STUDIES ON INDOOR SPORTS LIGHTING – BADMINTON AND TENNIS COURT

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in
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Submitted by

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ABSTRACT

This thesis examines the essential principles and advancements in indoor sports lighting design, specifically for tennis and badminton, where precise visibility is critical for athlete performance. It highlights the importance of uniform illumination, glare control, and color rendering to ensure players can accurately track fast-moving balls or shuttlecocks and anticipate player movements. The study explores the transformative impact of LED lighting, emphasizing benefits such as energy efficiency, customizable lighting levels, and reduced maintenance costs. The work also integrates the use of DIALux software for designing LED lighting systems that meet the required standards for tennis and badminton courts. Practical guidelines are provided for optimal fixture placement, lighting angles, and illuminance levels to enhance court visibility. Furthermore, the thesis underscores the role of well-designed lighting in ensuring fair competition, player safety, and an optimal experience for both participants and spectators. This research synthesizes technical considerations with practical applications, offering valuable insights into effective sports lighting design for indoor tennis and badminton environments.

CHAPTER 1: INTRODUCTION

Effective lighting plays a vital role in optimizing visibility and performance in sports environments, particularly in fast-paced and dynamic games like tennis and badminton. These sports require athletes to react quickly and accurately to the movements of a ball or shuttlecock, making clear visibility essential for optimal performance. Beyond enhancing visibility, a well-designed lighting system also significantly contributes to player safety and improves the overall spectator experience, fostering an environment that promotes fair competition and enjoyment. The lighting requirements for sports can generally be categorized into two types: aerial and ground-level sports. Aerial sports, such as tennis, involve playing objects that spend considerable time in the air, necessitating balanced illumination across both vertical and horizontal planes to ensure athletes can track the object effectively. Conversely, ground-level sports predominantly feature objects that remain close to or on the ground, which shifts the focus of lighting design primarily to the playing surface. Various organizations, including the International Commission on Illumination (CIE), National Lighting Council (NLC), and European Standards (EN), establish guidelines that define specific lighting standards for different sports. For example, CIE 042-1978 provides comprehensive standards for tennis courts, covering essential factors like luminaire selection and the overall design of an effective lighting system. These standards are crucial for enhancing player performance and ensuring a high-quality playing experience. This thesis will delve into these guidelines and their application in designing lighting solutions for both tennis and badminton, with particular emphasis on visibility, safety, and spectator engagement.

In both sports, the quality of lighting directly impacts gameplay, significantly affecting athletes' ability to track and respond to fast-moving objects. Tennis players depend on precise lighting to accurately follow the ball's trajectory, especially during high-speed serves and volleys. Similarly, badminton requires clear and consistent lighting as the shuttlecock moves rapidly across the court, enabling players to anticipate its path and react accordingly. This thesis will analyze the specific lighting requirements for these sports, emphasizing how optimized lighting design enhances performance, safety, and the overall playing experience. Recent advancements in lighting technology, particularly the widespread adoption of LED systems, have dramatically improved sports lighting capabilities. LED technology offers several key benefits, including energy efficiency, adjustable brightness levels, and superior color rendering. These features are crucial for creating optimal playing conditions, as they support both player performance and spectator enjoyment. This thesis will explore the impact of LED technology on sports lighting, highlighting how these innovations contribute to more efficient, adaptable, and visually effective lighting environments for dynamic sports like tennis and badminton.

Designing effective lighting systems for tennis and badminton involves careful consideration of several factors, including uniformity, glare reduction, optimal lighting angles, and adequate

illuminance levels across the entire playing area. Achieving these standards depends on the precise placement and distribution of lighting fixtures, which ensures consistent visibility and enhances player performance. Moreover, this design approach aligns with specific sports lighting standards and guidelines aimed at maintaining optimal visual conditions and safety on the court. The thesis will delve into these design principles, providing insights into best practices for lighting configuration in tennis and badminton environments.

Ultimately, this thesis examines the essential principles and design considerations for lighting systems tailored to tennis and badminton courts. It explores recent technological advancements that are reshaping modern sports lighting, provides practical guidelines for effective implementation, and analyzes the impact of well-designed lighting on gameplay, player safety, and the spectator experience. By taking a comprehensive approach, this research aims to establish best practices and underscore the critical role of lighting in enhancing both performance and enjoyment in these sports environments.

Objectives

The objectives of lighting systems for tennis and badminton focus on optimizing gameplay conditions, enhancing safety, and improving the spectator experience. The following key objectives outline the essential goals of effective sports lighting in these dynamic environments:

1. **Enhanced Visibility**: The primary objective is to provide sufficient and uniform illumination across the playing area, ensuring players can see the ball or shuttlecock clearly at all times. This clarity allows for quick and accurate reactions during fast-paced exchanges.

2. **Minimization of Glare**: Effective lighting design seeks to reduce glare, which can impair visibility and distract players. Techniques such as strategic fixture placement, shielded luminaires, and controlled light distribution are employed to maintain optimal visual conditions on the court.

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

4. **Safety and Injury Prevention**: Well-designed lighting illuminates' potential hazards, including uneven surfaces and court boundaries, thereby minimizing the risk of injuries during matches and practice sessions.

5. **Energy Efficiency**: Advances in LED technology focus on energy-efficient lighting solutions that reduce operational costs and environmental impact while maintaining high illumination quality necessary for sports activities.

6. **Flexibility and Adaptability**: Modern sports lighting systems are designed to be adaptable, allowing for adjustable lighting levels and configurations to suit different play levels and event types.

7. **Enhanced Spectator Experience**: Effective lighting improves the viewing experience for spectators, ensuring clear visibility of the action on the court and contributing to a more engaging atmosphere for fans attending matches.

These objectives collectively aim to enhance performance, safety, and enjoyment in tennis and badminton.

CHAPTER 2: FUNDAMENTALS OF SPORTS LIGHTING

2.1 Sports Lighting: an overview

Sports lighting encompasses specialized illumination systems designed for both indoor and outdoor sports facilities, ensuring optimal visibility during events, practices, and competitions. This overview highlights the key aspects of sports lighting:

1. **Purpose**: The primary goal is to provide adequate and uniform illumination across the playing area to enhance visibility for players, officials, and spectators. Proper lighting is essential for ensuring safety, improving performance, and enhancing the enjoyment of the sport.

2. **Design Considerations**:

- Uniformity: Achieving consistent light levels across the entire playing surface minimizes shadows and glare.
- Brightness: Illumination levels must be adequate and tailored to the specific sport and level of play.
- Color Rendering: Effective lighting must accurately render colors, allowing players and spectators to distinguish between various elements on the field.
- Glare Control: Minimizing glare is critical to prevent discomfort or distraction for players and officials.

3. **Technologies Used**:

- Metal Halide: A traditional source that provides high-intensity light suitable for outdoor sports.
- Fluorescent and High-Pressure Sodium Vapor Lamps: Previously used for non-televised and indoor sports.
- LED: Gaining popularity due to energy efficiency, durability, and dynamic control capabilities, used in both indoor and outdoor settings.

4. **Control Systems**: Advanced lighting setups often include controls for adjusting light levels according to event requirements, enabling dimming for practice sessions or full illumination for games.

5. **Environmental Considerations**: Modern lighting systems are designed for energy efficiency, significantly reducing operational costs and environmental impact, particularly with LED technology.

6. **Maintenance**: Regular maintenance, including fixture cleaning, bulb or LED replacement, and aiming angle adjustments, is crucial for optimal performance.

7. **Regulations and Standards**: Designs must comply with local regulations and international standards set by organizations like the International Commission on Illumination (CIE).

8. **Adaptability**: Lighting systems should be flexible enough to accommodate different sports played on the same field, meeting varying light level and uniformity requirements.

2.2 Necessity of sports lighting

Sports lighting is essential for various reasons that significantly enhance the experience and safety of athletes, spectators, and officials.

1. **Extended Playing Hours**: Sports lighting enables games to be played during evenings or in indoor venues where natural light is inadequate. This capability allows athletes to train and compete beyond daylight hours.

2. **Visibility and Safety**: Adequate lighting is crucial for clear visibility during matches and training sessions. It helps prevent collisions and injuries, ensuring that players can accurately judge the trajectory of the ball or shuttlecock.

3. **Broadcasting and Spectator Experience**: High-quality lighting is vital for broadcasting sports events, whether on television or through live streaming. Good illumination ensures that cameras capture clear images, enhancing the viewing experience for fans who cannot attend in person.

4. **Regulatory Compliance**: Sports associations and governing bodies establish specific lighting requirements to ensure fair play and safety. These regulations dictate minimum lighting levels, uniformity across the playing area, and glare control to maintain competitive integrity.

5. **Performance and Skill Development**: Optimal lighting conditions facilitate consistent visibility of the playing surface, enabling athletes to develop their skills during training and perform at their best in competitions.

6. **Community Engagement and Economic Impact**: Well-lit sports facilities attract larger crowds for various events, generating revenue from ticket sales and local businesses. This economic vitality fosters community pride and engagement through sports.

7. **Technological Advancements**: Recent advancements in lighting technology, particularly LED fixtures, have improved energy efficiency, durability, and the overall quality of illumination, reducing operational costs compared to traditional lighting sources.

In summary, sports lighting is vital for promoting safe and enjoyable sporting activities, supporting community engagement, and ensuring compliance with regulatory standards.

2.3 Terminologies of sports lighting

Understanding the specific terminologies related to sports lighting is essential for optimizing illumination systems in sports facilities. Below are key terms and their significance in the context of sports lighting:

1. **Lumens**: Lumens quantify the total amount of visible light emitted by a light source. This measurement helps determine the overall brightness of a lighting system, which is critical for ensuring sufficient illumination across a playing area.

2. **Lux**: Lux measures illuminance, indicating how much light is present at a specific point on a surface. This metric is vital for assessing the quality of light on playing surfaces and ensuring that athletes can see clearly during competitions and practice sessions.

3. **Uniformity of Illuminance**: Uniformity of illuminance refers to the consistency of light intensity across the playing surface. It is measured by the ratio between the minimum illuminance (the lowest light level) and the average illuminance (the overall light level) on the field or court. High uniformity ensures that players have consistent visibility, reducing risks associated with uneven lighting conditions that can affect depth perception and overall performance.

Factors Affecting Uniformity:

- Fixture Placement: Proper positioning of light fixtures helps avoid excessively bright or dark areas.
- Beam Angle and Spread: Selecting fixtures with appropriate beam angles ensures even light distribution.
- Mounting Height: The height at which fixtures are installed influences how evenly light spreads across the playing surface.
- Lighting Design: Effective design takes these factors into account to meet specific lighting level requirements for various sports.

4. Gradient: The horizontal illuminance gradient refers to the change in illuminance levels across the playing surface. It is crucial for ensuring uniform lighting conditions. A gradient is assessed by comparing illuminance levels across the width and length of the playing area. Ideally, a maximum 25% change in illuminance per 5 meters is recommended.

5. Glare Restriction: Glare occurs when excessive brightness or contrast causes discomfort or reduces visibility. To minimize glare:

- Fixture Selection: Use fixtures with proper shielding designed to direct light downward, reducing potential glare.
- Lighting Design: Carefully plan fixture layout to avoid direct lines of sight from players and spectators.

- Glare Ratings: Evaluate fixtures based on glare ratings, with acceptable values for sports lighting lying within 50.
- Lighting Control: Implement control systems to adjust light levels, reducing glare during different phases of events.

6. Flicker: Flicker refers to rapid variations in light output due to electric current cycling. While often imperceptible, flicker can lead to visual discomfort and affect performance, especially in fast-paced sports. Key considerations include:

- Causes: Flicker can result from power supply fluctuations or older lighting technologies.
- Effects: It can cause eye strain and impact concentration. Moreover, flicker can interfere with broadcasting quality.
- Regulations: Standards exist to minimize flicker frequency and amplitude, ensuring human health and performance are not compromised.

7. Color Rendering Index (CRI): The CRI measures a light source's ability to accurately reveal colors compared to natural light. It is expressed on a scale from 0 to 100, with higher values indicating better color rendering. The importance of CRI in sports lighting includes:

- Visual Clarity: High CRI helps athletes and spectators distinguish between team colors and other important markings.
- Colour Contrast: Proper rendering enhances contrast between different elements, aiding quick visual recognition.
- Broadcasting Quality: Good color rendering ensures that televised events display natural and vibrant colors.

8. Correlated Colour Temperature (CCT): CCT indicates the color appearance of emitted light, measured in Kelvin (K). In sports lighting:

- Colour Appearance: CCT values indicate whether the light appears warm or cool. Cooler temperatures (5000K to 6500K) enhance visibility.
- Visual Acuity: Cooler CCTs improve clarity, making it easier for players to see details.
- Broadcasting: Consistent CCT helps ensure accurate color reproduction in broadcasts.

9. Light Pollution: Light pollution refers to excessive artificial light spilling beyond its intended area, impacting the surrounding environment. Key types include:

- Sky Glow: Brightening of the night sky over urban areas.
- Glare: Excessive brightness causing discomfort.
- Light Trespass: Unwanted light intruding into areas where it is not needed.
- Clutter: Excessive grouping of light sources creating a confusing visual environment.

Causes of Light Pollution:

- Over-Illumination: Using more light than necessary.
- Improper Fixture Design: Fixtures lacking shielding can emit light in unintended directions.
- Control Systems: Ineffective use of timers and sensors may lead to prolonged operation.

Impacts:

- Ecological Effects: Disrupts wildlife behaviors and habitats.
- Human Health: Can interfere with sleep patterns and circadian rhythms.
- Astronomy: Hinders astronomical observations.
- Energy Waste: Contributes to environmental pollution and increased operational costs.

In conclusion, understanding these terminologies is vital for the effective design and implementation of sports lighting systems, ensuring optimal visibility, safety, and enjoyment for all participants and spectators involved.

2.4 Key factors of sports lighting

The effectiveness of sports lighting is critical for ensuring safe, enjoyable, and competitive environments in sports facilities. Several key factors must be considered in the design and implementation of lighting systems:

1. **Brightness and Uniformity**: Sufficient illumination levels across the playing area are vital to enhance visibility and safety for both players and spectators. A uniform lighting distribution minimizes glare and dark spots, ensuring all areas are adequately lit and reducing the risk of accidents.

2. **Colour Rendering Index**: A high Colour Rendering Index (CRI) is essential for accurate color representation, enabling clear differentiation between team uniforms, boundary lines, and other game elements. Effective color rendering enhances the overall visual experience for both participants and spectators.

3. **Glare Control**: Minimizing glare is crucial to prevent distraction and discomfort for athletes. Strategic fixture placement and effective shielding techniques are necessary to achieve optimal glare control, allowing players to focus on the game without visual disturbances.

4. **Flicker-Free Operation**: Stable, flicker-free lighting ensures consistent visibility, preventing potential negative effects on athletes' performance and comfort. Flickering lights can lead to visual discomfort and distract players, making it imperative to utilize technologies that provide stable light output.

5. **Energy Efficiency**: Adopting energy-efficient lighting technologies, such as LEDs, is important to reduce operational costs and environmental impact while maintaining performance standards. Energy-efficient systems contribute to sustainability goals and can significantly lower long-term utility expenses.

6. **Durability and Weather Resistance**: Choosing fixtures designed to withstand outdoor conditions—such as rain, wind, and temperature fluctuations—minimizes maintenance needs and extends the lifespan of the lighting system. Durable fixtures ensure consistent performance over time, especially in varied weather conditions.

7. **Adaptability and Control**: Implementing adjustable lighting controls enhances flexibility, allowing for changes in light levels based on different activities, events, or broadcast requirements. Automated systems can further improve efficiency and responsiveness to varying needs.

8. **Compliance with Standards**: Adhering to relevant national and international standards for sports lighting is essential to ensure safety, performance, and energy efficiency. Compliance with these guidelines guarantees that lighting installations meet established safety and performance benchmarks.

9. **Maintenance Requirements**: Considering the ease of maintenance and accessibility of fixtures is crucial for facilitating regular upkeep. Proper maintenance ensures consistent lighting performance and longevity of the system.

10. **Cost-Effectiveness**: Balancing the initial investment in lighting systems with long-term operational savings and benefits is key to achieving a cost-effective solution. A well-planned lighting design should provide optimal performance while being mindful of budget constraints.

By addressing these factors comprehensively, sports facilities can create optimal lighting conditions that enhance gameplay, improve spectator experience, and ensure overall safety for all participants.

2.5 Non-Televised Sports Lighting Design

Non-televised sports lighting focuses on providing adequate lighting for sports facilities where events are not broadcasted on television. The primary goal of these lighting systems is to create a

safe and comfortable environment for athletes, spectators, and officials at the venue. The design emphasizes sufficient visibility, uniform light distribution, and glare control, tailored to the specific needs of the sport and the venue. Unlike televised sports lighting, the requirements for visual quality are limited to those directly benefiting the participants and live audience without the additional complexities of catering to broadcast standards.

2.6 Televised Sports Lighting Design

Televised sports lighting is specifically designed for venues where events are broadcasted on television, requiring advanced lighting systems to meet the technical standards of broadcasters. These lighting designs focus on providing high-quality visuals for TV audiences, ensuring uniform brightness, proper color rendering, and glare control to enhance the viewing experience. In addition to meeting the needs of athletes and officials, televised lighting systems also incorporate precise lighting angles and intensity to support camera equipment, ensuring optimal image quality during live broadcasts.

CHAPTER 3: SPORTS LIGHTING LUMINAIRE

3.1 Luminaire and sport lighting luminaire

A sports lighting luminaire is a complete lighting unit specifically engineered to illuminate sports venues. It includes various components, such as the light source (e.g., bulbs or LEDs), housing or fixtures, reflectors, lenses, and diffusers, collectively designed to provide effective illumination during sporting events.

These luminaires are vital for ensuring visibility and safety for players, officials, and spectators in both indoor and outdoor settings. They can vary in design, shape, and size to meet the specific requirements of different sports and facilities, often featuring mounting options like ceiling-mounted or freestanding configurations.

Sports lighting luminaires can be classified based on their function. General lighting luminaires deliver uniform illumination across the playing area, while task lighting luminaires focus on specific activities, such as ensuring visibility during training sessions. Accent lighting luminaires may be utilized to highlight particular features or areas within the venue. Proper selection and arrangement of these luminaires are crucial for achieving optimal light distribution, uniformity, and glare control, thus enhancing the overall experience and performance in sports environments.

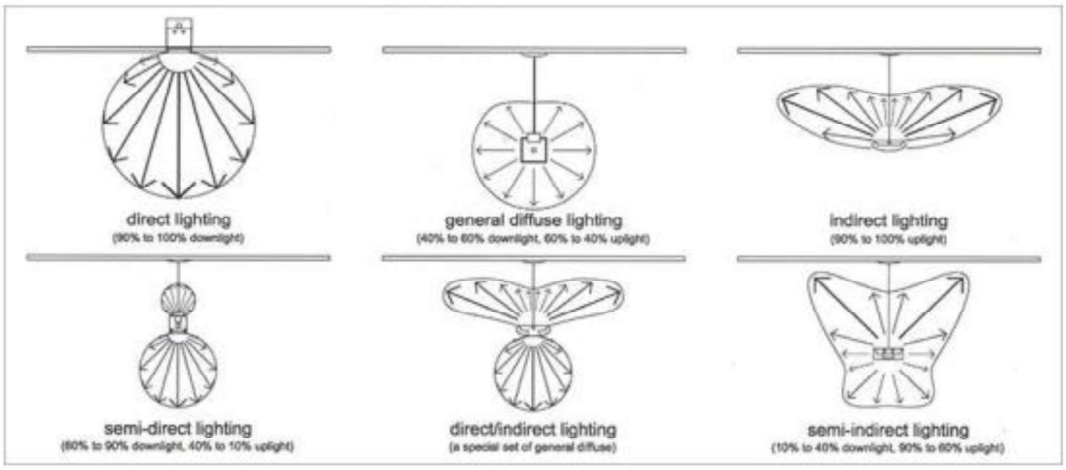


Fig1: Luminaires based on light distribution

Sports lighting luminaires are specialized fixtures designed to provide optimal illumination for sports venues, including fields, stadiums, and arenas. These luminaires play a critical role in enhancing visibility for athletes, officials, and spectators while ensuring a safe and enjoyable environment. The effectiveness of sports lighting is determined by various factors, including light distribution, design, application, and technology.

3.2 Classification of Sports Lighting Luminaires

1. **Light Distribution**: Sports lighting luminaires can be categorized based on how they distribute light:

- Direct Luminaires: Emit light predominantly downward, providing focused illumination on the playing surface without significant diffusion.
- Semi-Direct Luminaires: Direct 60% to 90% of emitted light downward while reflecting some light upward to reduce glare and enhance overall brightness.
- Indirect Luminaires: Designed to reflect light off ceilings or walls, creating diffuse, ambient illumination that minimizes direct glare.
- Semi-Indirect Luminaires: Distribute 60% to 90% of the emitted light upward, with the remaining light directed downward.
- Direct-Indirect Luminaires: Combine both direct and indirect lighting, effectively distributing light in both upward and downward directions for balanced illumination.

2. **Design and Form**: The design and mounting options of sports lighting luminaires can significantly impact their effectiveness:

- Ceiling-Mounted Luminaires: These fixtures can be flush-mounted or suspended and are often used to provide general illumination for large spaces.
- Wall-Mounted Luminaires: Although less common in sports settings, wall sconces can be used to provide ambient lighting in spectator areas.
- Floor Luminaires: Free-standing fixtures are less typical for sports applications, but they may be used in auxiliary areas such as locker rooms or waiting areas.
- Pendant Luminaires: Suspended fixtures can offer flexibility in design and light distribution, often used in high-ceiling venues.

3. **Application**: Sports lighting luminaires are designed with specific applications in mind:

- Indoor Sports Lighting: These luminaires must provide adequate illumination for sports like basketball and volleyball, where visibility is critical.
- Outdoor Sports Lighting: Fixtures designed for outdoor environments must withstand weather conditions while providing high brightness and uniform light distribution for sports like soccer and football.

4. **Light Source**: The choice of light source significantly affects the performance and efficiency of sports lighting luminaires:

- LED Luminaires: Widely used due to their energy efficiency, long lifespan, and superior brightness control. LEDs allow for precise light distribution and minimal glare, making them ideal for sports applications.

- Metal Halide Luminaires: Traditional fixtures often used in stadiums, offering high brightness and good color rendering but lower energy efficiency compared to LEDs.
- Fluorescent Luminaires: Less common for sports applications, but they can be used in auxiliary areas or practice facilities where high illumination levels are not as critical.

5. **Mounting Type**: The method of mounting also influences the performance of sports lighting:

Recessed Luminaires: Installed flush with ceilings, these fixtures provide a clean aesthetic and minimize light obstruction.

- Surface-Mounted Luminaires: Fixed directly onto the surface, they are easier to install and maintain but may require careful placement to avoid shadows.
- Track Luminaires: These systems allow for adjustable positioning and flexibility in directing light, which is beneficial for venues that host multiple types of events.

6. **Specialty Features**: Glare Control: Sports lighting luminaires must be designed to minimize glare, as excessive brightness can distract players and officials. Utilizing proper fixture placement and shielding techniques is essential for glare reduction.

- Durability and Weather Resistance: Luminaires used outdoors must be robust and resistant to various weather conditions, ensuring longevity and minimizing maintenance needs.
- Energy Efficiency: Modern sports lighting solutions focus on energy-efficient echnologies, particularly LEDs, to reduce operational costs and environmental impact.

Figure: BEGA 1000W luminaire for indoor sports lighting

Sports lighting luminaires are specialized lighting fixtures engineered to provide optimal illumination for various sporting venues, including fields, stadiums, and arenas. These luminaires are essential for ensuring visibility and safety during nighttime activities, enhancing the experience for athletes, spectators, and broadcasters alike. The design and performance of sports lighting luminaires are guided by specific requirements, such as high brightness, uniform light distribution, and minimal glare. This document outlines the key features, classifications, and types of sports lighting luminaires.

3.3 Key Features of Sports Lighting Luminaires

1. **High Output Light Sources**: Sports lighting luminaires typically utilize high-intensity light sources to deliver sufficient illumination over large areas. The common light sources include:

Metal Halide (MH) Lamps: Known for their high brightness and good color rendering, making them popular in large outdoor facilities.

- High-Pressure Sodium (HPS) Lamps: Valued for their energy efficiency but with lower color rendering capabilities, suitable for non-televised events.
- Light Emitting Diodes (LEDs): The modern choice, known for energy efficiency, long lifespan, low heat emission, and the ability to provide instant lighting with precise control.

2. **Optics and Light Control**: Precision optics are critical in sports lighting luminaires, controlling the direction and spread of light to ensure uniform distribution across the playing surface. These optics minimize spill light and glare while providing various beam angles to meet specific lighting requirements.

3. **Durability and Weather Resistance**: Given their outdoor installation, sports lighting luminaires must be constructed from durable, corrosion-resistant materials to withstand harsh weather conditions. Effective thermal management is also essential to maintain performance and prolong the lifespan of the light sources.

4. **Energy Efficiency**: With the increasing emphasis on sustainability, modern sports lighting increasingly utilizes LED technology. LEDs offer superior energy efficiency, a longer lifespan, and dimming capabilities, allowing for significant energy savings.

5. **Compliance with Standards**: Sports lighting luminaires must adhere to various local and international standards, specifying minimum lighting levels, uniformity ratios, glare limitations, and color rendering requirements suitable for different types of sports and competition levels.

6. **Mounting Options**: Flexibility in mounting is essential for optimal performance. Sports lighting luminaires can be installed on poles, integrated into structures, or positioned strategically to achieve desired lighting results.

Sports lighting luminaires can be classified based on several criteria, including light source, design, application, light distribution, and control systems.

1. **Based on Light Source**:

- Incandescent Luminaires: Rarely used due to inefficiency, they produce warm light but have a short lifespan.
- Halogen Luminaires: Offer improved efficiency over standard incandescent bulbs but still consume relatively high energy.
- Metal Halide (MH) Luminaires: Widely used in outdoor sports facilities due to their high intensity and good color rendering.
- High-Pressure Sodium (HPS) Luminaires: Efficient but with poor color rendering, often used where efficiency is prioritized.
- Fluorescent Luminaires: More common in indoor settings but not typically suited for high-intensity sports lighting.
- LED Luminaires: The current standard in sports lighting, favored for their efficiency and adaptability.

2. **Based on Design and Mounting**:

- Floodlights: Provide broad, high-intensity illumination, ideal for outdoor sports fields and stadiums. Common types include LED, metal halide, and high-pressure sodium floodlights.
- Downlights: Focus light directly downward, typically used in indoor sports facilities for targeted illumination.
- Wall-Mounted Lights: Used for supplemental lighting in areas where pole mounting is impractical.
- Pole-Mounted Lights: Elevated fixtures that provide high-intensity illumination, suitable for large sports facilities.

3. **Based on Light Distribution**:

- Asymmetric Distribution: Light is directed in one direction, focusing illumination on specific areas, ideal for sports courts.
- Symmetric Distribution: Light is evenly distributed in all directions, providing consistent coverage across playing fields.

4. **Based on Application**:

- General Lighting: Ensures overall illumination in large areas, suitable for stadiums and fields.
- Task Lighting: Focused lighting for specific activities, such as practice areas.
- Emergency Lighting: Ensures safety during power outages through automatic activation.
- Accent Lighting: Highlights specific features or branding, enhancing visual appeal.

5. Based on Control Systems:

- Manual Control: Basic operation via physical switches.
- Automatic Control: Utilizes sensors or timers for enhanced functionality.
- Smart Control: Integrated with IoT technology for advanced management and remote adjustments.

3.4 Types of Sports Lighting Luminaires

Sports lighting luminaires come in various types, each tailored to meet specific lighting requirements:

1. **Floodlights**: High-intensity fixtures that provide wide-angle illumination, commonly used in outdoor fields and stadiums. They can be LED, metal halide, or high-pressure sodium types.

2. **Downlights**: Direct light downward for focused illumination, ideal for indoor facilities or specific lighting tasks.

3. **Wall-Mounted Lights**: Provide side or accent lighting, suitable for outdoor practice areas or facilities where pole mounting isn't feasible.

4. **Pole-Mounted Lights**: Installed on tall poles to deliver high-level illumination across large outdoor sports facilities.

5. **Integrated Lighting Systems**: Combine various luminaires and technologies, offering customizable solutions for complex sports venues.

6. **Emergency and Backup Lighting**: Ensure safety during power failures with battery backup or generator-powered systems

7. **Accent and Decorative Lighting**: Designed to highlight specific features and enhance visual effects, contributing to branding and player zones.

8. **High-Mast Lighting**: Extremely high poles provide illumination over extensive areas, ideal for large sports complexes.


Figure 4&5: Tennis court sport lighting design (indoor)

3.5 Components of a luminaire

A luminaire is a complex assembly of components that work together to provide effective lighting. Understanding these components is essential for evaluating the performance, efficiency, and aesthetic appeal of lighting solutions. The main components of a luminaire include:

1. **Housing**: The outer casing or body that encloses and protects the internal components. Made from materials like metal, plastic, or glass, the housing also incorporates design features to enhance both aesthetics and functionality.

2. **Light Source**: This is the primary element responsible for emitting light. Various types of light sources are used, including incandescent bulbs, fluorescent tubes, and LED modules. The choice of light source significantly affects the luminaire's energy efficiency, color rendering capabilities, and overall lifespan.

3. **Socket or LED Module**: The socket connects the light source to the internal electrical wiring. In LED luminaires, the LED module is often integrated directly into the housing, streamlining the design.

4. **Optical System**: This component includes reflectors, lenses, diffusers, and other optical elements designed to control and distribute the light emitted by the source. The optical system is critical in determining the beam angle, light distribution pattern, and glare control, influencing how effectively the luminaire illuminates a space.

5. **Driver or Ballast**: For luminaires that utilize LED or fluorescent light sources, a driver or ballast is necessary to regulate the electrical current. This component ensures optimal operation and energy efficiency of the luminaire.

6. **Heat Sink**: In LED luminaires, heat sinks are incorporated to dissipate heat generated during operation. Effective thermal management is vital for maintaining the longevity and performance of LED technology.

7. **Mounting Hardware**: This includes brackets, arms, or clips used for securely mounting the luminaire to ceilings, walls, or poles. Proper mounting ensures alignment and stability, contributing to effective lighting performance.

8. **Electrical Wiring**: Internal wiring connects the light source, driver, and other electrical components to the power supply. This wiring is insulated and equipped with connectors to ensure safe and reliable electrical connections.

9. **Control Mechanisms**: Many luminaires feature control systems such as switches, dimmers, motion sensors, or smart lighting controls. These allow users to adjust lighting levels, automate operations, or integrate with building management systems for enhanced functionality.

