.500	6.500	8.000	-4.345	5.046	0.000	72.0	(C0,G0)	/
Thorn 96635929 AFP2 2M 192L85-740 A4 CL1 GY [STD]	3	-6.500	6.500	8.000	-10.211	5.294	0.000	64.0	(C0,G0)	/
Thorn 96635929 AFP2 2M 192L85-740 A4 CL1 GY [STD]	3	-6.500	6.500	8.000	-8.065	4.989	0.000	74.8	(C0,G0)	/
Thorn 96635929 AFP2 2M 192L85-740 A4 CL1 GY [STD]	4	6.500	6.500	8.000	7.438	4.909	0.000	77.0	(C0,G0)	/
Thorn 96635929 AFP2 2M 192L85-740 A4 CL1 GY [STD]	4	6.500	6.500	8.000	2.018	5.383	0.000	60.0	(C0,G0)	/
Thorn 96635929 AFP2 2M 192L85-740 A4 CL1 GY [STD]	4	6.500	6.500	8.000	2.973	5.285	0.000	65.0	(C0,G0)	/
Thorn 96635929 AFP2 2M 192L85-740 A4 CL1 GY [STD]	4	6.500	6.500	8.000	9.453	5.185	0.000	68.0	(C0,G0)	/
Thorn 96635929 AFP2 2M 192L85-740 A4 CL1 GY [STD]	4	6.500	6.500	8.000	3.571	5.134	0.000	68.0	(C0,G0)	/
Thorn 96635929 AFP2 2M 192L85-740 A4 CL1 GY [STD]	4	6.500	6.500	8.000	8.704	5.123	0.000	72.0	(C0,G0)	/
Thorn 96635929 AFP2 2M 192L85-740 A4 CL1 GY [STD]	4	6.500	6.500	8.000	4.345	5.046	0.000	72.0	(C0,G0)	/
Thorn 96635929 AFP2 2M 192L85-740 A4 CL1 GY [STD]	4	6.500	6.500	8.000	10.211	5.294	0.000	64.0	(C0,G0)	/
Thorn 96635929 AFP2 2M 192L85-740 A4 CL1 GY [STD]	4	6.500	6.500	8.000	8.065	4.989	0.000	74.8	(C0,G0)	/



Scale 1 : 189

List of the Calculation Grids

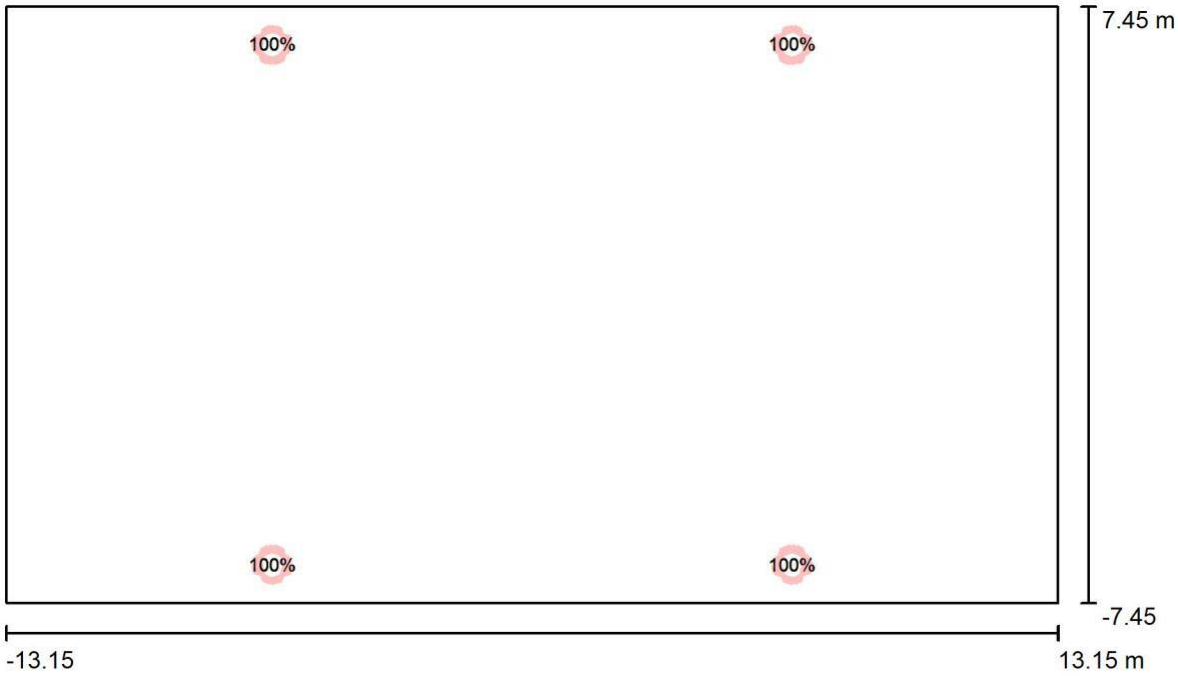
No.	Designation	Position [m]			Size [m]		Rotation [°]		
		X	Y	Z	L	W	X	Y	Z
1	Tennis court Calculation Grid (PA)	0.000	0.000	0.000	24.000	11.000	0.0	0.0	0.0
2	Camera Vertical	0.000	0.000	1.500	24.000	11.000	0.0	0.0	0.0

Tennis Court Area / control group commissioning

	1	2	3	4
I	100 %	/	/	0 %
Ⅱ		/ 75%	/	0 %
III		//30%	0%	

No.	Light scene
I	INTERNATIONAL
II	NATIONAL
III	TRANING

No.	Control group
1	LUMINAIRE FOR INTERNATIONAL
2	LUMINAIRE FOR NATIONAL
3	LUMINAIRE FOR TRANING
4	All other luminaires



Scale 1 : 189

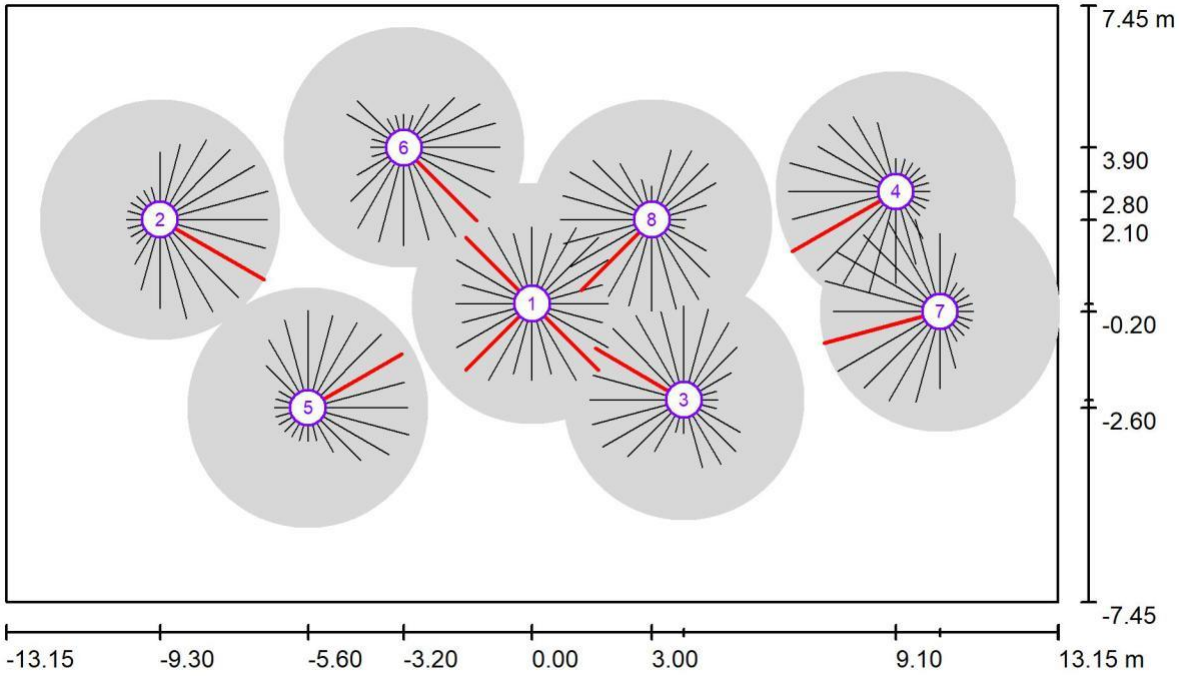
No.	Control group (Luminaire)	Dimming values (Total) [%]
1	LUMINAIRE FOR INTERNATIONAL (Thorn 96635929 AFP2 2M 192L85-740 A4 CL1 GY [STD])	100
	All other luminaires	0

