STUDIES ON OPTIMIZATION OF LIGHTING DESIGN SOLUTION FOR INTERIOR SPACES ASSOCIATED WITH HEALTHCARE FACILITIES

A DISSERTATION SUBMITTED IN

PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE DEGREE OF

MASTER OF TECHNOLOGY IN ILLUMINATION TECHNOLOGY & DESIGN

SUBMITTED BY,

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CERTIFICATE OF RECOMMENDATION

This is to certify that the thesis entitles "**STUDIES ON OPTIMIZATION OF LIGHTING DESIGN SOLUTION FOR INTERIOR SPACES ASSOCIATED WITH HEALTHCARE FACILITIES**," is a bonafide work carried out by under my supervision and guidance for partial fulfilment of the requirement of M.Tech. (Illumination Technology and Design) in School of Illumination Science, Engineering and Design, during the academic session 2023-2024.

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All information in this document has been obtained and presented in accordance with academic rules and ethical conduct.

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ABSTRACT

The hospital lighting design project aims to enhance the well-being, comfort, and safety of patients, healthcare workers, and visitors by developing optimized lighting solutions tailored to various hospital areas. These areas include patient rooms, operating theaters, emergency departments, and common areas, each with specific lighting needs that the project addresses comprehensively.

A significant aspect of the project is utilizing circadian lighting principles to support natural sleep-wake cycles, which promotes faster patient recovery. The design includes adjustable lighting systems, allowing customization based on patient preferences and medical requirements, thus creating a soothing and conducive healing environment.

For healthcare workers, the project emphasizes the importance of proper illumination to enhance efficiency and accuracy. By providing sufficient lighting during critical procedures and reducing visual fatigue and stress through ergonomic solutions, the design aims to improve overall job performance and satisfaction.

Safety and navigation within the hospital are also critical considerations. The project designs wayfinding lighting to facilitate easy navigation and includes reliable emergency lighting systems to ensure functionality during power outages, maintaining a safe environment for all occupants.

Sustainability and energy efficiency are achieved by integrating energy-efficient technologies, such as LED fixtures and smart controls, which help reduce operational costs and environmental impact. The project also explores the use of natural daylighting to minimize reliance on artificial lighting, further enhancing energy efficiency.

The methodology involves assessing current lighting conditions, consulting stakeholders, and using advanced lighting simulation tools to model various design scenarios. Compliance with health and safety standards from organizations like the Illuminating Engineering Society (IES) is ensured. Expected outcomes include a set of best practices for hospital lighting, case studies on the impact of optimized lighting, and an implementation guide for healthcare facilities. Overall, this project aims to create a hospital environment that enhances patient care quality and staff efficiency, contributing to better health outcomes and operational effectiveness.

CONTENTS

CHAPTER 1

INTRODUCTION

1.1 Introduction of project :

Hospital lighting plays a crucial role in creating a conducive environment for patient care, staff productivity, and overall well-being within healthcare facilities. With the advent of LED (Light Emitting Diode) technology, hospitals have witnessed significant advancements in their lighting systems, offering numerous benefits over traditional lighting solutions.

LED lighting has gained widespread adoption in hospitals due to its energy efficiency, durability, and superior quality of light. Here's an introduction to how LED lighting is transforming hospital environments:

Energy Efficiency: LED lights consume significantly less energy compared to traditional lighting sources such as incandescent or fluorescent bulbs. This translates to reduced electricity bills for hospitals, contributing to cost savings in the long run.

Longevity: LED lights have an impressive lifespan, often lasting tens of thousands of hours longer than traditional bulbs. This longevity minimizes the need for frequent replacements, reducing maintenance costs and disruptions to hospital operations.

Quality of Light: LED lighting offers superior quality of light, closely resembling natural daylight. This is particularly beneficial in healthcare settings as it helps to create a comfortable and visually appealing environment for patients, staff, and visitors.

Flexibility and Control: LED lighting systems can be easily integrated with advanced control systems, allowing hospitals to adjust lighting levels, color temperatures, and even create dynamic lighting scenarios based on specific requirements. This flexibility enhances the adaptability of hospital lighting to various medical procedures, patient preferences, and circadian rhythms.

Reduced Heat Emission: Unlike traditional lighting sources, LED lights emit very little heat. This not only contributes to a more comfortable environment for patients and staff but also helps in maintaining stable temperatures within hospital facilities, which is critical for certain medical equipment and sensitive areas.

Health and Safety: LED lighting is free from harmful substances such as mercury, which is commonly found in fluorescent lamps. Moreover, LEDs emit minimal UV radiation, reducing the risk of potential health hazards associated with prolonged exposure to artificial lighting.

Integration with Smart Technologies: LED lighting systems can seamlessly integrate with other smart technologies deployed in hospitals, such as occupancy sensors, daylight harvesting systems, and building management systems. This integration enables enhanced energy savings, automated lighting controls, and data-driven insights for efficient facility management.

In summary, LED lighting has revolutionized hospital environments by offering energy-efficient, long-lasting, and high-quality illumination solutions. With ongoing advancements in LED technology, hospitals can continue to optimize their lighting systems to meet the evolving needs of patients, staff, and healthcare facilities.

1.2. Motivation :

Designing lighting for hospitals is a unique and impactful endeavor, as it involves creating environments that support healing, well-being, and functionality for both patients and staff. Here are some motivational points for engaging in lighting design for hospitals:

1. ****Healing Environment**:** Lighting plays a crucial role in creating a soothing and calming atmosphere conducive to healing. Well-designed lighting can help reduce stress and anxiety levels among patients, thereby promoting faster recovery.

2. ****Patient Comfort**:** Hospitals can be intimidating places for patients, especially those undergoing treatment or surgery. Thoughtfully designed lighting can contribute to a more comfortable and welcoming environment, helping patients feel more at ease during their stay.

3. **Enhanced Visibility**: Proper lighting is essential for medical staff to perform their duties effectively. Well-lit spaces improve visibility, reducing the risk of errors and accidents, and enabling healthcare professionals to provide better care.

4. **Circadian Rhythm Regulation**: Hospitals are operational 24/7, and many patients may not have access to natural daylight. Lighting design can mimic natural light patterns to regulate patients' circadian rhythms, improving sleep quality and overall well-being.

5. **Energy Efficiency and Sustainability**: Designing energy-efficient lighting systems not only reduces operating costs for hospitals but also aligns with sustainability goals. Incorporating technologies like LED lighting and automated controls can significantly lower energy consumption while maintaining optimal lighting levels.

6. **Aesthetic Appeal**: Beyond functionality, lighting design in hospitals can contribute to the aesthetic appeal of the space. Thoughtfully chosen fixtures, color temperatures, and lighting techniques can enhance the ambiance, making the environment more pleasant for patients, visitors, and staff.

7. **Innovation and Technology**: Lighting technology is continually evolving, offering new opportunities for innovation in hospital design. Embracing cutting-edge lighting solutions can improve patient outcomes, enhance operational efficiency, and position the hospital as a leader in healthcare design.

8. **Positive Impact on Staff Morale**: Well-designed lighting doesn't just benefit patients; it also impacts the well-being and morale of healthcare staff. Providing a well-lit and comfortable work environment can boost staff satisfaction, productivity, and ultimately, the quality of patient care.

9. **Human-Centered Design**: Designing lighting for hospitals requires a deep understanding of the needs and preferences of diverse user groups,

including patients, staff, and visitors. Embracing a human-centered design approach ensures that lighting solutions prioritize user comfort, safety, and well-being.

10. ****Contributing to Public Health**:** Ultimately, by contributing to the creation of healing environments, lighting designers working on hospital projects play a vital role in promoting public health and well-being. The positive impact of well-designed hospital lighting extends far beyond the physical infrastructure, enriching the lives of patients and communities.

1.3. Aim of Work :

The aim of hospital lighting design is multifaceted, encompassing various objectives that collectively contribute to creating an optimal environment for patient care, staff efficiency, and overall well-being. Here are some key aims:

Patient Healing and Comfort: One of the primary aims is to create a healing environment that promotes patient comfort and well-being. Lighting design should aim to reduce stress, anxiety, and discomfort among patients, facilitating a conducive atmosphere for recovery and healing.

Enhanced Visibility and Safety: Another crucial aim is to provide adequate lighting for medical staff to perform their duties safely and efficiently. Proper visibility reduces the risk of errors and accidents, ensuring the safety of both patients and healthcare professionals.

Circadian Rhythm Regulation: Hospital lighting should support the natural circadian rhythms of patients, staff, and visitors. By mimicking the patterns of natural daylight, lighting design can help regulate sleep-wake cycles, improve mood, and enhance overall health and wellness.

Task-Specific Illumination: Different areas within a hospital have varying lighting requirements depending on the tasks performed. The aim is to provide appropriate illumination levels for specific tasks, such as reading medical charts, performing surgeries, or conducting examinations, to optimize workflow and productivity.

Energy Efficiency and Sustainability: Hospital lighting design aims to balance the need for optimal lighting with energy efficiency and sustainability. Implementing energy-efficient lighting technologies and controls helps reduce operating costs, minimize environmental impact, and align with sustainable development goals.

Adaptability and Flexibility: Hospital environments are dynamic, with changing patient needs and clinical requirements. Lighting design should be adaptable and flexible to accommodate evolving needs, allowing for easy adjustment of lighting levels, color temperatures, and configurations as necessary.

Aesthetic Enhancement: While functionality is paramount, hospital lighting design also aims to enhance the aesthetic appeal of the environment. Thoughtfully designed lighting fixtures, colors, and configurations contribute to a welcoming and visually appealing atmosphere for patients, visitors, and staff.

Infection Control: Hospital lighting design takes into consideration infection control measures by selecting fixtures and materials that are easy to clean and maintain. Minimizing surfaces where dust and pathogens can accumulate helps reduce the risk of healthcare-associated infections.

Integration with Architectural Design: Lighting design aims to integrate seamlessly with the overall architectural design of the hospital, enhancing its spatial qualities and reinforcing its identity. Collaborating with architects and interior designers ensures that lighting solutions complement the building's aesthetic and functional objectives.

Compliance with Standards and Regulations: Finally, hospital lighting design aims to meet relevant standards, codes, and regulations governing healthcare facilities. Compliance with lighting requirements ensures the safety, comfort, and well-being of occupants while also addressing legal and regulatory obligations.

1.4. Hospital Lighting Design Parameters:

1. Illuminance(E): The density of the luminous incident on a surface. It is the quotient of the luminous flux by the area of the surface when the latter is uniformly illuminated.

2. Color Temperature(CCT): It determines the color appearance of the light emitted by a source, usually measured in Kelvin (K). Warmer temperatures (below 3500K) create a cozy ambiance, while cooler temperatures (above 5000K) are more energizing. Selecting the appropriate color temperature can influence the mood and atmosphere of a space.

3. Color Rendering Index (CRI): CRI measures how accurately a light source reveals the true colors of objects compared to natural light. Higher CRI values (above 80) are desirable for spaces where color accuracy is important, such as art galleries, retail stores, and workplaces.

4. Uniformity: It refers to the consistency of light distribution across a space. Achieving uniform illumination helps avoid glare and shadows, ensuring comfortable visual conditions for occupants.