10. **Decorative Elements**: Depending on the application, luminaires may include decorative features such as shades, covers, or finishes that enhance their visual appeal and ensure integration with interior or exterior decor.

3.6 IP and IK ratings of a luminaire

IP Ratings: Ingress Protection (IP) ratings are standardized classifications defined by the International Electrotechnical Commission (IEC) that indicate the level of protection a luminaire offers against the intrusion of solid objects and moisture. The IP rating consists of two digits:

1. **Protection Against Solid Objects**:

- 0: No protection.
- 1: Protected against objects larger than 50mm (e.g., accidental touch by hands).
- 2: Protected against objects larger than 12.5mm (e.g., fingers).
- 3: Protected against objects larger than 2.5mm (e.g., tools and wires).
- 4: Protected against objects larger than 1.0mm (e.g., small tools).
- 5: Dust protected (limited ingress of dust).
- 6: Dust tight (complete protection against dust).

2. **Protection Against Liquids**:

- 0: No protection.
- 1: Protected against vertically falling drops of water.
- 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.
- 7: Protected against temporary immersion in water (up to 1 meter for 30 minutes).
- 8: Protected against continuous immersion in water at specified depths.

For example, an IP65-rated luminaire is dust-tight and protected against water jets, making it suitable for outdoor applications where exposure to rain and dust is likely. Selecting the appropriate IP rating ensures the luminaire's longevity and safety in various environmental conditions.

IK Ratings: IK ratings indicate the mechanical impact resistance of a luminaire's enclosure. This rating system is crucial for luminaires installed in areas where they may be exposed to physical shocks or vandalism. The IK rating is presented as a two-digit code, reflecting the level of impact resistance:

- IK00: No protection against impact.
- IK01: Protection against 0.14 joules impact (equivalent to impact of 0.25 kg mass dropped from 56 mm height).
- IK02: Protection against 0.2 joules impact.
- IK03: Protection against 0.35 joules impact.
- IK04: Protection against 0.5 joules impact.
- IK05: Protection against 0.7 joules impact.
- IK06: Protection against 1 joule impact.
- IK07: Protection against 2 joules impact.
- IK08: Protection against 5 joules impact.
- IK09: Protection against 10 joules impact.
- IK10: Protection against 20 joules impact.

Higher IK ratings denote greater impact resistance, ensuring that luminaires remain functional and safe despite accidental collisions. When selecting a luminaire, it is essential to consider both IP ratings for environmental protection and IK ratings for impact resistance based on the installation's specific conditions and potential hazards.

3. Photometric and Electrical parameters

Photometric and Electrical Parameters of a Luminaire.

I. Photometric Parameters: Photometric parameters of a luminaire encompass various measurements and characteristics that define how light is distributed, essential for assessing its performance and suitability for specific applications. Key photometric parameters include:

- Intensity Distribution: This parameter describes the distribution of light in different directions around the luminaire, often represented by polar diagrams

that show intensity at various angles.

- Light Distribution Curve: This curve illustrates how light intensity varies across horizontal and vertical planes, providing insight into the luminaire's performance in different orientations.
- Luminous Intensity: Measured in candelas (cd), this indicates the amount of light emitted in a specific direction, which is crucial for understanding how well the luminaire will illuminate an area.
- Beam Angle: This parameter defines the angle over which light is emitted, typically measured at points where the intensity drops to a certain percentage of its maximum.
- Colour Characteristics: Includes metrics like Correlated Colour Temperature (CCT) and Colour Rendering Index (CRI), which evaluate the color appearance and quality of the emitted light.
- Luminous Flux: The total amount of light emitted by the luminaire, measured in lumens (lm), is a fundamental measure of its output.
- Efficiency: Expressed in lumens per watt (lm/W), this indicates how effectively the luminaire converts electrical power into light output.
- Uniformity: This metric assesses how evenly light is distributed over a specified area, which is vital for minimizing glare and achieving consistent illumination.
- Glare Rating: Quantifies the potential discomfort caused by excessive brightness contrasts within the field of view, impacting visual comfort.
- Light Distribution Types: Specifies the nature of the light provided (direct, indirect, or semi-direct), influencing the luminaire's application suitability and overall visual comfort.

Photometric data is typically available in reports or product data sheets from manufacturers, assisting lighting designers and engineers in selecting the appropriate luminaires for specific projects.

II. Electrical Parameters: Electrical parameters refer to the characteristics associated with the luminaire's power consumption and operation within an electrical system. Important electrical parameters include:

- Voltage: The nominal operating voltage required for proper functioning, specified in volts (V).
- Power Consumption: The electrical power consumed at full capacity, measured in watts (W).
- Current Draw: The amount of current the luminaire requires from the power supply, easured in amperes (A).
- Power Factor: A dimensionless measure of the luminaire's efficiency in utilizing supplied electricity, expressed as a decimal or percentage.

- Operating Frequency: Relevant for fluorescent and LED luminaires that rely on specific electronic ballasts or drivers.
- Input Voltage Range: The safe operating voltage range, particularly important in regions with fluctuating voltage.
- Electrical Safety Ratings: Standards like IP (Ingress Protection) and IK (Impact Protection) that indicate resistance to dust, water ingress, and mechanical impacts.
- Electrical Connections: Specifications for installation methods, including terminals, connectors, and wiring requirements.
- Dimming Compatibility: Information regarding compatibility with dimming systems and supported protocols (e.g., 0-10V, DALI).
- Start-up Characteristics: Details about initial surge currents or time delays upon powering on.

These electrical parameters, typically found in product datasheets, are crucial for ensuring proper installation, operation, and maintenance of luminaires within electrical systems.

CHAPTER 4: SPORTS LIGHTING DESIGN AND STANDARDS

4.1 Design considerations of a sports lighting

The design of sports lighting is pivotal in enhancing visibility, performance, and safety in athletic venues. This complex task involves a multifaceted approach to ensure that lighting systems meet the unique requirements of various sports and environments. Below are the key considerations for effective sports lighting design, organized into distinct categories.

1. **Illumination Levels**

- General Lighting Levels: Different sports demand varying levels of illumination measured in lux. Professional-level sports, such as football and basketball, require significantly higher lux levels than recreational activities to ensure optimal visibility for players and spectators.
- Uniformity: Achieving uniform light distribution is critical to minimize shadows and prevent glare. Uneven lighting can hinder player performance and detract from the viewer experience, making uniformity a top priority in the design process.

2. **Lighting Distribution**

- Spotlights and Floodlights: An effective sports lighting system should combine spotlights and floodlights to cover the entire playing area comprehensively. Careful positioning and angling of these lights are essential to avoid creating direct glare for both players and spectators.
- Angle and Height: The appropriate angles and heights for mounting lights are crucial for ensuring comprehensive coverage. Typically, lights are installed on high poles or structures surrounding the field or court, which helps distribute light effectively across the playing area.

3. **Colour Temperature**

- White Light: Selecting lights with a colour temperature that replicates natural daylight (approximately 4000K to 6000K) helps reduce eye strain and improves visual clarity. This is particularly important in fast-paced sports where visual accuracy is vital.
- Colour Rendering Index (CRI): A high CRI is advantageous as it enhances the clarity and accuracy of colours, which is important for players and spectators alike. This ensures that players can accurately perceive the ball and other objects, improving gameplay.

4. **Glare Control**

- Shielding: Implementing shields or louvers can significantly minimize glare for players and spectators. Proper shielding directs light where it is needed, preventing unnecessary light spill into undesired areas.
- Light Fixtures: Choosing fixtures designed specifically to reduce glare enhances both

player performance and spectator comfort. Glare can be distracting and impair visibility, making glare control an essential element of sports lighting design.

5. **Energy Efficiency**

- LED Technology: Utilizing LED lights is recommended due to their energy efficiency and longer lifespan compared to traditional lighting options. LEDs also offer better control over light distribution and dimming, further enhancing their suitability for sports applications.
- Smart Controls: Implementing smart controls, such as dimming, scheduling, and motion sensors, can optimize energy usage and adapt the lighting to different needs and conditions. This not only saves energy but also improves the overall lighting quality.

6. **Maintenance and Durability**

- Weather Resistance: It is crucial to ensure that lighting fixtures are rated for outdoor use and can withstand various environmental conditions, including rain, wind, and extreme temperatures.
- Ease of Maintenance: Designing the lighting system for easy access and maintenance is important. Regular upkeep is essential for ensuring consistent performance and safety, making it easier to replace bulbs and perform repairs when necessary.

7. **Regulations and Standards**

- Compliance: Adherence to local and international standards for sports lighting, such as those from the Illuminating Engineering Society (IES) and the International Lighting Commission (CIE), is essential for ensuring the system meets safety and performance requirements.
- Event-Specific Requirements: Special consideration must be given to the specific lighting requirements for televised or high-profile events, which may impose stricter standards to ensure optimal visual quality for broadcasts.

8. **Aesthetic Considerations**

- Integration: The lighting design should complement the aesthetics of the venue and blend seamlessly with the surrounding environment. A well-integrated lighting system enhances the overall appeal of the sports facility.
- Spectator Experience: Ensuring that the lighting enhances the spectator experience is crucial. The system should provide a clear and engaging view of the event, making the atmosphere enjoyable for all attendees.

9. **Safety and Security**

- Emergency Lighting: Incorporating emergency lighting ensures safety during power outages or emergencies, allowing for safe evacuation and continued visibility.
- Surveillance: Adequate lighting enhances security around the venue by improving visibility for surveillance cameras and reducing the risk of accidents, contributing to a safer environment for players and spectators alike.

By addressing these comprehensive design considerations, sports lighting systems can be developed that enhance the playing experience, meet regulatory requirements, and provide a safe and enjoyable environment for all participants and viewers.

4.2 Approach to design sports lighting

Designing sports lighting requires a systematic, multi-step approach to meet the specific needs of the sport, venue, and its users. The following outlines the essential steps in developing an effective sports lighting system.

I. **Requirements Assessment**

- Sport-Specific Needs: Begin by identifying the sport and its lighting requirements, such as required illumination levels, field dimensions, and play type, as well as whether the setting is professional or recreational.
- Venue Details: Consider the venue type (e.g., stadium or indoor arena), its size, and existing infrastructure that might affect lighting.

II. **Site Assessment**

- Location Survey: Measure the area, noting any structures, such as stands or trees, that could impact lighting.
- Environmental Conditions: Evaluate factors like weather, potential for light pollution, and surrounding landscape characteristics.

III. **Determine Lighting Levels and Uniformity**

- Illumination Standards: Use industry standards to identify the required lux levels, ensuring they align with the sport's needs.
- Uniform Light Distribution: Design for uniform light distribution to minimize shadows and maintain consistent brightness.

IV. **Selection of Lighting Technology**

- Fixture Choice: Select appropriate fixtures (LED, metal halide) based on efficiency, longevity, and light quality.
- Colour Temperature and CRI: Choose daylight-like colour temperature (4000K–6000K) and a high Colour Rendering Index (CRI) to enhance visual clarity.

V. **Lighting Layout Design**

- Fixture Placement: Plan light arrangement using photometric software to simulate distribution.
- Height and Angle: Set mounting height and angle to optimize coverage and prevent glare.

VI. **Control Systems and Compliance**

- Smart Controls: Integrate dimming and automated scheduling for energy efficiency and adaptability.
- Regulatory Compliance: Ensure alignment with local and international standards, especially for high-profile events.

VII. **Maintenance and Validation**

- Ease of Maintenance: Design with accessibility in mind to facilitate upkeep.
- Testing and Adjustment: Validate the system post-installation and make adjustments as necessary.

VIII. **Monitoring and Optimization**

- Ongoing Evaluation: Regularly review performance and seek user feedback to maintain optimal lighting quality.

Following these steps helps create a lighting system that enhances player performance, spectator experience, and safety while meeting regulatory standards.

CHAPTER 5: SPORTS LIGHTING DESIGN OF A BADMINTON AND TENNIS PLAYGROUND

Case study - 1

5.1 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

$p \leq 0.2 \times 5 log d$

$= 0.93m$

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 center 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 9m.

So, $H = 9m$

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

$Eavg = (N \times \Phi \times Cu \times LLF)/A$

$N = (Eavg \times A) / (\Phi \times Cu \times LLF)$

$= (2000 \times 16 \times 9) / (105831 \times 0.4 \times 0.8)$

$= 8.5$

≈ 9

N = number of luminaires required

$Eavg$ = 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 9. But in case of dialux design the number of luminaires taken as 14. Because, with the help of 5 luminaires, all the values as per NLC 2010 can't be achieved.

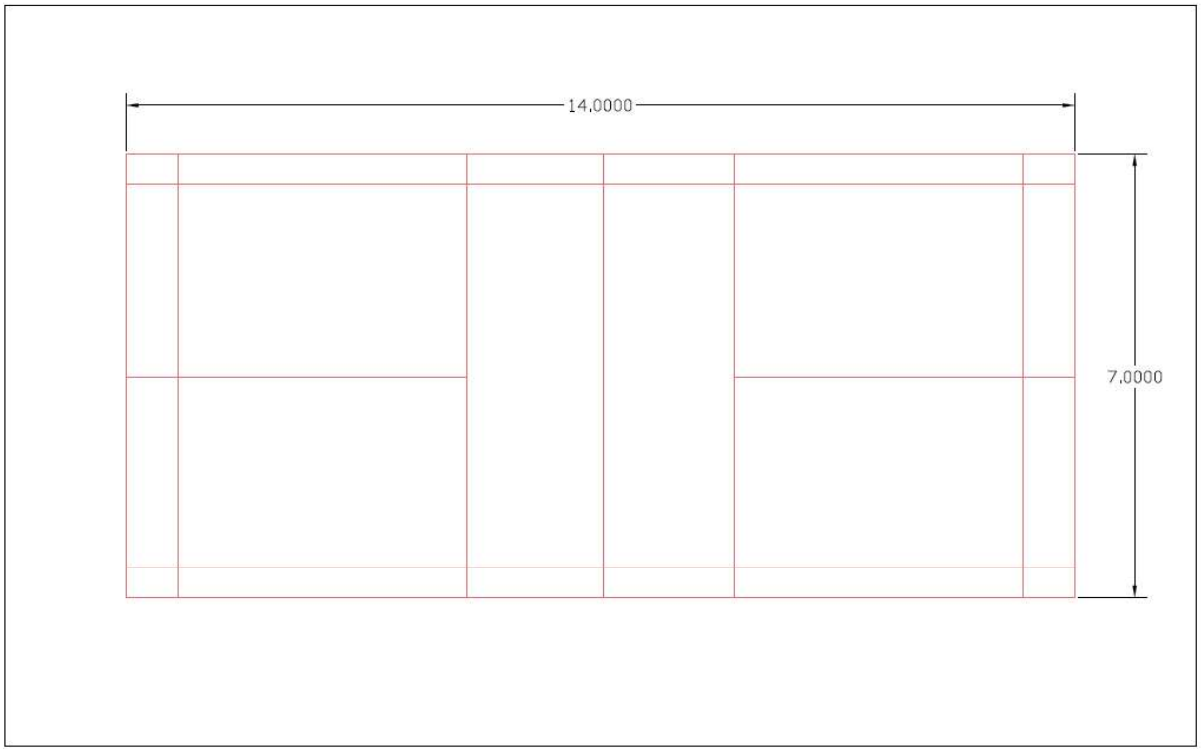
So, N = 14

Luminaire details = BEGA 1000W FLOOD LIGHT, wide beam, double asymmetric.

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}	2382	2110	279	1500-3000	1000-2000	500
E_V	2711	2398	316	2200	1000	-
E_{min}	2018	1802	237	-	-	-
E_{max}	2591	2284	302	-	-	-
U_1(Emin/max)	0.78	0.79	0.78	0.7	0.5	0.5
U_2(Emin/avg)	0.85	0.85	0.85	0.8	0.7	0.7

Layout of the playing area of a badminton court



Case study-2

5.2 Overview of a Tennis court

Dimension of the court

Total area (TA) = 24m x 11m

Estimation of grid dimension

$P \leq 0.2 \times 5\log d$

= 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

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

$= 8.13 \times \tan 25°$

= 3.79m

≈ 4m

H = average mounting height

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

$\theta = 20° - 25°$

From above the calculation, the value of mounting height of the pole is 4m. But in Dialux design the mounting height taken as 9m.

So, H = 9m

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

$Eavg = (N \times \Phi \times Cu \times LLF) / A$

$N = (Eavg \times A) / (\Phi \times Cu \times LLF)$

= (2000 × 24 ×11) / (105831 × 0.4 ×0.8)

= 15.59

≈ 16

N = number of luminaires required

$Eavg$ = 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 16. But in case of dialux design the number of luminaires taken as 32. Because, with the help of 16 luminaires, all the values as per NLC 2010 can't be achieved. Also to maintain the proper ULR appropriate number of luminaires needed.

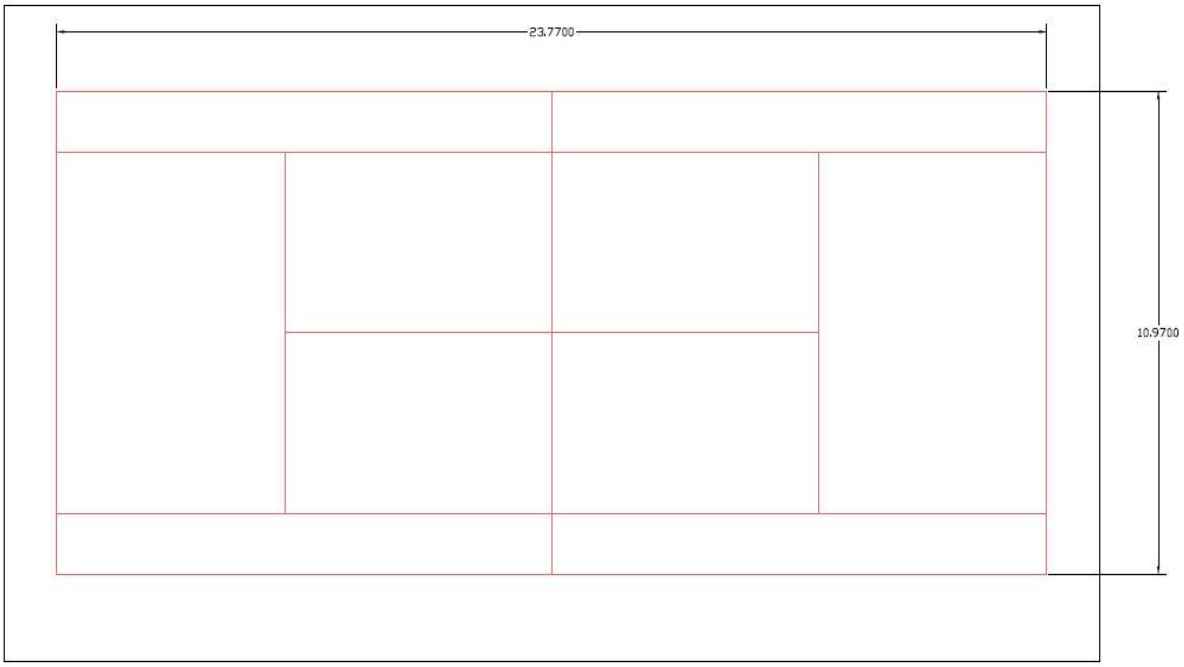
So, N = 32

Luminaire details = BEGA 1000W FLOOD LIGHT, wide beam, double asymmetric.

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}	1842	1612	253	1500-3000	1000-2000	500
E_V	1897	1660	261	2200	1000	-
E_{min}	1745	1528	241	-	-	-
E_{max}	1916	1676	264	-	-	-
U_1(Emin/max)	0.91	0.91	0.91	0.7	0.5	0.5
U_2(Emin/avg)	0.95	0.95	0.95	0.8	0.7	0.7

Layout of the playing area of a Tennis court



Chapter 6: SPORTS LIGHTING DESIGN METHODOLOGY

Sports Lighting Design Methodology

Designing outdoor sports lighting requires a structured approach to optimize player performance, safety, and the spectator experience. This methodology provides a comprehensive framework for creating an effective sports lighting system that meets technical, environmental, and regulatory requirements.

I. **Defining Project Scope and Requirements**

- Sport-Specific Requirements: Identify the lighting needs for the specific sport (e.g., soccer, tennis, badminton) and the level of play (recreational, professional).

- Field Dimensions: Measure the field or court to ensure accurate fixture placement.

- Lighting Standards: Follow relevant standards from bodies like the International Tennis Federation or regional regulations.

II. **Site Analysis**

- Site Survey: Identify obstacles such as trees or buildings that may affect lighting.
- Environmental Conditions: Assess local weather patterns, daylight hours, and potential light pollution.

III. **Selection of Lighting Fixtures**

- Choosing Fixtures: Use suitable lighting technologies (e.g., LEDs, high-intensity discharge lamps).
- Consider: Luminaire Efficiency: Balancing brightness and energy consumption.
- Beam Angles: Wide, narrow, or medium beams depending on coverage needs.
- Durability: Ensure fixtures are weather-resistant and easy to maintain.
- Photometric Data: Collect photometric files (e.g., IES or LDT files) for accurate modeling.

IV. **Lighting Layout Design**

- Create a Model: Utilize design software (e.g., DIALux, AGi32) to build a 3D model of the sports field.
- Luminaire Placement: Place fixtures strategically to ensure uniform coverage:
- Corner Placement: Fixtures at field corners.
- Perimeter Placement: Along the field's sides or boundaries.
- Overhead/Mast Placement: High-mounted lights for large fields.

V. **Configuring Lighting Parameters**

- Fixture Height and Angles: Adjust height, tilt, and orientation to reduce shadows and maximize coverage.
- Illuminance Levels: Set illuminance based on the sport's requirements:
- Recreational: 200–300 lux.
- Professional: 500–1000 lux, depending on competition level.

VI. **Simulations and Performance Analysis**

- Generate Simulations: Use software to run simulations for the designed layout.
- Evaluate Key Metrics:
- Average Illuminance: Measure brightness consistency.
- Uniformity Ratio: Ensure even lighting (target ratio ≥ 0.6).
- Glare: Minimize glare for players and spectators.

VII. **Design Optimization**

- Adjustments: Refine luminaire placement or settings based on simulation feedback.
- Re-Simulation: Validate improvements through further simulations.

VIII. **Documentation and Compliance**

- Generate Reports:

Include:

- Lighting Plans: Diagrams showing fixture placement.
- Illuminance Data: Details on light levels and uniformity.
- Compliance: Verification with standards and regulations.

Review:

- Ensure documentation aligns with project requirements.

IX. **Installation Planning and Supervision**

- Prepare Installation Specifications: Detail mounting heights, fixture types, and electrical requirements.
- Oversee Installation: Ensure the setup follows the design specifications.

X. **Post-Installation Evaluation**

- Performance Verification: Confirm that the installed system meets design expectations.
- Adjustments: Fine-tune angles or settings as needed based on real-world performance.

XI. **Maintenance and Upkeep**

- Develop a Maintenance Plan: Schedule regular inspections and maintenance to ensure optimal performance.
- Monitor for Issues: Address problems promptly and ensure ongoing compliance with standards.

This methodology ensures a well-planned, efficient lighting system that enhances performance and safety while meeting regulatory requirements. Through proper site analysis, fixture selection, simulations, and maintenance planning, the lighting design will remain effective over time, providing reliable illumination for both players and spectators.

CHAPTER 7: RESULTS AND ANALYSIS

7.1 Comparing and Analysis the data

Proper lighting is crucial for tennis and badminton, as it must meet the specific needs of players, officials, and spectators. The table provided compares lighting requirements with actual results, focusing on key parameters for International, National, and Practice matches for both sports. This comparison highlights the differences between standard lighting guidelines and the achieved outcomes, ensuring that the lighting design satisfies the performance and visibility criteria for all levels of competition.

In the case of **Badminton**, the lighting design has successfully met the standard requirements across all match levels:

- For **International matches**, the average illuminance achieved is 2382 lux for the playing area (PA) and 2348 lux for the total area (TA), both of which meet the standard requirements with sufficient uniformity.
- Similarly, for **National** and **Practice matches**, appropriate illuminance values and uniformity have been achieved for both PA and TA.
- In all cases, the vertical illuminance for camera operations meets the required standards for proper telecasting.
- The maximum glare values are below 30 for all match types, ensuring good visibility for players and officials.
- The **Upward Light Ratio (ULR)** is below 7% for international (1%), national (0.5%), and practice (1.5%) matches, indicating minimal upward light spillage. Overall, the lighting design ensures glare-free vision and optimal playing conditions for all levels of badminton matches.

For **Tennis**, the results are similarly effective:

- For **International matches**, the average illuminance is 1842 lux with a uniformity of 0.95, both within the acceptable range for proper playing conditions.
- **National** and **Practice matches** have achieved average illuminance values of 1612 lux and 253 lux, respectively, aligning with the standards for those levels.
- Illuminance under the camera vertical is suitable for telecasting in both international and national matches.
- Maximum glare values remain below 30 across all match types, well within the acceptable limit of 50 for glare-free vision.
- ULR remains below 7% for all match levels, ensuring minimal upward light pollution.

In summary, the achieved values for both badminton and tennis confirm that the lighting design is appropriate for glare-free vision, telecasting requirements, and optimal playing conditions for international, national, and practice matches.

7.2 Observed sports lighting design challenges

Designing indoor sports lighting using DIALux 4.13 presents several challenges, each requiring careful consideration to meet performance standards and practical requirements. These challenges include:

1. **Accurate Field Representation**
   - Challenge: Creating a precise 3D model of the sports field with accurate dimensions and features.
   - Solution: Utilize detailed field measurements and CAD files to ensure accurate modeling.

2. **Uniform Light Distribution**
   - Challenge: Achieving consistent light coverage across the entire field, avoiding shadows and dark spots.
   - Solution: Experiment with different fixture placements and heights using DIALux's simulation tools. Adjust the design based on light distribution analysis.

3. **Illuminance Levels**
   - Challenge: Meeting the required illuminance levels for different sports and ensuring uniform distribution across the field.
   - Solution: Input accurate photometric data for selected fixtures and adjust placement according to simulation results. Reference sports lighting standards for target illuminance levels.

4. **Glare Management**
   - Challenge: Reducing glare to prevent discomfort and distraction for players and spectators.
   - Solution: Use fixtures with glare control features, adjusting angles and shielding. Simulate glare in DIALux and refine the design accordingly.

5. **Light Pollution Control**
   - Challenge: Minimizing light spill and controlling light pollution to prevent affecting surrounding areas.
   - Solution: Incorporate cutoff or shielded fixtures, model the surrounding environment, and adjust the design to limit light spill.

6. **Fixture and Cable Integration**
   - Challenge: Integrating lighting fixtures with existing infrastructure and managing cable routes.
   - Solution: Coordinate with installation teams to ensure compatibility with existing structures. Plan cable routes carefully within the design model.

7. **Realistic Simulation**
- Challenge: Ensuring simulations accurately reflect real-world lighting conditions.
- Solution: Validate design by comparing simulated results with actual field conditions and make necessary adjustments.

8. **Software Limitations**
- Challenge: DIALux 4.13 may have limitations in handling complex environments or advanced lighting scenarios.
- Solution: Supplement DIALux with additional tools if needed and stay updated on software versions and enhancements.

By addressing these challenges, an effective indoor sports lighting design can be achieved, ensuring optimal performance and compliance with relevant standards.

CHAPTER 8: CONCLUSION AND FUTURE SCOPE

In conclusion, the design of effective indoor sports lighting for badminton and tennis courts requires a comprehensive approach that addresses key factors such as proper illuminance, uniform light distribution, and glare control. Achieving optimal lighting conditions involves strategic fixture placement, effective light pollution management, and the use of advanced simulation tools to ensure precision and performance. These factors are essential not only for enhancing player performance but also for improving the overall experience of spectators and officials.

Adherence to established lighting standards is critical in creating lighting designs that meet the specific requirements of each sport, while continuous updates on technological advancements play a pivotal role in maintaining efficiency. The integration of smart controls, dynamic lighting adjustments, and eco-friendly solutions such as energy-efficient LEDs or solar-assisted lighting will further contribute to sustainable lighting designs that reduce environmental impact without compromising performance.

By leveraging cutting-edge simulation tools, lighting designs can be optimized to address challenges such as maintaining consistent illuminance levels, reducing glare, and controlling light spill. These efforts ensure that the lighting system enhances both the functionality and visual quality of the sports environment. Moreover, as technology evolves, future lighting designs should integrate regular updates and innovations to ensure long-term performance, energy efficiency, and sustainability.

Ultimately, the combination of advanced lighting technologies and well-considered design practices will lead to the development of sports lighting systems that not only support players' and spectators' needs but also contribute to environmental sustainability and energy conservation, positioning them as future-ready solutions for indoor sports facilities.

The future of indoor sports lighting for tennis and badminton using BEGA 1000W LED lights will enhance precision, performance, and energy efficiency. BEGA LEDs will incorporate advanced optics for precise light control, minimizing glare and shadows, which is vital for high-performance sports. Integration with sensors and smart controls will enable dynamic, real-time lighting adjustments based on game conditions, ensuring optimal visibility. These LEDs will also offer superior energy efficiency with high lumen output per watt, while sustainable technologies, such as solar-assisted lighting, will reduce environmental impact.

Durability, customization, and sustainability will be central to BEGA 1000W LED designs. These lights will require minimal maintenance and have a long lifespan, lowering operational costs. Programmable features and remote operation capabilities will allow flexibility in adjusting lighting for different events. With reduced light pollution, eco-friendly materials, and circadian-optimized lighting, BEGA LEDs will contribute to sustainability goals, making them a promising solution for the future of indoor sports lighting.