Light loss factor: 0.80, ULR (Upward Light Ratio): 2.0% **Scale 1:189**

Luminaire Parts List

No.	Pieces	Designation (Correction Factor)	F (Luminaire) [lm]	F (Lamps) [lm]	P [W]
1	36	Thorn 96635929 AFP2 2M 192L85-740 A4 CL1 GY [STD] (1.000)	72987	72987	483.0
			Total: 2627532	Total: 2627532	17388.0

Tennis Court Area / INTERNATIONAL / GR Observer (Results Overview)



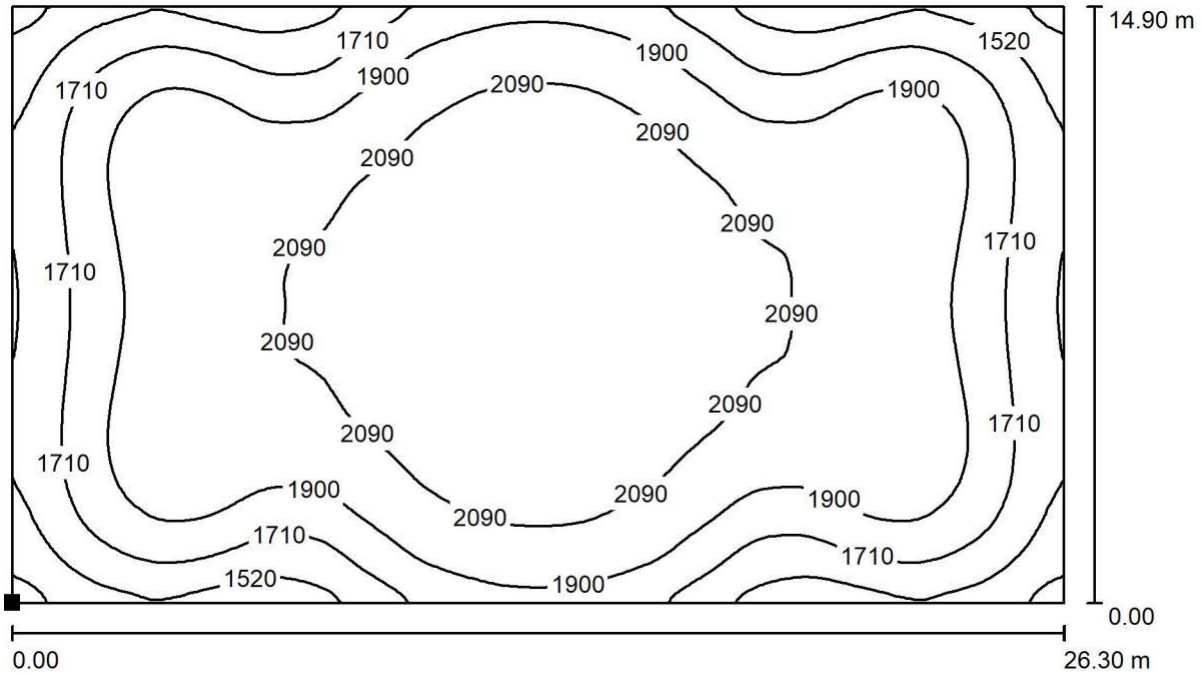
Scale 1 : 189

GR Observerlist

No.	Designation	Position [m]			Viewing sector [°]				Max
		X	Y	Z	Start	End	Increment	Slope angle	
1	GR Observer 1	0.000	0.000	1.500	0.0	360.0	15.0	-2.0	28 2)
2	GR Observer 2	-9.300	2.100	1.500	0.0	360.0	15.0	-2.0	36 2)
3	GR Observer 3	3.800	-2.400	1.500	0.0	360.0	15.0	-2.0	31 2)
4	GR Observer 4	9.100	2.800	1.500	0.0	360.0	15.0	-2.0	36 2)
5	GR Observer 5	-5.600	-2.600	1.500	0.0	360.0	15.0	-2.0	32 2)
6	GR Observer 6	-3.200	3.900	1.500	0.0	360.0	15.0	-2.0	31 2)
7	GR Observer 7	10.200	-0.200	1.500	0.0	360.0	15.0	-2.0	36 2)
8	GR Observer 8	3.000	2.100	1.500	0.0	360.0	15.0	-2.0	30 2)

2) The calculated equivalent veil luminance of the environment is based on the assumption of a complete diffuse reflection behavior of the environment (acc. EN 12464-2).

Tennis Court Area / INTERNATIONAL / Playing area / Surface 1 / Isolines (E)



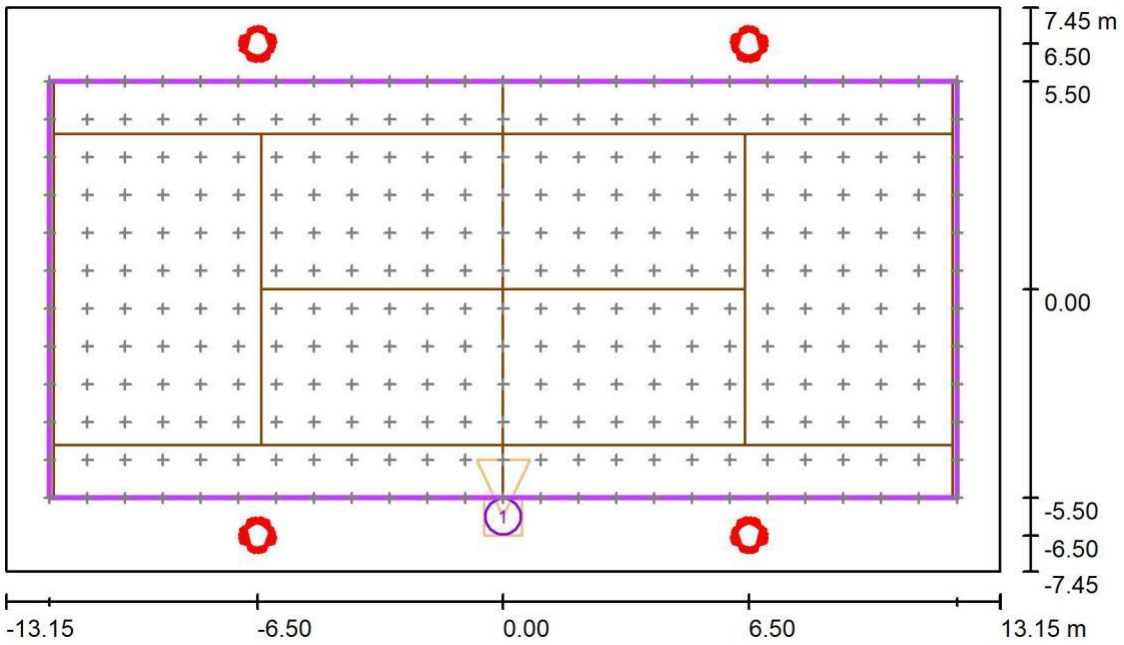
Values in Lux, Scale 1 : 189

Position of surface in external scene:
Marked point:
(-13.150 m, -7.450 m, 0.000 m)