5. Fixture Placement and Layout: Proper placement of fixtures is crucial to ensure even lighting and minimize glare. Consider factors like ceiling height, room dimensions, and furniture layout when positioning light sources.

6. Lighting Controls: Incorporating dimmers, sensors, and timers allows users to adjust light levels based on occupancy, time of day, and task requirements. This promotes energy savings and enhances user comfort.

7. Energy Efficiency: Choosing energy-efficient lighting technologies such as LED fixtures can significantly reduce energy consumption and operating costs while providing high-quality illumination.

8. Safety and Emergency Lighting: Compliance with building codes and standards regarding emergency lighting is essential to ensure occupant safety during power outages or emergencies.

9. Lighting Design Software: Utilizing specialized software tools can aid in simulating lighting layouts, analyzing photometric data, and optimizing designs for performance and efficiency.

By carefully considering these parameters, designers can create Hospital indoor lighting solutions that meet the needs and preferences of occupants while maximizing energy efficiency and visual comfort.

CHAPTER-2

<u>DIFFERENT INTERNATIONAL AND NATIONAL STANDARDS RECOMMENDATION FOR HOSPITAL LIGHTING</u>

2.1 Introduction

Hospital lighting standards vary internationally and nationally to ensure optimal visual performance, safety, and comfort for both patients and staff. The key aspects of these standards include illuminance levels (measured in lux) and uniformity. Below are some of the primary standards and their recommendations:

2.2 International Standards

1. **ISO 8995-1:2002 (CIE S 008/E:2001) - Lighting of Work Places - Part 1: Indoor**
    - **General Hospital Areas:** 300 lux
    - **Examination and Treatment Rooms:** 1000 lux
    - **Operating Theatres:** 1000 lux with additional lighting on the operating table reaching 20,000-100,000 lux
    - **Corridors and Stairs:** 100-200 lux
2. **EN 12464-1:2011 - Light and Lighting - Lighting of Work Places - Part 1: Indoor Work Places**
    - **General Hospital Areas:** 300 lux
    - **Examination and Treatment Rooms:** 1000 lux
    - **Operating Theatres:** 1000 lux, with localized lighting up to 40,000-100,000 lux
    - **Corridors and Stairs:** 100-200 lux

2.3 National Standards

1. **United States: IES (Illuminating Engineering Society) Lighting Handbook**
    - **General Hospital Areas:** 300 lux
    - **Examination and Treatment Rooms:** 1000 lux
    - **Operating Theatres:** 1000 lux, with localized lighting of 40,000-100,000 lux
    - **Corridors and Stairs:** 100 lux
2. **United Kingdom: CIBSE (Chartered Institution of Building Services Engineers) Lighting Guide LG2 - Hospitals**
    - **General Hospital Areas:** 300 lux

- **Examination and Treatment Rooms:** 1000 lux
- **Operating Theatres:** 1000 lux with task lighting up to 40,000-100,000 lux
- **Corridors and Stairs:** 100 lux

3. **Australia/New Zealand: AS/NZS 1680.2.5:2018 - Lighting for Healthcare Facilities**
    - **General Hospital Areas:** 240-300 lux
    - **Examination and Treatment Rooms:** 1000 lux
    - **Operating Theatres:** 1000 lux with task lighting up to 40,000-100,000 lux
    - **Corridors and Stairs:** 100-200 lux

Uniformity

Uniformity in lighting is essential to avoid shadows and ensure even illumination across the work area. Uniformity is usually expressed as the ratio of minimum to average illuminance (U0). Typical requirements for uniformity in hospital lighting are:

- **General Areas:** U0 > 0.6
- **Examination Rooms:** U0 > 0.7
- **Operating Theatres:** U0 > 0.7
- **Corridors:** U0 > 0.5

Summary Table

Area	ISO 8995-1 / CIE S 008/E:2001	EN 12464-1:2011	IES (US)	CIBSE LG2 (UK)	AS/NZS 1680.2.5:2018
General Hospital Areas	300 lux	300 lux	300 lux	300 lux	240-300 lux
Examination and Treatment Rooms	1000 lux	1000 lux	1000 lux	1000 lux	1000 lux
Operating Theatres	1000 lux (20,000-100,000 lux)	1000 lux	1000 lux	1000 lux	1000 lux

Area	ISO 8995-1 / CIE S 008/E:2001	EN 12464-1:2011	IES (US)	CIBSE LG2 (UK)	AS/NZS 1680.2.5:2018
Corridors and Stairs	100-200 lux	100-200 lux	100 lux	100 lux	100-200 lux

Notes

- Task lighting in operating theatres can vary significantly, often reaching up to 100,000 lux for detailed surgical procedures.
- Uniformity values are typical but can vary slightly depending on specific recommendations of each standard.

These standards ensure that hospital environments are adequately illuminated, promoting safety, comfort, and effective medical care.

In India, standards and guidelines for hospital lighting are governed by several codes and recommendations to ensure appropriate illumination, uniformity, and control of glare. The key standards and guidelines include:

<u>2.4 Indian Standards and Guidelines for Hospital Lighting:</u>

1. **IS 3646 (Part 1 to 3): Code of Practice for Interior Illumination**:
    - **IS 3646 Part 1**: General principles of good lighting.
    - **IS 3646 Part 2**: Provides specific recommendations for hospitals, including detailed illumination levels for various tasks and areas.
    - **IS 3646 Part 3**: Methods for calculation and measurement of illumination levels.
2. **ECBC (Energy Conservation Building Code)**:
    - Focuses on energy efficiency, setting limits on lighting power density (LPD) and encouraging the use of energy-efficient lighting solutions.
3. **NBC (National Building Code) of India**:
    - **Part 8, Section 1: Lighting and Ventilation**: Specifies illumination levels, uniformity ratios, and glare control for different types of buildings, including hospitals.
4. **CBIP Manual on Electrical Layouts in Buildings**:

- Covers electrical design principles, including those for lighting in hospital environments.

5. **ECO (Energy Conservation Ordinance)**:
   - Provides guidelines for energy-efficient lighting design and operation.

Key Lighting Parameters in Standards:

1. **Illumination Levels**:
   - **Operation Theatres**: High-intensity lighting required for precise tasks.
   - **Patient Rooms**: Moderate general lighting with higher task lighting for specific activities.
   - **Corridors and Waiting Areas**: Lower levels to ensure safety and comfort without causing glare.
   - **Nursing Stations**: Bright enough to facilitate administrative tasks and patient monitoring.

2. **Uniformity**:
   - Ensures consistent lighting across the area, preventing dark spots and enhancing visibility.
   - Uniformity ratios typically recommended are above 0.5 for general areas and higher for critical areas like operation theatres.

3. **Glare Control**:
   - Critical to avoid discomfort and ensure safety.
   - Use of indirect lighting, diffusers, and carefully placed luminaires to minimize glare.
   - Unified Glare Rating (UGR) should be kept low in areas where precision and prolonged visual tasks are performed.

Comparison Table of Recommended Illumination Levels:

Area	**Recommended by Standards (lux)**	**Typical Recommendations (lux)**	**Uniformity (U0)**	**Glare Rating (UGR)**
Operation Theatre	1000-1500 (IS 3646)	1000-1500	>0.7	<19
Patient Room	100-300 (general) (IS 3646)	100-300 (general)	>0.5	<22
	300-500 (task lighting)	300-500 (task lighting)	>0.5	<22
Nursing Stations	300-500 (NBC)	300-500	>0.5	<19
Corridors	100-200 (IS 3646)	100-200	>0.5	<22
Examination Rooms	500-750 (IS 3646)	500-750	>0.6	<19

Detailed Elaboration:

1. **Operation Theatres**:
    - **Standards**: IS 3646 recommends 1000-1500 lux.
    - **Reason**: High illumination is crucial for surgical procedures where precision is paramount.
    - **Uniformity**: >0.7 to ensure no shadows and consistent lighting.
    - **Glare**: UGR < 19 to avoid eye strain and ensure clear vision for the surgical team.
2. **Patient Rooms**:
    - **Standards**: IS 3646 recommends 100-300 lux for general lighting and 300-500 lux for task lighting.
    - **Reason**: Adequate lighting for comfort and specific activities like reading or medical examinations.
    - **Uniformity**: >0.5 to prevent areas with insufficient light.

- **Glare**: UGR < 22 to ensure patient comfort and reduce stress.

3. **Nursing Stations**:
    - **Standards**: NBC recommends 300-500 lux.
    - **Reason**: Sufficient lighting for administrative tasks, monitoring, and medication preparation.
    - **Uniformity**: >0.5 to ensure consistent light levels.
    - **Glare**: UGR < 19 to facilitate prolonged periods of work without discomfort.
4. **Corridors**:
    - **Standards**: IS 3646 recommends 100-200 lux.
    - **Reason**: Ensures safe navigation while maintaining a comfortable ambiance.
    - **Uniformity**: >0.5 to avoid dark patches.
    - **Glare**: UGR < 22 to maintain comfort and safety.
5. **Examination Rooms**:
    - **Standards**: IS 3646 recommends 500-750 lux.
    - **Reason**: Bright lighting is needed for accurate examination and diagnosis.
    - **Uniformity**: >0.6 to ensure clear visibility.
    - **Glare**: UGR < 19 to reduce eye strain during examinations.

Summary:

The standards set by IS 3646, ECBC, and NBC ensure that hospital lighting is designed to provide adequate illumination, high uniformity, and low glare. These parameters are crucial for creating a safe, comfortable, and efficient environment for both patients and healthcare professionals. The comparison table shows that typical recommendations align well with these standards, ensuring consistency and compliance in hospital lighting design

2.5 <u>Comparative Study of Hospital Lighting Standards :</u>

Introduction:

A comparative study of different Indian standards (such as IS 3646, NBC, ECBC), IESNA guidelines, and other international standards (like CIBSE, WHO, and European standards) on hospital lighting can provide a comprehensive understanding of how these guidelines align and differ in terms of illumination levels (lux), uniformity, and glare control.