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- Badminton Court Lighting, https://www.hindlighting.com/blogs/news/badminton-court-lighting-sports-lights-indoor-outdoor-badminton-court-lighting (seen on 05-05-2024)
- LED Tennis Court Lighting Layout & Design Guide, Sports venue calculator
- 2024 Ultimate Guide to Tennis Court Lighting Layout & Design, Stouchlighting
- Tennis court lighting, https://sxlighting.com/en/blog/iluminacao-para-quadras-de-tenis/ (seen on 08-06-2024)
- Specifications for International standard facilities, **BWF (Badminton World Federation)**
- X-H Lee, J-T Yang et al. 'An LED-based luminaire for badminton court illumination', Lighting Res. Technol. 2015; 0: 1-11
- Jane Preema Salis et al. 'Lighting Design Of An Indoor Sports Facility- A Case Study', 2019 Second International Conference on Advanced Computational and Communication Paradigms (ICACCP)
- Badminton Lighting, https://www.agcled.com/applications/badminton-lighting.html (seen on 02-07-2024)
- R. A. Hargroves, M. Trezzi, I. C. Henry, 'Glare Evaluation of Tennis Court Floodlighting', SAGE Journals
- How to Choose the Right Lights for Badminton Courts, Wosen Lighting Technology Limited
- Lighting for Badminton Halls, Trilux
- Guide to Tennis Court Lighting, MKLights
- A Complete Guide To Tennis Court Lighting, LUXIFIC
- Ultimate Guide: Badminton Court Lighitng Design & Cost, https://www.enkarl.com/ultimate-guide-badminton-court-lighting-design-cost/ (seen on 10-07-2024)

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Table of contents

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Table of contents

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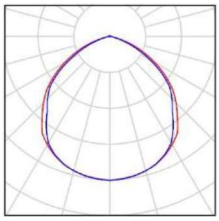
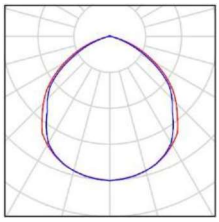
SAHARIYAR KABIR BADMINTON / Luminaire parts list

26 Pieces	BEGA 1000W FLOOD LIGHT BEGA (Type 1) Article No.: Luminous flux (Luminaire): 105679 lm Luminous flux (Lamps): 105831 lm Luminaire Wattage: 1000.0 W Luminaire classification according to CIE: 100 CIE flux code: 54 87 99 100 100 Fitting: 1 x User defined (Correction Factor 1.000).	See our luminaire catalog for an image of the luminaire.	
8 Pieces	BEGA 200W FLOOD LIGHT BEGA Article No.: Luminous flux (Luminaire): 21136 lm Luminous flux (Lamps): 21166 lm Luminaire Wattage: 195.6 W Luminaire classification according to CIE: 100 CIE flux code: 54 87 99 100 100 Fitting: 1 x User defined (Correction Factor 1.000).	See our luminaire catalog for an image of the luminaire.	

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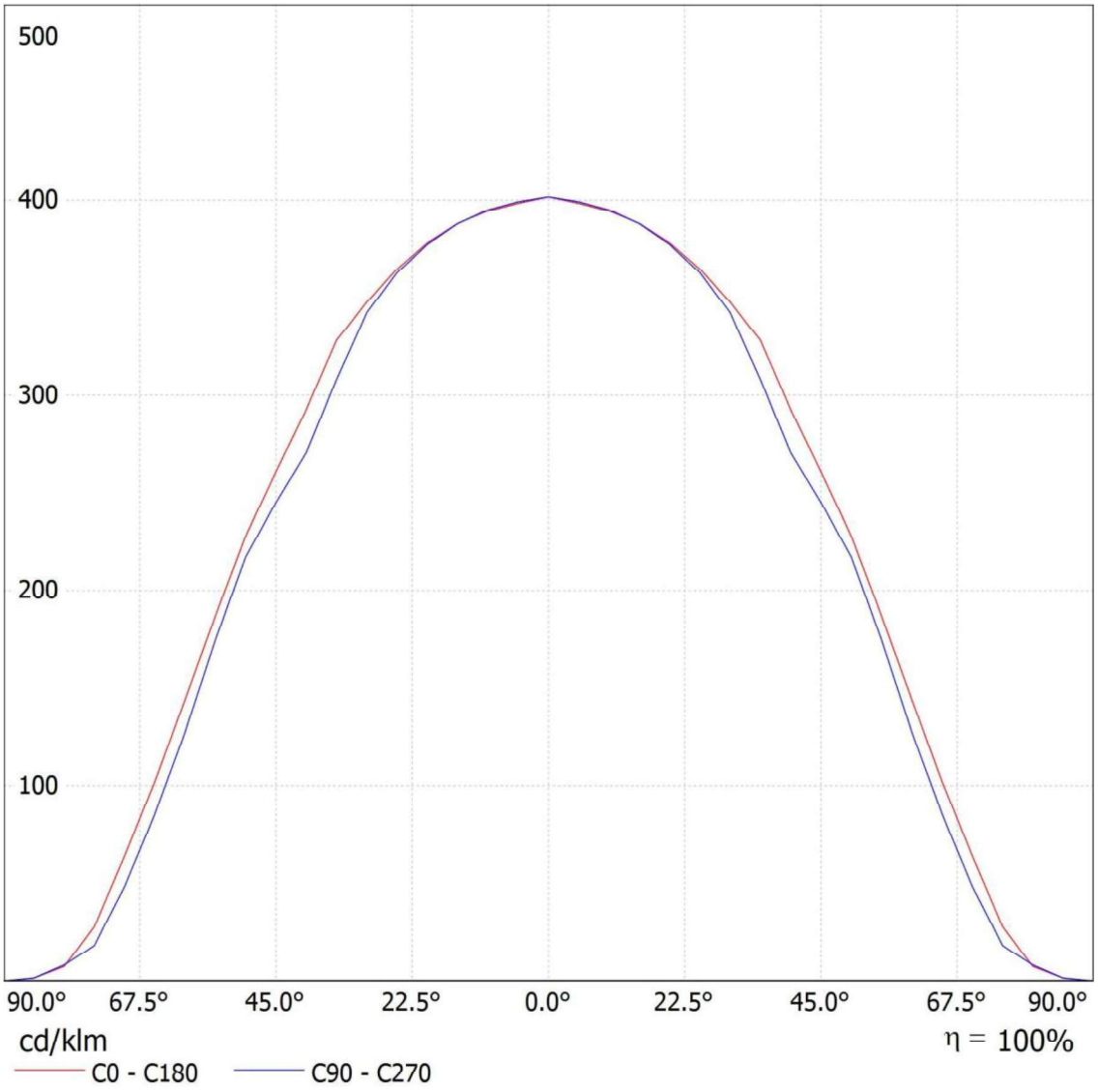
BEGA 1000W FLOOD LIGHT BEGA / LDC (Linear)

Luminaire: BEGA 1000W FLOOD LIGHT BEGA
Lamps: 1 x



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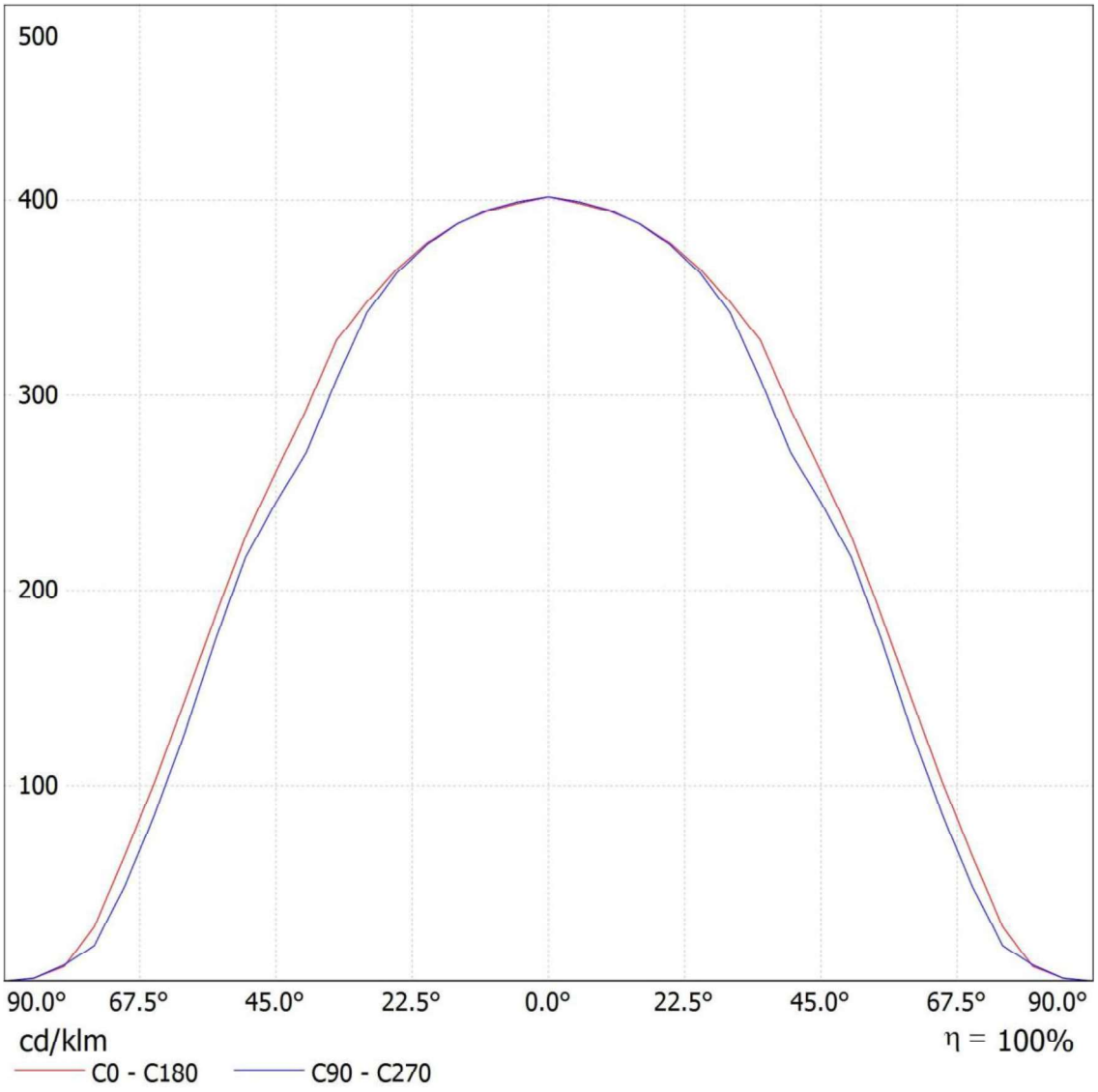
BEGA 200W FLOOD LIGHT BEGA / LDC (Linear)

Luminaire: BEGA 200W FLOOD LIGHT BEGA
Lamps: 1 x



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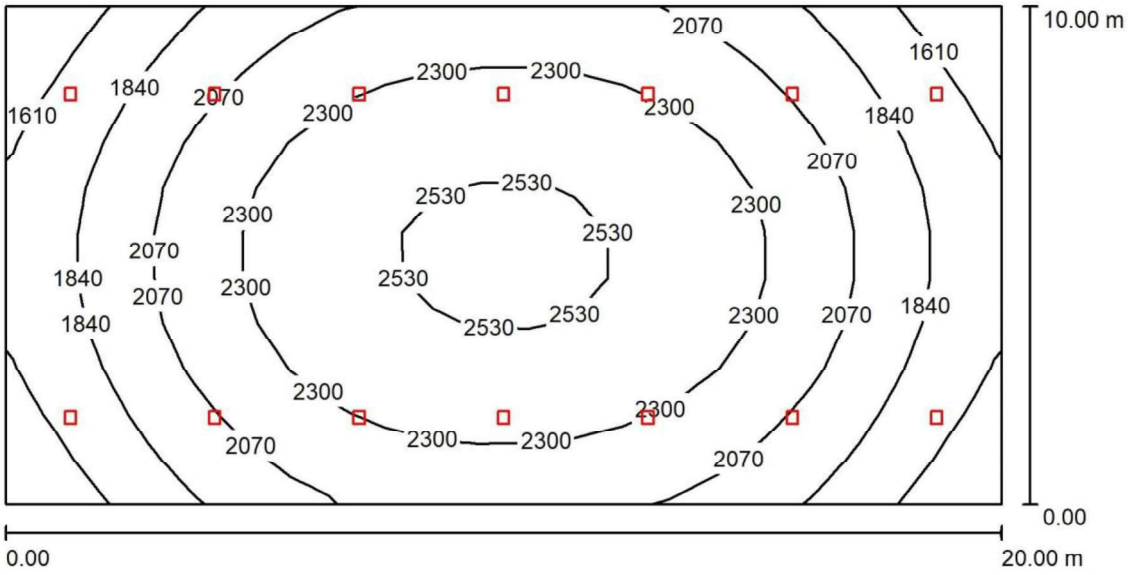
INTER NATIONAL BADMINTON / Summary



Height of Room: 12.000 m, Mounting Height: 10.500 m, Light loss factor: 0.80

Values in Lux, Scale 1:143

Surface	r [%]	E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0
Workplane	/	2114	1446	2583	0.684
Floor	10	2117	1376	2582	0.650
Ceiling	30	251	174	341	0.692
Walls (4)	20	1327	161	5195	/

Workplane:

Height:	0.000 m
Grid:	21 x 11 Points
Boundary Zone:	0.000 m

Illuminance Quotient (according to LG7): Walls / Working Plane: 0.627, Ceiling / Working Plane: 0.119.

Luminaire Parts List

No.	Pieces	Designation (Correction Factor)	F (Luminaire) [lm]	F (Lamps) [lm]	P [W]
1	14	BEGA 1000W FLOOD LIGHT BEGA (Type 1)* (1.000)	105679	105831	1000.0
*Modified Technical Specifications			Total: 1479499	Total: 1481638	14000.0

Specific connected load: 70.00 W/m² = 3.31 W/m²/100 lx (Ground area: 200.00 m²)

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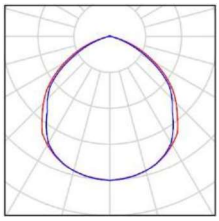
INTER NATIONAL BADMINTON / Luminaire parts list

14 Pieces BEGA 1000W FLOOD LIGHT BEGA (Type 1)

Article No.:
Luminous flux (Luminaire): 105679 lm
Luminous flux (Lamps): 105831 lm
Luminaire Wattage: 1000.0 W
Luminaire classification according to CIE: 100
CIE flux code: 54 87 99 100 100
Fitting: 1 x User defined (Correction Factor 1.000).

See our luminaire catalog for an image of the luminaire.



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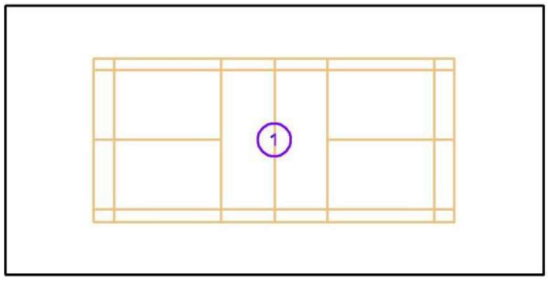
INTER NATIONAL BADMINTON / Sport Sites (Coordinates List)

Badminton



No.	Position [m]			Size Playing Area [m]		Size Total Area [m]		Rotation [°]		
	X	Y	Z	L	W	L	W	X	Y	Z
1	10.000	5.000	0.000	13.400	6.100	14.010	6.710	0.0	0.0	0.0

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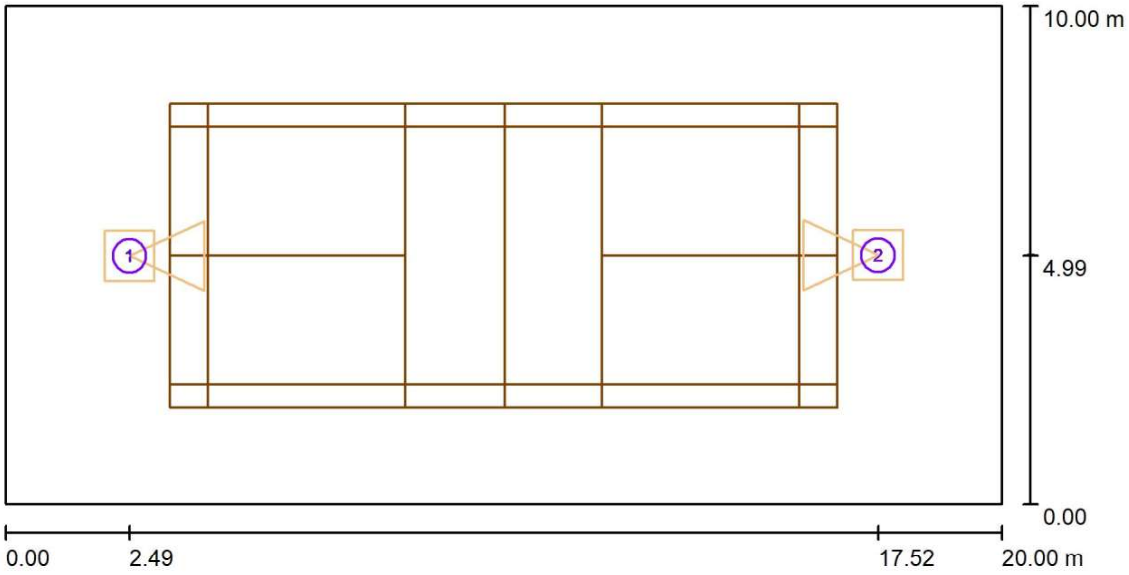
INTER NATIONAL BADMINTON / TV Cameras (Coordinates List)



Scale 1 : 143

List of the TV Cameras

No.	Designation	Position [m]		
		X	Y	Z
1	TV Camera 2	2.490	4.993	2.500
2	TV Camera 2	17.517	5.008	2.500

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INTER NATIONAL BADMINTON / Photometric Results

Total Luminous Flux: 1479499 lm
Total Load: 14000.0 W
Light loss factor: 0.80
Boundary Zone: 0.000 m

Surface	Average illuminances [lx]			Reflection factor [%]	Average luminance [cd/m²]
	direct	indirect	total		
Workplane	1910	204	2114	/	/
Floor	1910	207	2117	10	67
Ceiling	13	238	251	30	24
Wall 1	1162	214	1376	20	88
Wall 2	1008	221	1230	20	78
Wall 3	1162	219	1380	20	88
Wall 4	1008	213	1221	20	78

Uniformity on the working plane
u0: 0.684 (1:1)
E_{min} / E_{max}: 0.560 (1:2)

Illuminance Quotient (according to LG7): Walls / Working Plane: 0.627, Ceiling / Working Plane: 0.119.

Specific connected load: 70.00 W/m² = 3.31 W/m²/100 lx (Ground area: 200.00 m²)

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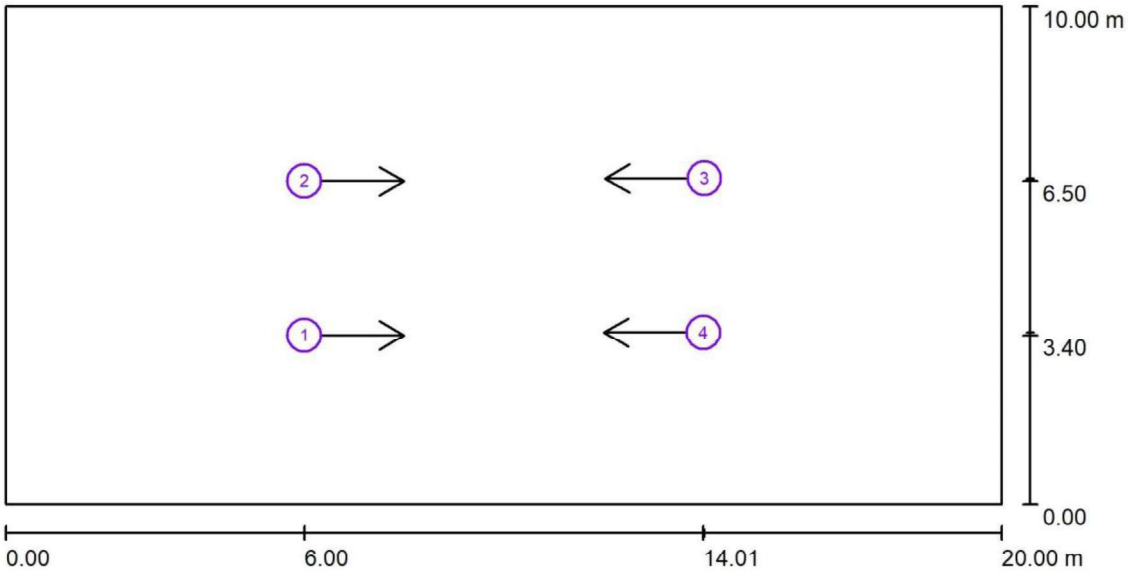
INTER NATIONAL BADMINTON / UGR Observer (results overview)



Scale 1 : 143

UGR Calculation Points List

No.	Designation	Position [m] X	Y	Z	Viewing direction [°]	Value
1	UGR Calculation Point 1	6.000	3.400	1.200	0.0	>30
2	UGR Calculation Point 1	6.000	6.500	1.200	0.0	>30
3	UGR Calculation Point 1	14.035	6.555	1.200	180.0	>30
4	UGR Calculation Point 1	14.012	3.455	1.200	180.0	>30

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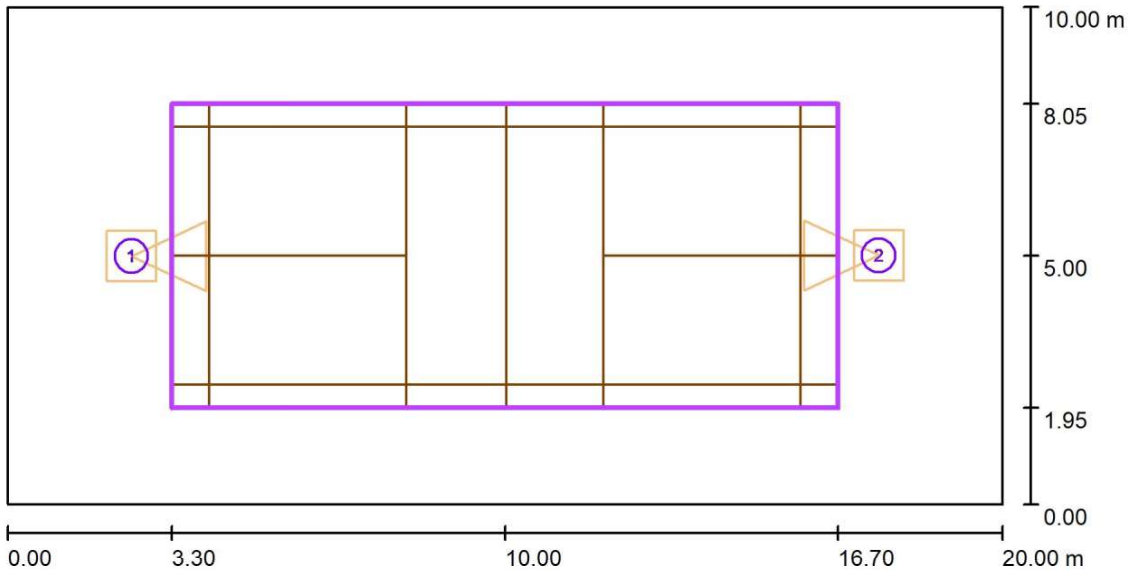
INTER NATIONAL BADMINTON / Badminton 1 Calculation Grid (PA) / Summary



Scale 1 : 143

Position: (10.000 m, 5.000 m, 0.000 m)
Size: (13.400 m, 6.100 m)
Rotation: (0.0°, 0.0°, 0.0°)
Type: Normal, Grid: 27 x 13 Points
Belongs to the following sport arena: Badminton 1

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	2382	2018	2591	0.85	0.78	/	0.000	/
2	vertical, 0.0°	736	331	994	0.45	0.33	3.24	1.500	/
3	Camera	1330	1202	2003	0.90	0.60	1.79	1.000	1
4	Camera	1103	1014	1678	0.92	0.60	2.16	1.000	2

$E_{h\,m}/E_m$ = Relationship between middle horizontal and vertical illuminance, H = Measuring Height

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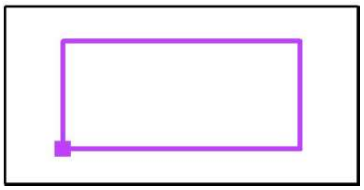
INTER NATIONAL BADMINTON / Badminton 1 Calculation Grid (PA) / Gradient Graphics (E, Horizontal)

Values in %, Scale 1 : 96

Not all calculated values could be displayed.

Position of surface in room:
Marked point: (3.300 m, 1.950 m, 0.00 m)



Maximum Change: 6%
Selected Limit Value: 20% (Values below this limit value are not output.)
Distance for the Gradient Grid: 1.000 m

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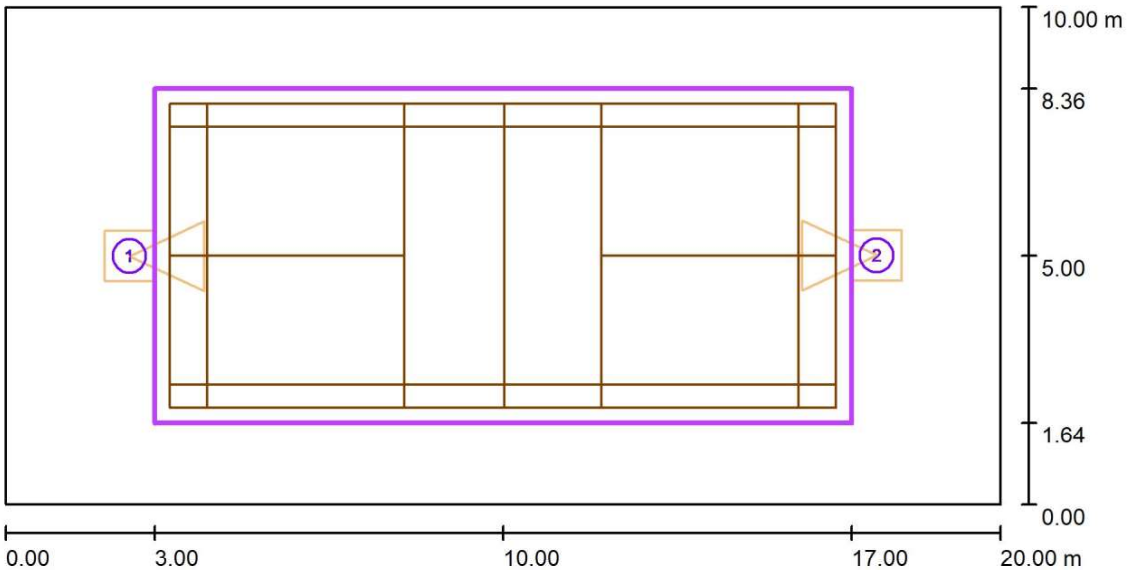
INTER NATIONAL BADMINTON / Badminton 1 Calculation Grid (TA) / Summary



Scale 1 : 143

Position: (10.000 m, 5.000 m, 0.000 m)
Size: (14.010 m, 6.710 m)
Rotation: (0.0°, 0.0°, 0.0°)
Type: Normal, Grid: 29 x 14 Points
Belongs to the following sport arena: Badminton 1

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	2348	1926	2590	0.82	0.74	/	0.000	/
2	vertical, 0.0°	689	281	959	0.41	0.29	3.41	1.000	/
3	Camera	1343	1186	2131	0.88	0.56	1.75	1.000	1
4	Camera	1119	1014	1969	0.91	0.52	2.10	1.000	2

$E_{h\,m}/E_m$ = Relationship between middle horizontal and vertical illuminance, H = Measuring Height

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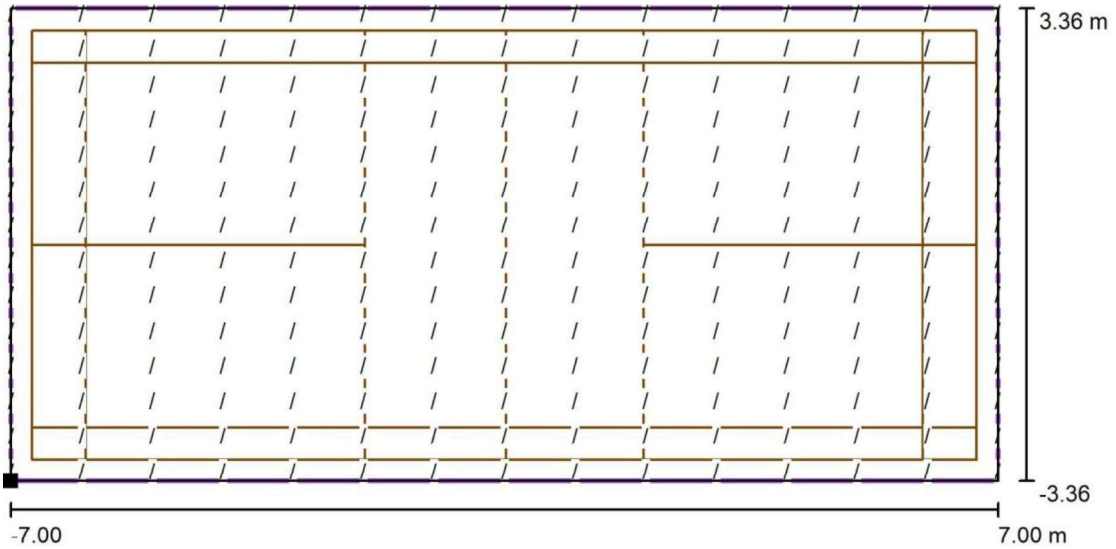
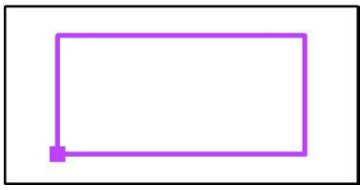
INTER NATIONAL BADMINTON / Badminton 1 Calculation Grid (TA) / Gradient Graphics (E, Horizontal)



Values in %, Scale 1 : 101

Not all calculated values could be displayed.