Grid: 128 x 128 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
1913	1257	2165	0.657	0.581

Tennis Court Area / INTERNATIONAL / Tennis court Calculation Grid (PA) / Summary



Scale 1 : 200

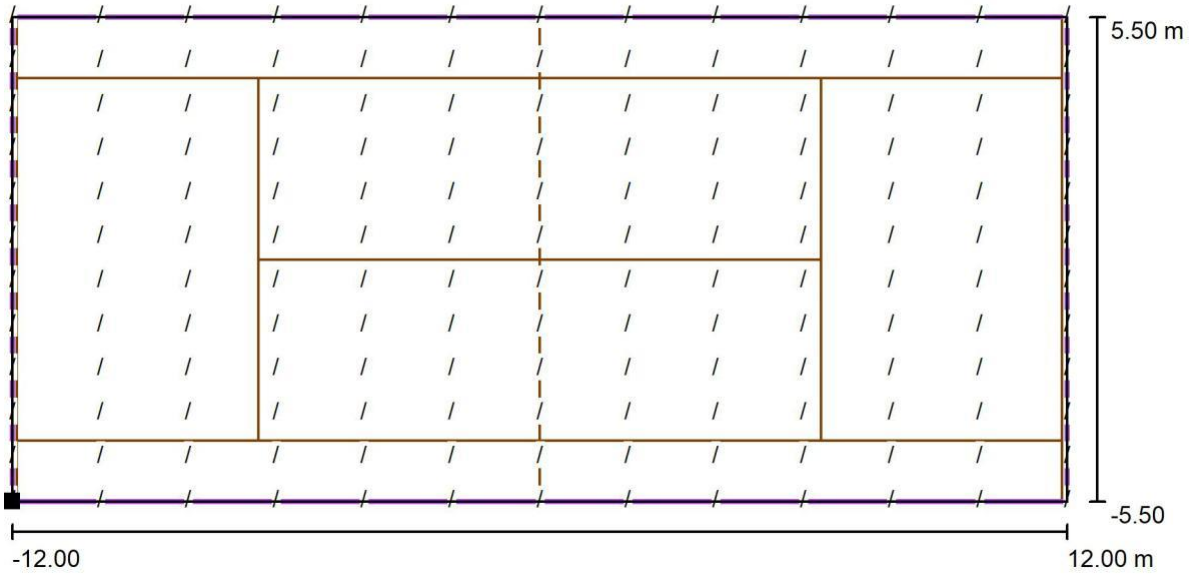
Position: (0.000 m, 0.000 m, 0.000 m)
Size: (24.000 m, 11.000 m)
Rotation: (0.0°, 0.0°, 0.0°)
Type: Normal, Grid: 25 x 12 Points
Belongs to the following sport arena: Tennis court

Results overview

No.	Type	E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}	Eh m/Em	H [m]	Camera
1	horizontal	2000	1610	2164	0.81	0.74	/	0.000	/
2	Camera	2030	1366	2826	0.67	0.48	0.99	1.500	1

Eh m/Em = Relationship between middle horizontal and vertical illuminance, H = Measuring Height

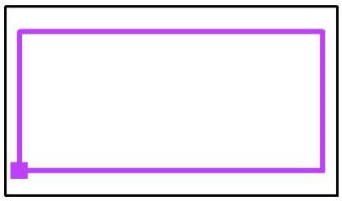
Tennis Court Area / INTERNATIONAL / Tennis court Calculation Grid (PA) / Gradient Graphics (E, Horizontal)



Values in %, Scale 1 : 172

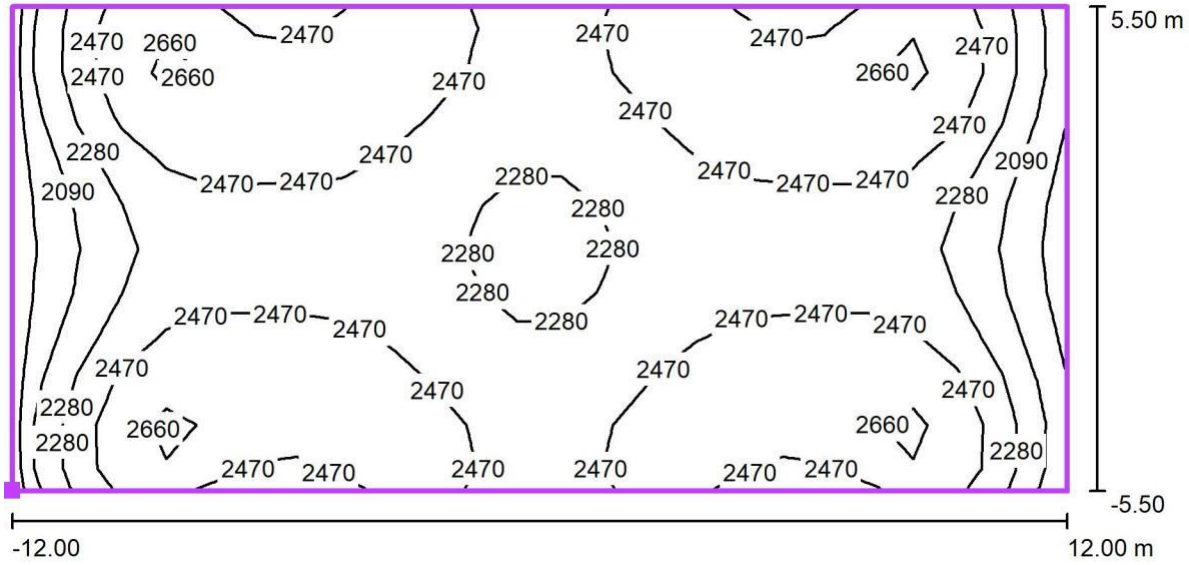
Not all calculated values could be displayed.