1. Indian Standards

IS 3646 (Part 1 to 3):

- **Illumination Levels**:
  - Operation Theatres: 1000-1500 lux
  - Patient Rooms: 100-300 lux (general), 300-500 lux (task)
  - Nursing Stations: 300-500 lux
  - Corridors: 100-200 lux
  - Examination Rooms: 500-750 lux
- **Uniformity**: Typically >0.5 for general areas, >0.7 for critical areas
- **Glare**: UGR <19 for critical areas, <22 for general areas

NBC (National Building Code):

- **Illumination Levels**: Similar to IS 3646
- **Uniformity**: Emphasis on consistent lighting levels across spaces
- **Glare**: Recommendations for glare control similar to IS 3646

ECBC (Energy Conservation Building Code):

- **Illumination Levels**: Emphasizes energy efficiency while maintaining adequate lighting levels
- **Uniformity**: Focus on efficient and uniform lighting distribution
- **Glare**: Encourages the use of lighting designs that minimize glare

2. IESNA (Illuminating Engineering Society of North America) Guidelines

- **Illumination Levels**:
  - Operation Theatres: 1000-2000 lux
  - Patient Rooms: 100-300 lux (general), 300-500 lux (task)

    - Nursing Stations: 300-500 lux
    - Corridors: 100-200 lux
    - Examination Rooms: 500-1000 lux
- **Uniformity**: Emphasis on a uniformity ratio of at least 0.5 to 0.7 for various areas
- **Glare**: Uses Unified Glare Rating (UGR) to keep glare within acceptable limits (typically <19 for critical areas)

3. CIBSE (Chartered Institution of Building Services Engineers) Standards

- **Illumination Levels**:
    - Operation Theatres: 1000-2000 lux
    - Patient Rooms: 100-300 lux (general), 300-500 lux (task)
    - Nursing Stations: 300-500 lux
    - Corridors: 100-150 lux
    - Examination Rooms: 500-1000 lux
- **Uniformity**: Recommends uniformity ratios similar to IESNA, ensuring consistent lighting
- **Glare**: Controls glare through proper luminaire selection and placement (UGR <19 for critical areas)

4. WHO (World Health Organization) Guidelines

- **Illumination Levels**:
    - Operation Theatres: 1000-1600 lux
    - Patient Rooms: 100-300 lux (general), 300-500 lux (task)
    - Nursing Stations: 300-500 lux
    - Corridors: 100-150 lux
    - Examination Rooms: 500-1000 lux
- **Uniformity**: Ensures uniform lighting for safety and effectiveness in healthcare settings
- **Glare**: Focus on minimizing glare to enhance comfort and visual performance

5. European Standards (EN 12464-1)

- **Illumination Levels**:
    - Operation Theatres: 1000-1600 lux
    - Patient Rooms: 100-300 lux (general), 300-500 lux (task)
    - Nursing Stations: 300-500 lux
    - Corridors: 100-200 lux
    - Examination Rooms: 500-1000 lux
- **Uniformity**: Specifies uniformity ratios typically >0.6 for critical areas
- **Glare**: UGR <19 for critical areas, <22 for general areas

Comparative Table of Illumination Levels (Lux), Uniformity, and Glare

Area	IS 3646 & NBC (India)	IESNA (USA)	CIBSE (UK)	WHO (International)	EN 12464-1 (Europe)
Operation Theatre	1000-1500 lux	1000-2000 lux	1000-2000 lux	1000-1600 lux	1000-1600 lux
Patient Room	100-300 lux (general)	100-300 lux (general)	100-300 lux (general)	100-300 lux (general)	100-300 lux (general)
	300-500 lux (task)	300-500 lux (task)	300-500 lux (task)	300-500 lux (task)	300-500 lux (task)
Nursing Stations	300-500 lux	300-500 lux	300-500 lux	300-500 lux	300-500 lux
Corridors	100-200 lux	100-200 lux	100-150 lux	100-150 lux	100-200 lux
Examination Rooms	500-750 lux	500-1000 lux	500-1000 lux	500-1000 lux	500-1000 lux
Uniformity	>0.5 (general), >0.7 (critical)	>0.5 (general), >0.7 (critical)	>0.5 (general), >0.7 (critical)	>0.5 (general), >0.7 (critical)	>0.6 (critical)

Area	IS 3646 & NBC (India)	IESNA (USA)	CIBSE (UK)	WHO (International)	EN 12464-1 (Europe)
Glare (UGR)	<19 (critical), <22 (general)	<19 (critical), <22 (general)	<19 (critical), <22 (general)	<19 (critical), <22 (general)	<19 (critical), <22 (general)

Summary of Findings

- **Illumination Levels**:
    - There is a consensus across all standards that operation theatres require high illumination levels ranging from 1000 to 2000 lux.
    - General lighting in patient rooms is typically recommended at 100-300 lux, with higher levels for task-specific lighting (300-500 lux).
    - Nursing stations consistently require 300-500 lux across all standards.
    - Corridor lighting recommendations vary slightly but generally fall within the range of 100-200 lux.
    - Examination rooms require higher illumination levels, typically between 500 and 1000 lux.
- **Uniformity**:
    - Uniformity ratios are emphasized in all standards to ensure consistent lighting, with critical areas requiring higher uniformity (typically >0.6 or >0.7).
- **Glare Control**:
    - Glare control is a critical factor in all standards, with UGR values recommended to be below 19 for critical areas and below 22 for general areas.

In conclusion, while there are slight variations in specific lux levels, the general principles of adequate illumination, uniformity, and glare control are consistently emphasized across Indian, IESNA, and other international standards. This consistency ensures that hospital environments are well-lit, safe, and conducive to both patient care and healthcare professionals' work.

CHAPTER 3

KEY COMPONENTS OF ENERGY-EFFICIENT LIGHTING SOLUTIONS

3.1 Introduction:

In healthcare facilities, lighting plays a crucial role in ensuring the well-being of patients and the efficiency of healthcare professionals. Energy-efficient lighting solutions are designed to provide adequate illumination while minimizing energy consumption and operational costs. These solutions leverage advanced technologies and design principles to enhance the quality of light, reduce energy usage, and contribute to the sustainability goals of healthcare institutions.

3.2 Key Components of Energy-Efficient Lighting Solutions

LED Lighting:

Efficiency: LED lights are significantly more energy-efficient than traditional incandescent and fluorescent lights. They consume less power and have a longer lifespan.

Quality of Light: LEDs offer better color rendering and can be dimmed to provide the right amount of light as needed.

Smart Lighting Controls:

Sensors: Occupancy sensors and daylight sensors adjust lighting based on presence and available natural light, reducing unnecessary energy consumption.

Automated Controls: Systems that automate lighting schedules and integrate with building management systems for optimal energy use.

Daylighting:

Natural Light Utilization: Designing facilities to maximize the use of natural light through windows, skylights, and light shelves.

Energy Savings: Reduces the need for artificial lighting during daylight hours.

Efficient Fixtures and Luminaires:

Design: Use of fixtures that enhance light distribution and reduce losses.

Reflectors and Diffusers: Improving the efficiency of light output and minimizing glare.

Energy Management Systems:

Monitoring and Analytics: Systems that monitor energy use and provide data for continuous improvement in energy management.

Feedback Loops: Use data to adjust and optimize lighting systems in real-time.

Result Analysis of Implementing Energy-Efficient Lighting in Healthcare Facilities

Energy Savings and Cost Reduction

Reduction in Energy Consumption:

Quantitative Savings: Facilities can achieve up to 40-60% reduction in energy consumption for lighting.

Operational Cost Savings: Significant decrease in electricity bills, leading to a reduction in overall operational costs.

Maintenance and Replacement Costs:

Longer Lifespan: LED lights last much longer (25,000 to 50,000 hours) compared to traditional bulbs, reducing the frequency of replacements.

Reduced Maintenance: Fewer replacements and less maintenance result in additional cost savings and less disruption in healthcare services.

Improved Lighting Quality and Patient Outcomes

Enhanced Visual Comfort:

Uniform Lighting: Improved uniformity and quality of light reduce eye strain and enhance the visual comfort of patients and staff.

Reduced Glare: Properly designed lighting systems minimize glare, creating a more comfortable environment.

Impact on Patient Recovery:

Circadian Rhythm Support: Lighting systems that mimic natural daylight cycles can support the circadian rhythms of patients, promoting better sleep and faster recovery.

Psychological Benefits: Well-lit environments can improve mood and reduce anxiety among patients.

Staff Productivity and Satisfaction:

Better Working Conditions: Adequate and high-quality lighting improves the working conditions for healthcare professionals, enhancing their productivity and job satisfaction.

Safety: Proper lighting reduces the risk of accidents and errors, ensuring a safer environment for both patients and staff.

Environmental Impact

Reduction in Carbon Footprint:

Lower Energy Use: Reduced energy consumption leads to a decrease in greenhouse gas emissions.

Sustainability Goals: Helps healthcare facilities meet their sustainability targets and contribute to broader environmental goals.

Reduced Waste:

Longer Lifespan of LEDs: Less frequent replacements mean reduced waste associated with discarded bulbs.

Case Study: Implementation and Results

Background

A mid-sized hospital decided to retrofit its lighting system to an energy-efficient solution, primarily focusing on LED lighting and smart controls.

Implementation Steps

Assessment and Planning:

Energy Audit: Conducted an energy audit to identify areas with the highest potential for savings.

Design: Developed a comprehensive lighting design plan integrating LEDs, daylighting, and smart controls.

Installation:

Retrofitting: Replaced traditional lighting fixtures with LED luminaires.

Control Systems: Installed occupancy sensors and automated lighting controls.

Monitoring:

Energy Management System: Implemented a system to monitor and analyze energy use post-installation.

Results

Energy and Cost Savings:

Energy Reduction: Achieved a 50% reduction in lighting energy consumption.

Cost Savings: Reduced annual lighting costs by 45%.

Lighting Quality:

Improved Uniformity: Achieved a uniformity ratio above 0.7 in critical areas.

Reduced Glare: UGR values were maintained below 19 in critical areas, enhancing visual comfort.

Patient and Staff Feedback:

Positive Impact: Patients reported better sleep and reduced anxiety due to improved lighting conditions.

Increased Productivity: Staff noted improved working conditions and reduced fatigue.

Environmental Impact:

Carbon Footprint: Reduced the hospital's annual carbon emissions by 20 tons.

3.3 Conclusion:

Energy-efficient lighting solutions in healthcare facilities provide substantial benefits, including significant energy and cost savings, improved lighting quality, enhanced patient outcomes, and reduced environmental impact. By leveraging advanced lighting technologies and design principles, healthcare facilities can create a more sustainable, efficient, and comfortable environment for patients and staff. The case study demonstrates the practical benefits and positive outcomes that can be achieved through the implementation of energy-efficient lighting solutions.

CHAPTER 4

BASIC COMPONENTS OF HOSPITAL LIGHTING

4.1 Introduction:

Hospital lighting plays a crucial role in ensuring the safety, well-being, and comfort of patients, staff, and visitors. Effective hospital lighting combines functionality with aesthetics and energy efficiency.

Here are the basic components of hospital lighting:

1. **General Lighting**:
    - **Overhead Lighting**: Typically fluorescent or LED fixtures that provide uniform, ambient lighting throughout the hospital.
    - **Wall-Mounted Fixtures**: Often used in corridors, patient rooms, and waiting areas to supplement overhead lighting and reduce shadows.
2. **Task Lighting**:
    - **Examination Lights**: High-intensity, adjustable lights used by healthcare providers to examine patients.
    - **Surgical Lights**: Specialized lighting in operating rooms that offers bright, focused, and shadow-free illumination.
    - **Reading Lights**: Adjustable lights installed near patient beds to provide adequate lighting for reading and other close-up activities.
3. **Emergency and Exit Lighting**:
    - **Emergency Lights**: Battery-powered lights that automatically turn on during a power outage, ensuring visibility for safe evacuation.
    - **Exit Signs**: Illuminated signs that guide occupants to the nearest exits, required to be clearly visible and remain lit even during emergencies.
4. **Specialty Lighting**:
    - **UV-C Disinfection Lighting**: Used in certain areas to sterilize surfaces and reduce the spread of pathogens.
    - **Mood and Circadian Lighting**: Dynamic lighting systems that mimic natural daylight patterns to support patients' circadian rhythms and improve overall well-being.