Position of surface in room:
Marked point: (2.995 m, 1.645 m, 0.00 m)



Maximum Change: 7%
Selected Limit Value: 20% (Values below this limit value are not output.)
Distance for the Gradient Grid: 1.000 m

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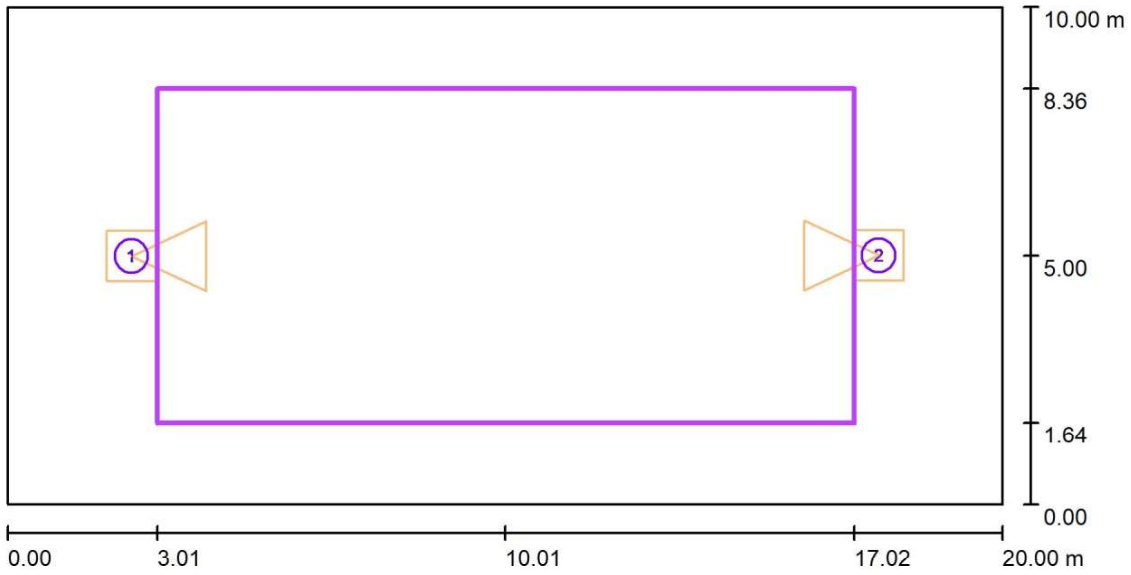
INTER NATIONAL BADMINTON / VERTICAL GRID / Summary



Scale 1 : 143

Position: (10.012 m, 5.002 m, 1.500 m)
Size: (14.008 m, 6.719 m)
Rotation: (0.0°, 0.0°, 0.0°)
Type: Normal, Grid: 29 x 14 Points

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	2711	2208	2992	0.81	0.74	/	0.000	/
2	vertical, 0.0°	816	345	1103	0.42	0.31	3.32	1.000	/
3	Camera	1168	1049	2026	0.90	0.52	2.32	1.000	1
4	Camera	879	379	1103	0.43	0.34	3.08	1.000	2

E_h $_m/E_m$ = Relationship between middle horizontal and vertical illuminance, H = Measuring Height

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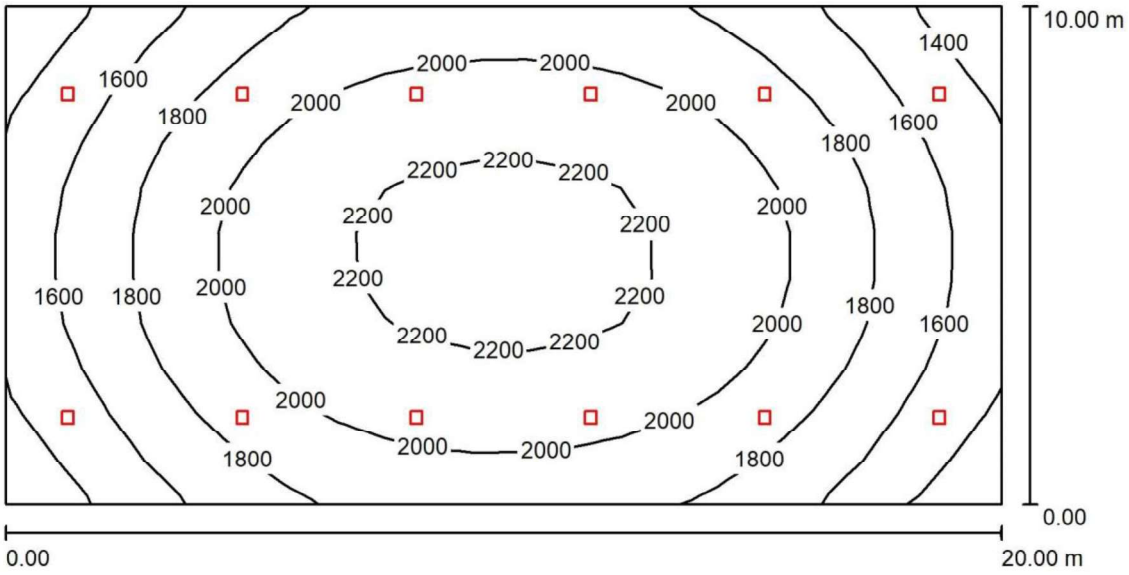
NATIONAL BADMINTON / Summary



Height of Room: 12.000 m, Mounting Height: 10.000 m, Light loss factor: 0.80

Values in Lux, Scale 1:143

Surface	r [%]	E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0
Workplane	/	1878	1297	2274	0.691
Floor	10	1879	1225	2277	0.652
Ceiling	30	205	151	256	0.737
Walls (4)	20	1120	127	5527	/

Workplane:

Height:	0.000 m
Grid:	21 x 11 Points
Boundary Zone:	0.000 m

Illuminance Quotient (according to LG7): Walls / Working Plane: 0.596, Ceiling / Working Plane: 0.109.

Luminaire Parts List

No.	Pieces	Designation (Correction Factor)	F (Luminaire) [lm]	F (Lamps) [lm]	P [W]
1	12	BEGA 1000W FLOOD LIGHT BEGA (Type 1)* (1.000)	105679	105831	1000.0
*Modified Technical Specifications			Total: 1268142	Total: 1269976	12000.0

Specific connected load: 60.00 W/m² = 3.19 W/m²/100 lx (Ground area: 200.00 m²)

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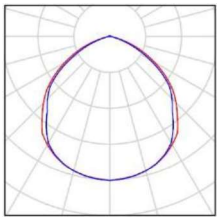
NATIONAL BADMINTON / Luminaire parts list

12 Pieces BEGA 1000W FLOOD LIGHT BEGA (Type 1)

Article No.:
Luminous flux (Luminaire): 105679 lm
Luminous flux (Lamps): 105831 lm
Luminaire Wattage: 1000.0 W
Luminaire classification according to CIE: 100
CIE flux code: 54 87 99 100 100
Fitting: 1 x User defined (Correction Factor 1.000).

See our luminaire catalog for an image of the luminaire.



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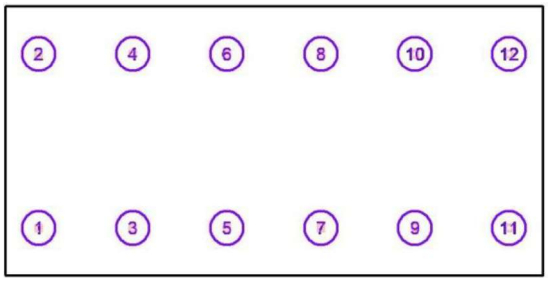
NATIONAL BADMINTON / Luminaires (coordinates list)

BEGA 1000W FLOOD LIGHT BEGA (Type 1)

105679 lm, 1000.0 W, 1 x 1 x User defined (Correction Factor 1.000).



No.	Position [m]			Rotation [°]		
	X	Y	Z	X	Y	Z
1	1.250	1.750	10.000	0.0	0.0	90.0
2	1.250	8.250	10.000	0.0	0.0	90.0
3	4.750	1.750	10.000	0.0	0.0	90.0
4	4.750	8.250	10.000	0.0	0.0	90.0
5	8.250	1.750	10.000	0.0	0.0	90.0
6	8.250	8.250	10.000	0.0	0.0	90.0
7	11.750	1.750	10.000	0.0	0.0	90.0
8	11.750	8.250	10.000	0.0	0.0	90.0
9	15.250	1.750	10.000	0.0	0.0	90.0
10	15.250	8.250	10.000	0.0	0.0	90.0
11	18.750	1.750	10.000	0.0	0.0	90.0
12	18.750	8.250	10.000	0.0	0.0	90.0

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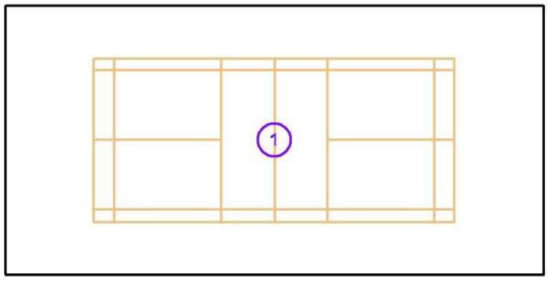
NATIONAL BADMINTON / Sport Sites (Coordinates List)

Badminton



No.	Position [m]			Size Playing Area [m]		Size Total Area [m]		Rotation [°]		
	X	Y	Z	L	W	L	W	X	Y	Z
1	10.000	5.000	0.000	13.400	6.100	14.010	6.710	0.0	0.0	0.0

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NATIONAL BADMINTON / Photometric Results

Total Luminous Flux: 1268142 lm
Total Load: 12000.0 W
Light loss factor: 0.80
Boundary Zone: 0.000 m

Surface	Average illuminances [lx]			Reflection factor [%]	Average luminance [cd/m²]
	direct	indirect	total		
Workplane	1700	178	1878	/	/
Floor	1699	180	1879	10	60
Ceiling	11	195	205	30	20
Wall 1	964	183	1147	20	73
Wall 2	878	189	1067	20	68
Wall 3	964	188	1152	20	73
Wall 4	878	182	1059	20	67

Uniformity on the working plane
u0: 0.691 (1:1)
E_{min} / E_{max}: 0.570 (1:2)

Illuminance Quotient (according to LG7): Walls / Working Plane: 0.596, Ceiling / Working Plane: 0.109.

Specific connected load: 60.00 W/m² = 3.19 W/m²/100 lx (Ground area: 200.00 m²)

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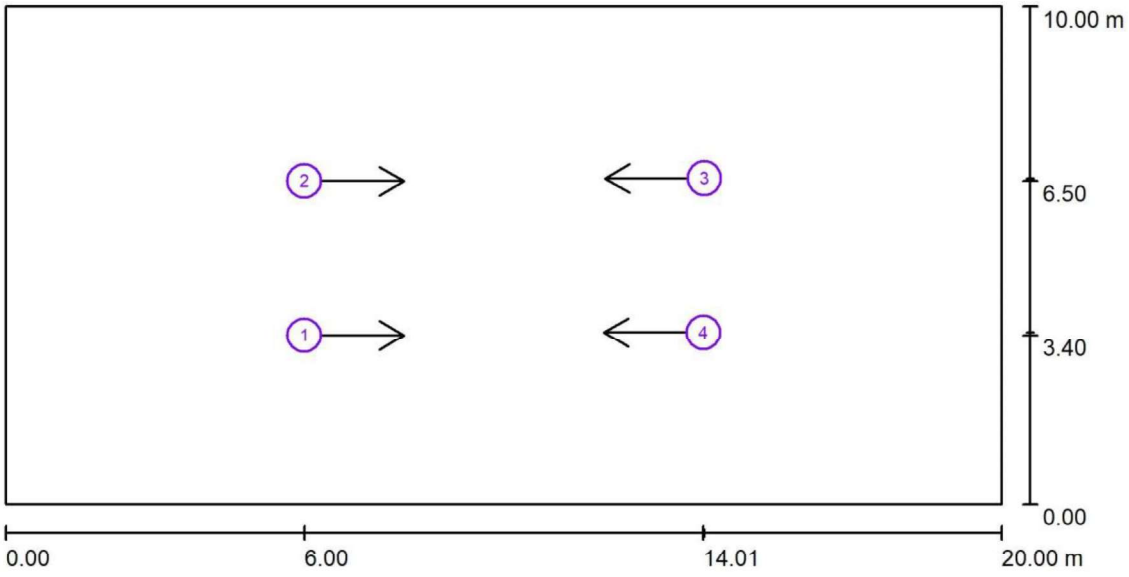
NATIONAL BADMINTON / UGR Observer (results overview)



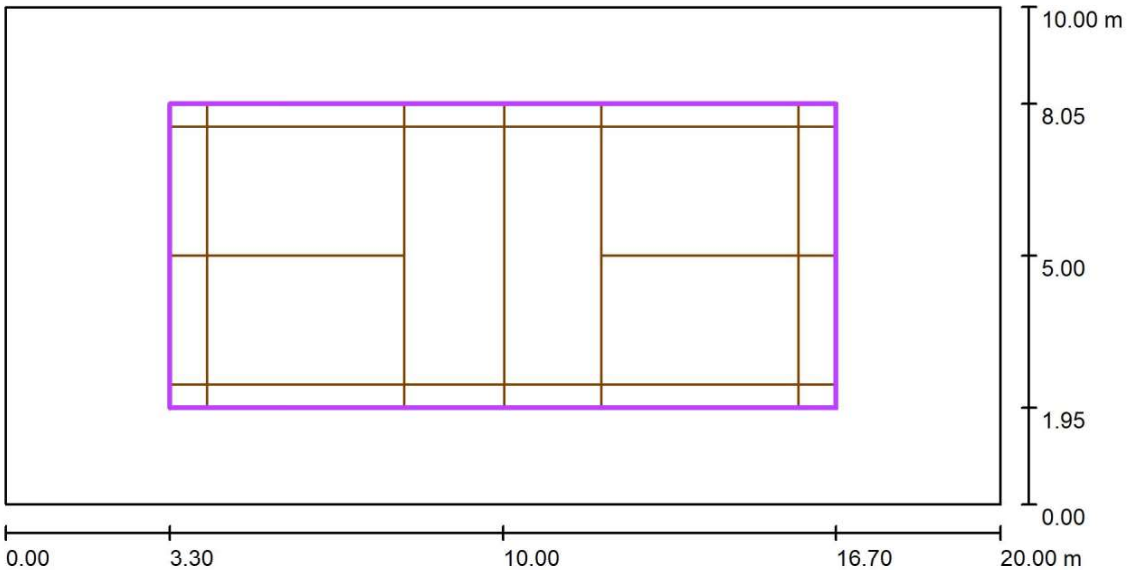
Scale 1 : 143

UGR Calculation Points List

No.	Designation	Position [m] X	Y	Z	Viewing direction [°]	Value
1	UGR Calculation Point 1	6.000	3.400	1.200	0.0	>30
2	UGR Calculation Point 1	6.000	6.500	1.200	0.0	>30
3	UGR Calculation Point 1	14.035	6.555	1.200	180.0	>30
4	UGR Calculation Point 1	14.012	3.455	1.200	180.0	>30

Operator
Telephone
Fax
e-Mail

NATIONAL BADMINTON / Badminton 1 Calculation Grid (PA) / Summary



Scale 1 : 143

Position: (10.000 m, 5.000 m, 0.000 m)
Size: (13.400 m, 6.100 m)
Rotation: (0.0°, 0.0°, 0.0°)
Type: Normal, Grid: 27 x 13 Points
Belongs to the following sport arena: Badminton 1

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	2110	1802	2284	0.85	0.79	/	0.000	/
2	vertical, 0.0°	672	332	883	0.49	0.38	3.14	1.500	/

$E_{h\,m}/E_m$ = Relationship between middle horizontal and vertical illuminance, H = Measuring Height

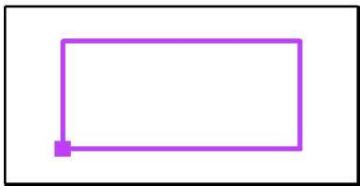
Operator
Telephone
Fax
e-Mail

NATIONAL BADMINTON / Badminton 1 Calculation Grid (PA) / Gradient Graphics (E, Horizontal)

Values in %, Scale 1 : 96

Not all calculated values could be displayed.

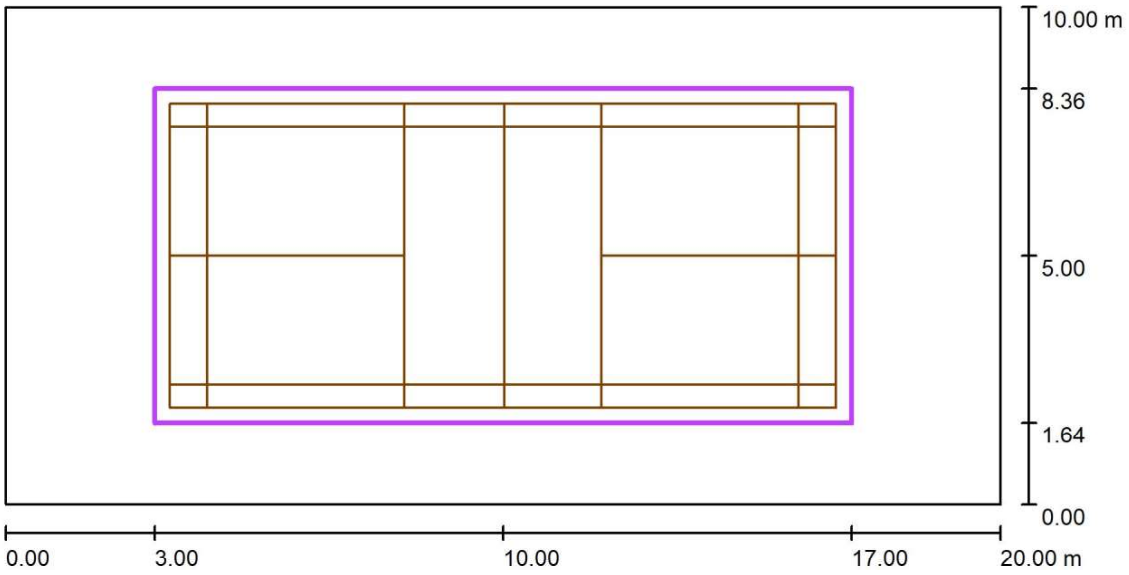
Position of surface in room:
Marked point: (3.300 m, 1.950 m, 0.00 m)



Maximum Change: 6%
Selected Limit Value: 20% (Values below this limit value are not output.)
Distance for the Gradient Grid: 1.000 m

Operator
Telephone
Fax
e-Mail

NATIONAL BADMINTON / Badminton 1 Calculation Grid (TA) / Summary



Scale 1 : 143

Position: (10.000 m, 5.000 m, 0.000 m)
Size: (14.010 m, 6.710 m)
Rotation: (0.0°, 0.0°, 0.0°)
Type: Normal, Grid: 29 x 14 Points
Belongs to the following sport arena: Badminton 1

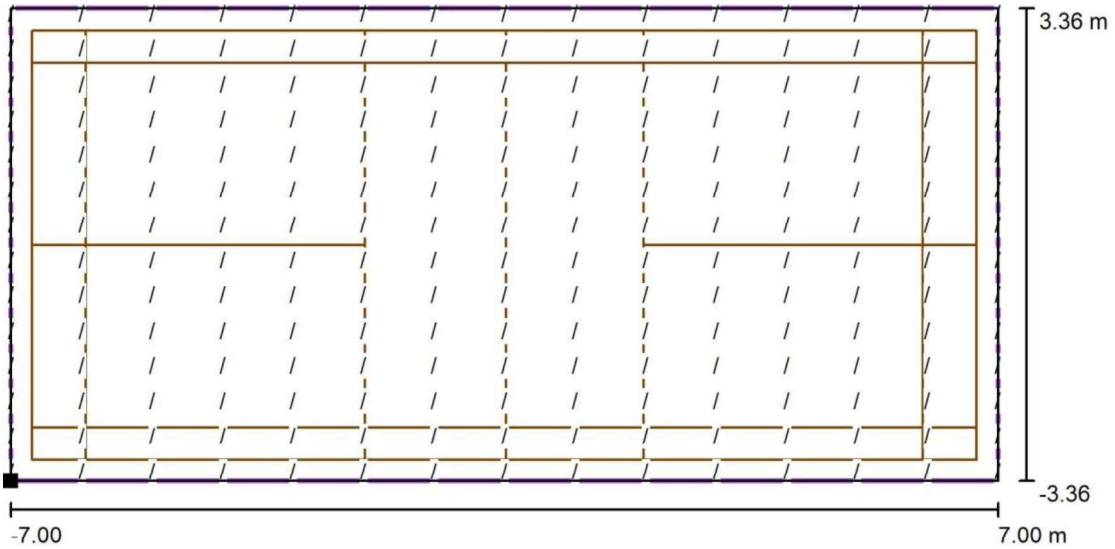
Results overview

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	2081	1722	2283	0.83	0.75	/	0.000	/
2	vertical, 0.0°	628	276	850	0.44	0.33	3.31	1.000	/

$E_{h\,m}/E_m$ = Relationship between middle horizontal and vertical illuminance, H = Measuring Height

Operator
Telephone
Fax
e-Mail

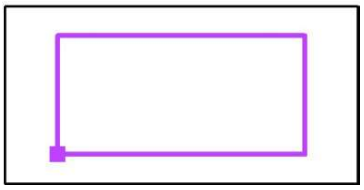
NATIONAL BADMINTON / Badminton 1 Calculation Grid (TA) / Gradient Graphics (E, Horizontal)



Values in %, Scale 1 : 101

Not all calculated values could be displayed.

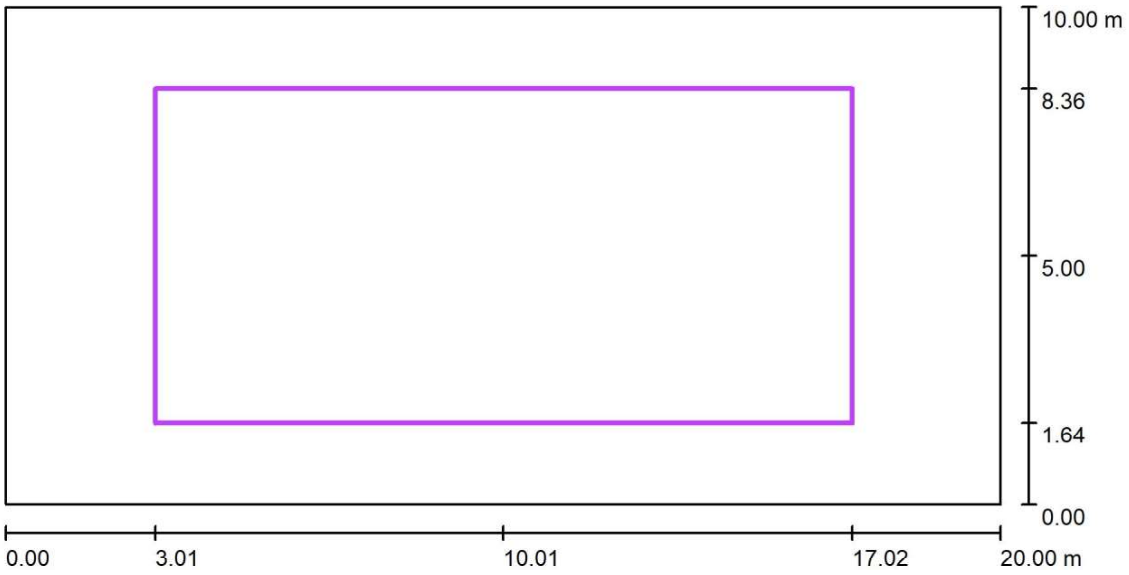
Position of surface in room:
Marked point: (2.995 m, 1.645 m, 0.00 m)



Maximum Change: 7%
Selected Limit Value: 20% (Values below this limit value are not output.)
Distance for the Gradient Grid: 1.000 m

Operator
Telephone
Fax
e-Mail

NATIONAL BADMINTON / VERTICAL GRID / Summary



Scale 1 : 143

Position: (10.012 m, 5.002 m, 1.500 m)
Size: (14.008 m, 6.719 m)
Rotation: (0.0°, 0.0°, 0.0°)
Type: Normal, Grid: 29 x 14 Points

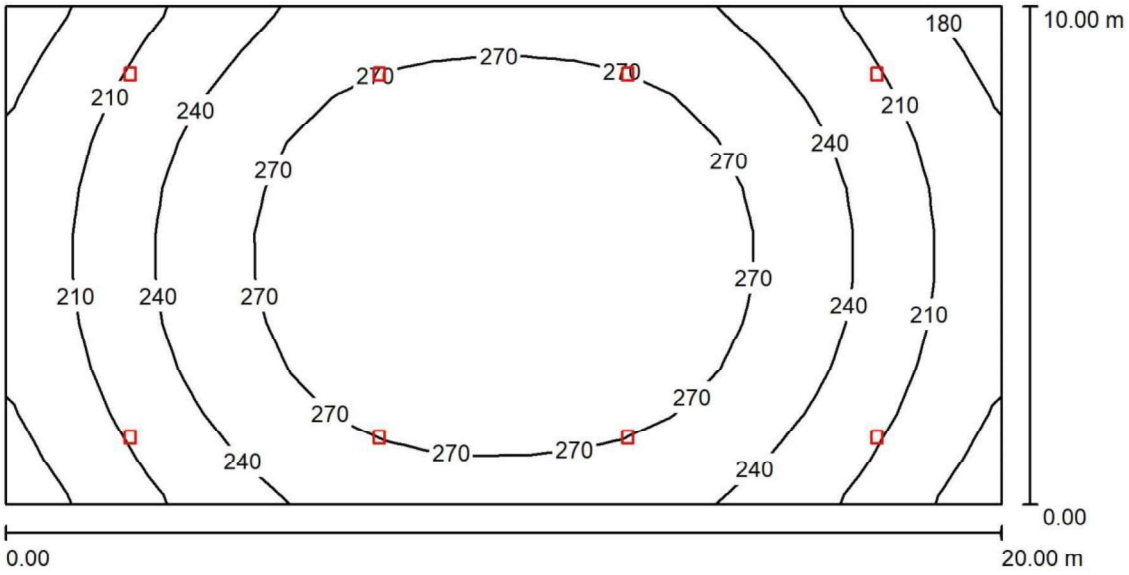
Results overview

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	2398	1985	2626	0.83	0.76	/	0.000	/
2	vertical, 0.0°	744	350	975	0.47	0.36	3.22	1.000	/

$E_{h\ m}/E_m$ = Relationship between middle horizontal and vertical illuminance, H = Measuring Height

Operator
Telephone
Fax
e-Mail

TRANING BADMINTON / Summary



Height of Room: 12.000 m, Mounting Height: 10.000 m, Light loss factor: 0.80

Values in Lux, Scale 1:143

Surface	r [%]	E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0
Workplane	/	248	172	299	0.692
Floor	10	248	160	300	0.644
Ceiling	30	28	19	37	0.690
Walls (4)	20	150	18	992	/

Workplane:

Height:	0.000 m
Grid:	21 x 11 Points
Boundary Zone:	0.000 m

Illuminance Quotient (according to LG7): Walls / Working Plane: 0.604, Ceiling / Working Plane: 0.114.

Luminaire Parts List

No.	Pieces	Designation (Correction Factor)	F (Luminaire) [lm]	F (Lamps) [lm]	P [W]
1	8	BEGA 200W FLOOD LIGHT BEGA (1.000)	21136	21166	195.6
			Total: 169086	Total: 169330	1564.8

Specific connected load: 7.82 W/m² = 3.15 W/m²/100 lx (Ground area: 200.00 m²)

Operator
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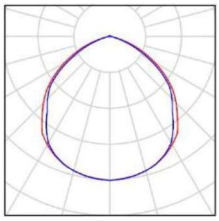
Fax
e-Mail

TRANING BADMINTON / Luminaire parts list

8 Pieces	BEGA 200W FLOOD LIGHT BEGA Article No.: Luminous flux (Luminaire): 21136 lm Luminous flux (Lamps): 21166 lm Luminaire Wattage: 195.6 W Luminaire classification according to CIE: 100 CIE flux code: 54 87 99 100 100 Fitting: 1 x User defined (Correction Factor 1.000).	See our luminaire catalog for an image of the luminaire.



Operator
Telephone
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e-Mail

TRANING BADMINTON / Photometric Results

Total Luminous Flux: 169086 lm
Total Load: 1564.8 W
Light loss factor: 0.80
Boundary Zone: 0.000 m

Surface	Average illuminances [lx]			Reflection factor [%]	Average luminance [cd/m²]
	direct	indirect	total		
Workplane	225	23	248	/	/
Floor	225	24	248	10	7.90
Ceiling	1.41	27	28	30	2.69
Wall 1	139	24	163	20	10
Wall 2	99	26	125	20	7.94
Wall 3	139	25	164	20	10
Wall 4	99	25	124	20	7.88

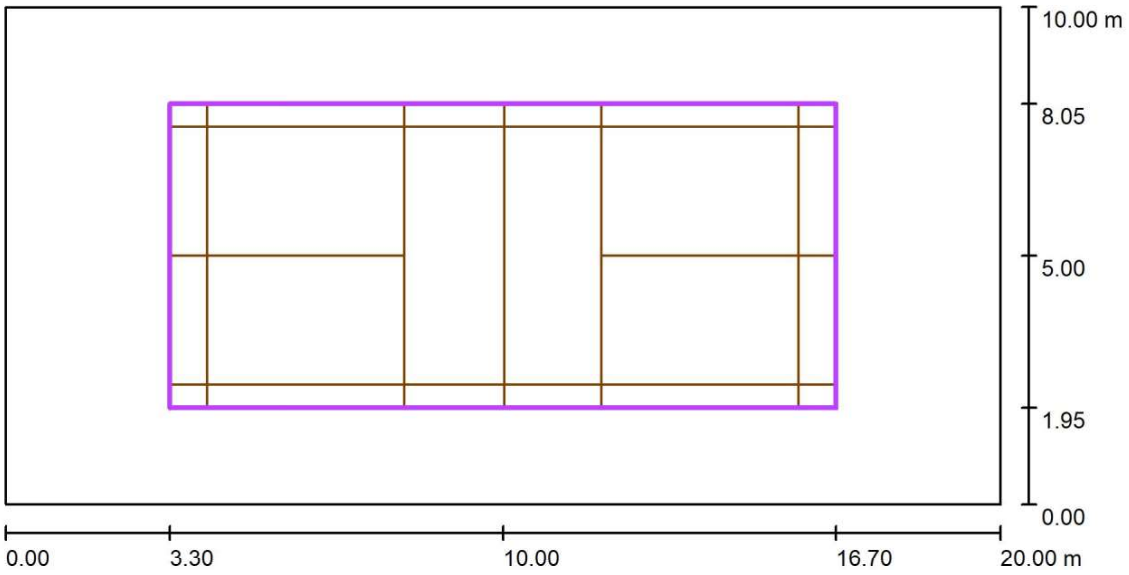
Uniformity on the working plane
u0: 0.692 (1:1)
E_{min} / E_{max}: 0.574 (1:2)

Illuminance Quotient (according to LG7): Walls / Working Plane: 0.604, Ceiling / Working Plane: 0.114.

Specific connected load: 7.82 W/m² = 3.15 W/m²/100 lx (Ground area: 200.00 m²)

Operator
Telephone
Fax
e-Mail

TRANING BADMINTON / Badminton 1 Calculation Grid (PA) / Summary



Scale 1 : 143

Position: (10.000 m, 5.000 m, 0.000 m)
Size: (13.400 m, 6.100 m)
Rotation: (0.0°, 0.0°, 0.0°)
Type: Normal, Grid: 27 x 13 Points
Belongs to the following sport arena: Badminton 1

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	279	237	302	0.85	0.78	/	0.000	/

$E_{h\,m}/E_m$ = Relationship between middle horizontal and vertical illuminance, H = Measuring Height

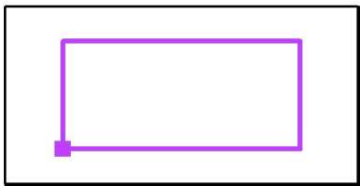
Operator
Telephone
Fax
e-Mail

TRANING BADMINTON / Badminton 1 Calculation Grid (PA) / Gradient Graphics (E, Horizontal)

Values in %, Scale 1 : 96

Not all calculated values could be displayed.