Position of surface in external scene: Marked point: (-12.000 m, -5.500 m, 0.000 m)



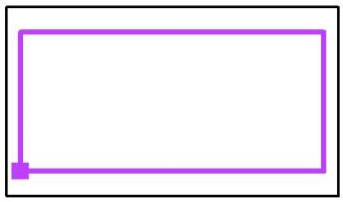
Maximum Change: 20%
Selected Limit Value: 25% (Values below this limit value are not output.)
Distance for the Gradient Grid: 2.000 m

Tennis Court Area / INTERNATIONAL / Camera Vertical / Isolines (E, Horizontal)



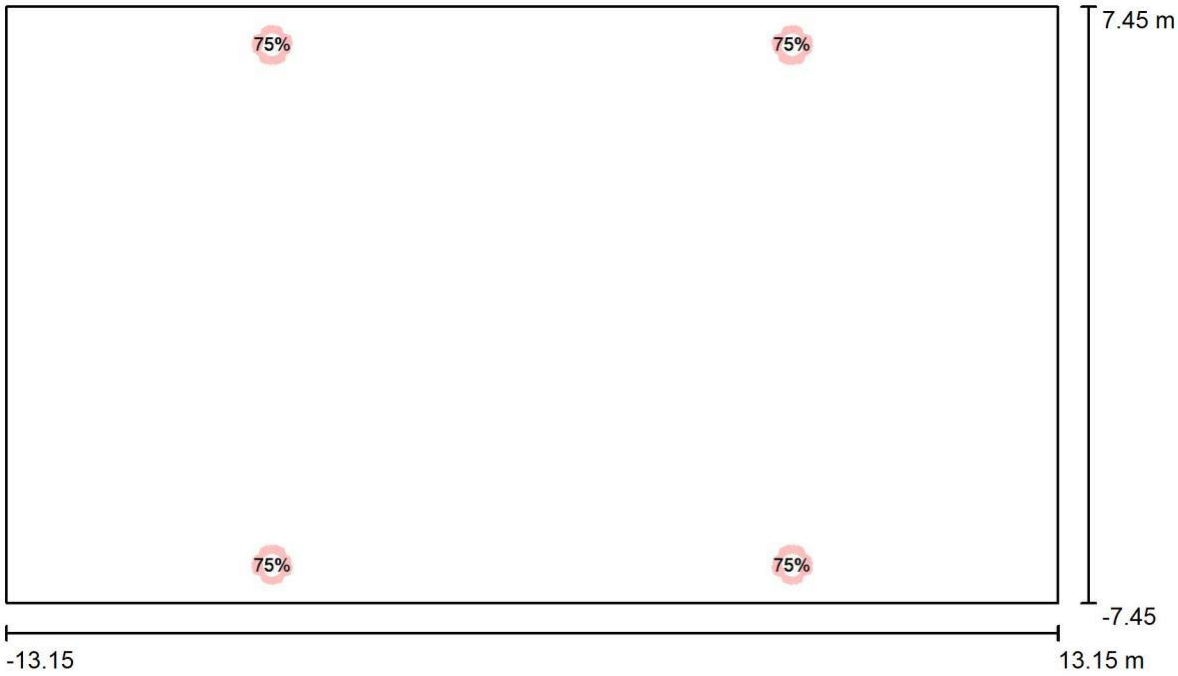
Values in Lux, Scale 1 : 172

Position of surface in external scene: Marked point: (-12.000 m, -5.500 m, 1.500 m)



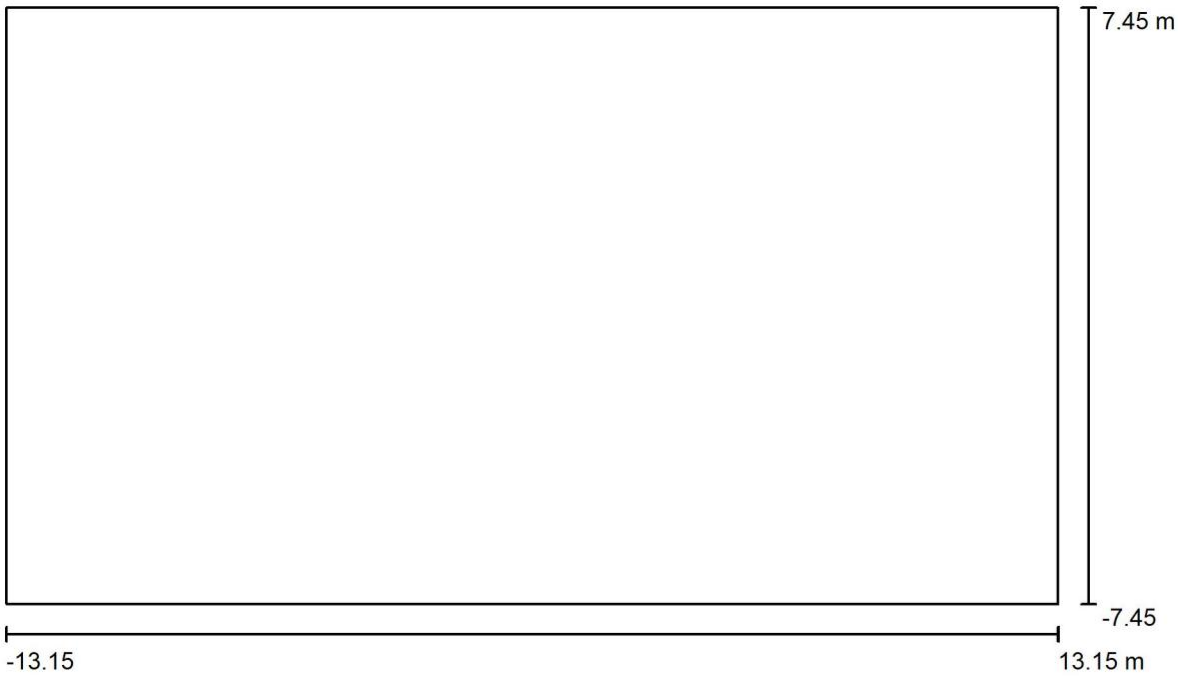
Grid: 25 x 12 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
2392	1783	2709	0.75	0.66



Scale 1 : 189

No.	Control group (Luminaire)	Dimming values (Total) [%]
1	LUMINAIRE FOR NATIONAL (Thorn 96635929 AFP2 2M 192L85-740 A4 CL1 GY [STD])	75
	All other luminaires	0

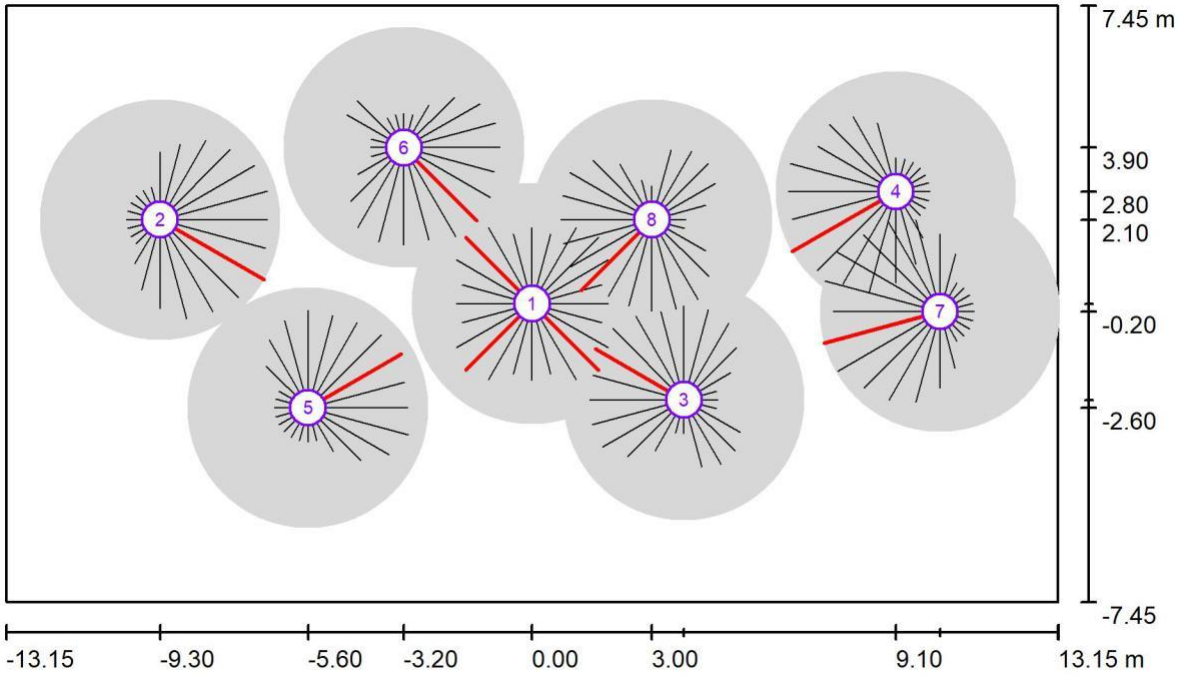


Light loss factor: 0.80, ULR (Upward Light Ratio): 2.0% **Scale 1:189**

Luminaire Parts List

No.	Pieces	Designation (Correction Factor)	F (Luminaire) [lm]	F (Lamps) [lm]	P [W]
1	36	Thorn 96635929 AFP2 2M 192L85-740 A4 CL1 GY [STD] (1.000)	72987	72987	483.0
			Total: 2627532	Total: 2627532	17388.0