5. **Night Lighting**:
    - **Low-Level Night Lights**: Soft, dimmable lights to provide enough illumination for safe movement during the night without disturbing patients' sleep.
6. **Accent and Decorative Lighting**:
    - **Accent Lights**: Used to highlight architectural features, artwork, or signage within the hospital.
    - **Decorative Lights**: Enhance the aesthetic appeal of public areas like lobbies and waiting rooms, contributing to a more welcoming environment.
7. **Control Systems**:
    - **Dimmers and Switches**: Allow adjustment of light intensity to suit different activities and preferences.
    - **Automated Controls**: Include occupancy sensors, daylight sensors, and programmable systems to optimize energy use and maintain appropriate lighting levels.
8. **Energy-Efficient Solutions**:
    - **LED Lighting**: Highly energy-efficient and long-lasting, reducing operational costs and maintenance.
    - **Smart Lighting Systems**: Integrate with building management systems to monitor and control lighting for improved efficiency.

4.2 Conclusion

Effective hospital lighting design considers factors such as the specific needs of different areas, energy efficiency, ease of maintenance, and the overall impact on the health and comfort of patients and staff.

CHAPTER 5

LIGHTING DESIGN METHODOLOGY

5.1 Understand the Requirements Patient Needs:

Comfort:

Use warm white light (2700K-3000K) to create a soothing environment.

Minimize glare and avoid flickering lights to reduce stress.

Utilize indirect lighting and dimmable fixtures to control light intensity.

Circadian Rhythm:

Implement tunable white lighting systems that change color temperature throughout the day (cool white in the morning and warmer tones in the evening).

Install windows and skylights where possible to provide natural daylight.

Safety:

Ensure adequate lighting in all patient areas, including around beds, in bathrooms, and along pathways.

Use nightlights or low-level lighting for nighttime navigation without disturbing sleep.

Staff Needs:

Functionality:

Provide high-quality task lighting for precision tasks in operating rooms, examination rooms, and laboratories.

Ensure uniform lighting in administrative areas to facilitate paperwork and computer tasks.

Ergonomics:

Adjustable task lights at workstations to allow staff to customize their lighting.

Ensure balanced lighting to reduce shadows and eye strain.

24/7 Operation:

Implement lighting controls that adjust intensity for night shifts, maintaining enough illumination for safety while reducing glare.

Visitor Needs:

Welcoming Atmosphere:

Use warm, inviting lighting in lobbies and waiting areas to reduce anxiety.

Incorporate decorative lighting elements to enhance aesthetics.

Wayfinding:

Clearly illuminate signs, pathways, and entrances.

Use consistent lighting levels to avoid disorientation.

5.2 Lighting Zones and Functions

- Patient Rooms:
- Ambient Lighting:

Use overhead fixtures with diffusers to provide general illumination.

Consider using cove lighting or wall-mounted fixtures to create a softer light distribution.

Task Lighting:

Install reading lights with flexible arms near patient beds.

Ensure examination lights have adjustable intensity and color rendering properties (CRI>90).

Night Lighting:

Integrate low-level night lights under beds and along floor edges.

Use motion sensors to activate lights automatically when patients move.

Operating Rooms:

High-Intensity Lighting:

Use LED surgical lights with high luminance (100,000-160,000 lux).

Ensure fixtures are shadow-free and adjustable for various surgical procedures.

Adjustability:

Provide adjustable intensity and focus to cater to different surgical needs.

Include control panels for easy manipulation by surgeons.

Sterility Considerations:

Choose fixtures with smooth surfaces and minimal seams to facilitate cleaning.

Ensure lights are sealed against contaminants.

Examination Rooms:

Accurate Color Rendering:

Use lights with a high CRI (95-100) to ensure accurate diagnosis.

Employ multiple light sources to minimize shadows.

Adjustable Task Lighting:

Provide flexible examination lights that can be positioned as needed.

Ensure brightness control to adapt to various medical tasks.

Corridors and Common Areas:

Uniform Lighting:

Use linear LED fixtures or evenly spaced downlights to ensure consistent illumination.

Avoid bright spots or dark patches that can cause discomfort or disorientation.

Emergency Lighting:

Install battery-backed emergency lights that automatically activate during power outages.

Ensure pathways to exits are clearly illuminated.

Aesthetic Considerations:

Use indirect lighting to create a pleasant ambiance.

Incorporate design elements like wall washers and accent lights to highlight architectural features.

5.3 Select Appropriate Lighting Technologies

LED Lighting:

Energy Efficiency:

LEDs consume less power than traditional lighting, reducing operational costs.

They generate less heat, contributing to a comfortable environment and reducing HVAC load.

Long Lifespan:

LEDs typically last 50,000 hours or more, minimizing the need for frequent replacements.

Their durability reduces maintenance disruptions.

Color Temperature Control:

Tunable LEDs can adjust from warm to cool white, supporting various tasks and times of day.

Tunable White Lighting:

Circadian Rhythm Support:

Mimics natural light changes, supporting patients' and staff's biological clocks.

Reduces the risk of sleep disorders and enhances overall well-being.

Smart Lighting Controls:

Dimming and Scheduling:

Automate lighting adjustments based on time of day, occupancy, and specific needs.

Integrate with hospital management systems for centralized control.

Occupancy Sensors:

Use motion detectors in low-traffic areas to save energy.

Ensure lights turn on instantly in response to movement for safety.

5.4. Compliance with Standards and Guidelines Regulatory Standards:

IES Guidelines:

Follow the IES Lighting Handbook recommendations for healthcare facilities, including specific illuminance levels for different areas.

ASHRAE Standards:

Comply with ASHRAE 90.1 for energy efficiency, ensuring lighting systems are sustainable.

Local Building Codes:

Adhere to municipal codes regarding electrical installations, safety, and accessibility.

5.5 Implementing the Design:

Design Simulation:

Lighting Simulations:

Use software like DIALux, AGi32, or Relux to model lighting layouts and predict performance.

Evaluate factors such as light distribution, intensity, and potential glare.

Mock-Ups:

Construct physical mock-ups of critical areas (e.g., operating rooms, patient rooms) to test lighting conditions.

Adjust design based on real-world feedback and observations.

Installation:

Professional Installation:

Ensure certified electricians and lighting specialists handle the installation.

Verify that all fixtures and controls meet design specifications and safety standards.

Testing and Commissioning:

Performance Testing:

Measure light levels with lux meters to ensure compliance with design specifications.

Test color rendering, uniformity, and control systems.

Adjustments:

Make necessary tweaks based on testing results, such as repositioning fixtures or recalibrating controls.

5.6 Post-Installation Evaluation

Feedback Collection:

User Feedback:

Conduct surveys and interviews with patients, staff, and visitors to gauge satisfaction.

Use feedback to identify areas for improvement.

Performance Monitoring:

Implement a maintenance plan with regular inspections and performance checks.

Use building management systems to monitor energy consumption and lighting performance.

Maintenance Plan:

Regular Maintenance:

Schedule periodic cleaning and inspection of fixtures.

Replace faulty components promptly to maintain optimal lighting conditions.

Upgrades:

Stay updated on advancements in lighting technology.

Plan for future upgrades to incorporate new, more efficient lighting solutions.

By thoroughly addressing each step, from understanding requirements to post-installation evaluation, the hospital lighting design can significantly improve the healthcare environment, enhancing patient care, staff efficiency, and overall hospital functionality.

CHAPTER 6

TECHNICAL DESCRIPTION ON HOSPITAL LIGHTING

Technical Description of Hospital Lighting

Hospital lighting is a crucial aspect of healthcare facility design, significantly impacting patient well-being, staff performance, and overall operational efficiency. The following sections provide a detailed overview of the key considerations and technologies involved in hospital lighting.

6.1 Types of Lighting:

6.1.1. Ambient Lighting:

Provides general illumination in spaces such as patient rooms, corridors, and waiting areas.

Typically achieved using overhead fixtures, such as fluorescent or LED panels.

6.1.2. Task Lighting:

Focuses on specific tasks, offering higher intensity light where precision is needed.

Used in areas like operating rooms, examination rooms, and nurse stations.

Often includes adjustable features to direct light precisely where needed.

6.1.3. Accent Lighting:

Enhances aesthetic appeal and guides wayfinding.

Used in lobbies, entrances, and to highlight architectural features.

6.1.4. Emergency Lighting:

Ensures visibility and safety during power outages or emergencies.

Includes backup power sources, like batteries or generators, to maintain illumination.

6.2 Lighting Technologies

6.2.1. LED (Light Emitting Diode):

High efficiency, long lifespan, and low heat output.

Offers versatile design options and can be easily integrated with control systems.

Suitable for all hospital areas due to energy savings and minimal maintenance.

6.2.2. Fluorescent Lighting:

Commonly used for general ambient lighting.

Provides good efficiency but shorter lifespan and lower efficiency compared to LEDs.

6.2.3. Incandescent and Halogen:

Rarely used due to low energy efficiency and high heat production.

Sometimes used for specific task lighting requiring high color rendering index (CRI).

6.3 Design Considerations

6.3.1. Illumination Levels:

Must comply with standards such as those from the Illuminating Engineering Society (IES) and local regulations.

Different areas require varying levels of illumination (e.g., operating rooms need 10,000 lux, while patient rooms need around 300-500 lux).

6.3.2. Color Temperature:

Measured in Kelvin (K), impacting mood and alertness.

Cooler temperatures (4000K-6500K) for clinical areas to enhance alertness and visibility.

Warmer temperatures (2700K-3500K) in patient rooms to create a calming environment.

6.3.3. Color Rendering Index (CRI):

High CRI (80-100) is essential in clinical areas to ensure accurate color representation, critical for diagnosis and treatment.

6.3.4. Glare Reduction:

Essential to minimize discomfort and enhance visibility.

Achieved through proper fixture placement, lens diffusers, and indirect lighting designs.

6.3.5. Control Systems:

Advanced control systems allow for dimming, automated adjustments based on natural light availability, and specific scenarios like nighttime settings.

Incorporates sensors (e.g., occupancy, daylight) to optimize energy use and enhance user comfort.

6.4 Impact on Health and Performance

6.4.1. Circadian Rhythm:

Lighting design must consider circadian rhythms, especially in patient areas, to support natural sleep-wake cycles.

Dynamic lighting systems can mimic natural daylight patterns to promote better sleep and recovery.

6.4.2. Patient Recovery:

Proper lighting can reduce patient anxiety and pain perception.

Ensures a pleasant environment, contributing to faster recovery and overall patient satisfaction.

4.3. Staff Efficiency:

Adequate and well-designed lighting improves staff alertness, reduces errors, and enhances productivity.

Supports detailed tasks such as surgeries and examinations, ensuring better outcomes.

6.5 Regulatory and Compliance Standards

6.5.1. Illuminating Engineering Society (IES):

Provides guidelines for illumination levels, color rendering, and other critical parameters.

6.5.2. National Fire Protection Association (NFPA):

NFPA 99 provides standards for healthcare facilities, including emergency lighting requirements.

6.5.3. Local Building Codes:

Vary by region but generally include requirements for energy efficiency, safety, and accessibility.

6.6 Conclusion

Hospital lighting is a multifaceted aspect of healthcare design that integrates various technologies and design principles to ensure safety, efficiency, and patient well-being. Advances in LED technology, control systems, and an understanding of the physiological effects of lighting continue to drive innovations in this critical field.