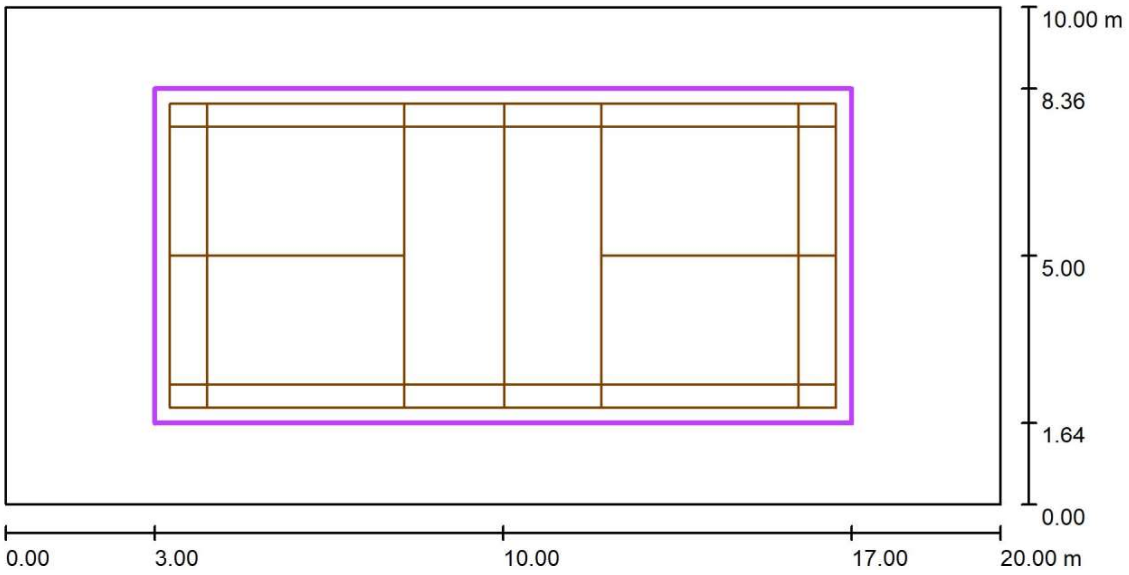
Position of surface in room:
Marked point: (3.300 m, 1.950 m, 0.000 m)



Maximum Change: 6%
Selected Limit Value: 20% (Values below this limit value are not output.)
Distance for the Gradient Grid: 1.000 m

Operator
Telephone
Fax
e-Mail

TRANING BADMINTON / Badminton 1 Calculation Grid (TA) / Summary



Scale 1 : 143

Position: (10.000 m, 5.000 m, 0.000 m)
Size: (14.010 m, 6.710 m)
Rotation: (0.0°, 0.0°, 0.0°)
Type: Normal, Grid: 29 x 14 Points
Belongs to the following sport arena: Badminton 1

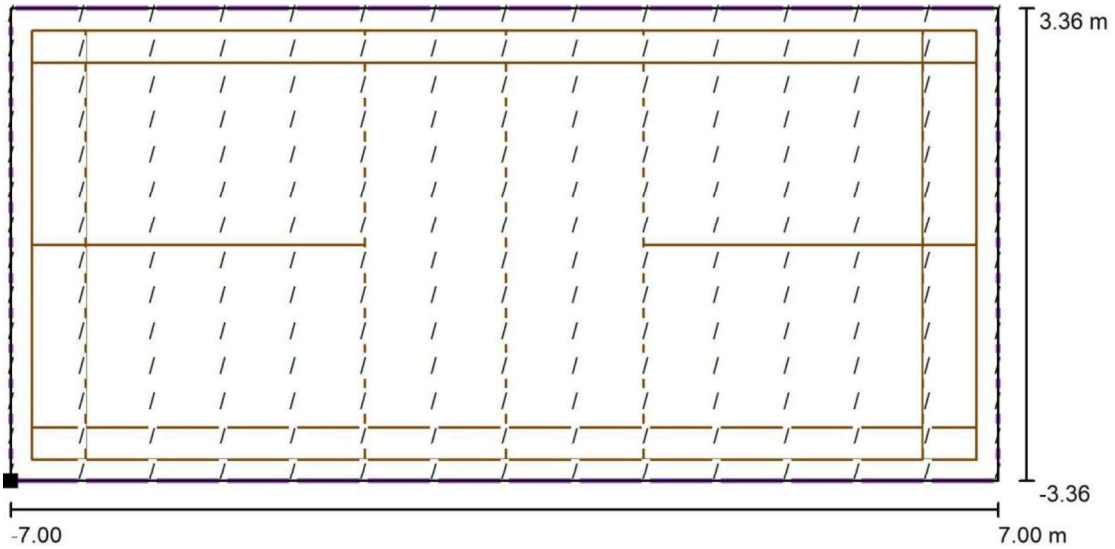
Results overview

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	275	227	302	0.82	0.75	/	0.000	/

$E_{h\,m}/E_m$ = Relationship between middle horizontal and vertical illuminance, H = Measuring Height

Operator
Telephone
Fax
e-Mail

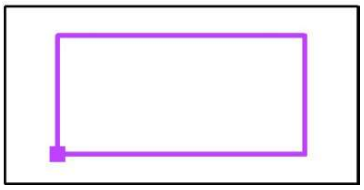
TRANING BADMINTON / Badminton 1 Calculation Grid (TA) / Gradient Graphics (E, Horizontal)



Values in %, Scale 1 : 101

Not all calculated values could be displayed.

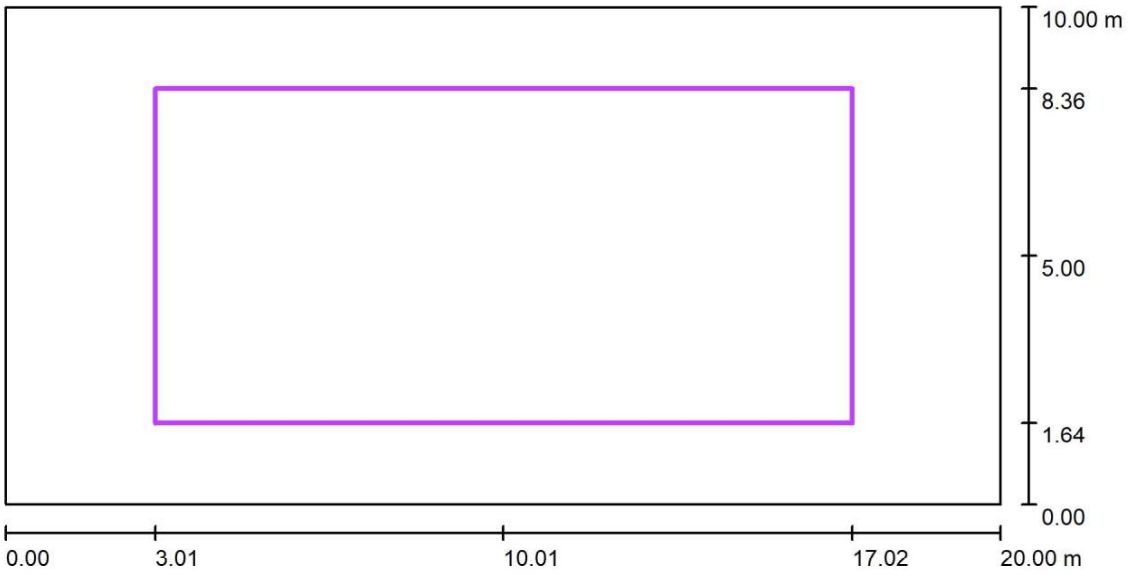
Position of surface in room:
Marked point: (2.995 m, 1.645 m, 0.000 m)



Maximum Change: 7%
Selected Limit Value: 20% (Values below this limit value are not output.)
Distance for the Gradient Grid: 1.000 m

Operator
Telephone
Fax
e-Mail

TRANING BADMINTON / VERTICAL GRID / Summary



Scale 1 : 143

Position: (10.012 m, 5.002 m, 1.500 m)
Size: (14.008 m, 6.719 m)
Rotation: (0.0°, 0.0°, 0.0°)
Type: Normal, Grid: 29 x 14 Points

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	316	261	345	0.83	0.76	/	0.000	/

$E_{h\,m}/E_m$ = Relationship between middle horizontal and vertical illuminance, H = Measuring Height

SPORTS LIGHTING DESIGN DETAILS FOR TENNIS COURT

DESIGN REFERENCE NO:

Date: 06.11.2024
Operator: SAHARIYAR KABIR

Operator
Telephone
Fax
e-Mail

Table of contents

Operator
Telephone
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Table of contents

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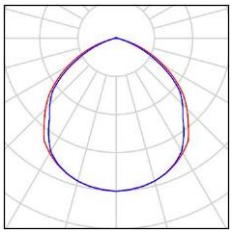
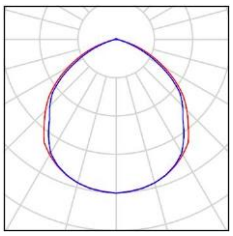
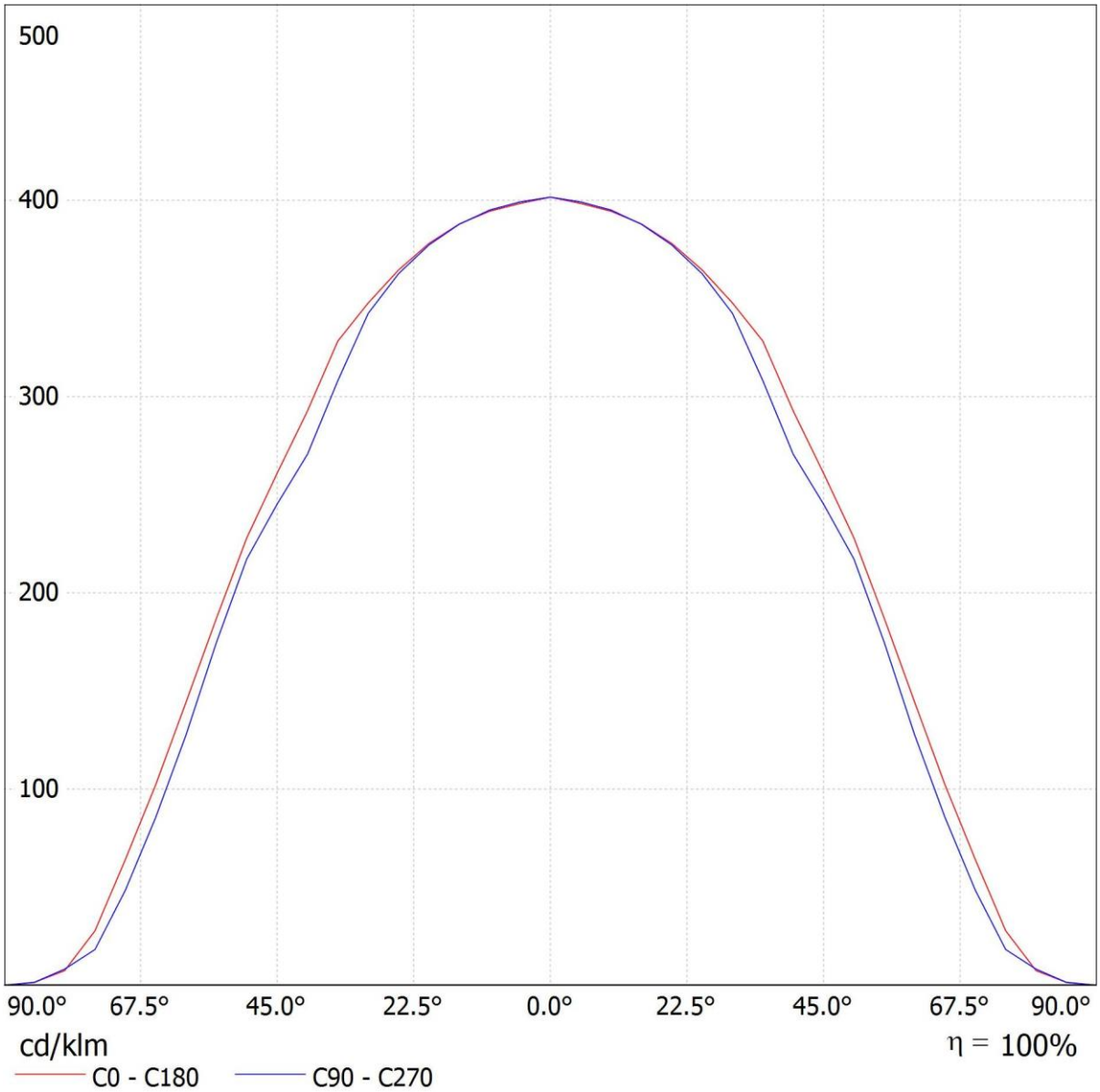
SAHARIYAR KABIR TENNIS / Luminaire parts list

60 Pieces	BEGA 1000W FLOOD LIGHT BEGA (Type 1) Article No.: Luminous flux (Luminaire): 105679 lm Luminous flux (Lamps): 105831 lm Luminaire Wattage: 1000.0 W Luminaire classification according to CIE: 100 CIE flux code: 54 87 99 100 100 Fitting: 1 x User defined (Correction Factor 1.000).	See our luminaire catalog for an image of the luminaire.	
22 Pieces	BEGA 200W FLOOD LIGHT BEGA Article No.: Luminous flux (Luminaire): 21136 lm Luminous flux (Lamps): 21166 lm Luminaire Wattage: 195.6 W Luminaire classification according to CIE: 100 CIE flux code: 54 87 99 100 100 Fitting: 1 x User defined (Correction Factor 1.000).	See our luminaire catalog for an image of the luminaire.	

Operator
Telephone
Fax
e-Mail

BEGA 1000W FLOOD LIGHT BEGA / LDC (Linear)

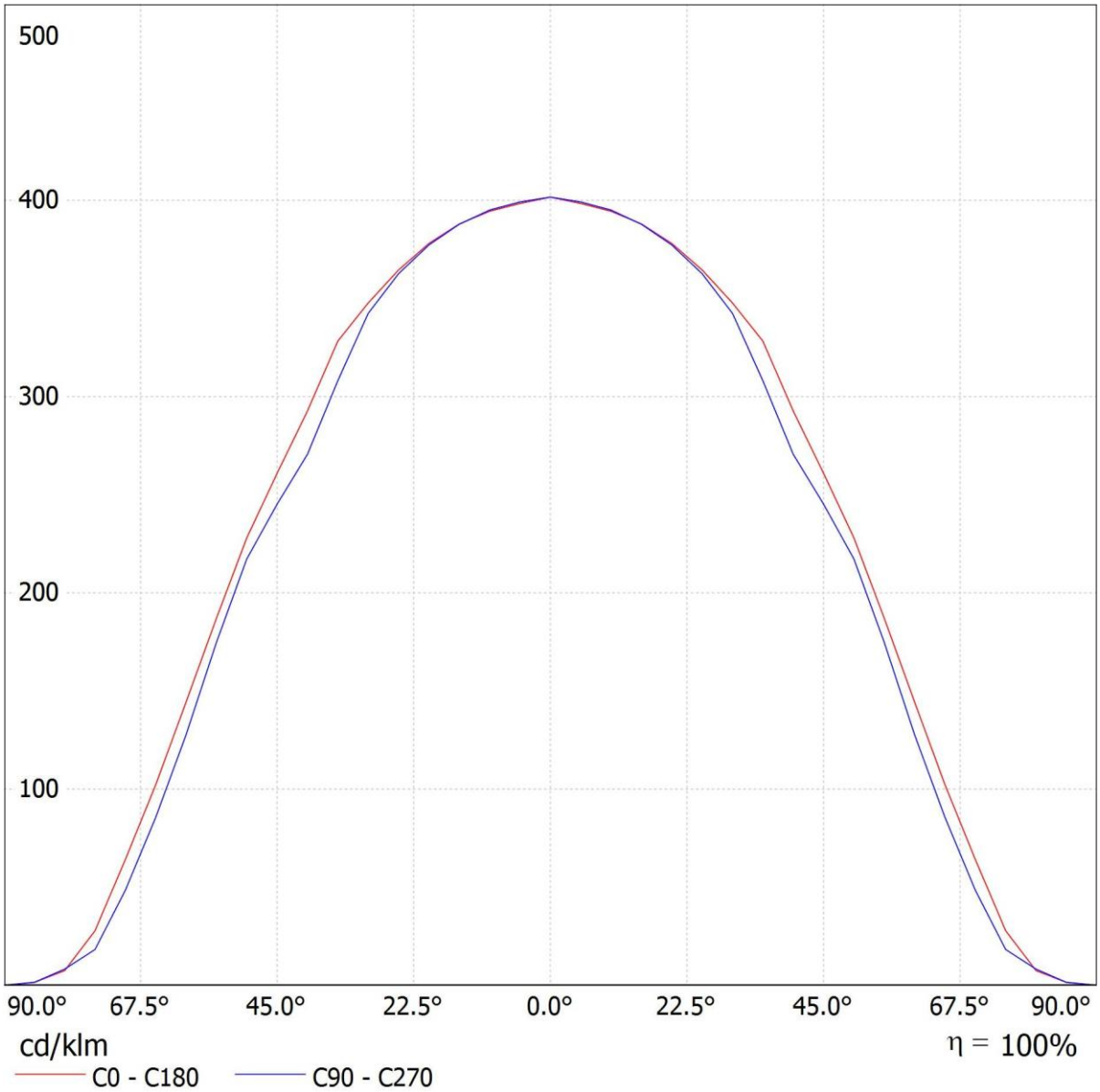
Luminaire: BEGA 1000W FLOOD LIGHT BEGA
Lamps: 1 x



Operator
Telephone
Fax
e-Mail

BEGA 200W FLOOD LIGHT BEGA / LDC (Linear)

Luminaire: BEGA 200W FLOOD LIGHT BEGA
Lamps: 1 x



Operator
Telephone
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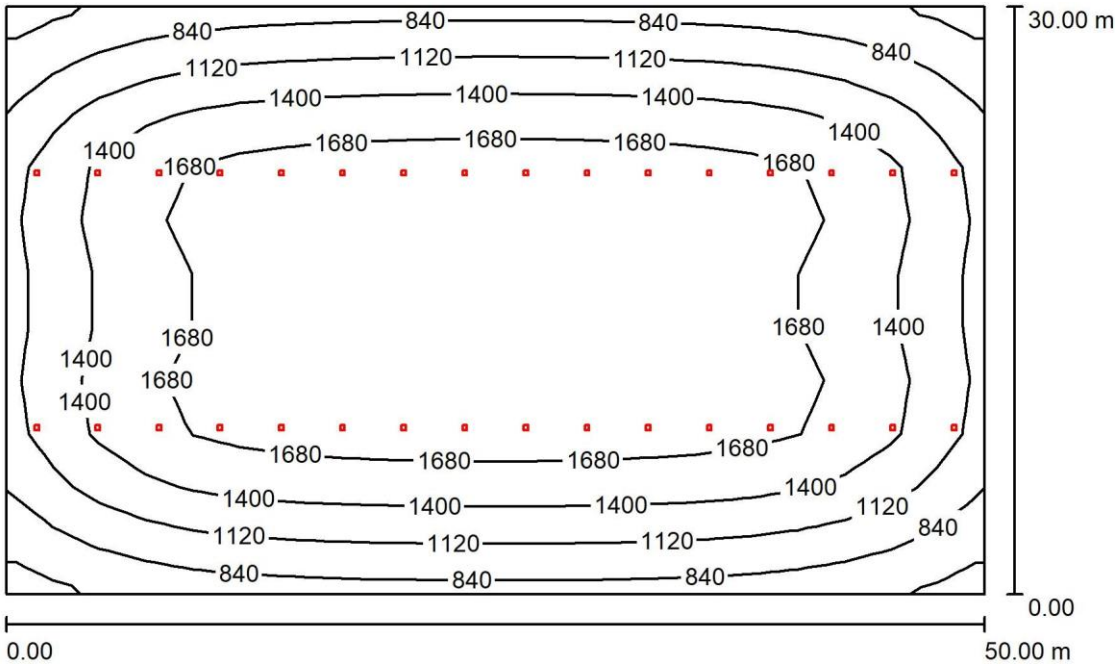
INTER NATIONAL TENNIS / Summary



Height of Room: 12.000 m, Mounting Height: 10.000 m, Light loss factor: 0.80

Values in Lux, Scale 1:386

Surface	r [%]	E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0
Workplane	/	1416	560	1915	0.395
Floor	10	1422	449	1922	0.316
Ceiling	30	118	71	176	0.602
Walls (4)	20	426	67	3526	/

Workplane:
Height: 0.000 m
Grid: 21 x 11 Points
Boundary Zone: 0.000 m

UGR (CIE, SHR = 0.25.)

	Lengthways-	Across
Left Wall	>30	>30
Lower Wall	>30	>30

to luminaire axis

Illuminance Quotient (according to LG7): Walls / Working Plane: 0.302, Ceiling / Working Plane: 0.083.

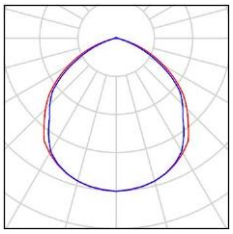
Luminaire Parts List

No.	Pieces	Designation (Correction Factor)	F (Luminaire) [lm]	F (Lamps) [lm]	P [W]
1	32	BEGA 1000W FLOOD LIGHT BEGA (Type 1)* (1.000)	105679	105831	1000.0
*Modified Technical Specifications			Total: 3381712	Total: 3386602	32000.0

Specific connected load: 21.33 W/m² = 1.51 W/m²/100 lx (Ground area: 1500.00 m²)

Operator
Telephone
Fax
e-Mail

INTER NATIONAL TENNIS / Luminaire parts list

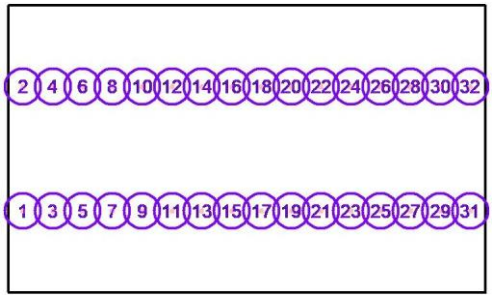
32 Pieces	BEGA 1000W FLOOD LIGHT BEGA (Type 1) Article No.: Luminous flux (Luminaire): 105679 lm Luminous flux (Lamps): 105831 lm Luminaire Wattage: 1000.0 W Luminaire classification according to CIE: 100 CIE flux code: 54 87 99 100 100 Fitting: 1 x User defined (Correction Factor 1.000).	See our luminaire catalog for an image of the luminaire.	

Operator
Telephone
Fax
e-Mail

INTER NATIONAL TENNIS / Luminaires (coordinates list)

BEGA 1000W FLOOD LIGHT BEGA (Type 1)

105679 lm, 1000.0 W, 1 x 1 x User defined (Correction Factor 1.000).



No.	Position [m]			Rotation [°]		
	X	Y	Z	X	Y	Z
1	1.567	8.500	10.000	0.0	0.0	90.0
2	1.567	21.500	10.000	0.0	0.0	90.0
3	4.691	8.500	10.000	0.0	0.0	90.0
4	4.691	21.500	10.000	0.0	0.0	90.0
5	7.816	8.500	10.000	0.0	0.0	90.0
6	7.816	21.500	10.000	0.0	0.0	90.0
7	10.940	8.500	10.000	0.0	0.0	90.0
8	10.940	21.500	10.000	0.0	0.0	90.0
9	14.065	8.500	10.000	0.0	0.0	90.0
10	14.065	21.500	10.000	0.0	0.0	90.0
11	17.189	8.500	10.000	0.0	0.0	90.0
12	17.189	21.500	10.000	0.0	0.0	90.0
13	20.313	8.500	10.000	0.0	0.0	90.0
14	20.313	21.500	10.000	0.0	0.0	90.0
15	23.438	8.500	10.000	0.0	0.0	90.0
16	23.438	21.500	10.000	0.0	0.0	90.0
17	26.562	8.500	10.000	0.0	0.0	90.0
18	26.562	21.500	10.000	0.0	0.0	90.0
19	29.687	8.500	10.000	0.0	0.0	90.0
20	29.687	21.500	10.000	0.0	0.0	90.0
21	32.811	8.500	10.000	0.0	0.0	90.0
22	32.811	21.500	10.000	0.0	0.0	90.0
23	35.935	8.500	10.000	0.0	0.0	90.0
24	35.935	21.500	10.000	0.0	0.0	90.0
25	39.060	8.500	10.000	0.0	0.0	90.0
26	39.060	21.500	10.000	0.0	0.0	90.0
27	42.184	8.500	10.000	0.0	0.0	90.0
28	42.184	21.500	10.000	0.0	0.0	90.0

Operator
Telephone
Fax
e-Mail

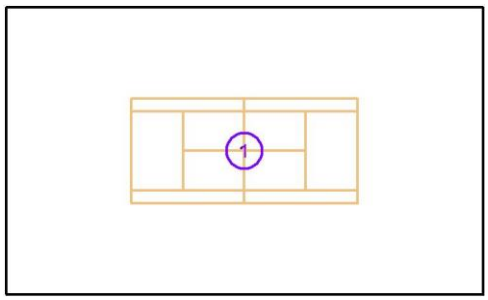
INTER NATIONAL TENNIS / Luminaires (coordinates list)

No.	Position [m]			Rotation [°]		
	X	Y	Z	X	Y	Z
29	45.309	8.500	10.000	0.0	0.0	90.0
30	45.309	21.500	10.000	0.0	0.0	90.0
31	48.433	8.500	10.000	0.0	0.0	90.0
32	48.433	21.500	10.000	0.0	0.0	90.0

Operator
Telephone
Fax
e-Mail

INTER NATIONAL TENNIS / Sport Sites (Coordinates List)

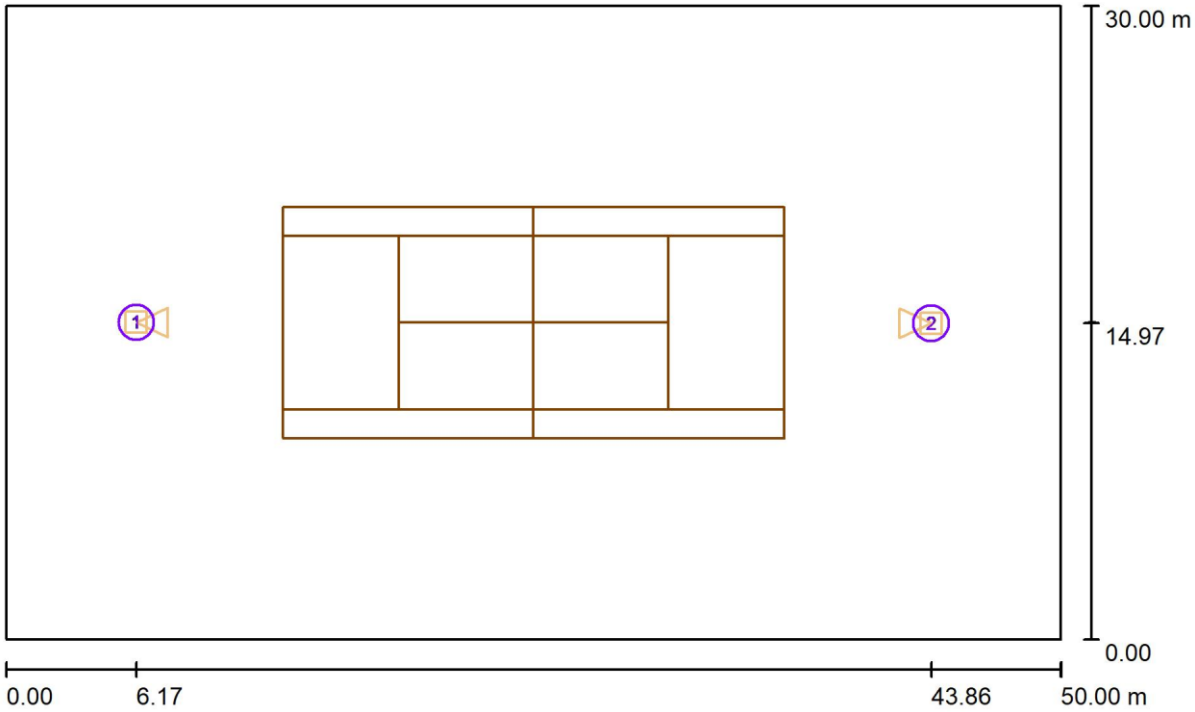
Tennis



No.	Position [m]			Size Playing Area [m]		Size Total Area [m]		Rotation [°]		
	X	Y	Z	L	W	L	W	X	Y	Z
1	25.000	15.000	0.000	23.770	10.970	23.770	10.970	0.0	0.0	0.0

Operator
Telephone
Fax
e-Mail

INTER NATIONAL TENNIS / TV Cameras (Coordinates List)