Tennis Court Area / NATIONAL / GR Observer (Results Overview)



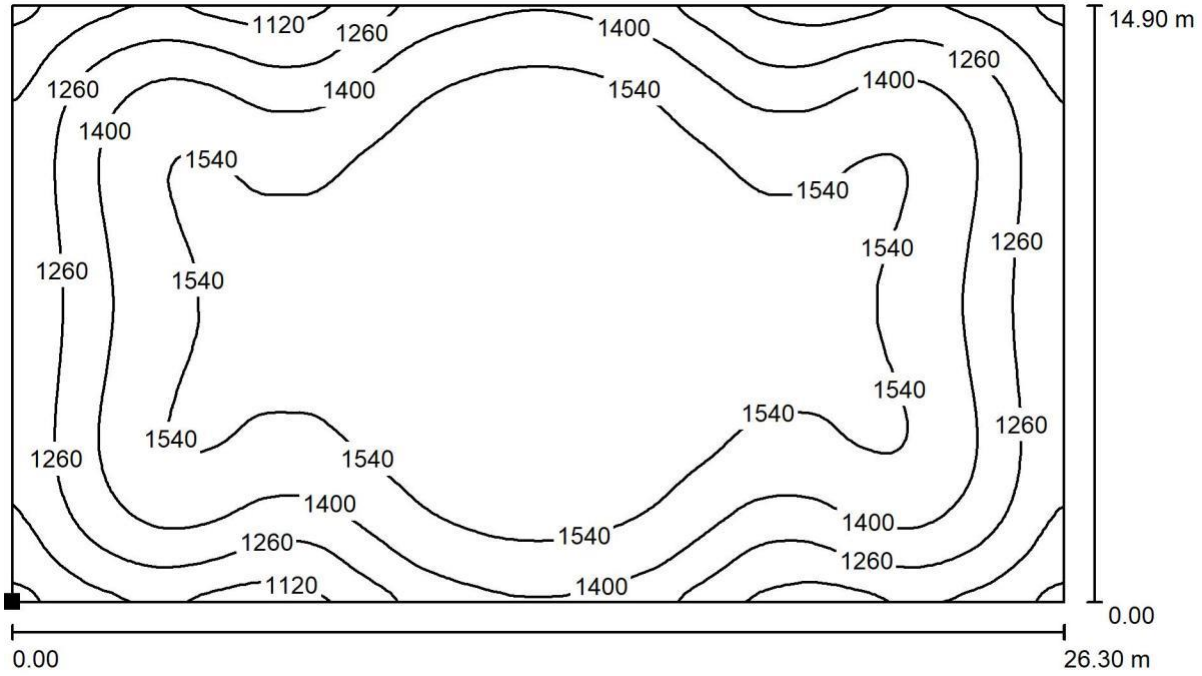
Scale 1 : 189

GR Observerlist

No.	Designation	Position [m]			Viewing sector [°]				Max
		X	Y	Z	Start	End	Increment	Slope angle	
1	GR Observer 1	0.000	0.000	1.500	0.0	360.0	15.0	-2.0	28 2)
2	GR Observer 2	-9.300	2.100	1.500	0.0	360.0	15.0	-2.0	35 2)
3	GR Observer 3	3.800	-2.400	1.500	0.0	360.0	15.0	-2.0	30 2)
4	GR Observer 4	9.100	2.800	1.500	0.0	360.0	15.0	-2.0	35 2)
5	GR Observer 5	-5.600	-2.600	1.500	0.0	360.0	15.0	-2.0	32 2)
6	GR Observer 6	-3.200	3.900	1.500	0.0	360.0	15.0	-2.0	30 2)
7	GR Observer 7	10.200	-0.200	1.500	0.0	360.0	15.0	-2.0	35 2)
8	GR Observer 8	3.000	2.100	1.500	0.0	360.0	15.0	-2.0	30 2)

2) The calculated equivalent veil luminance of the environment is based on the assumption of a complete diffuse reflection behavior of the environment (acc. EN 12464-2).

Tennis Court Area / NATIONAL / Playing area / Surface 1 / Isolines (E)

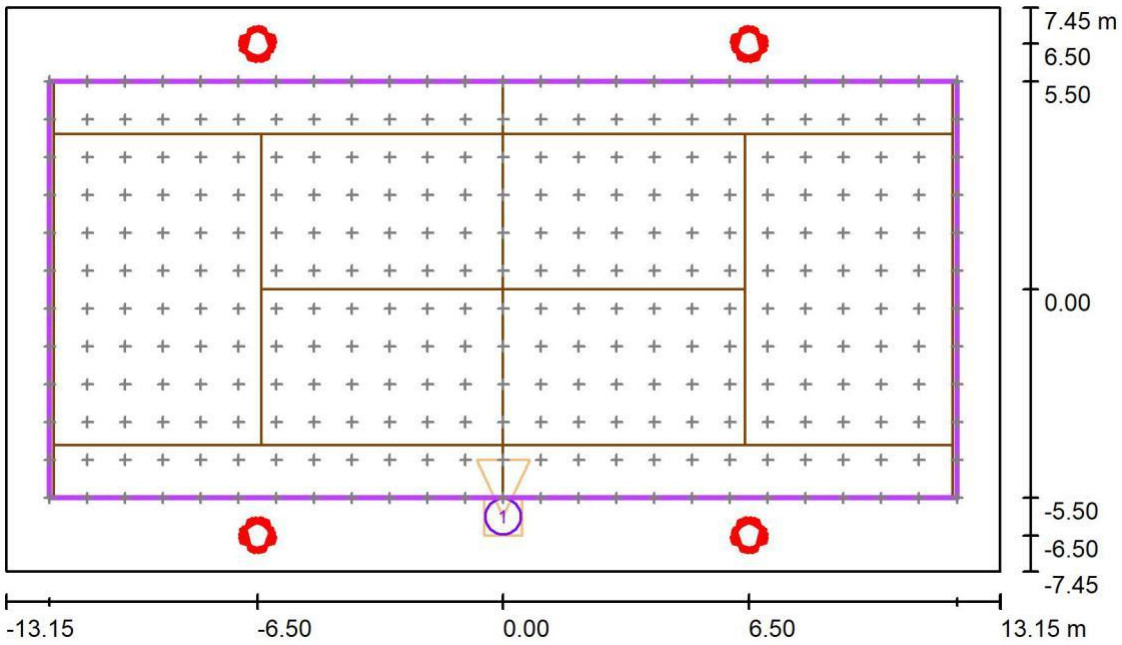


Values in Lux, Scale 1 : 189

Position of surface in external scene:
Marked point:
(-13.150 m, -7.450 m, 0.000 m)