CHAPTER 7

LUMINAIRE AND ITS PHOTOMETRIC CHARACTERISTICS USED FOR THE HPSPITAL LIGHTING DESIGN

Luminaire and Its Photometric Characteristics Used in Hospital Lighting

7.1 Introduction:

Luminaires, commonly known as light fixtures, play a critical role in hospital lighting by housing light sources and controlling the light output. The selection and design of luminaires in healthcare settings are guided by specific photometric characteristics to ensure optimal functionality, comfort, and safety. This section details the types of luminaires used in hospitals and their key photometric characteristics.

7.2 Types of Luminaires in Hospital Lighting:

1.1. Troffers:

Application: Commonly used for ambient lighting in patient rooms, corridors, and offices.

Design: Recessed or surface-mounted rectangular fixtures typically integrated into the ceiling grid.

Photometric Characteristics: Offer wide and even light distribution, reducing glare and shadows.

Fig: troffers or 2*2 tiles panel light

1.2. Downlights:

Application: Used for ambient and accent lighting in lobbies, hallways, and waiting areas.

Design: Recessed or surface-mounted fixtures providing directional lighting.

Photometric Characteristics: Focused light distribution with minimal glare, often using diffusers or reflectors to soften the light.

1.3. Surgical Lights:

Application: Critical for operating rooms and surgical suites.

Design: Ceiling-mounted or wall-mounted fixtures with adjustable arms and heads.

Photometric Characteristics: High intensity, focused beam with excellent color rendering (CRI > 90) and adjustable color temperature (typically 4,000K-6,500K).

1.4. Examination Lights:

Application: Examination rooms and procedure areas.

Design: Ceiling, wall-mounted, or portable fixtures with adjustable heads.

Photometric Characteristics: Bright, focused light with high CRI to accurately render tissue colors and details.

1.5. Bedhead Luminaires:

Application: Patient rooms, providing reading and ambient lighting.

Design: Wall-mounted fixtures near the patient's bed.

Photometric Characteristics: Combination of direct and indirect lighting with adjustable intensity, often with a warm color temperature to create a comforting environment.

1.6. Wall Washers:

Application: Accent lighting in lobbies, corridors, and patient rooms.

Design: Fixtures designed to distribute light evenly across walls.

Photometric Characteristics: Uniform light distribution with minimal shadows and glare.

1.7. Emergency Lights:

Application: All critical areas, including exits and corridors.

Design: Battery-backed or generator-supported fixtures that activate during power outages.

Photometric Characteristics: Reliable, bright light with consistent output, ensuring visibility during emergencies.

7.3 Photometric Characteristics:

2.1. Luminous Flux (Lumen Output):

Definition: The total amount of light emitted by a luminaire, measured in lumens (lm).

Importance: Determines the overall brightness of the light fixture. Higher luminous flux is essential for task lighting, while moderate levels are suitable for ambient lighting.

2.2. Illuminance (Lux):

Definition: The amount of light falling on a surface, measured in lux (lx).

Importance: Ensures that specific areas receive adequate lighting for their intended use. For example, operating rooms require high illuminance (10,000 lx) compared to patient rooms (300-500 lx).

2.3. Luminous Efficacy:

Definition: The efficiency of a luminaire, calculated as the ratio of luminous flux to power consumption (lm/W).

Importance: Indicates energy efficiency. High luminous efficacy is desirable for reducing operational costs and energy consumption.

2.4. Color Temperature:

Definition: The color appearance of the light, measured in Kelvin (K).

Importance: Influences mood and functionality. Cooler temperatures (4,000K-6,500K) enhance alertness and are used in clinical areas, while warmer temperatures (2,700K-3,500K) create a calming atmosphere in patient rooms.

2.5. Color Rendering Index (CRI):

Definition: A measure of how accurately a light source reveals colors, on a scale from 0 to 100.

Importance: High CRI (80-100) is crucial in medical environments to ensure accurate color perception, which is vital for diagnosis and treatment.

2.6. Uniformity:

Definition: The evenness of light distribution across an area.

Importance: Prevents areas of shadow and glare, which can cause visual discomfort and hinder tasks. Achieved through appropriate fixture placement and design.

2.7. Beam Angle:

Definition: The angle at which light is emitted from a luminaire.

Importance: Determines the spread of light. Narrow beam angles are used for focused tasks, while wider angles are suitable for general illumination.

2.8. Glare Control:

Definition: The minimization of direct or reflected bright light that can cause discomfort or reduce visibility.

Importance: Essential for visual comfort and safety. Achieved through the use of diffusers, louvers, and indirect lighting techniques.

2.9. Dimming Capability:

Definition: The ability to adjust the light output of a luminaire.

Importance: Enhances comfort and flexibility, allowing for tailored lighting levels based on activities and time of day. Dimming can also contribute to energy savings.

7.4 Conclusion

Luminaires in hospital lighting must meet specific photometric criteria to ensure that they provide the appropriate illumination for various tasks, contribute to patient well-being, and support staff efficiency. Understanding and implementing these photometric characteristics—luminous flux, illuminance, luminous efficacy, color temperature, CRI, uniformity, beam angle, glare control, and dimming capability—are critical to creating a safe, effective, and comfortable healthcare environment. Advances in lighting technology, particularly with LEDs, continue to enhance the capabilities and efficiency of hospital luminaires.

CHAPTER 8

INTRODUCTION TO DIALUX 4.13 and AUTOCAD

Introduction to DIALux 4.13 and AutoCAD :

DIALux 4.13

8.1 Overview:

DIALux 4.13 is a comprehensive and widely used professional lighting design software. It allows lighting designers, architects, and engineers to create, calculate, and visualize lighting projects in various environments, including hospitals, offices, industrial spaces, and outdoor areas. The software supports a detailed analysis of lighting effects, ensuring that designs meet both aesthetic and functional requirements.

8.1.1 Key Features:

- **Luminaire Catalog:** DIALux 4.13 includes an extensive catalog of luminaires from various manufacturers. This allows designers to select and implement real-world products in their projects.
- **Photometric Calculations:** The software performs detailed photometric calculations, providing precise data on illumination levels (lux), uniformity, glare, and other critical lighting parameters.
- **Daylighting Analysis:** DIALux allows for the integration of natural light through daylighting analysis, optimizing the use of available daylight to reduce energy consumption.
- **Visualization Tools:** Users can generate realistic visualizations and renderings of their lighting designs, helping to communicate the effects and benefits of different lighting solutions.
- **Compliance and Standards:** The software helps ensure that lighting designs comply with international standards and guidelines, such as those from the Illuminating Engineering Society (IES).

8.1.2 Applications:

- **Hospital Lighting:** DIALux 4.13 is particularly useful for designing lighting systems in hospitals, where precise and reliable lighting is crucial for patient care and staff performance.
- **Commercial and Industrial Projects:** The software is also extensively used for office buildings, factories, retail spaces, and more.

AutoCAD

8.2 Overview:

AutoCAD is a leading computer-aided design (CAD) software developed by Autodesk. It is widely used by architects, engineers, and construction professionals for creating detailed 2D and 3D drawings. AutoCAD supports the precise drafting and modeling required for various design and engineering projects.

8.2.1 Key Features:

- **2D Drafting and Annotation:** AutoCAD provides robust tools for creating detailed 2D drawings, including lines, shapes, text, and dimensions.
- **3D Modeling:** The software offers powerful 3D modeling capabilities, allowing users to create and manipulate complex 3D geometries.
- **Layer Management:** AutoCAD allows for efficient organization of drawings through layer management, helping users categorize different elements (e.g., walls, electrical systems, furniture).
- **File Compatibility:** AutoCAD supports a wide range of file formats, including DWG, DXF, and PDF, facilitating easy integration with other software and collaboration among different stakeholders.
- **Customization and Automation:** Users can customize the interface and automate repetitive tasks using AutoLISP, scripts, and macros.

8.2.2 Applications:

- **Architectural Design:** AutoCAD is essential for drafting architectural plans, elevations, and sections, providing the foundation for building design and construction.
- **Engineering and Construction:** The software is used for creating detailed engineering drawings and plans, ensuring accuracy and compliance with specifications.
- **Product Design and Manufacturing:** AutoCAD is also applied in product design, where precise geometric modeling is crucial for manufacturing processes.

8.3 Integration of DIALux 4.13 and AutoCAD in Hospital Lighting Design

Workflow Integration:

Architectural Modeling in AutoCAD:

Create detailed architectural drawings of the hospital layout, including floor plans, elevations, and sections.

Use layer management to organize different elements such as walls, ceilings, and electrical systems.

Importing Plans into DIALux:

Export the AutoCAD drawings in a compatible format (e.g., DWG).

Import these plans into DIALux 4.13 as the basis for the lighting design project.

Lighting Design and Analysis in DIALux:

Define room and space boundaries based on the imported plans.

Select appropriate luminaires from the DIALux catalog, considering energy efficiency and lighting quality.

Perform photometric calculations to ensure the design meets required illumination levels and standards.

Integrate natural light through daylighting analysis and optimize the use of artificial lighting.

Visualization and Optimization:

Use DIALux visualization tools to create realistic renderings of the lighting design.

Make necessary adjustments to fixture placement and settings based on the analysis.

Documentation and Collaboration:

Generate detailed reports and documentation from DIALux, including calculation results and visualizations.

Export the final lighting design back into AutoCAD for overlay onto the architectural plans.

Collaborate with architects, engineers, and other stakeholders to finalize the design.

8.4 Conclusion :

DIALux 4.13 and AutoCAD together provide a powerful combination for designing energy-efficient and compliant hospital lighting systems. AutoCAD's precision in drafting and modeling forms the foundation, while DIALux's advanced lighting simulation and analysis capabilities ensure that the lighting design is both effective and efficient. This integrated approach ensures that hospital lighting systems meet the highest standards of performance, safety, and comfort.

CHAPTER 9

DESIGN TECHNIQUES ON HOSPITAL LIGHTING DESIGN

Design Techniques for Hospital Lighting Using Dialux 4.13 and AutoCAD

9.1. Efficient Planning and Analysis:

9.1.1. Detailed Needs Assessment:

- **Objective:** Understand the specific lighting requirements of different hospital areas to avoid over-lighting and under-lighting.
- **Technique:** Use surveys, interviews, and observational studies to gather data from medical staff, patients, and facility managers.

9.1.2. Accurate Architectural Modeling:

- **Objective:** Create precise 2D and 3D models of the hospital layout.
- **Software:** AutoCAD
- **Steps:**
    1. Import architectural drawings into AutoCAD.
    2. Verify dimensions and scales to ensure accuracy.
    3. Create separate layers for different elements (walls, ceilings, furniture).

9.2. Lighting Design in Dialux 4.13

9.2.1. Importing and Setting Up the Project:

- **Steps:**
    1. Export AutoCAD plans in DWG format.
    2. Import these plans into Dialux 4.13 to use as the basis for your lighting design.
    3. Define room boundaries and assign room types to ensure accurate lighting calculations.

9.2.2. Selecting Energy-Efficient Luminaires:

- **Objective:** Choose luminaires with high luminous efficacy and long lifespan.
- **Technique:** Use the Dialux luminaire catalog to select LED fixtures, which are energy-efficient and have lower maintenance costs compared to traditional lighting.

9.2.3. Daylighting Integration:

- **Objective:** Maximize the use of natural light to reduce the need for artificial lighting.
- **Steps:**
    1. Analyze the building's orientation and window placements.
    2. Use Dialux's daylighting tools to simulate natural light penetration.
    3. Incorporate daylight sensors to adjust artificial lighting based on natural light availability.