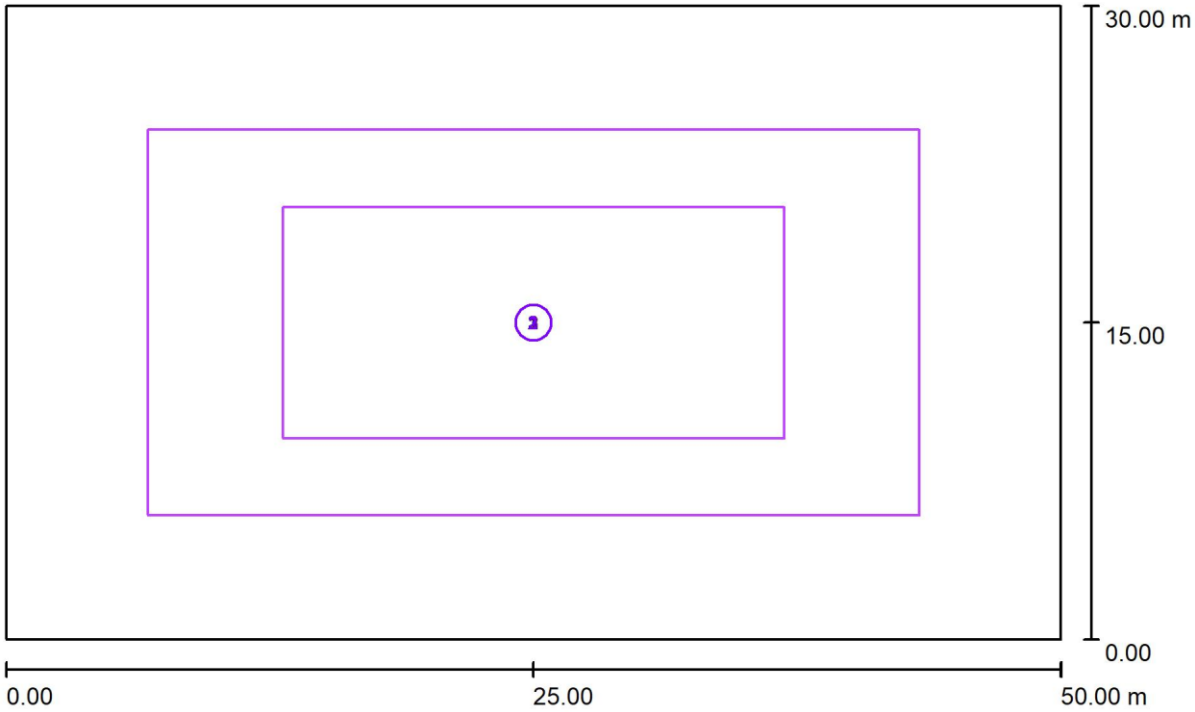
Scale 1 : 358

List of the TV Cameras

No.	Designation	Position [m]		
		X	Y	Z
1	TV Camera 2	6.173	15.013	2.500
2	TV Camera 2	43.856	14.972	2.500

Operator
Telephone
Fax
e-Mail

INTER NATIONAL TENNIS / Calculation Grid (Coordinates List)



Scale 1 : 358

List of the Calculation Grids

No.	Designation	Position [m]			Size [m]		Rotation [°]		
		X	Y	Z	L	W	X	Y	Z
1	TOTAL PLAYING AREA	25.000	15.000	0.000	36.570	18.270	0.0	0.0	0.0
2	Tennis 1 Calculation Grid (PA)	25.000	15.000	0.000	23.770	10.970	0.0	0.0	0.0
3	VERTICAL GRID	25.000	15.000	1.500	36.570	18.270	0.0	0.0	0.0

Operator
Telephone
Fax
e-Mail

INTER NATIONAL TENNIS / Photometric Results

Total Luminous Flux: 3381712 lm
Total Load: 32000.0 W
Light loss factor: 0.80
Boundary Zone: 0.000 m

Surface	Average illuminances [lx]			Reflection factor [%]	Average luminance [cd/m²]
	direct	indirect	total		
Workplane	1355	60	1416	/	/
Floor	1361	61	1422	10	45
Ceiling	3.97	114	118	30	11
Wall 1	289	86	375	20	24
Wall 2	431	85	516	20	33
Wall 3	289	83	372	20	24
Wall 4	431	80	511	20	33

Uniformity on the working plane
u0: 0.395 (1:3)
E_{min} / E_{max}: 0.292 (1:3)

UGR	Lengthways-	Across	to luminaire axis
Left Wall	>30	>30	
Lower Wall	>30	>30	

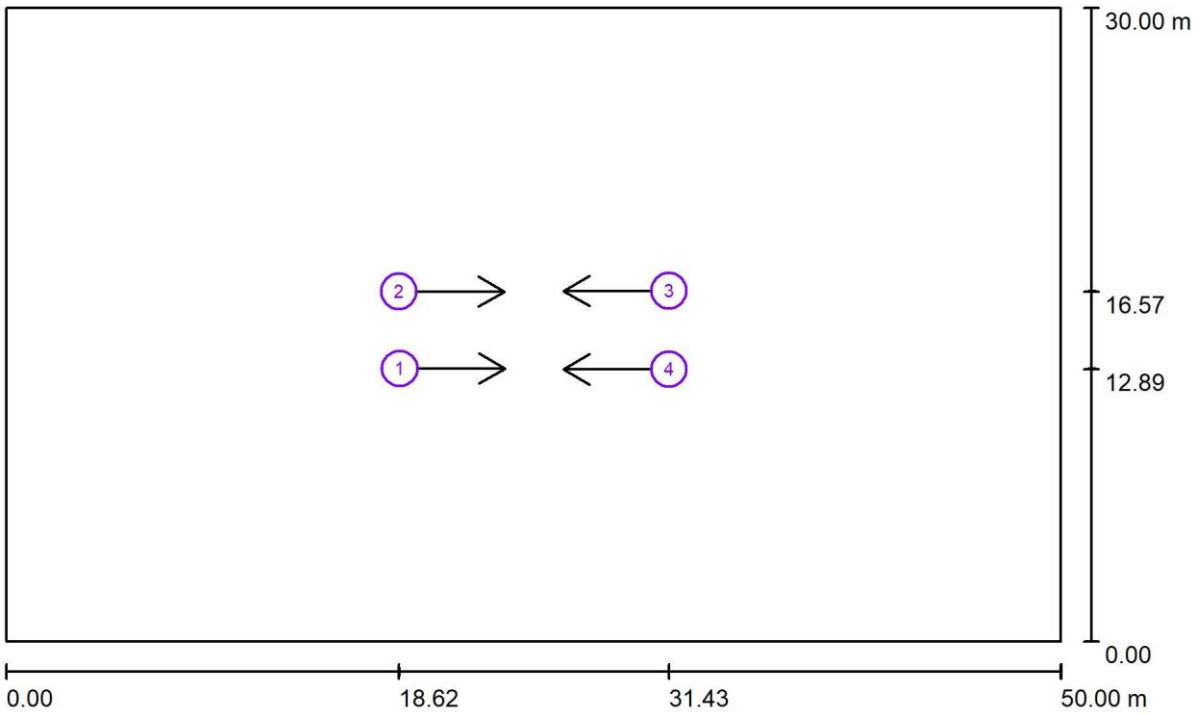
(CIE, SHR = 0.25.)

Illuminance Quotient (according to LG7): Walls / Working Plane: 0.302, Ceiling / Working Plane: 0.083.

Specific connected load: 21.33 W/m² = 1.51 W/m²/100 lx (Ground area: 1500.00 m²)

Operator
Telephone
Fax
e-Mail

INTER NATIONAL TENNIS / UGR Observer (results overview)



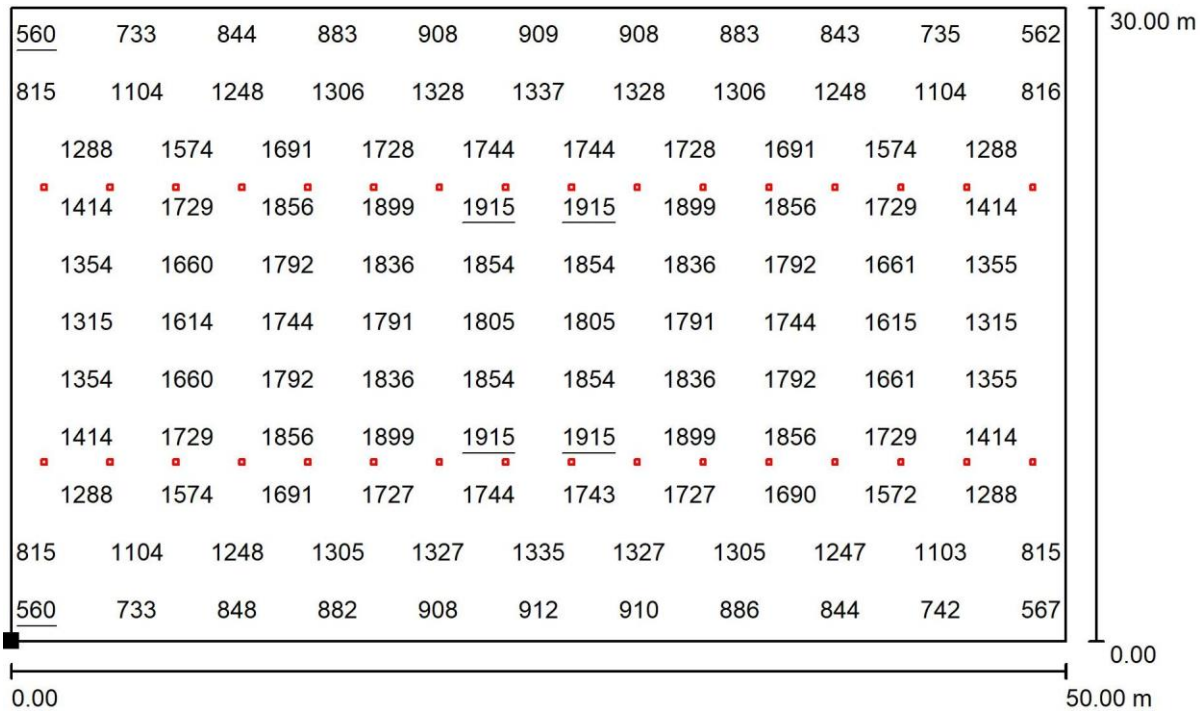
Scale 1 : 358

UGR Calculation Points List

No.	Designation	Position [m]			Viewing direction [°]	Value
		X	Y	Z		
1	UGR Calculation Point 1	18.655	12.917	1.200	0.0	>30
2	UGR Calculation Point 1	18.624	16.570	1.200	0.0	>30
3	UGR Calculation Point 1	31.425	16.601	1.200	180.0	>30
4	UGR Calculation Point 1	31.425	12.886	1.200	180.0	>30

Operator
Telephone
Fax
e-Mail

INTER NATIONAL TENNIS / Workplane / Value Chart (E)



Values in Lux, Scale 1 : 358

Not all calculated values could be displayed.

Position of surface in room:
Marked point:
(0.000 m, 0.000 m, 0.000 m)

Grid: 21 x 11 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
1416	560	1915	0.395	0.292

Operator
Telephone
Fax
e-Mail

INTER NATIONAL TENNIS / Floor / Value Chart (E)

554	696	793	858	883	913	914	925	916	924	908	898	861	820	724	609
704	885	1018	1095	1136	1159	1171	1175	1175	1173	1164	1144	1109	1045	936	774
863	1079	1242	1331	1377	1401	1413	1418	1418	1415	1406	1386	1348	1277	1146	938
1053	1300	1477	1573	1626	1653	1666	1672	1671	1667	1657	1635	1592	1504	1340	1082
1149	1432	1623	1727	1782	1811	1825	1831	1837	1833	1823	1799	1754	1658	1483	1193
1203	1496	1697	1808	1866	1897	1912	1919	1918	1914	1903	1878	1829	1728	1545	1245
1179	1461	1657	1770	1830	1861	1877	1884	1883	1879	1867	1842	1792	1689	1510	1221
1149	1417	1611	1725	1785	1818	1834	1841	1841	1836	1825	1798	1747	1644	1464	1185
1122	1386	1575	1689	1749	1782	1800	1807	1807	1802	1790	1762	1711	1611	1434	1162
1135	1390	1580	1694	1754	1787	1804	1812	1812	1807	1795	1767	1716	1616	1438	1171
1160	1433	1627	1741	1801	1834	1850	1857	1857	1853	1841	1814	1763	1660	1480	1197
1187	1472	1670	1782	1841	1872	1888	1895	1894	1890	1878	1852	1803	1701	1520	1228
1200	1485	1685	1794	1852	1882	1897	1903	1909	1905	1894	1869	1822	1722	1539	1243
1121	1400	1592	1694	1750	1778	1792	1797	1797	1793	1782	1759	1714	1620	1443	1159
987	1231	1413	1513	1565	1591	1604	1610	1608	1604	1594	1573	1530	1451	1305	1069
821	1021	1175	1262	1306	1329	1342	1347	1347	1343	1334	1315	1278	1209	1085	890
658	824	946	1018	1057	1079	1090	1094	1094	1092	1083	1064	1031	971	869	721
523	651	744	804	829	856	858	867	860	867	852	842	806	768	677	572

30.00 m

0.00

0.00

50.00 m

Values in Lux, Scale 1 : 358

Not all calculated values could be displayed.

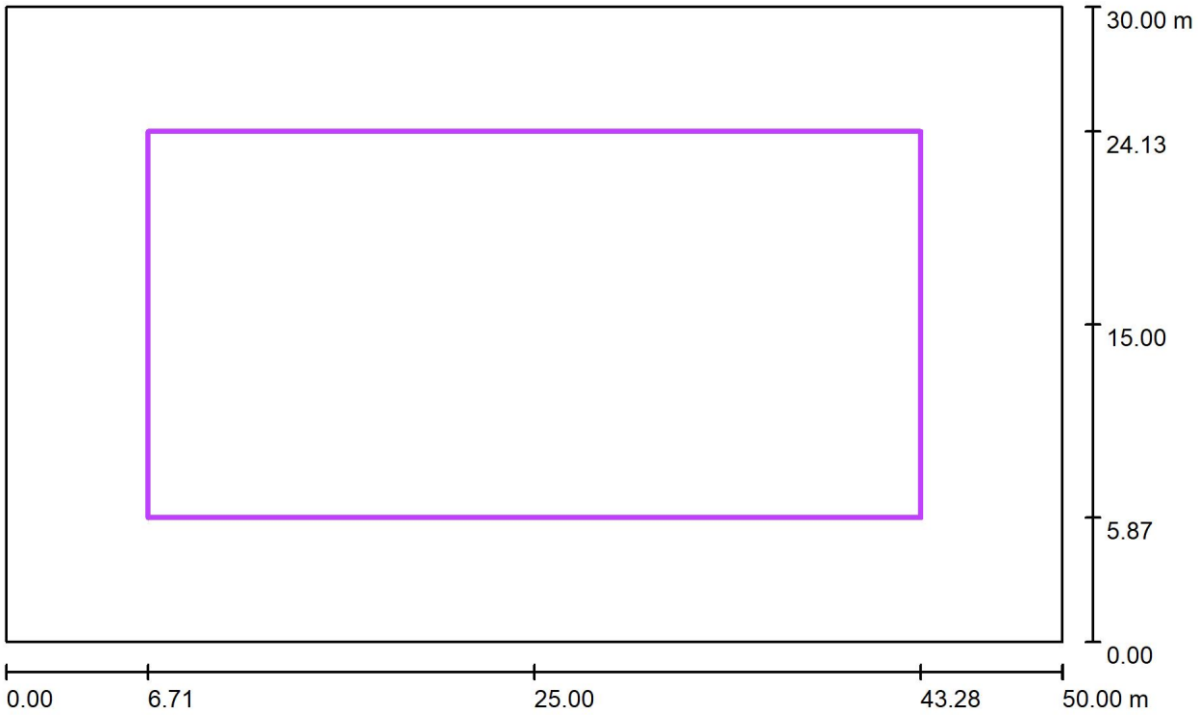
Position of surface in room:
Marked point:
(0.000 m, 0.000 m, 0.000 m)

Grid: 128 x 128 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
1422	449	1922	0.316	0.234

Operator
Telephone
Fax
e-Mail

INTER NATIONAL TENNIS / TOTAL PLAYING AREA / Summary



Scale 1 : 358

Position: (25.000 m, 15.000 m, 0.000 m)
Size: (36.570 m, 18.270 m)
Rotation: (0.0°, 0.0°, 0.0°)
Type: Normal, Grid: 37 x 19 Points

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	1770	1429	1916	0.81	0.75	/	0.000	/
2	vertical, 0.0°	597	316	682	0.53	0.46	2.96	1.000	/

$E_{h\,m}/E_m$ = Relationship between middle horizontal and vertical illuminance, H = Measuring Height

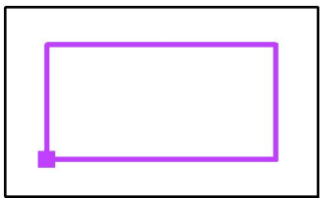
Operator
Telephone
Fax
e-Mail

INTER NATIONAL TENNIS / TOTAL PLAYING AREA / Gradient Graphics (E, Horizontal)

Values in %, Scale 1 : 262

Not all calculated values could be displayed.

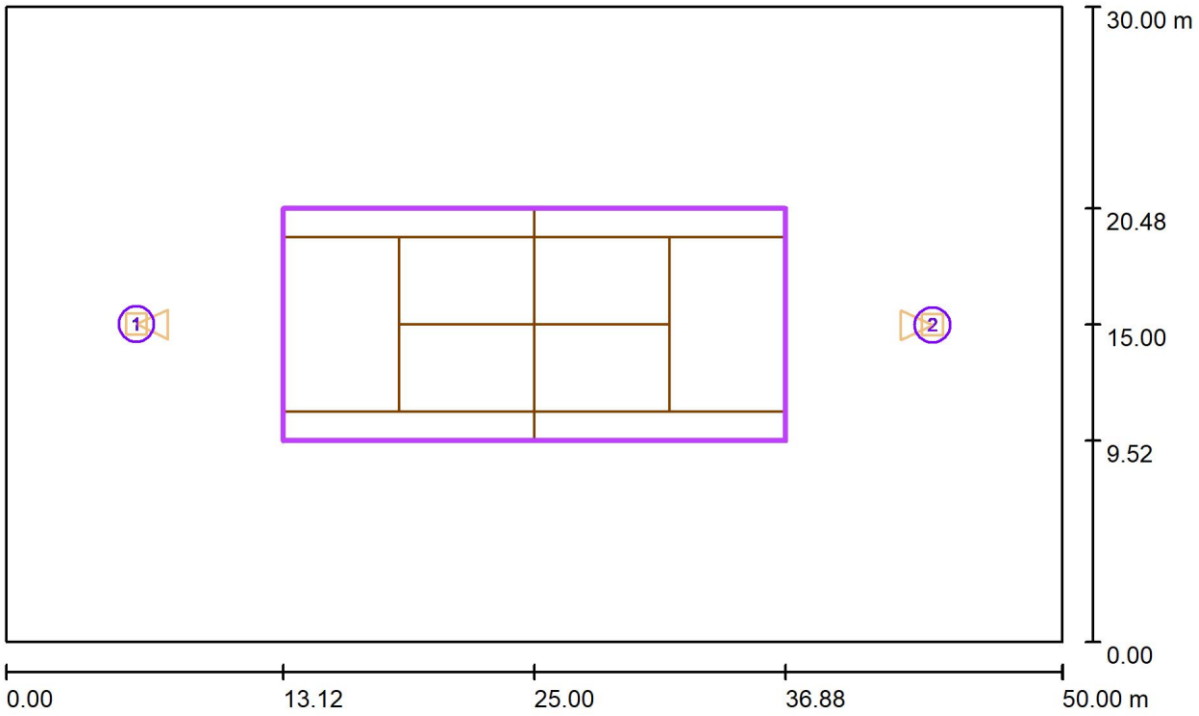
Position of surface in room:
Marked point: (6.715 m, 5.865 m, 0.000 m)



Maximum Change: 8%
Selected Limit Value: 20% (Values below this limit value are not output.)
Distance for the Gradient Grid: 1.000 m

Operator
Telephone
Fax
e-Mail

INTER NATIONAL TENNIS / Tennis 1 Calculation Grid (PA) / Summary



Scale 1 : 358

Position: (25.000 m, 15.000 m, 0.000 m)
Size: (23.770 m, 10.970 m)
Rotation: (0.0°, 0.0°, 0.0°)
Type: Normal, Grid: 48 x 22 Points
Belongs to the following sport arena: Tennis 1

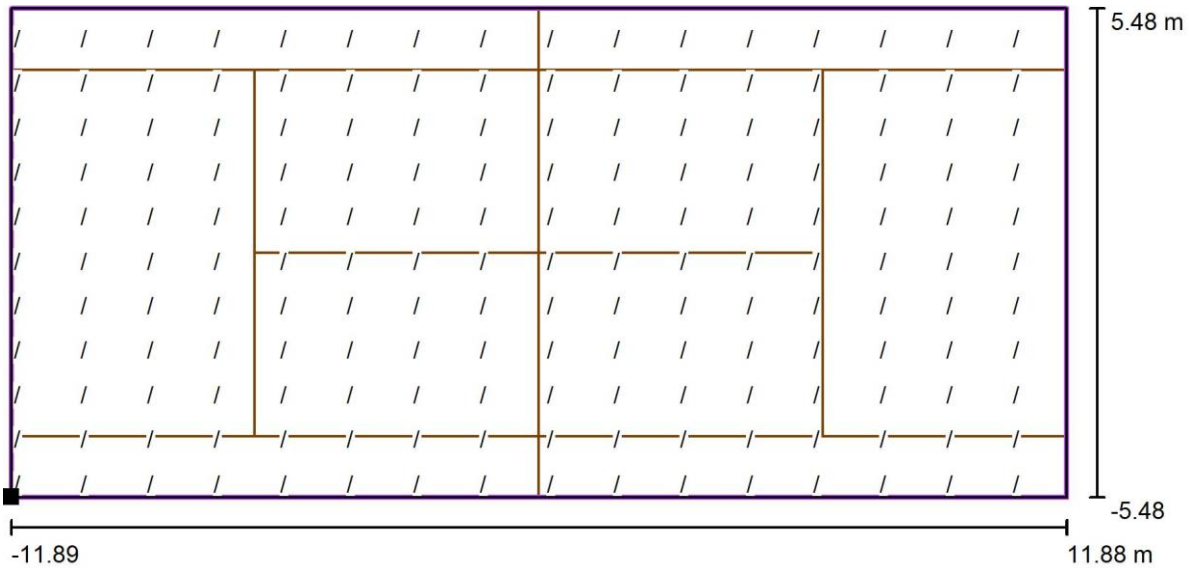
Results overview

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	1842	1745	1916	0.95	0.91	/	0.000	/
2	vertical, 0.0°	636	531	683	0.83	0.78	2.90	1.000	/
3	Camera	768	709	845	0.92	0.84	2.40	1.000	1
4	Camera	713	683	754	0.96	0.90	2.58	1.000	2

$E_{h\,m}/E_m$ = Relationship between middle horizontal and vertical illuminance, H = Measuring Height

Operator
Telephone
Fax
e-Mail

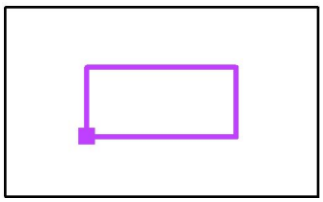
INTER NATIONAL TENNIS / Tennis 1 Calculation Grid (PA) / Gradient Graphics (E, Horizontal)



Values in %, Scale 1 : 170

Not all calculated values could be displayed.

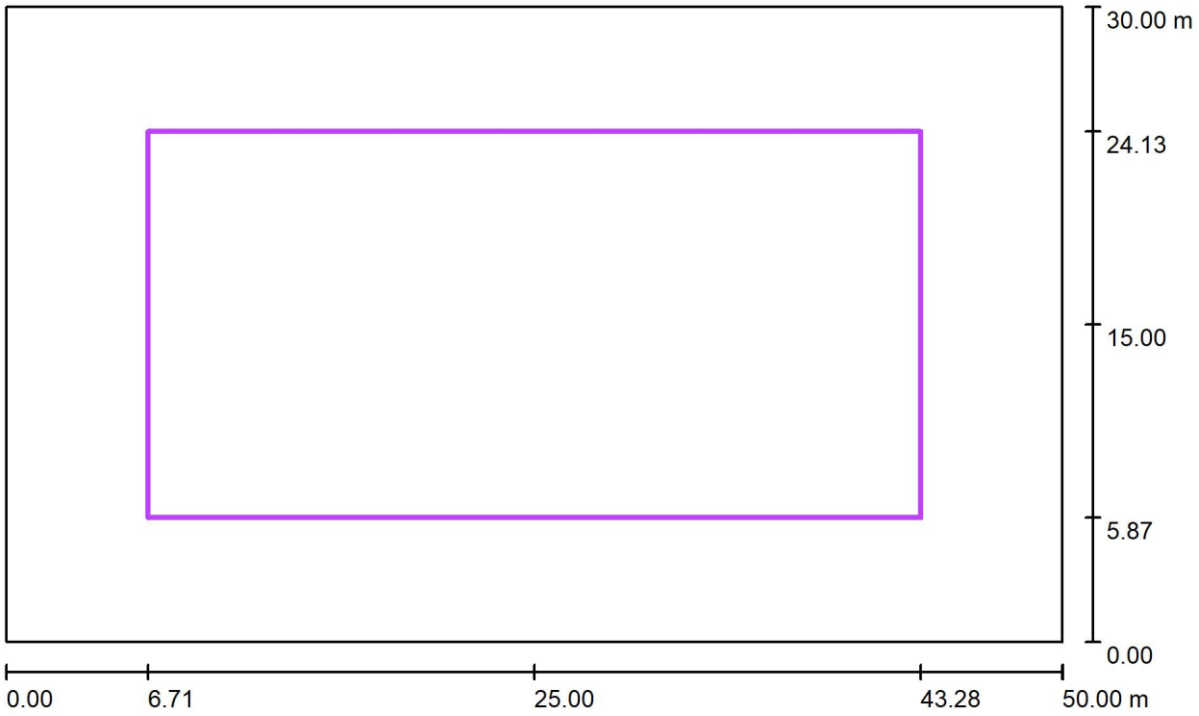
Position of surface in room:
Marked point: (13.115 m, 9.515 m, 0.000 m)



Maximum Change: 2%
Selected Limit Value: 20% (Values below this limit value are not output.)
Distance for the Gradient Grid: 1.000 m

Operator
Telephone
Fax
e-Mail

INTER NATIONAL TENNIS / VERTICAL GRID / Summary



Scale 1 : 358

Position: (25.000 m, 15.000 m, 1.500 m)
Size: (36.570 m, 18.270 m)
Rotation: (0.0°, 0.0°, 0.0°)
Type: Normal, Grid: 37 x 19 Points

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	1897	1554	2115	0.82	0.73	/	0.000	/
2	vertical, 0.0°	643	366	746	0.57	0.49	2.95	1.000	/

$E_{h\,m}/E_m$ = Relationship between middle horizontal and vertical illuminance, H = Measuring Height

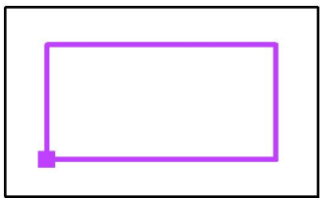
Operator
Telephone
Fax
e-Mail

INTER NATIONAL TENNIS / VERTICAL GRID / Gradient Graphics (E, Horizontal)

Values in %, Scale 1 : 262

Not all calculated values could be displayed.

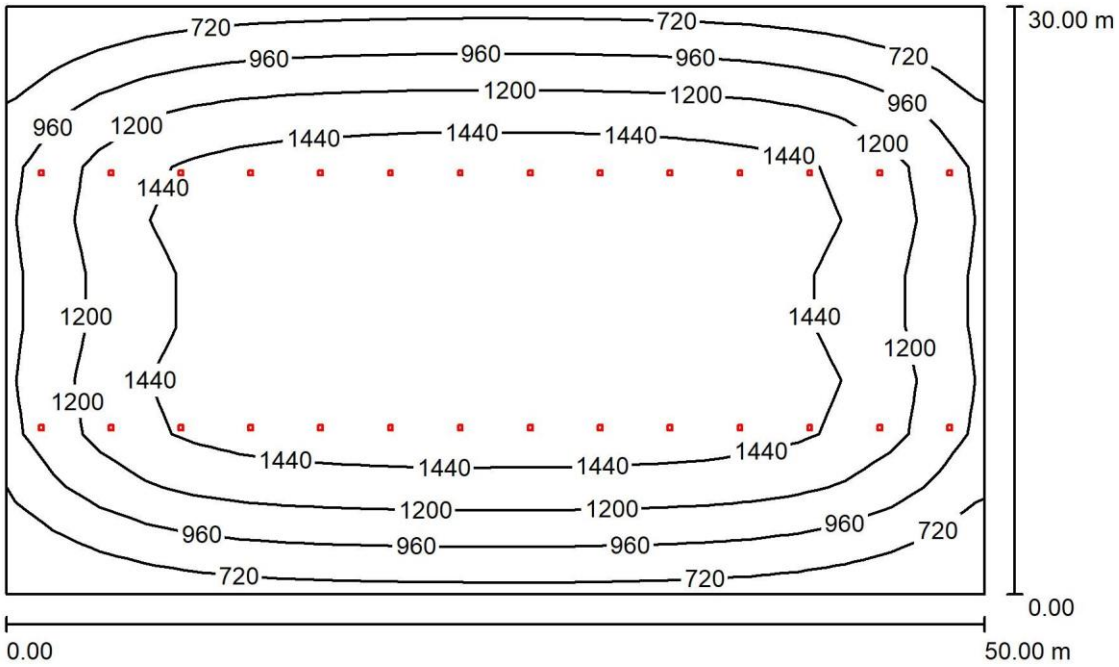
Position of surface in room:
Marked point: (6.715 m, 5.865 m, 1.500 m)



Maximum Change: 10%
Selected Limit Value: 20% (Values below this limit value are not output.)
Distance for the Gradient Grid: 1.000 m

Operator
Telephone
Fax
e-Mail

NATIONAL TENNIS / Summary



Height of Room: 12.000 m, Mounting Height: 10.000 m, Light loss factor: 0.80

Values in Lux, Scale 1:386

Surface	r [%]	E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0
Workplane	/	1239	489	1675	0.394
Floor	10	1245	392	1682	0.315
Ceiling	30	104	62	167	0.595
Walls (4)	20	373	59	2727	/

Workplane:
Height: 0.000 m
Grid: 21 x 11 Points
Boundary Zone: 0.000 m

UGR (CIE, SHR = 0.25.)

	Lengthways-	Across
Left Wall	>30	>30
Lower Wall	>30	>30

to luminaire axis

Illuminance Quotient (according to LG7): Walls / Working Plane: 0.302, Ceiling / Working Plane: 0.083.