Grid: 128 x 128 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
1435	943	1623	0.657	0.581



Scale 1 : 200

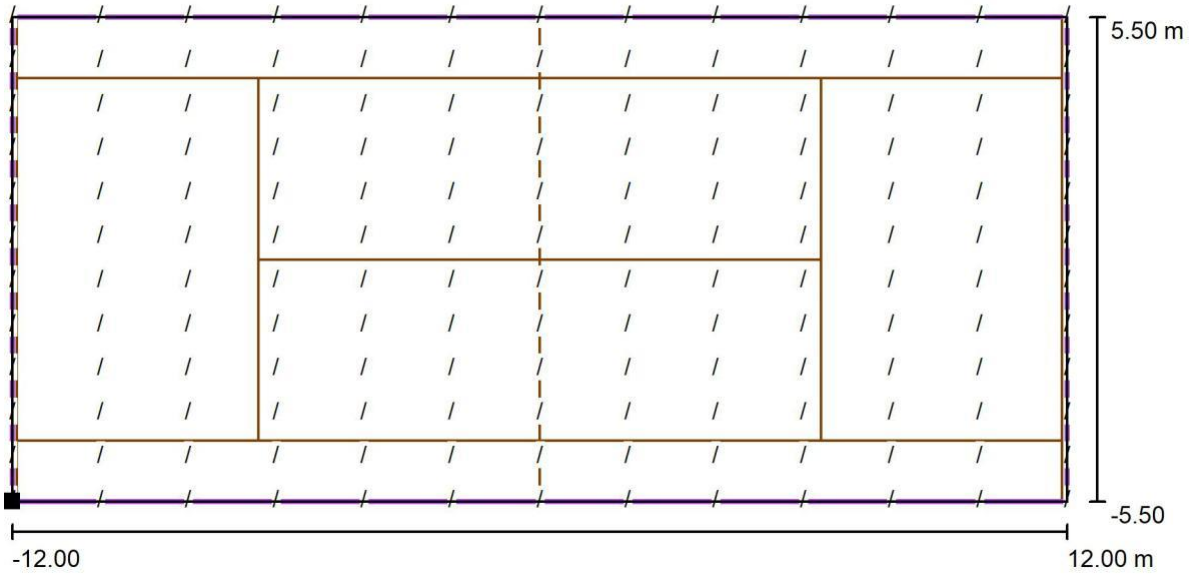
Position: (0.000 m, 0.000 m, 0.000 m)
Size: (24.000 m, 11.000 m)
Rotation: (0.0°, 0.0°, 0.0°)
Type: Normal, Grid: 25 x 12 Points
Belongs to the following sport arena: Tennis court

Results overview

No.	Type	E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}	E_h m/E_m	H [m]	Camera
1	horizontal	1500	1208	1623	0.81	0.74	/	0.000	/
2	Camera	1523	1025	2119	0.67	0.48	0.99	1.500	1

Eh m/Em = Relationship between middle horizontal and vertical illuminance, H = Measuring Height

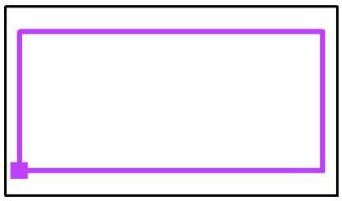
Tennis Court Area / NATIONAL / Tennis court Calculation Grid (PA) / Gradient Graphics (E, Horizontal)



Values in %, Scale 1 : 172

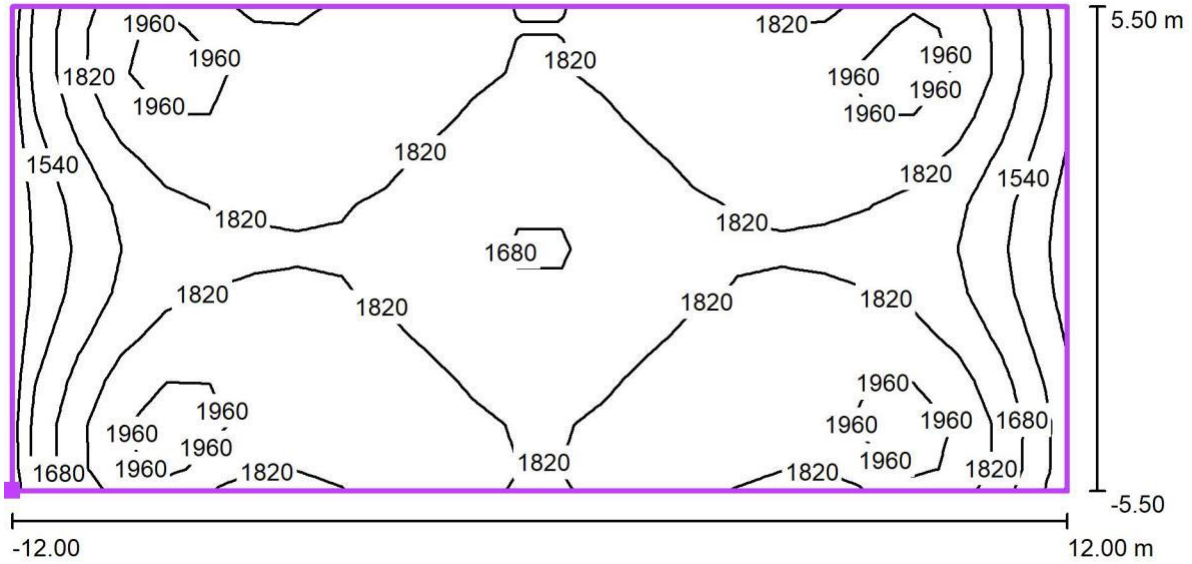
Not all calculated values could be displayed.

Position of surface in external scene: Marked point: (-12.000 m, -5.500 m, 0.000 m)



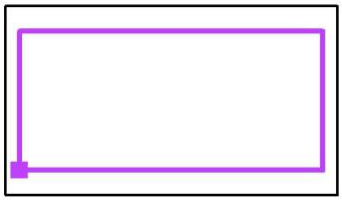
Maximum Change: 20%
Selected Limit Value: 25% (Values below this limit value are not output.)
Distance for the Gradient Grid: 2.000 m

Tennis Court Area / NATIONAL / Camera Vertical / Isolines (E, Horizontal)