9.2.4. Zoning and Control Systems:

- **Objective:** Implement advanced lighting control systems to adjust lighting based on occupancy and daylight availability.
- **Steps:**
    1. Divide the hospital into lighting zones.
    2. Use Dialux to simulate different lighting scenarios and optimize control strategies.
    3. Integrate occupancy sensors, daylight sensors, and dimming controls to reduce energy consumption.

9.3. Photometric Optimization:

9.3.1. Illumination Level Calculation:

- **Objective:** Ensure that each area receives the appropriate amount of light without exceeding energy usage.
- **Steps:**
    1. Perform photometric calculations in DIALux to determine the required lux levels.

2. Adjust luminaire placement and settings to achieve optimal illumination levels.

9.3.2. Uniformity and Glare Control:

- **Objective:** Provide uniform lighting distribution and minimize glare to enhance visual comfort.
- **Steps:**
  1. Use Dialux to analyze light distribution patterns.
  2. Select fixtures with diffusers and appropriate beam angles.
  3. Position luminaires to avoid direct lines of sight to bright light sources.

9.4. Energy-Efficient Strategies:

9.4.1. Use of LED Technology:

- **Objective:** Leverage the energy-saving benefits of LED lighting.
- **Benefits:** LEDs have higher luminous efficacy, longer lifespan, and lower heat emissions compared to traditional lighting.

9.4.2. Advanced Control Systems:

- **Objective:** Implement smart lighting controls to enhance energy efficiency.
- **Steps:**
  1. Integrate occupancy sensors to automatically turn off lights in unoccupied areas.
  2. Use daylight harvesting systems to dim artificial lighting based on natural light levels.
  3. Employ programmable lighting controls to schedule lighting based on the time of day and hospital operations.

9.4.3. Regular Maintenance and Upgrades:

- **Objective:** Ensure that the lighting system remains energy-efficient over time.
- **Steps:**
  1. Schedule regular maintenance to clean and replace luminaires as needed.

2. Upgrade lighting controls and fixtures to newer, more efficient models when available.

9.5 Conclusion

Designing an energy-efficient hospital lighting system using DIALux 4.13 and AutoCAD involves a detailed and systematic approach. By leveraging the advanced features of these tools, such as accurate modeling, photometric calculations, and daylight integration, you can create a lighting design that meets the specific needs of hospital environments while minimizing energy consumption. Implementing smart control systems and regular maintenance further enhances the efficiency and sustainability of the lighting design.

CHAPTER 10

ENERGY EFFICIENT LIGHTING SOLUTIONS FOR HEALTHCARE FACILITIES USING DIFFERENT TYPES OF LED LUMINAIRES AND RESULT ANALYSIS

10.1 Introduction:

In the modern healthcare environment, effective lighting design is critical for both patient care and operational efficiency. Lighting in hospitals must meet rigorous standards to ensure patient safety, comfort, and the optimal functioning of medical staff. As energy costs continue to rise and the push for sustainable practices grows, the focus on energy-efficient lighting solutions has never been more pertinent.

This chapter delves into the design and implementation of energy-efficient lighting solutions for healthcare facilities, with a particular emphasis on the use of various types of LED luminaires. LEDs are renowned for their long lifespan, reduced energy consumption, and superior light quality compared to traditional lighting technologies. However, the selection and configuration of LED luminaires must be carefully considered to balance energy efficiency with adequate illumination levels.

We will explore two distinct lighting configurations within a hospital consultation room, comparing their power consumption, achieved lux levels, and uniformity. The goal is to determine which configuration provides optimal lighting performance while minimizing energy usage. Through detailed analysis, we aim to offer insights into how different LED lighting solutions can be leveraged to create an energy-efficient and effective healthcare environment.

By the end of this chapter, readers will gain a comprehensive understanding of the key factors involved in designing energy-efficient hospital lighting systems and the implications of power consumption on overall performance and sustainability. This analysis will provide a framework for making informed decisions about lighting solutions in healthcare settings, ensuring that patient care and energy efficiency are both prioritized.

Hospital Lighting Design Case Study: Lakhimpur Kheri Medical College Hospital ,UP

To apply the principles of energy-efficient lighting design, we examined the layout of Lakhimpur Kheri Hospital using AutoCAD software. This real-world case study allows us to evaluate and compare different lighting configurations in a practical setting. By analyzing the specific requirements and layout of the hospital, we aim to determine the most effective and efficient lighting solutions.

Analysis of AutoCAD Layout

The AutoCAD layout of Lakhimpur Khiri Hospital, Uttarpradesh provides detailed information about the spatial arrangement and dimensions of various rooms, corridors, and common areas. This data is crucial for designing a lighting system that ensures adequate illumination while optimizing energy usage. The layout includes

Fig: AutoCAD layout details of hospital

10.2 Energy Efficient Lighting Solutions for Healthcare Facilities Using LED Luminaires

Overview: Energy-efficient lighting is crucial for healthcare facilities, where the quality and reliability of lighting significantly impact patient care and staff performance. This involves using LED luminaires to meet specific lux levels and uniformity standards as per guidelines like IESNA, IS3646, NLC, ECBC, and CBIP. Here, we outline appropriate LED lighting solutions for various hospital areas and discuss the analysis and achievement of required lux levels and uniformity.

Key Standards for Lighting in Healthcare Facilities:

- **IESNA (Illuminating Engineering Society of North America)**
- **IS 3646 (Indian Standard for Interior Lighting)**
- **NLC (National Lighting Code)**
- **ECBC (Energy Conservation Building Code)**
- **CBIP (Central Board of Irrigation and Power)**

LED Luminaire Solutions for Different Hospital Areas:

1. **Consultation Room:**
    - **Lighting Requirements:** 350-500 lux, uniform lighting.

- **LED Luminaires:** Recessed panel lights, adjustable downlights.
- **Analysis:** Ensure uniform distribution to avoid shadows on work surfaces.

2. **Patient Room:**
   - **Lighting Requirements:** 150-300 lux for general lighting, 300 lux for task lighting.
   - **LED Luminaires:** Bedhead units with reading lights, dimmable ceiling lights.
   - **Analysis:** Use dimmable options to adjust light levels based on patient comfort and activities.
3. **Corridor:**
   - **Lighting Requirements:** 100-200 lux.
   - **LED Luminaires:** Linear LED fixtures, recessed troffers.
   - **Analysis:** Ensure continuous and uniform lighting to enhance safety and visibility.
4. **Toilet:**
   - **Lighting Requirements:** 200-300 lux.
   - **LED Luminaires:** Moisture-resistant ceiling lights, vanity lights.
   - **Analysis:** Ensure sufficient lighting for visibility while preventing glare.
5. **Waiting Area:**
   - **Lighting Requirements:** 200-300 lux.
   - **LED Luminaires:** Pendant lights, recessed downlights.
   - **Analysis:** Create a welcoming ambiance with uniform light distribution.
6. **Laboratories:**
   - **Lighting Requirements:** 500-750 lux.
   - **LED Luminaires:** High CRI panel lights, task lights.
   - **Analysis:** Ensure high uniformity and accurate color rendering for detailed work.
7. **ECG Room:**

- **Lighting Requirements:** 300-500 lux.
- **LED Luminaires:** Glare-free panel lights.
- **Analysis:** Prevent glare and ensure consistent light distribution for accurate readings.

8. **Cubicles:**
   - **Lighting Requirements:** 300-500 lux.
   - **LED Luminaires:** Recessed downlights, task lights.
   - **Analysis:** Provide focused lighting for tasks and ensure privacy with adequate lighting.
9. **Faculty Room:**
   - **Lighting Requirements:** 300-500 lux.
   - **LED Luminaires:** Adjustable downlights, desk lamps.
   - **Analysis:** Ensure comfortable and adjustable lighting for reading and work.
10. **Professor's Room:**
    - **Lighting Requirements:** 300-500 lux.
    - **LED Luminaires:** Dimmable ceiling lights, desk lamps.
    - **Analysis:** Provide flexible lighting options to suit different tasks and meetings.

Result Analysis for Achieving Lux Levels and Uniformity

Using DIALux 4.13 and AutoCAD for Analysis:

1. **Import Architectural Plans:**
   - Import detailed plans into DIALux from AutoCAD, ensuring accurate room dimensions and features.
2. **Define Room Parameters:**
   - Assign room types and dimensions in DIALux based on the architectural plans.
3. **Select and Place Luminaires:**
   - Choose appropriate LED luminaires from the DIALux catalog and place them strategically in each room.

4. **Perform Photometric Calculations:**
    - Run simulations to calculate lux levels and check for uniformity. Adjust luminaire placement and settings to achieve desired results.
5. **Review Results:**
    - **Lux Levels:** Verify that the calculated lux levels meet the requirements specified by IESNA, IS 3646, NLC, ECBC, and CBIP standards.
    - **Uniformity:** Ensure that the uniformity ratio (U1/U2) meets recommended standards, typically around 0.6 or higher for most areas.

10.3 Energy-Efficient Hospital Lighting Design: Evaluating the Impact of Power Consumption

In hospital lighting design, higher power consumption is generally considered **bad** for several reasons:

1. Energy Efficiency:

- **Lower Energy Bills:** Hospitals operate 24/7, and lighting is a significant part of the energy consumption. More power consumption translates directly to higher energy bills.
- **Environmental Impact:** Higher power usage means greater demand on energy resources, leading to higher carbon emissions and a larger environmental footprint.

2. Operational Costs:

- **Cost Savings:** Reducing power consumption can lead to significant cost savings over time. Energy-efficient lighting reduces operational expenses, allowing the hospital to allocate resources more effectively.

3. Sustainability:

- **Green Building Certifications:** Many hospitals strive to achieve green building certifications (like LEED) which emphasize energy efficiency and sustainability. Lower power consumption helps in achieving these certifications.
- **Corporate Social Responsibility (CSR):** Hospitals with lower energy consumption contribute positively to their CSR goals by demonstrating a commitment to sustainability.

4. System Performance and Maintenance:

- **Heat Generation:** Higher power consumption often means more heat generation, which can affect the performance and longevity of lighting fixtures. It can also increase the cooling load on HVAC systems.
- **Maintenance Costs:** Energy-efficient lighting typically has a longer lifespan and requires less maintenance, reducing overall costs.

5. Patient and Staff Well-being:

- **Comfort and Safety:** Energy-efficient lighting solutions often provide better quality light (e.g., appropriate color temperature and uniformity) which can improve the comfort and safety of patients and staff.
- **Glare and Eye Strain:** High power consumption does not necessarily equate to better lighting quality. Efficient lighting design focuses on optimal lux levels and uniformity, minimizing glare and reducing eye

10.4. Detailed Analysis of Hospital Consultation Room Lighting Using Two Configurations:

Objective:

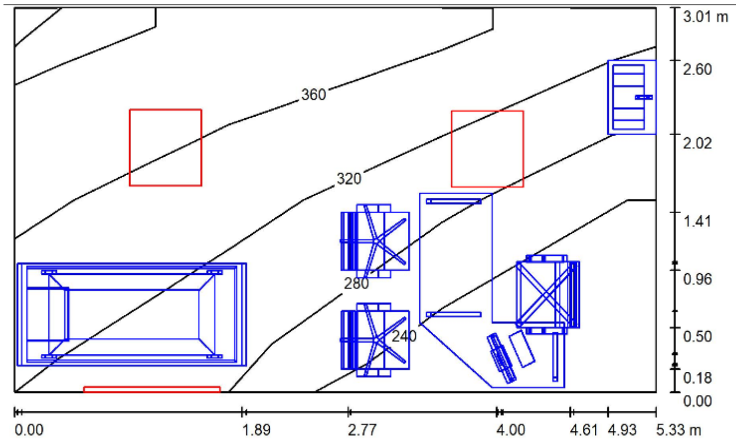
To compare the lighting performance and energy consumption in a hospital consultation room using two different configurations, ensuring the room meets the required lux levels efficiently.