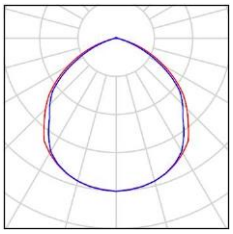
Luminaire Parts List

No.	Pieces	Designation (Correction Factor)	F (Luminaire) [lm]	F (Lamps) [lm]	P [W]
1	28	BEGA 1000W FLOOD LIGHT BEGA (Type 1)* (1.000)	105679	105831	1000.0
*Modified Technical Specifications			Total: 2958998	Total: 2963276	28000.0

Specific connected load: 18.67 W/m² = 1.51 W/m²/100 lx (Ground area: 1500.00 m²)

Operator
Telephone
Fax
e-Mail

NATIONAL TENNIS / Luminaire parts list

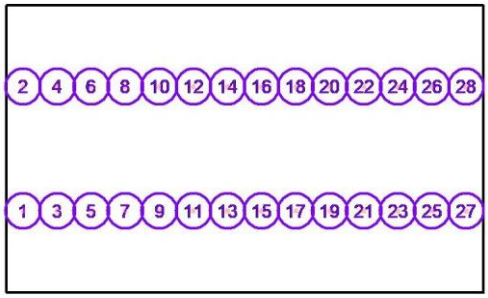
28 Pieces	BEGA 1000W FLOOD LIGHT BEGA (Type 1) Article No.: Luminous flux (Luminaire): 105679 lm Luminous flux (Lamps): 105831 lm Luminaire Wattage: 1000.0 W Luminaire classification according to CIE: 100 CIE flux code: 54 87 99 100 100 Fitting: 1 x User defined (Correction Factor 1.000).	See our luminaire catalog for an image of the luminaire.	

Operator
Telephone
Fax
e-Mail

NATIONAL TENNIS / Luminaires (coordinates list)

BEGA 1000W FLOOD LIGHT BEGA (Type 1)

105679 lm, 1000.0 W, 1 x 1 x User defined (Correction Factor 1.000).

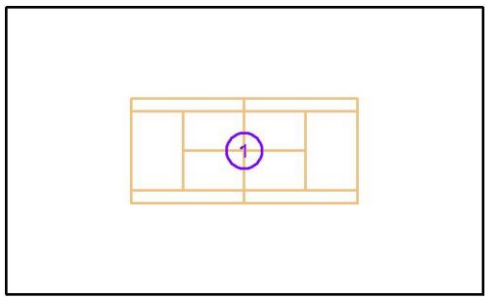


No.	Position [m]			Rotation [°]		
	X	Y	Z	X	Y	Z
1	1.790	8.500	10.000	0.0	0.0	90.0
2	1.790	21.500	10.000	0.0	0.0	90.0
3	5.361	8.500	10.000	0.0	0.0	90.0
4	5.361	21.500	10.000	0.0	0.0	90.0
5	8.932	8.500	10.000	0.0	0.0	90.0
6	8.932	21.500	10.000	0.0	0.0	90.0
7	12.504	8.500	10.000	0.0	0.0	90.0
8	12.504	21.500	10.000	0.0	0.0	90.0
9	16.075	8.500	10.000	0.0	0.0	90.0
10	16.075	21.500	10.000	0.0	0.0	90.0
11	19.646	8.500	10.000	0.0	0.0	90.0
12	19.646	21.500	10.000	0.0	0.0	90.0
13	23.217	8.500	10.000	0.0	0.0	90.0
14	23.217	21.500	10.000	0.0	0.0	90.0
15	26.788	8.500	10.000	0.0	0.0	90.0
16	26.788	21.500	10.000	0.0	0.0	90.0
17	30.359	8.500	10.000	0.0	0.0	90.0
18	30.359	21.500	10.000	0.0	0.0	90.0
19	33.930	8.500	10.000	0.0	0.0	90.0
20	33.930	21.500	10.000	0.0	0.0	90.0
21	37.501	8.500	10.000	0.0	0.0	90.0
22	37.501	21.500	10.000	0.0	0.0	90.0
23	41.072	8.500	10.000	0.0	0.0	90.0
24	41.072	21.500	10.000	0.0	0.0	90.0
25	44.643	8.500	10.000	0.0	0.0	90.0
26	44.643	21.500	10.000	0.0	0.0	90.0
27	48.214	8.500	10.000	0.0	0.0	90.0
28	48.214	21.500	10.000	0.0	0.0	90.0

Operator
Telephone
Fax
e-Mail

NATIONAL TENNIS / Sport Sites (Coordinates List)

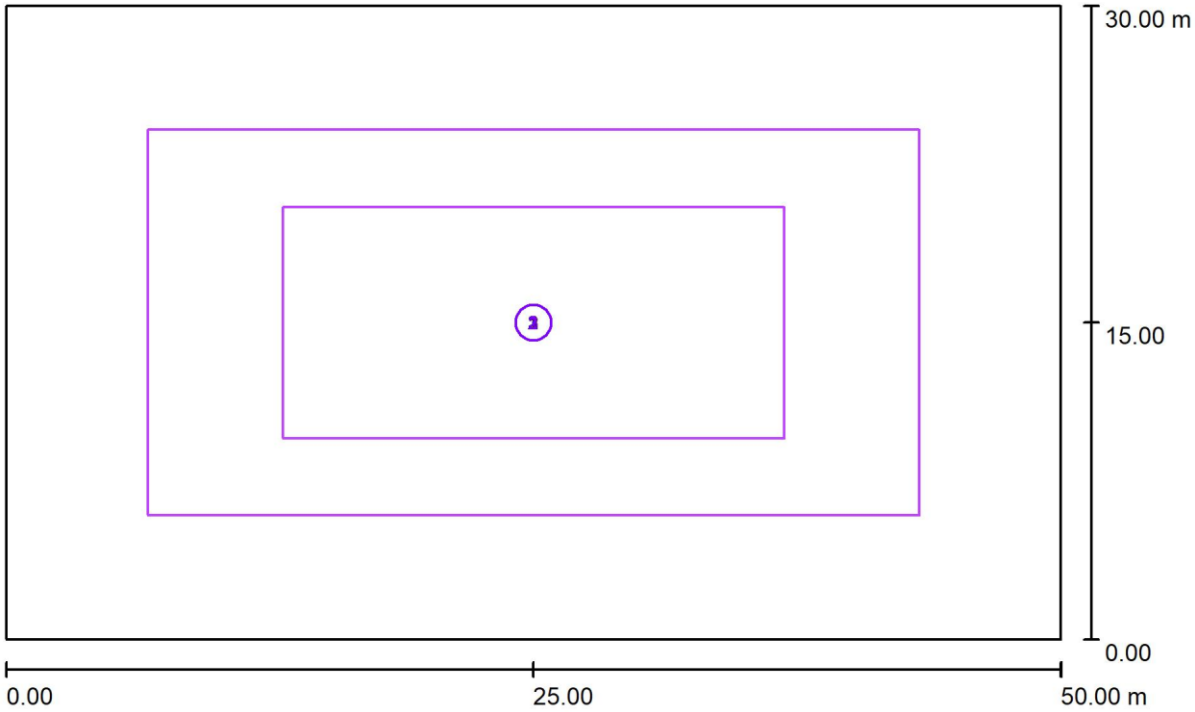
Tennis



No.	Position [m]			Size Playing Area [m]		Size Total Area [m]		Rotation [°]		
	X	Y	Z	L	W	L	W	X	Y	Z
1	25.000	15.000	0.000	23.770	10.970	23.770	10.970	0.0	0.0	0.0

Operator
Telephone
Fax
e-Mail

NATIONAL TENNIS / Calculation Grid (Coordinates List)



Scale 1 : 358

List of the Calculation Grids

No.	Designation	Position [m]			Size [m]		Rotation [°]		
		X	Y	Z	L	W	X	Y	Z
1	Tennis 1 Calculation Grid (PA)	25.000	15.000	0.000	23.770	10.970	0.0	0.0	0.0
2	TOTAL PLAYING AREA	25.000	15.000	0.000	36.570	18.270	0.0	0.0	0.0
3	VERTICAL GRID	25.000	15.000	1.500	36.570	18.270	0.0	0.0	0.0

Operator
Telephone
Fax
e-Mail

NATIONAL TENNIS / Photometric Results

Total Luminous Flux: 2958998 lm
Total Load: 28000.0 W
Light loss factor: 0.80
Boundary Zone: 0.000 m

Surface	Average illuminances [lx]			Reflection factor [%]	Average luminance [cd/m²]
	direct	indirect	total		
Workplane	1186	53	1239	/	/
Floor	1191	53	1245	10	40
Ceiling	3.58	100	104	30	9.90
Wall 1	253	75	328	20	21
Wall 2	376	74	451	20	29
Wall 3	253	73	326	20	21
Wall 4	376	70	446	20	28

Uniformity on the working plane
u0: 0.394 (1:3)
E_{min} / E_{max}: 0.292 (1:3)

UGR	Lengthways-	Across	to luminaire axis
Left Wall	>30	>30	
Lower Wall	>30	>30	

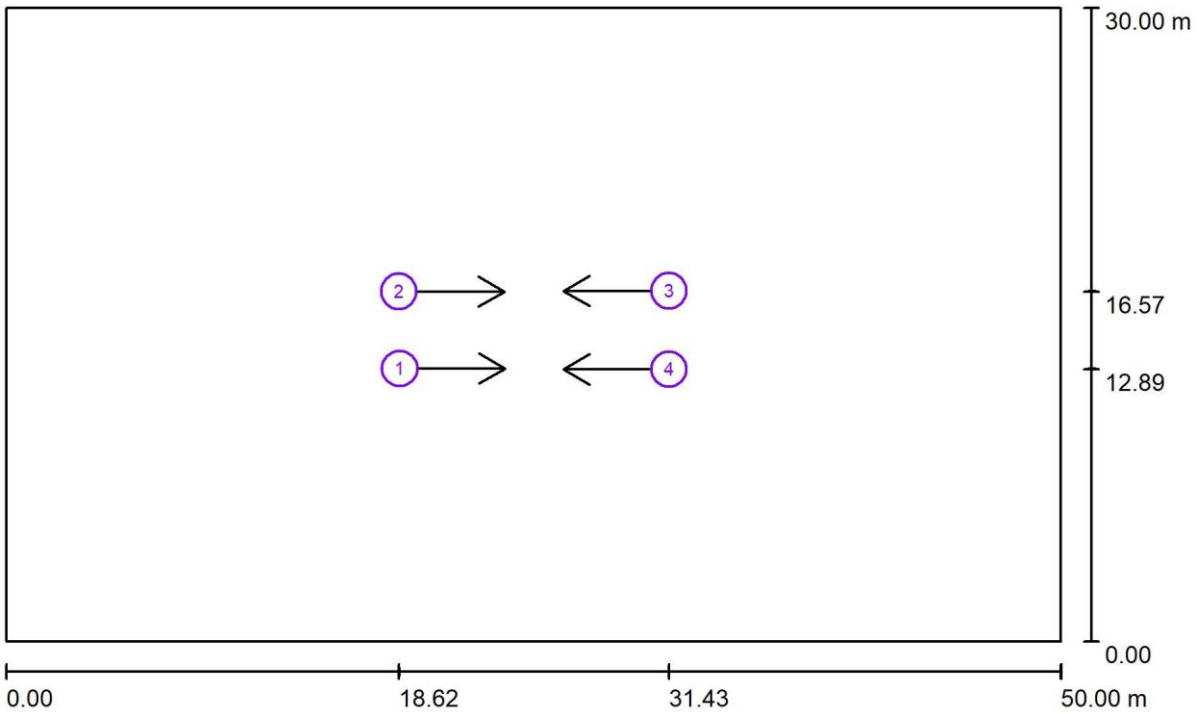
(CIE, SHR = 0.25.)

Illuminance Quotient (according to LG7): Walls / Working Plane: 0.302, Ceiling / Working Plane: 0.083.

Specific connected load: 18.67 W/m² = 1.51 W/m²/100 lx (Ground area: 1500.00 m²)

Operator
Telephone
Fax
e-Mail

NATIONAL TENNIS / UGR Observer (results overview)



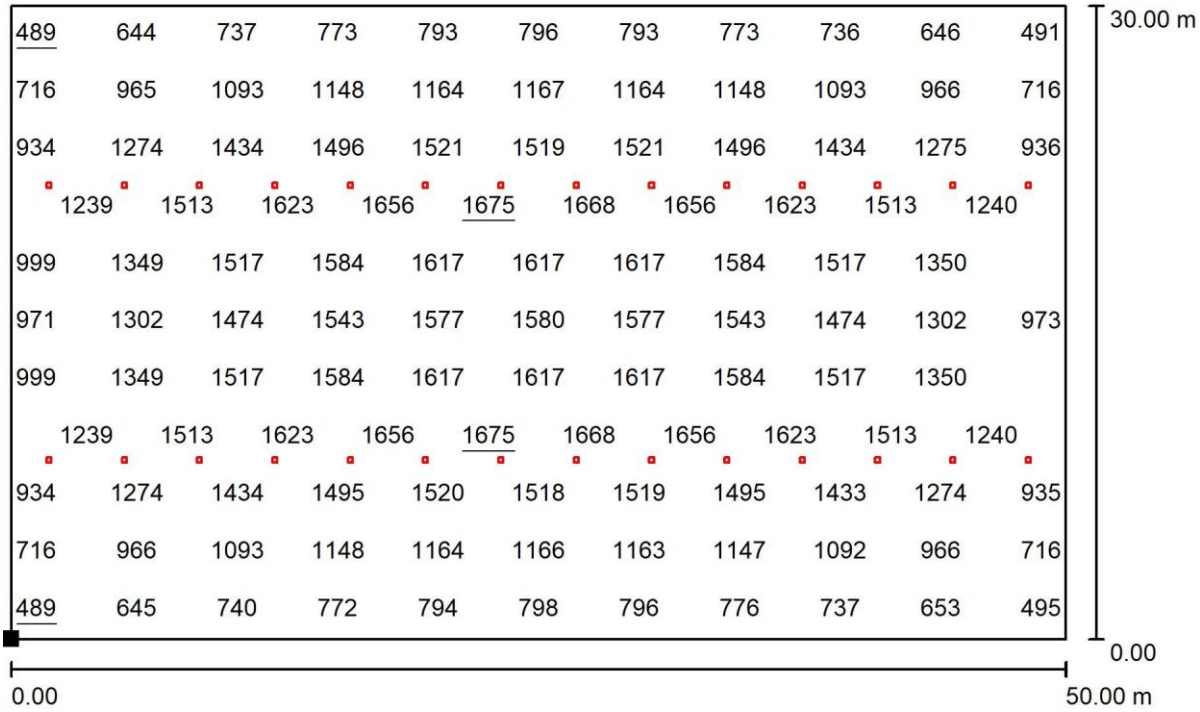
Scale 1 : 358

UGR Calculation Points List

No.	Designation	Position [m]			Viewing direction [°]	Value
		X	Y	Z		
1	UGR Calculation Point 1	18.655	12.917	1.200	0.0	>30
2	UGR Calculation Point 1	18.624	16.570	1.200	0.0	>30
3	UGR Calculation Point 1	31.425	16.601	1.200	180.0	>30
4	UGR Calculation Point 1	31.425	12.886	1.200	180.0	>30

Operator
Telephone
Fax
e-Mail

NATIONAL TENNIS / Workplane / Value Chart (E)



Values in Lux, Scale 1 : 358

Not all calculated values could be displayed.

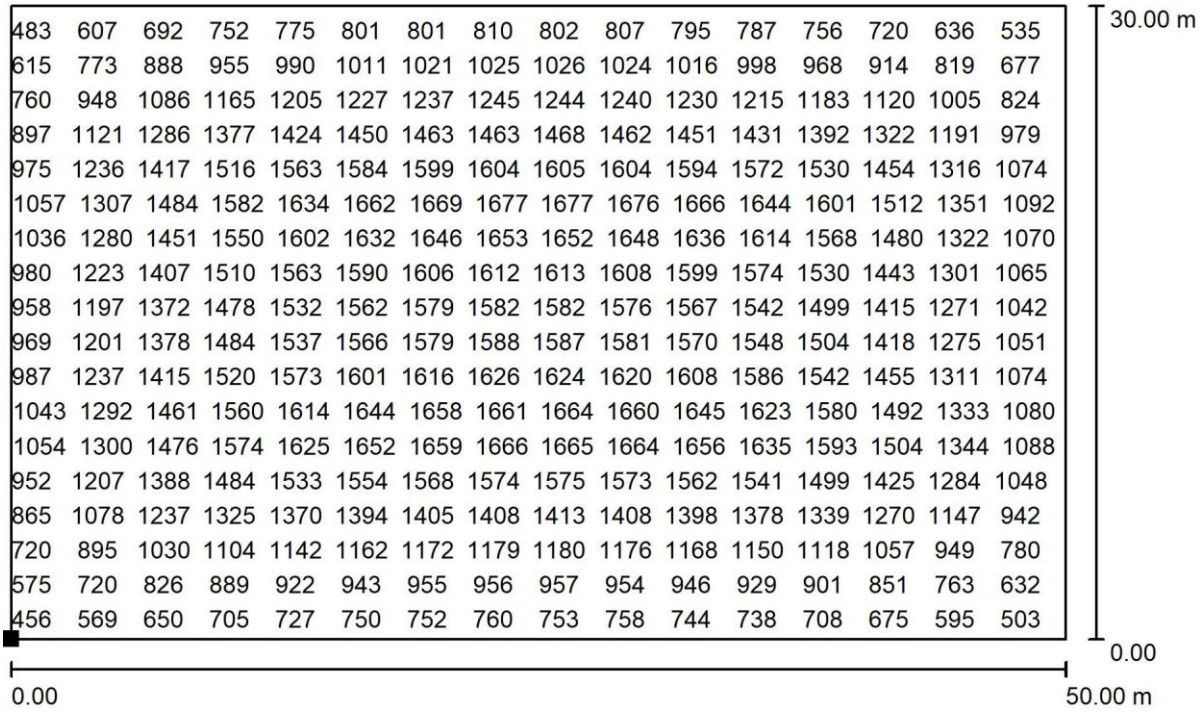
Position of surface in room:
Marked point:
(0.000 m, 0.000 m, 0.000 m)

Grid: 21 x 11 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
1239	489	1675	0.394	0.292

Operator
Telephone
Fax
e-Mail

NATIONAL TENNIS / Floor / Value Chart (E)



Values in Lux, Scale 1 : 358

Not all calculated values could be displayed.

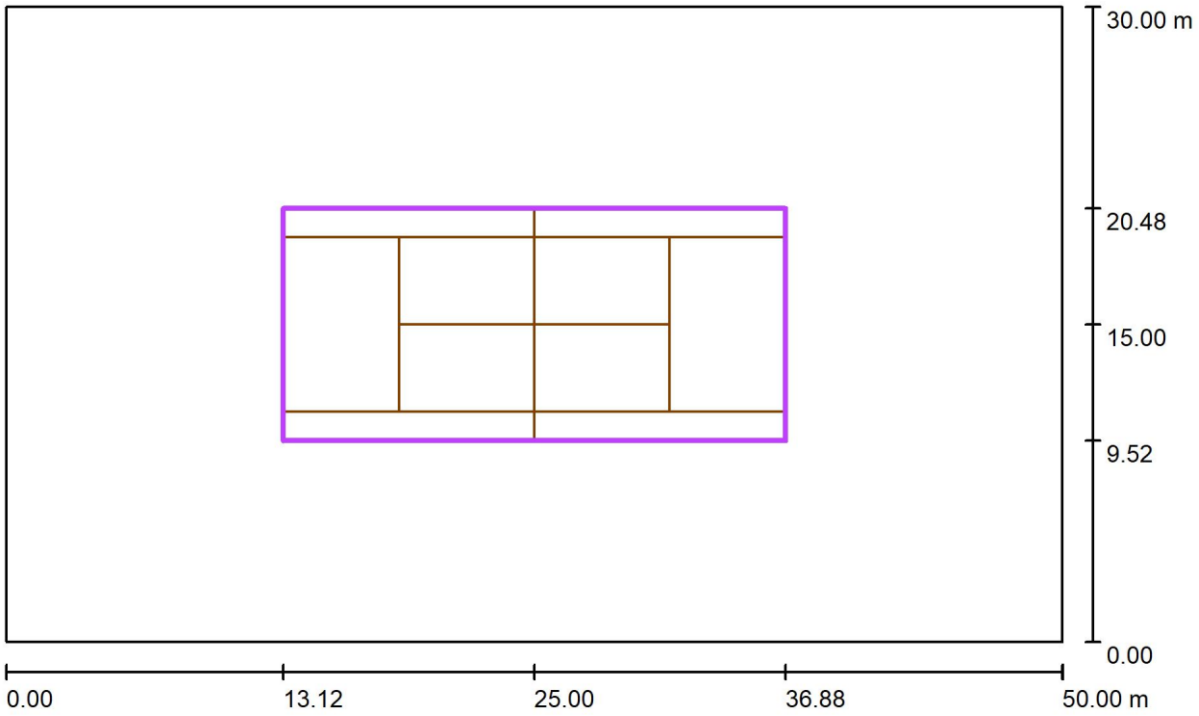
Position of surface in room:
Marked point:
(0.000 m, 0.000 m, 0.000 m)

Grid: 128 x 128 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
1245	392	1682	0.315	0.233

Operator
Telephone
Fax
e-Mail

NATIONAL TENNIS / Tennis 1 Calculation Grid (PA) / Summary



Scale 1 : 358

Position: (25.000 m, 15.000 m, 0.000 m)
Size: (23.770 m, 10.970 m)
Rotation: (0.0°, 0.0°, 0.0°)
Type: Normal, Grid: 48 x 22 Points
Belongs to the following sport arena: Tennis 1

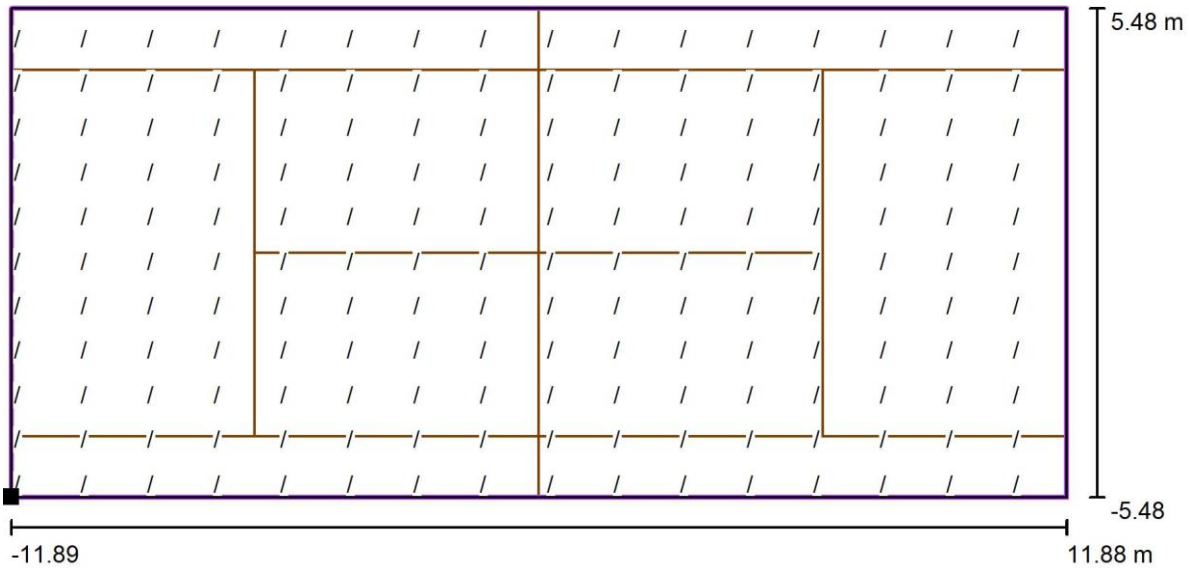
Results overview

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	1612	1528	1676	0.95	0.91	/	0.000	/
2	vertical, 0.0°	557	462	600	0.83	0.77	2.89	1.000	/

$E_{h\,m}/E_m$ = Relationship between middle horizontal and vertical illuminance, H = Measuring Height

Operator
Telephone
Fax
e-Mail

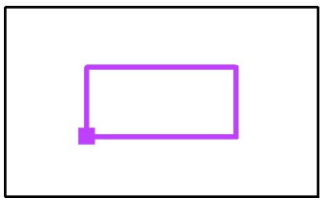
NATIONAL TENNIS / Tennis 1 Calculation Grid (PA) / Gradient Graphics (E, Horizontal)



Values in %, Scale 1 : 170

Not all calculated values could be displayed.

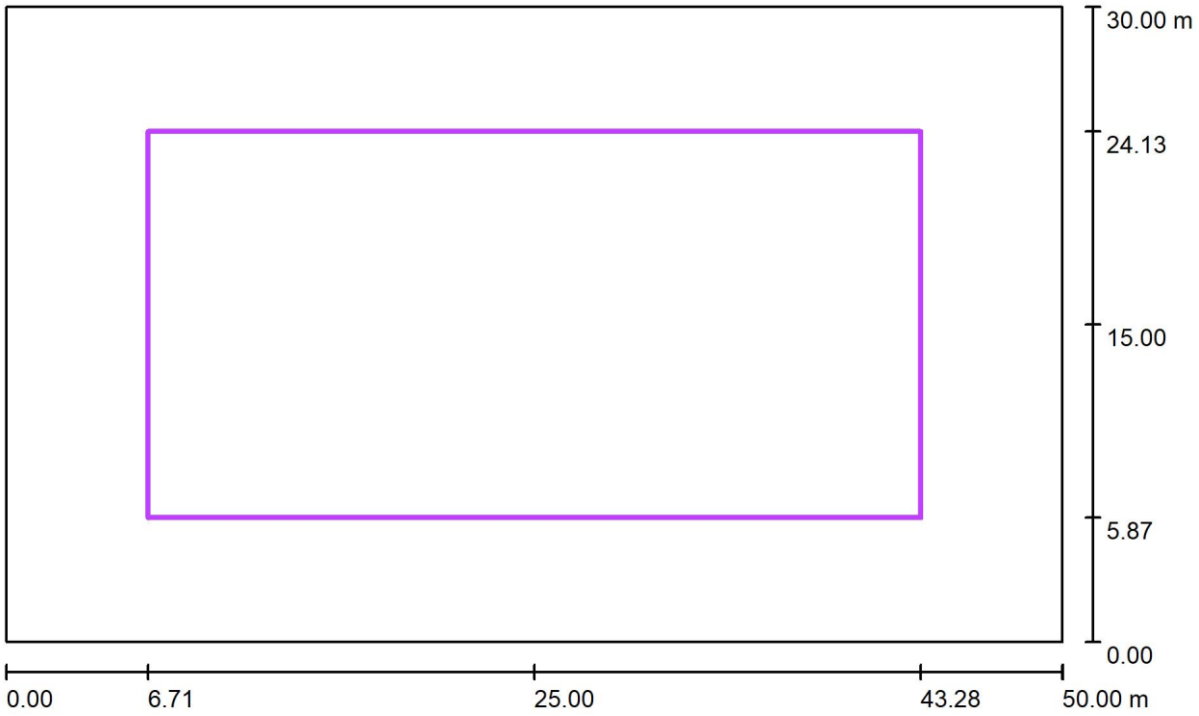
Position of surface in room:
Marked point: (13.115 m, 9.515 m, 0.000 m)



Maximum Change: 2%
Selected Limit Value: 20% (Values below this limit value are not output.)
Distance for the Gradient Grid: 1.000 m

Operator
Telephone
Fax
e-Mail

NATIONAL TENNIS / TOTAL PLAYING AREA / Summary



Scale 1 : 358

Position: (25.000 m, 15.000 m, 0.000 m)
Size: (36.570 m, 18.270 m)
Rotation: (0.0°, 0.0°, 0.0°)
Type: Normal, Grid: 37 x 19 Points

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	1549	1249	1676	0.81	0.75	/	0.000	/
2	vertical, 0.0°	523	283	599	0.54	0.47	2.96	1.000	/

$E_{h\,m}/E_m$ = Relationship between middle horizontal and vertical illuminance, H = Measuring Height

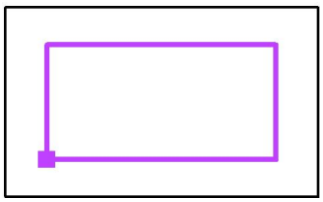
Operator
Telephone
Fax
e-Mail

NATIONAL TENNIS / TOTAL PLAYING AREA / Gradient Graphics (E, Horizontal)

Values in %, Scale 1 : 262

Not all calculated values could be displayed.

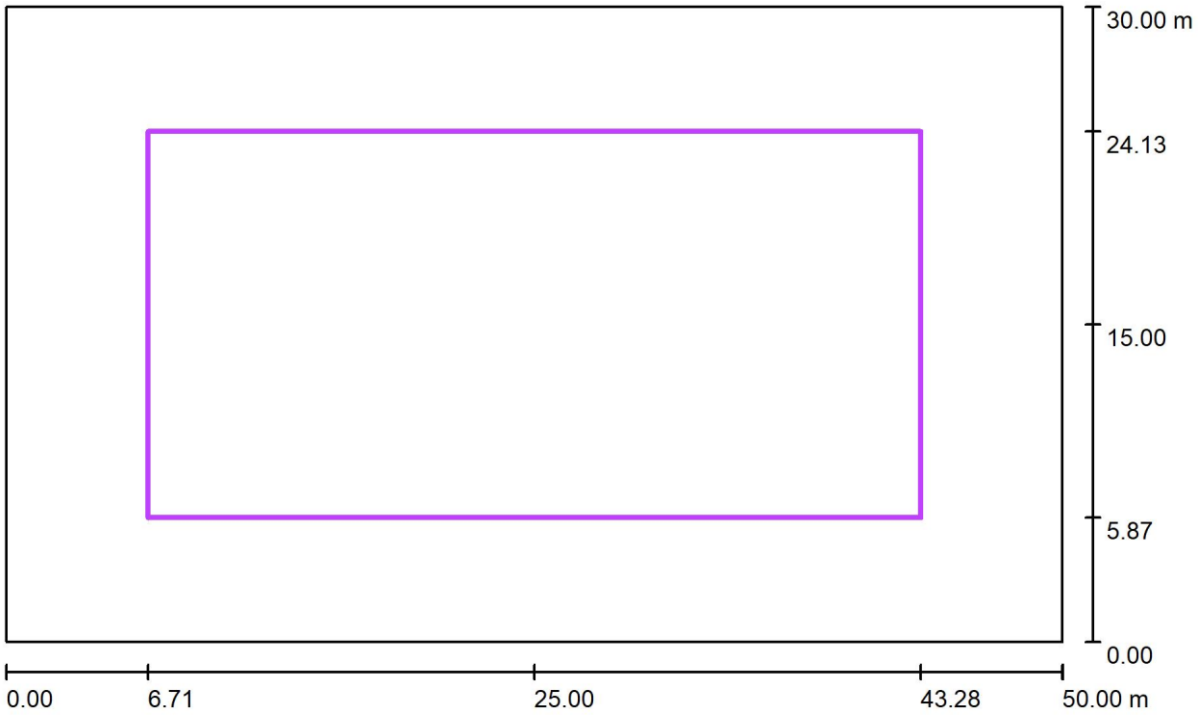
Position of surface in room:
Marked point: (6.715 m, 5.865 m, 0.000 m)



Maximum Change: 8%
Selected Limit Value: 20% (Values below this limit value are not output.)
Distance for the Gradient Grid: 1.000 m

Operator
Telephone
Fax
e-Mail

NATIONAL TENNIS / VERTICAL GRID / Summary



Scale 1 : 358

Position: (25.000 m, 15.000 m, 1.500 m)
Size: (36.570 m, 18.270 m)
Rotation: (0.0°, 0.0°, 0.0°)
Type: Normal, Grid: 37 x 19 Points

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	1660	1364	1849	0.82	0.74	/	0.000	/
2	vertical, 0.0°	564	327	657	0.58	0.50	2.95	1.000	/

$E_{h\,m}/E_m$ = Relationship between middle horizontal and vertical illuminance, H = Measuring Height

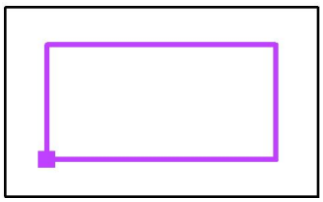
Operator
Telephone
Fax
e-Mail

NATIONAL TENNIS / VERTICAL GRID / Gradient Graphics (E, Horizontal)

Values in %, Scale 1 : 262

Not all calculated values could be displayed.