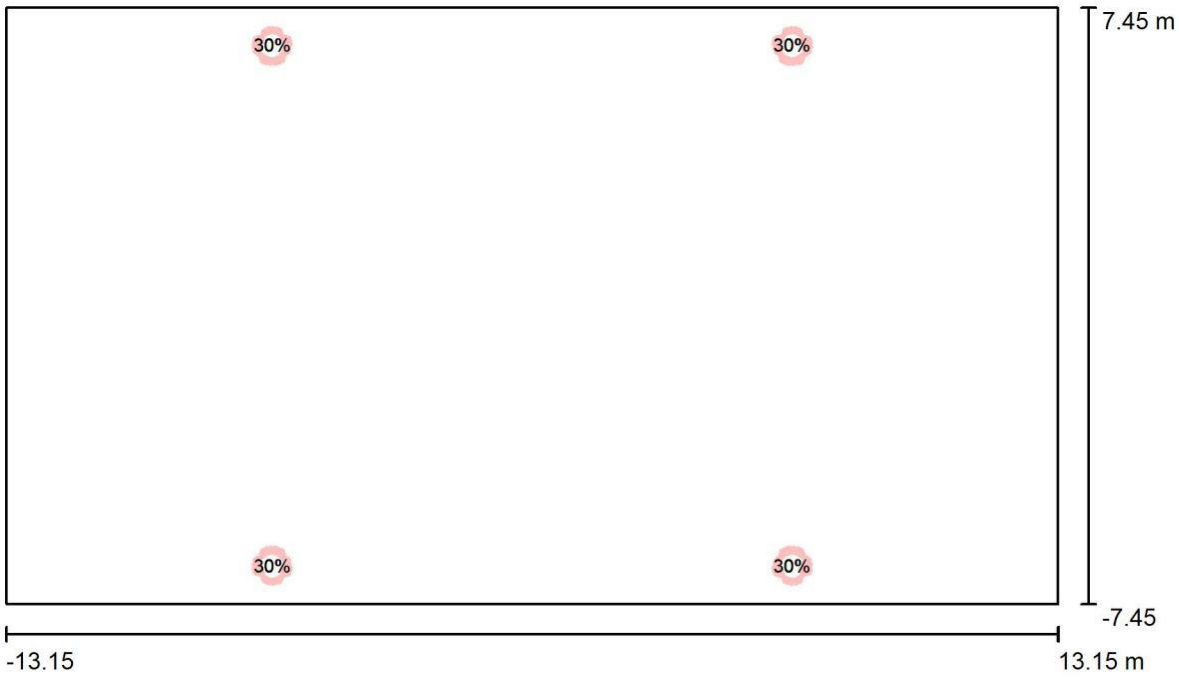
Values in Lux, Scale 1 : 172

Position of surface in external scene: Marked point: (-12.000 m, -5.500 m, 1.500 m)



Grid: 25 x 12 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
1794	1337	2031	0.75	0.66



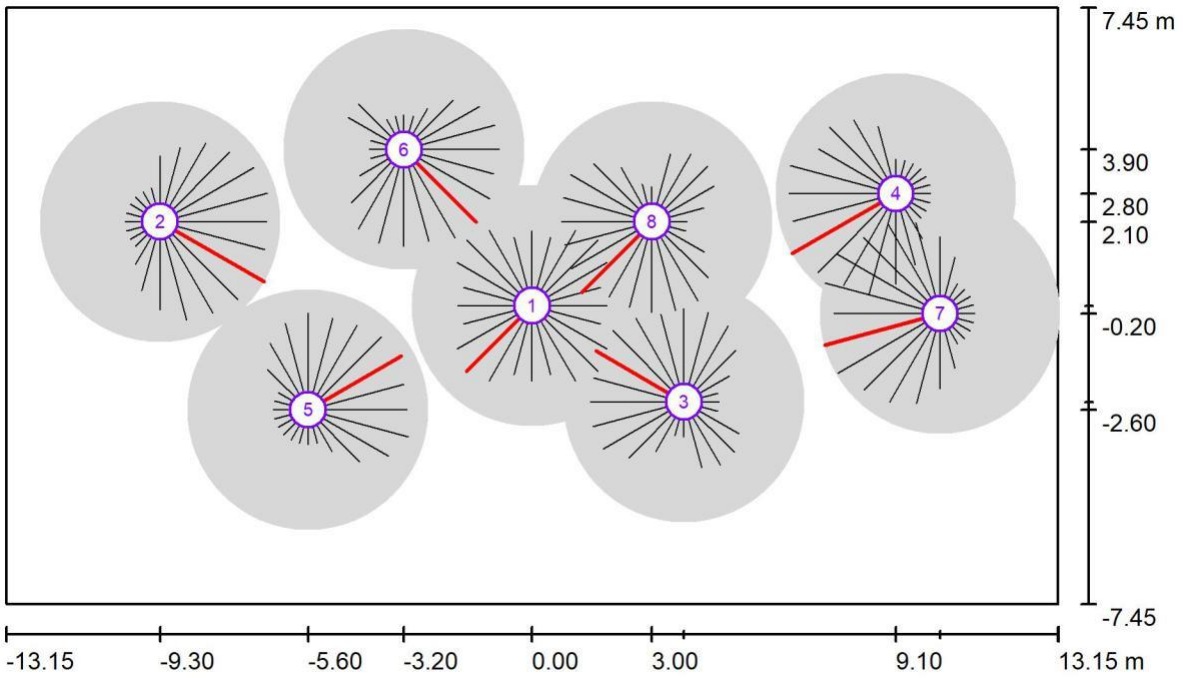
Scale 1 : 189

No.	Control group (Luminaire)	Dimming values (Total) [%]
1	LUMINAIRE FOR TRANING (Thorn 96635929 AFP2 2M 192L85-740 A4 CL1 GY [STD])	30
	All other luminaires	0

Light loss factor: 0.80, ULR (Upward Light Ratio): 2.0% **Scale 1:189**

Luminaire Parts List

No.	Pieces	Designation (Correction Factor)	F (Luminaire) [lm]	F (Lamps) [lm]	P [W]
1	36	Thorn 96635929 AFP2 2M 192L85-740 A4 CL1 GY [STD] (1.000)	72987	72987	483.0
			Total: 2627532	Total: 2627532	17388.0