Provided Data:

Configuration 1:

- **Fixtures:**
  - CCS-103-20-65-HL2-DP-NWH: Quantity = 1
  - LCTLRNE-36-FO-CDL: Quantity = 2
- **Total Power Consumption:** 85.9W
- **Achieved Lux Level:** 319 lux
- **Uniformity:** 0.718

Dialux output:



Height of Room: 3.000 m, Light loss factor: 0.85 Values in Lux, Scale 1:39

Surface	ρ [%]	E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0
Workplane	/	319	229	386	0.718
Floor	20	185	13	300	0.072
Ceiling	70	128	56	594	0.440
Walls (4)	50	189	19	5531	/

Workplane:
Height: 0.760 m
Grid: 3 x 2 Points
Boundary Zone: 0.000 m

Illuminance Quotient (according to LG7): Walls / Working Plane: 0.720, Ceiling / Working Plane: 0.423.

Luminaire Parts List

No.	Pieces	Designation (Correction Factor)	Φ (Luminaire) [lm]	Φ (Lamps) [lm]	P [W]
1	1	Crompton Greaves Consumer Electricals Ltd 01 CCS-103-20-65-HL2-DP-NWH (1.000)	2303	2313	17.5
2	2	Crompton Greaves Consumer Electricals Ltd 05 LCTLRNE-36-FO-CDL (1.000)	3906	3946	34.2
			Total: 10114	Total: 10205	85.9

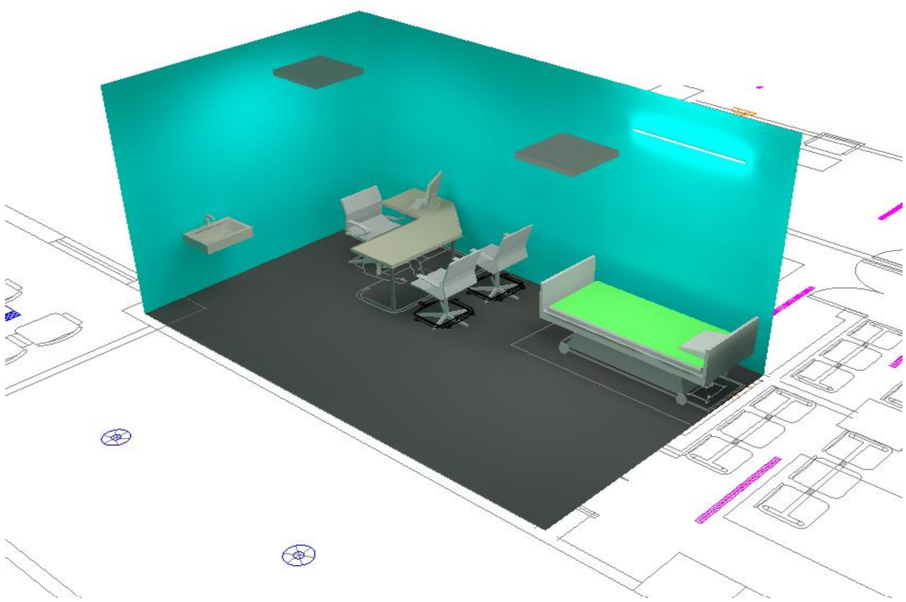


Fig: 3d side view of consulting room

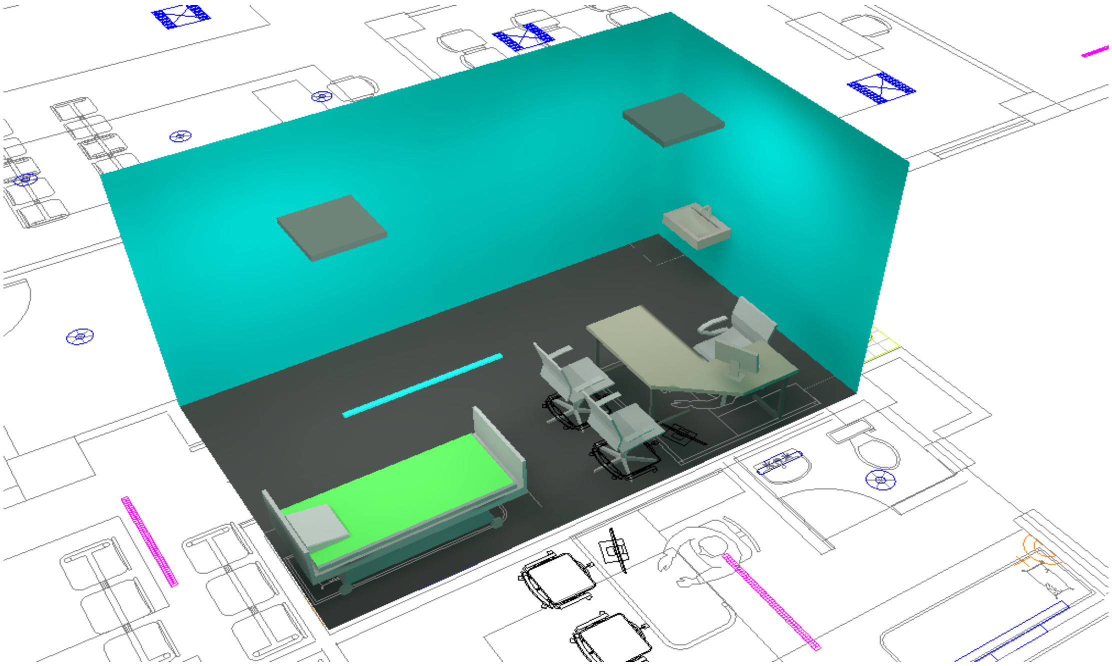


Fig: 3d top view of consulting room

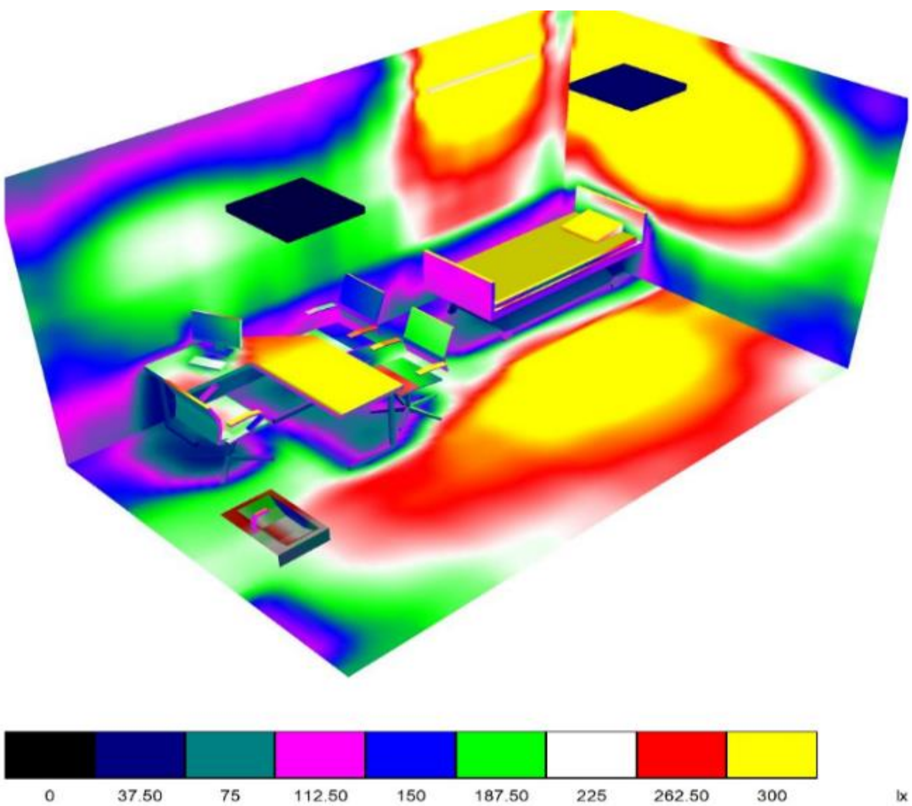
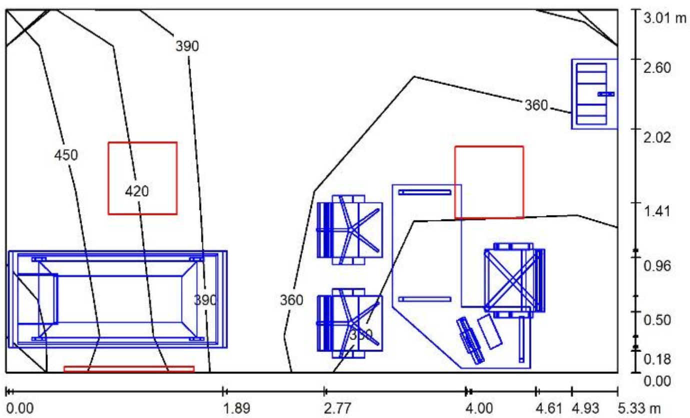


Fig:3d rendering of consulting room

Configuration 2:

- **Fixtures:**
    - CCS-100-40-65-SL-DP-NWH: Quantity = 1
    - LCTLRNE-30-FO-CDL: Quantity = 2
- **Total Power Consumption:** 100.3W
- **Achieved Lux Level:** 263 lux
- **Uniformity:** 0.448

Dialux Output:



Surface	ρ [%]	E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0
Workplane	/	263	118	358	0.448
Floor	20	162	12	261	0.077
Ceiling	70	117	53	398	0.452
Walls (4)	50	173	17	3498	/

Workplane:

Height:	0.760 m
Grid:	5 x 3 Points
Boundary Zone:	0.000 m

Illuminance Quotient (according to LG7): Walls / Working Plane: 0.747, Ceiling / Working Plane: 0.443.