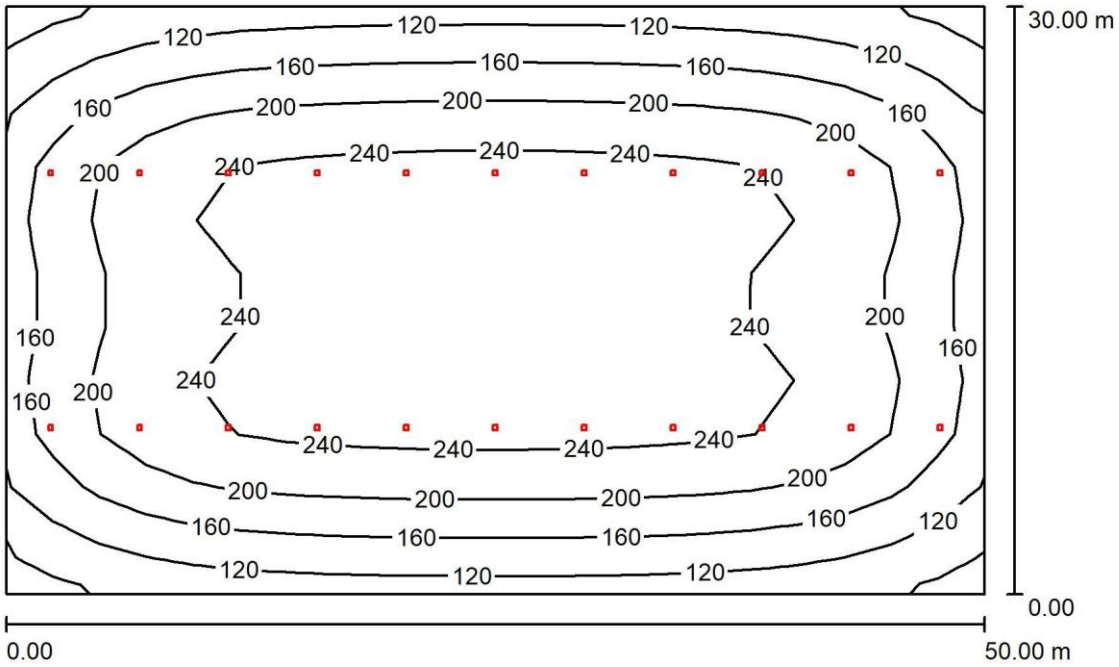
Position of surface in room:
Marked point: (6.715 m, 5.865 m, 1.500 m)



Maximum Change: 10%
Selected Limit Value: 20% (Values below this limit value are not output.)
Distance for the Gradient Grid: 1.000 m

Operator
Telephone
Fax
e-Mail

TRANING TENNIS / Summary



Height of Room: 12.000 m, Mounting Height: 10.000 m, Light loss factor: 0.80

Values in Lux, Scale 1:386

Surface	r [%]	E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0
Workplane	/	195	77	264	0.394
Floor	10	196	62	264	0.316
Ceiling	30	16	9.80	29	0.602
Walls (4)	20	58	9.36	342	/

Workplane:
Height: 0.000 m
Grid: 21 x 11 Points
Boundary Zone: 0.000 m

UGR (CIE, SHR = 0.25.)

	Lengthways-	Across
Left Wall	>30	>30
Lower Wall	>30	>30

to luminaire axis

Illuminance Quotient (according to LG7): Walls / Working Plane: 0.301, Ceiling / Working Plane: 0.083.

Luminaire Parts List

No.	Pieces	Designation (Correction Factor)	F (Luminaire) [lm]	F (Lamps) [lm]	P [W]
1	22	BEGA 200W FLOOD LIGHT BEGA (1.000)	21136	21166	195.6
			Total: 464985	Total: 465658	4303.2

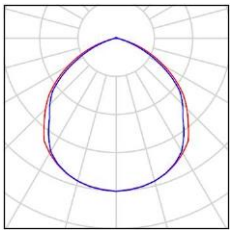
Specific connected load: 2.87 W/m² = 1.47 W/m²/100 lx (Ground area: 1500.00 m²)

Operator
Telephone
Fax
e-Mail

TRANING TENNIS / Luminaire parts list

22 Pieces BEGA 200W FLOOD LIGHT BEGA
Article No.:
Luminous flux (Luminaire): 21136 lm
Luminous flux (Lamps): 21166 lm
Luminaire Wattage: 195.6 W
Luminaire classification according to CIE: 100
CIE flux code: 54 87 99 100 100
Fitting: 1 x User defined (Correction Factor 1.000).

See our luminaire catalog for an image of the luminaire.

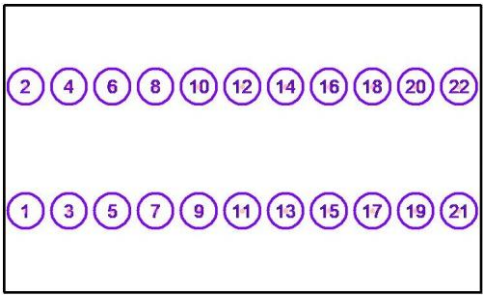


Operator
Telephone
Fax
e-Mail

TRANING TENNIS / Luminaires (coordinates list)

BEGA 200W FLOOD LIGHT BEGA

21136 lm, 195.6 W, 1 x 1 x User defined (Correction Factor 1.000).

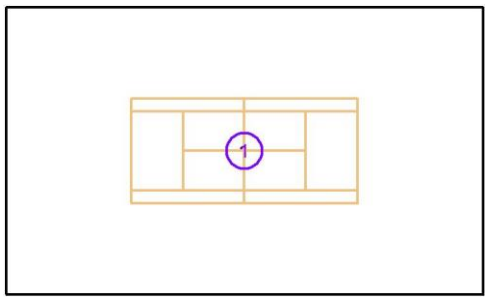


No.	Position [m]			Rotation [°]		
	X	Y	Z	X	Y	Z
1	2.273	8.500	10.000	0.0	0.0	90.0
2	2.273	21.500	10.000	0.0	0.0	90.0
3	6.818	8.500	10.000	0.0	0.0	90.0
4	6.818	21.500	10.000	0.0	0.0	90.0
5	11.364	8.500	10.000	0.0	0.0	90.0
6	11.364	21.500	10.000	0.0	0.0	90.0
7	15.909	8.500	10.000	0.0	0.0	90.0
8	15.909	21.500	10.000	0.0	0.0	90.0
9	20.455	8.500	10.000	0.0	0.0	90.0
10	20.455	21.500	10.000	0.0	0.0	90.0
11	25.000	8.500	10.000	0.0	0.0	90.0
12	25.000	21.500	10.000	0.0	0.0	90.0
13	29.545	8.500	10.000	0.0	0.0	90.0
14	29.545	21.500	10.000	0.0	0.0	90.0
15	34.091	8.500	10.000	0.0	0.0	90.0
16	34.091	21.500	10.000	0.0	0.0	90.0
17	38.636	8.500	10.000	0.0	0.0	90.0
18	38.636	21.500	10.000	0.0	0.0	90.0
19	43.182	8.500	10.000	0.0	0.0	90.0
20	43.182	21.500	10.000	0.0	0.0	90.0
21	47.727	8.500	10.000	0.0	0.0	90.0
22	47.727	21.500	10.000	0.0	0.0	90.0

Operator
Telephone
Fax
e-Mail

TRANING TENNIS / Sport Sites (Coordinates List)

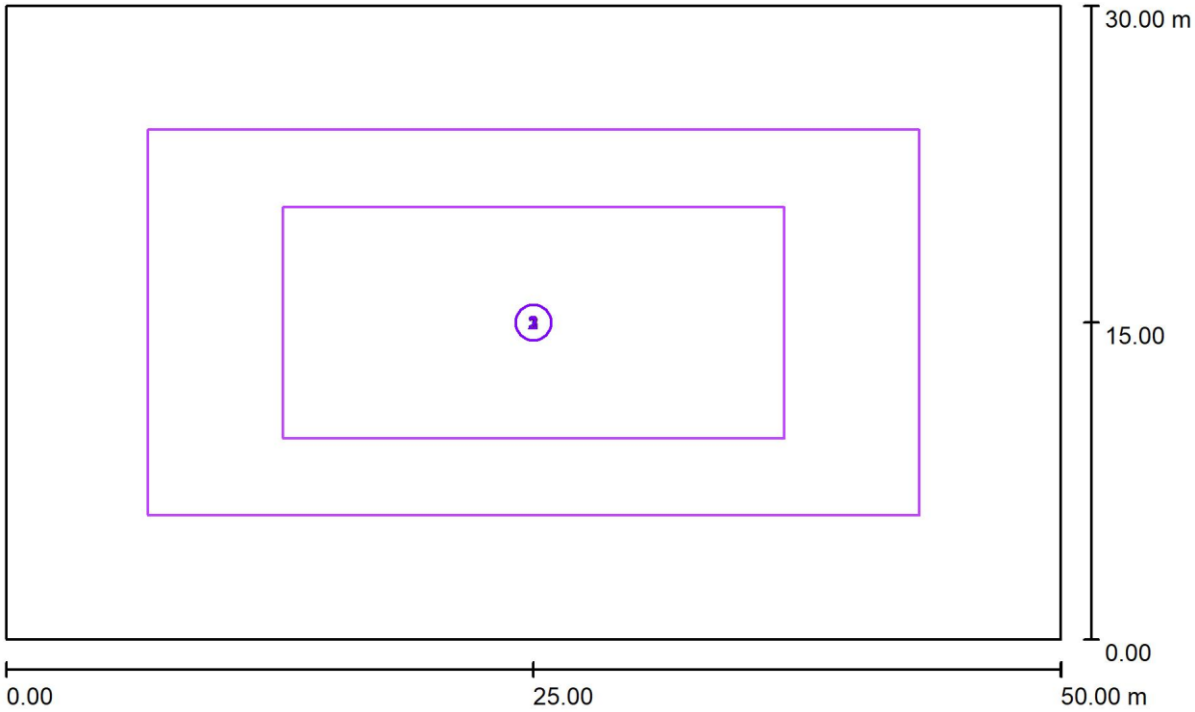
Tennis



No.	Position [m]			Size Playing Area [m]		Size Total Area [m]		Rotation [°]		
	X	Y	Z	L	W	L	W	X	Y	Z
1	25.000	15.000	0.000	23.770	10.970	23.770	10.970	0.0	0.0	0.0

Operator
Telephone
Fax
e-Mail

TRANING TENNIS / Calculation Grid (Coordinates List)



Scale 1 : 358

List of the Calculation Grids

No.	Designation	Position [m]			Size [m]		Rotation [°]		
		X	Y	Z	L	W	X	Y	Z
1	Tennis 1 Calculation Grid (PA)	25.000	15.000	0.000	23.770	10.970	0.0	0.0	0.0
2	TOTAL PLAYING AREA	25.000	15.000	0.000	36.570	18.270	0.0	0.0	0.0
3	VERTICAL	25.000	15.000	1.500	36.570	18.270	0.0	0.0	0.0

Operator
Telephone
Fax
e-Mail

TRANING TENNIS / Photometric Results

Total Luminous Flux: 464985 lm
Total Load: 4303.2 W
Light loss factor: 0.80
Boundary Zone: 0.000 m

Surface	Average illuminances [lx]			Reflection factor [%]	Average luminance [cd/m²]
	direct	indirect	total		
Workplane	187	8.31	195	/	/
Floor	187	8.37	196	10	6.23
Ceiling	0.56	16	16	30	1.55
Wall 1	40	12	52	20	3.29
Wall 2	59	12	70	20	4.48
Wall 3	40	11	51	20	3.26
Wall 4	59	11	70	20	4.44

Uniformity on the working plane
u0: 0.394 (1:3)
E_{min} / E_{max}: 0.292 (1:3)

UGR	Lengthways-	Across	to luminaire axis
Left Wall	>30	>30	
Lower Wall	>30	>30	

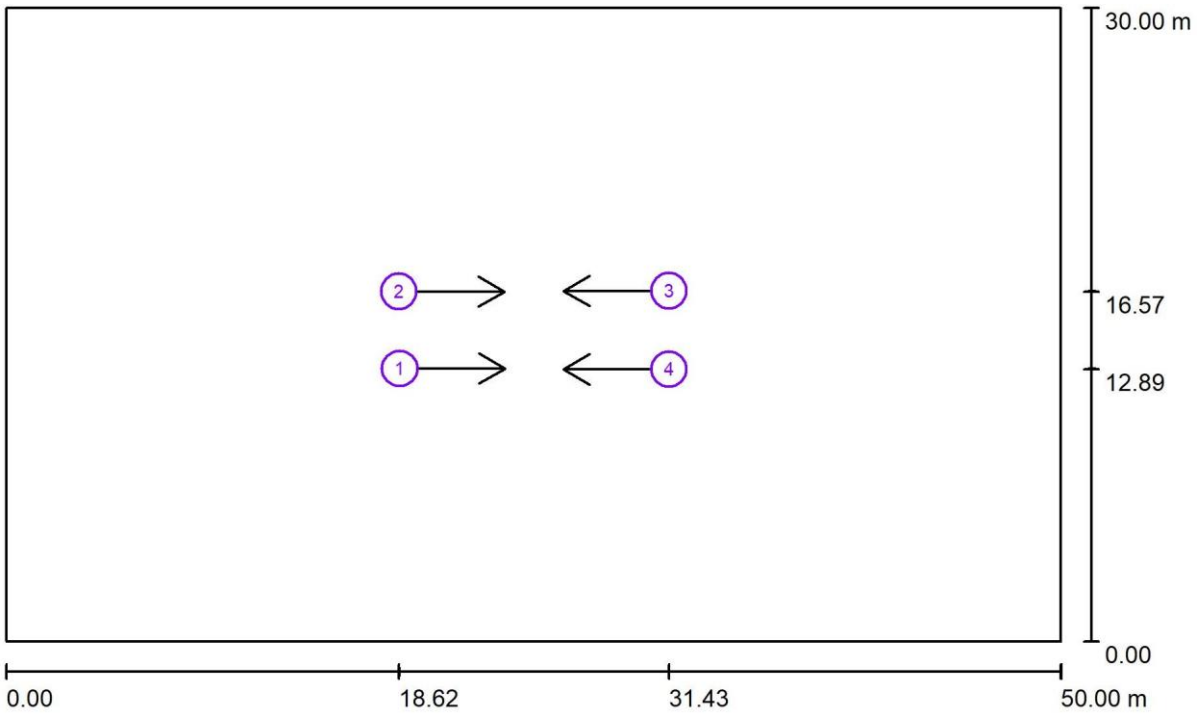
(CIE, SHR = 0.25.)

Illuminance Quotient (according to LG7): Walls / Working Plane: 0.301, Ceiling / Working Plane: 0.083.

Specific connected load: 2.87 W/m² = 1.47 W/m²/100 lx (Ground area: 1500.00 m²)

Operator
Telephone
Fax
e-Mail

TRANING TENNIS / UGR Observer (results overview)



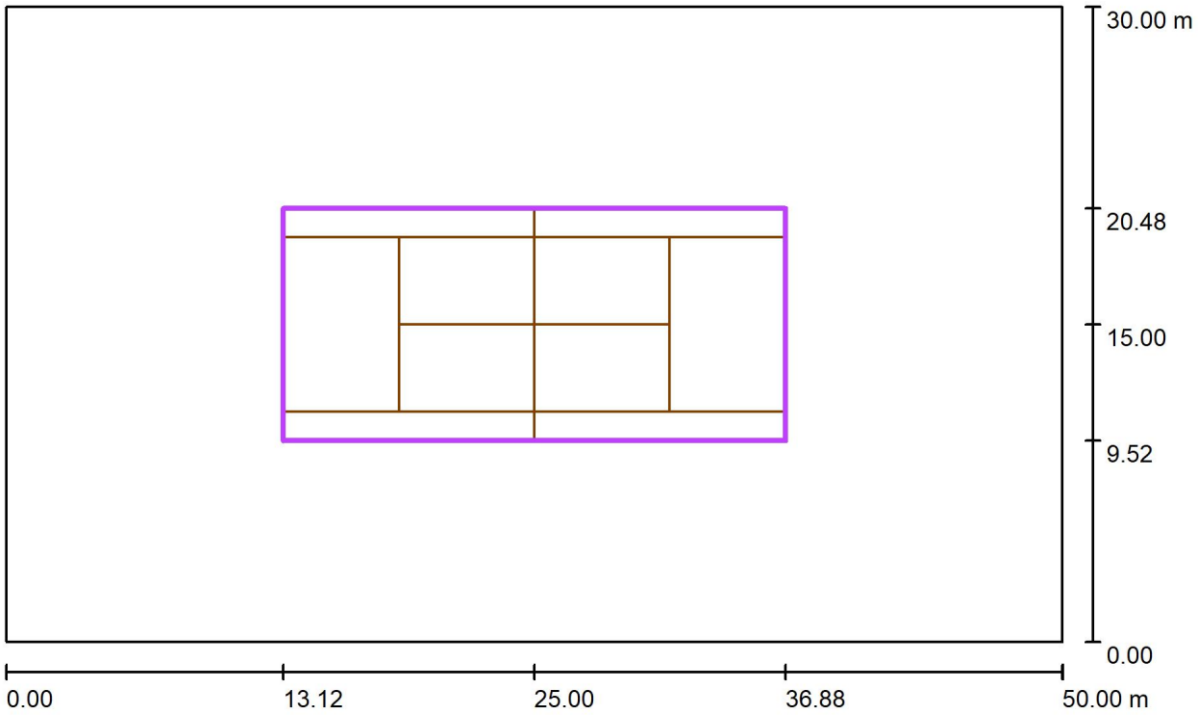
Scale 1 : 358

UGR Calculation Points List

No.	Designation	Position [m] X	Y	Z	Viewing direction [°]	Value
1	UGR Calculation Point 1	18.655	12.917	1.200	0.0	>30
2	UGR Calculation Point 1	18.624	16.570	1.200	0.0	>30
3	UGR Calculation Point 1	31.425	16.601	1.200	180.0	>30
4	UGR Calculation Point 1	31.425	12.886	1.200	180.0	>30

Operator
Telephone
Fax
e-Mail

TRANING TENNIS / Tennis 1 Calculation Grid (PA) / Summary



Scale 1 : 358

Position: (25.000 m, 15.000 m, 0.000 m)
Size: (23.770 m, 10.970 m)
Rotation: (0.0°, 0.0°, 0.0°)
Type: Normal, Grid: 48 x 22 Points
Belongs to the following sport arena: Tennis 1

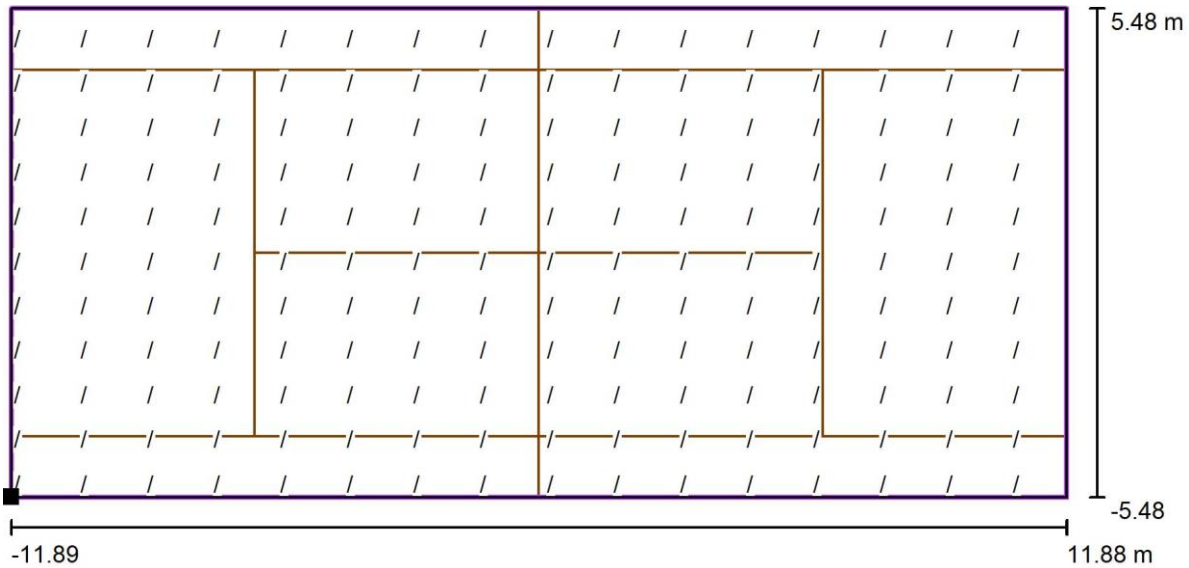
Results overview

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	253	241	264	0.95	0.91	/	0.000	/

$E_{h\,m}/E_m$ = Relationship between middle horizontal and vertical illuminance, H = Measuring Height

Operator
Telephone
Fax
e-Mail

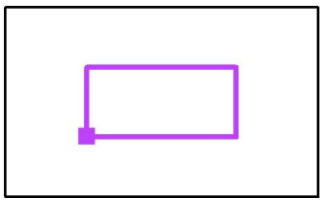
TRANING TENNIS / Tennis 1 Calculation Grid (PA) / Gradient Graphics (E, Horizontal)



Values in %, Scale 1 : 170

Not all calculated values could be displayed.

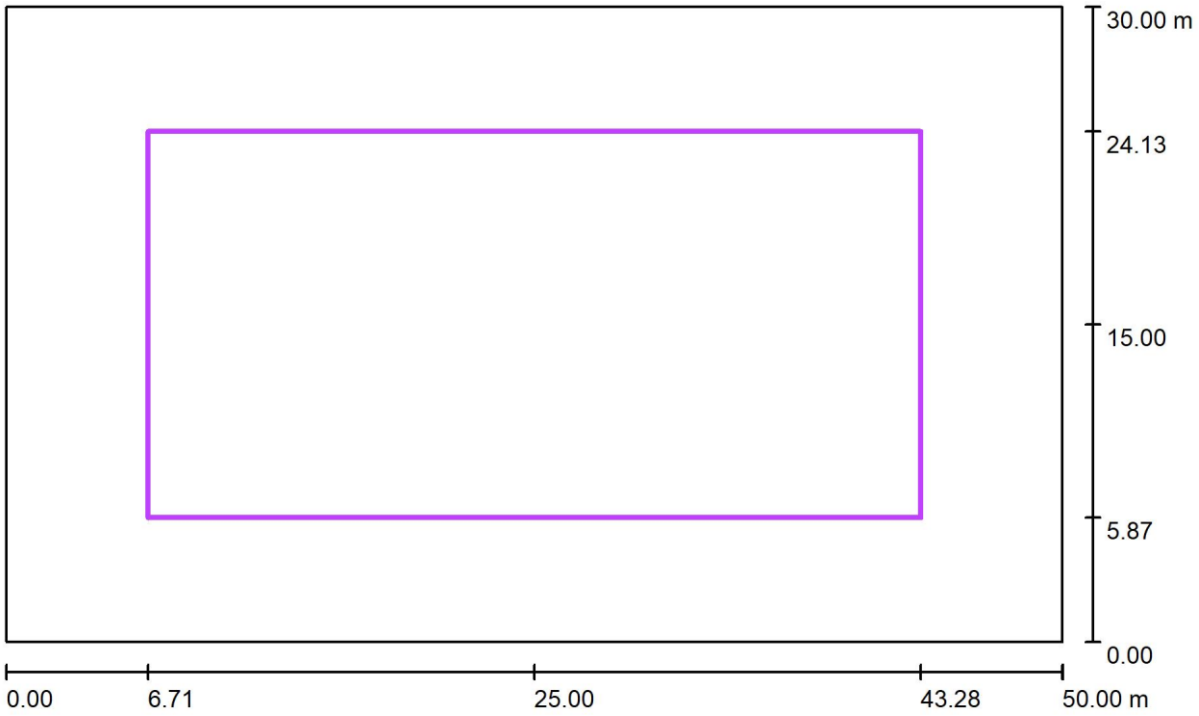
Position of surface in room:
Marked point: (13.115 m, 9.515 m, 0.000 m)



Maximum Change: 2%
Selected Limit Value: 20% (Values below this limit value are not output.)
Distance for the Gradient Grid: 1.000 m

Operator
Telephone
Fax
e-Mail

TRANING TENNIS / TOTAL PLAYING AREA / Summary



Scale 1 : 358

Position: (25.000 m, 15.000 m, 0.000 m)
Size: (36.570 m, 18.270 m)
Rotation: (0.0°, 0.0°, 0.0°)
Type: Normal, Grid: 37 x 19 Points

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	243	197	264	0.81	0.75	/	0.000	/

$E_{h\,m}/E_m$ = Relationship between middle horizontal and vertical illuminance, H = Measuring Height

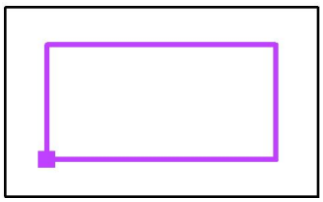
Operator
Telephone
Fax
e-Mail

TRANING TENNIS / TOTAL PLAYING AREA / Gradient Graphics (E, Horizontal)

Values in %, Scale 1 : 262

Not all calculated values could be displayed.

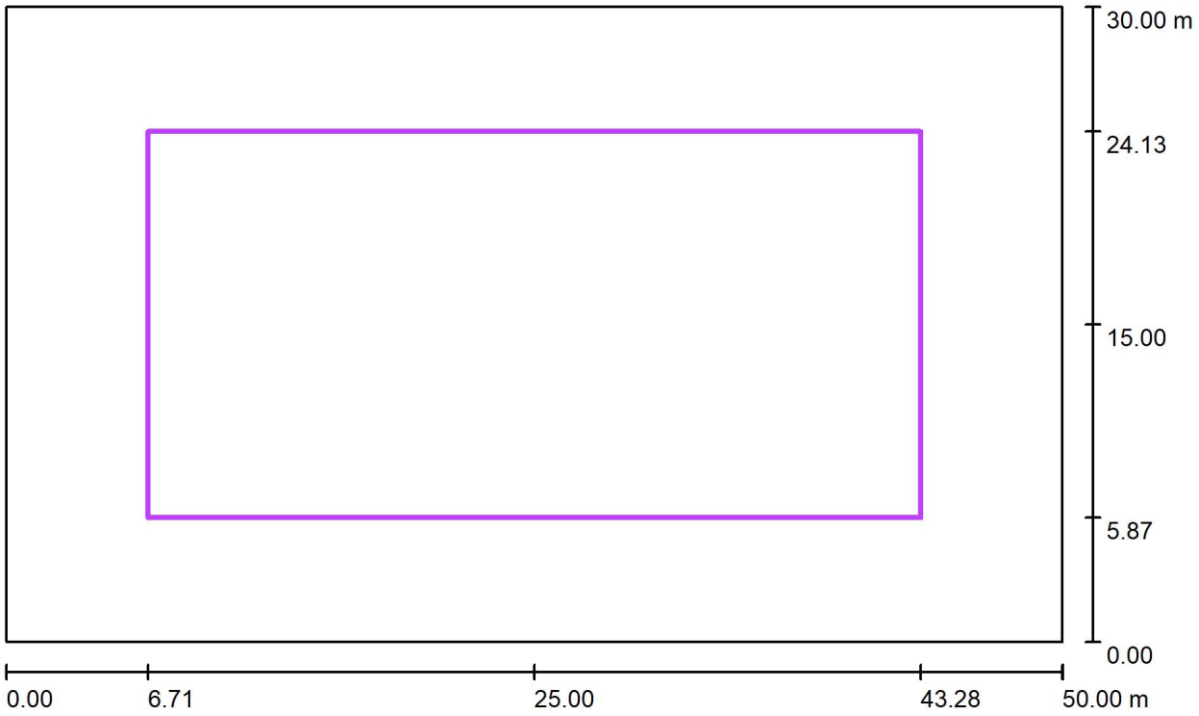
Position of surface in room:
Marked point: (6.715 m, 5.865 m, 0.000 m)



Maximum Change: 8%
Selected Limit Value: 20% (Values below this limit value are not output.)
Distance for the Gradient Grid: 1.000 m

Operator
Telephone
Fax
e-Mail

TRANING TENNIS / VERTICAL / Summary



Scale 1 : 358

Position: (25.000 m, 15.000 m, 1.500 m)
Size: (36.570 m, 18.270 m)
Rotation: (0.0°, 0.0°, 0.0°)
Type: Normal, Grid: 37 x 19 Points

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	261	214	291	0.82	0.73	/	0.000	/
2	vertical, 0.0°	89	47	104	0.54	0.45	2.95	1.000	/

$E_{h\,m}/E_m$ = Relationship between middle horizontal and vertical illuminance, H = Measuring Height

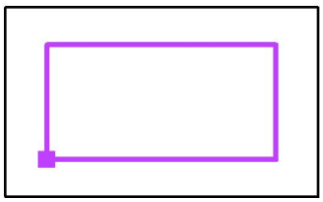
Operator
Telephone
Fax
e-Mail

TRANING TENNIS / VERTICAL / Gradient Graphics (E, Horizontal)

Values in %, Scale 1 : 262

Not all calculated values could be displayed.

Position of surface in room:
Marked point: (6.715 m, 5.865 m, 1.500 m)



Maximum Change: 10%
Selected Limit Value: 20% (Values below this limit value are not output.)
Distance for the Gradient Grid: 1.000 m