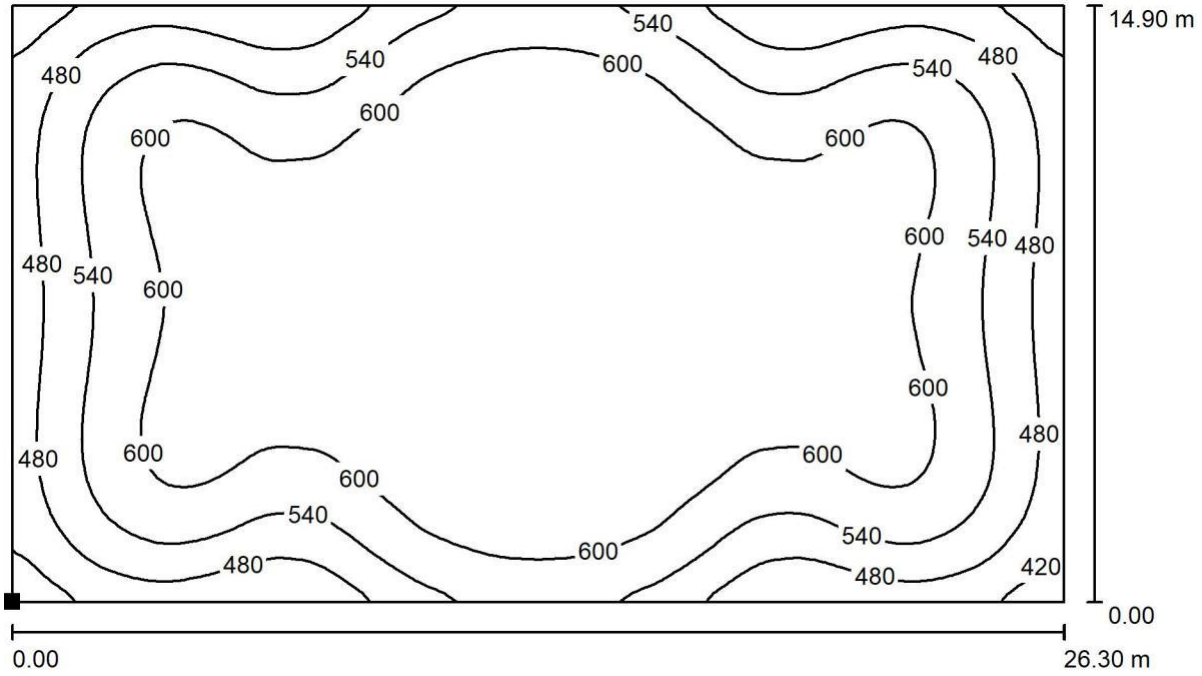
Scale 1 : 189

GR Observerlist

No.	Designation	Position [m]			Viewing sector [°]				Max
		X	Y	Z	Start	End	Increment	Slope angle	
1	GR Observer 1	0.000	0.000	1.500	0.0	360.0	15.0	-2.0	27 2)
2	GR Observer 2	-9.300	2.100	1.500	0.0	360.0	15.0	-2.0	34 2)
3	GR Observer 3	3.800	-2.400	1.500	0.0	360.0	15.0	-2.0	29 2)
4	GR Observer 4	9.100	2.800	1.500	0.0	360.0	15.0	-2.0	34 2)
5	GR Observer 5	-5.600	-2.600	1.500	0.0	360.0	15.0	-2.0	31 2)
6	GR Observer 6	-3.200	3.900	1.500	0.0	360.0	15.0	-2.0	29 2)
7	GR Observer 7	10.200	-0.200	1.500	0.0	360.0	15.0	-2.0	34 2)
8	GR Observer 8	3.000	2.100	1.500	0.0	360.0	15.0	-2.0	29 2)

2) The calculated equivalent veil luminance of the environment is based on the assumption of a complete diffuse reflection behavior of the environment (acc. EN 12464-2).

Tennis Court Area / TRANING / Playing area / Surface 1 / Isolines (E)



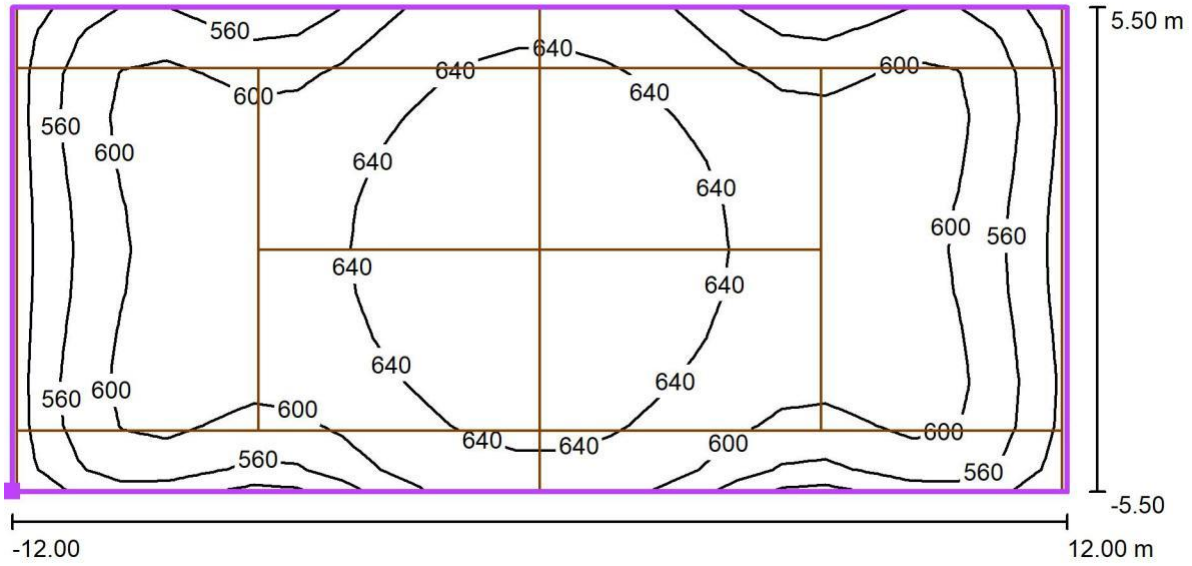
Values in Lux, Scale 1 : 189

Position of surface in external scene:
Marked point:
(-13.150 m, -7.450 m, 0.000 m)

Grid: 128 x 128 Points

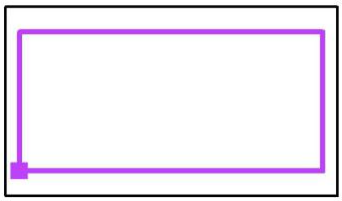
E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
574	377	649	0.657	0.581

Tennis Court Area / TRANING / Tennis court Calculation Grid (PA) / Isolines (E, Horizontal)



Values in Lux, Scale 1 : 172

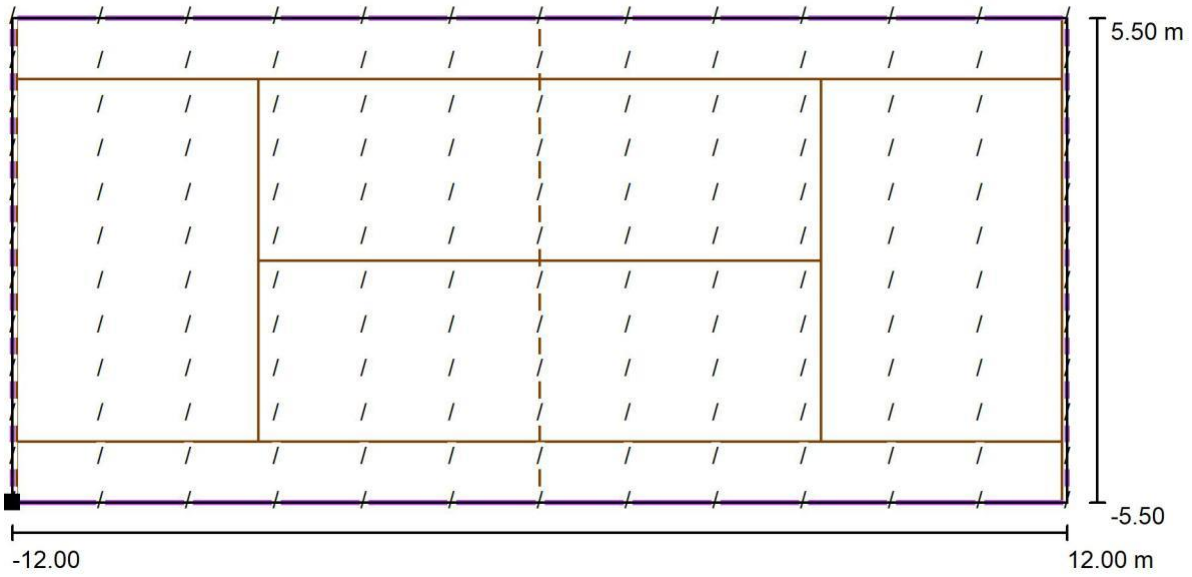
Position of surface in external scene: Marked point: (-12.000 m, -5.500 m, 0.000 m)



Grid: 25 x 12 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
600	483	649	0.81	0.74

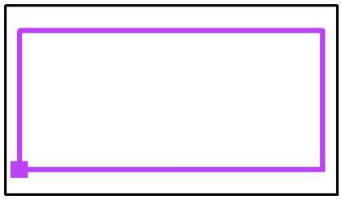
Tennis Court Area / TRANING / Tennis court Calculation Grid (PA) / Gradient Graphics (E, Horizontal)



Values in %, Scale 1 : 172

Not all calculated values could be displayed.

Position of surface in external scene: Marked point: (-12.000 m, -5.500 m, 0.000 m)



Maximum Change: 20%
Selected Limit Value: 25% (Values below this limit value are not output.)
Distance for the Gradient Grid: 2.000 m