Luminaire Parts List

No.	Pieces	Designation (Correction Factor)	Φ (Luminaire) [lm]	Φ (Lamps) [lm]	P [W]
1	1	Crompton Greaves Consumer Electricals Ltd 01 CCS-100-40-65-SL-DP-NWH (1.000)	3990	4007	37.3
2	2	Crompton Greaves Consumer Electricals Ltd 01 LCTLRNE-30-FO-CDL (1.000)	3551	3553	31.5
			Total: 11093	Total: 11113	100.3

Specific connected load: 6.26 W/m² = 1.96 W/m²/100 lx (Ground area: 16.03 m²)

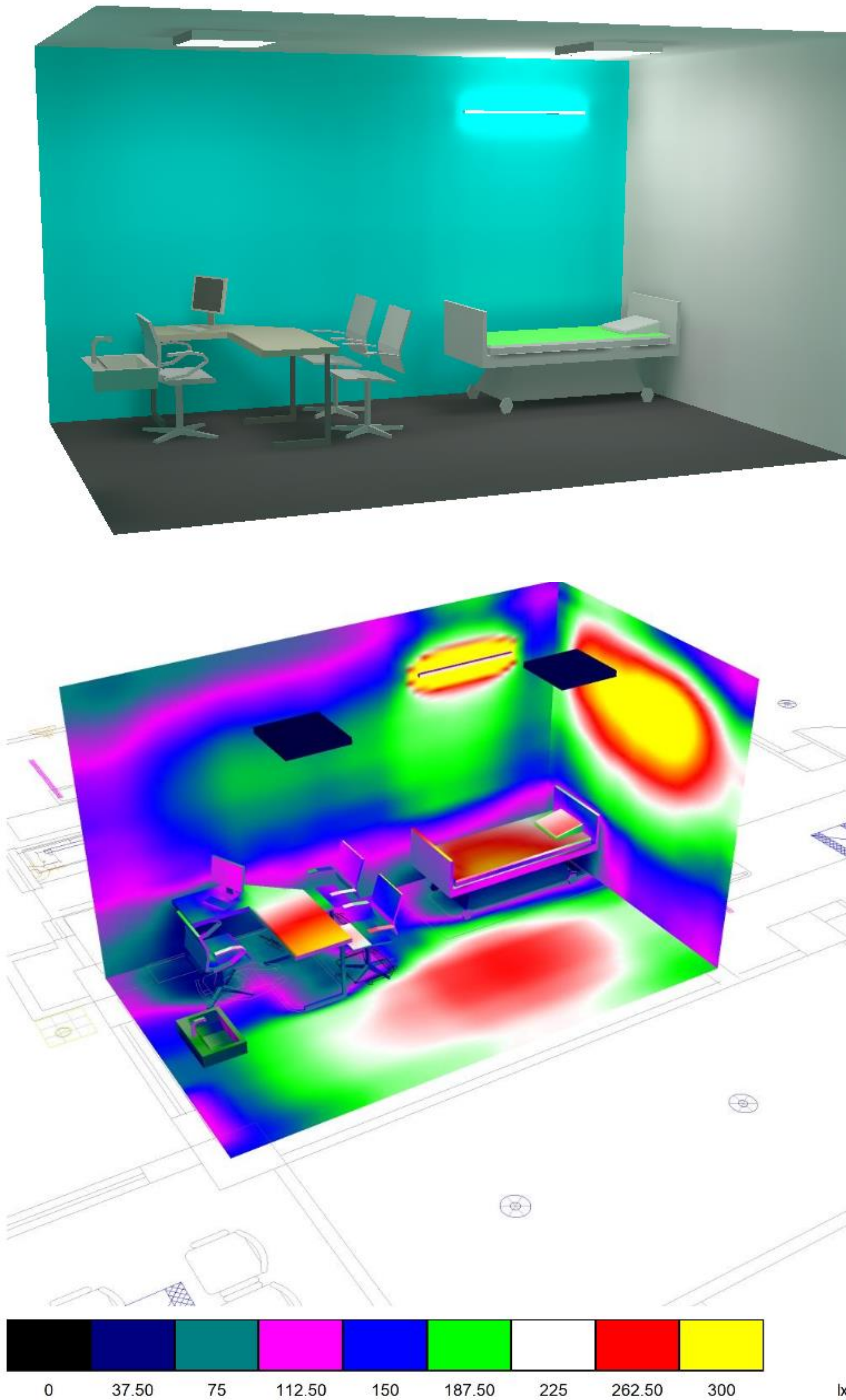


Fig: False color rending of consulting room(confi.2)

Comparison Table:

Criteria	Configuration 1	Configuration 2	Recommended Standards
Fixtures	**1**x CCS-103-20-65-HL2-DP-NWH & **2**x LCTLRNE-36-FO-CDL	**1**x CCS-100-40-65-SL-DP-NWH & **2**x LCTLRNE-30-FO-CDL	N/A
Total Power Consumption	85.9W	100.3W	Lower is better for energy efficiency
Achieved Lux Level	319 lux	263 lux	300-500 lux (IS 3646, NBC, CBIP, IESNA)
Uniformity	0.718	0.448	≥ 0.6
Meets Lux Level Standard	Yes	No	Yes
Meets Uniformity Standard	Yes	No	Yes
Energy Efficiency	More efficient	Less efficient	N/A

Comparison and Insights:

Configuration 1:

- **Energy Efficiency:** Consumes 85.9W, which is lower than Configuration 2.
- **Lux Level:** Achieves 319 lux, which is well within the required range (300-500 lux) for a consultation room.
- **Uniformity:** Provides a uniformity of 0.718, indicating a more evenly distributed light, which is preferable for a comfortable and effective consultation environment.

Configuration 2:

- **Higher Energy Consumption:** Consumes 100.3W, which is higher than Configuration 1.

- **Lower Lux Level:** Achieves 263 lux, which is below the required range and may not be sufficient for all tasks in the consultation room.
- **Poor Uniformity:** Provides a uniformity of 0.448, indicating less even light distribution, which could result in areas that are too bright or too dim.

Recommendations:

1. **Configuration 1 is the better choice:**
    - **Energy Efficiency:** Consumes 85.9W, which is lower than Configuration 2.
    - **Lux Level:** Achieves 319 lux, which is within the required range (300-500 lux) for a consultation room.
    - **Uniformity:** Provides a uniformity of 0.718, indicating a more evenly distributed light, which is preferable for a comfortable and effective consultation environment.
2. **Configuration 2 is less efficient:**
    - **Higher Energy Consumption:** Consumes 100.3W, which is higher than Configuration 1.
    - **Lower Lux Level:** Achieves only 263 lux, which is below the required range and may not be sufficient for all tasks in the consultation room.
    - **Poor Uniformity:** Provides a uniformity of 0.448, indicating less even light distribution, which could result in areas that are too bright or too dim.

Conclusion:

Configuration 1 (one CCS-103-20-65-HL2-DP-NWH and two LCTLRNE-36-FO-CDL fixtures) is more sufficient and optimal for a hospital consultation room. It offers better energy efficiency, higher lux levels within the required range, and better light uniformity compared to Configuration 2. This makes Configuration 1 the preferred choice for achieving optimal lighting conditions in the consultation room.

❖ Luminaire Selection Criteria for Hospital LED Lighting

Selecting the appropriate luminaires for hospital LED lighting is essential for ensuring optimal illumination, energy efficiency, patient comfort, and compliance with standards. Here are the key criteria to consider:

1. Lighting Quality

- **Lux Levels:** Ensure that the luminaires provide adequate illumination levels for different areas:
    - **Consultation Rooms:** 300-500 lux
    - **Corridors and Waiting Areas:** 100-200 lux
    - **Operation Theaters and ICUs:** 1000-1500 lux
- **Uniformity:** Aim for high uniformity (≥ 0.6) to ensure even light distribution and prevent shadows, which is critical for medical tasks.
- **Color Rendering Index (CRI):** A CRI of 80 or higher is recommended for accurate color rendering, important for medical diagnostics and patient care.
- **Color Temperature:** Select suitable color temperatures:
    - **Warm White (3000K-3500K):** For patient rooms and waiting areas to create a comfortable and calming environment.
    - **Natural White (4000K-4500K):** For examination and operating rooms to provide clear visibility and reduce eye strain.

2. Energy Efficiency

- **Luminous Efficacy:** Choose luminaires with high luminous efficacy (e.g., >100 lm/W) to ensure maximum light output per watt of energy consumed.
- **Power Consumption:** Opt for LED luminaires with lower power consumption to reduce energy costs and enhance sustainability.

3. Durability and Maintenance

- **Lifespan:** Select LEDs with a long lifespan (e.g., 50,000 hours or more) to minimize maintenance and replacement costs.
- **Heat Dissipation:** Ensure the luminaire design includes efficient heat dissipation to maintain performance and extend the lifespan of the LEDs.

- **Ease of Maintenance:** Choose fixtures that are easy to clean and maintain, especially important in sterile environments like operating rooms.

4. Glare and Visual Comfort

- **Glare Control:** Opt for luminaires with features to minimize glare, such as diffusers or anti-glare coatings, to enhance visual comfort for patients and staff.
- **Flicker-Free Operation:** Ensure the LEDs operate without flicker to prevent discomfort and health issues associated with prolonged exposure to flickering lights.

5. Compliance and Safety

- **Standards and Certifications:** Ensure the luminaires comply with relevant standards and certifications (e.g., IS 3646, NBC, CBIP, IESNA) for safety and performance.
- **Ingress Protection (IP) Rating:** Select luminaires with appropriate IP ratings for different areas (e.g., higher IP ratings for operating rooms and wet areas).

6. Control and Flexibility

- **Dimmability:** Choose dimmable LEDs to adjust lighting levels according to specific needs and times of the day.
- **Smart Controls:** Consider luminaires compatible with smart control systems for automated lighting management, improving energy efficiency and flexibility.

7. Cost and Budget

- **Initial Cost vs. Total Cost of Ownership:** Evaluate the initial purchase cost against the total cost of ownership, including energy savings, maintenance, and lifespan.

8. Aesthetic and Integration

- **Design and Aesthetics:** Select luminaires that complement the interior design of the hospital, contributing to a pleasant environment.
- **Ease of Installation:** Ensure the luminaires are easy to install and integrate with the existing electrical and architectural setup.

Technical details of luminaire:

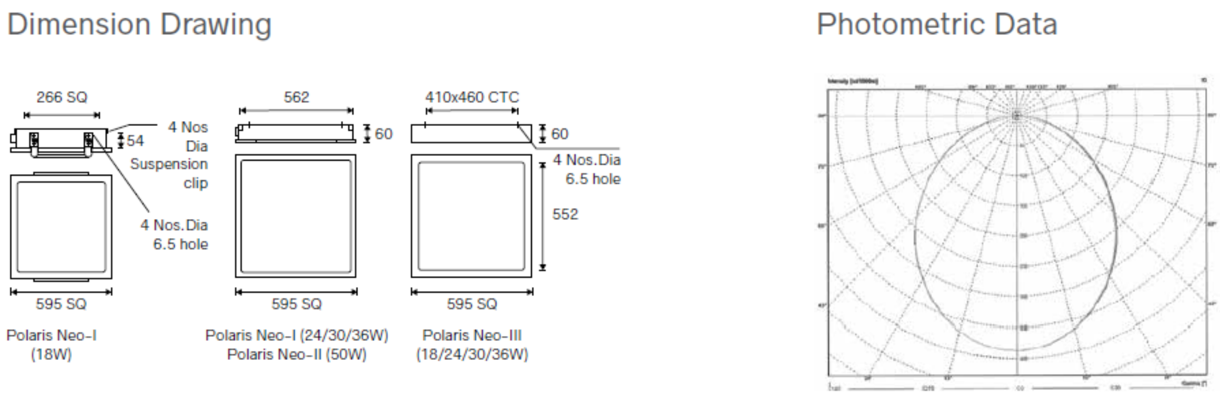


Fig: Dimensions & photometric curve of luminaires

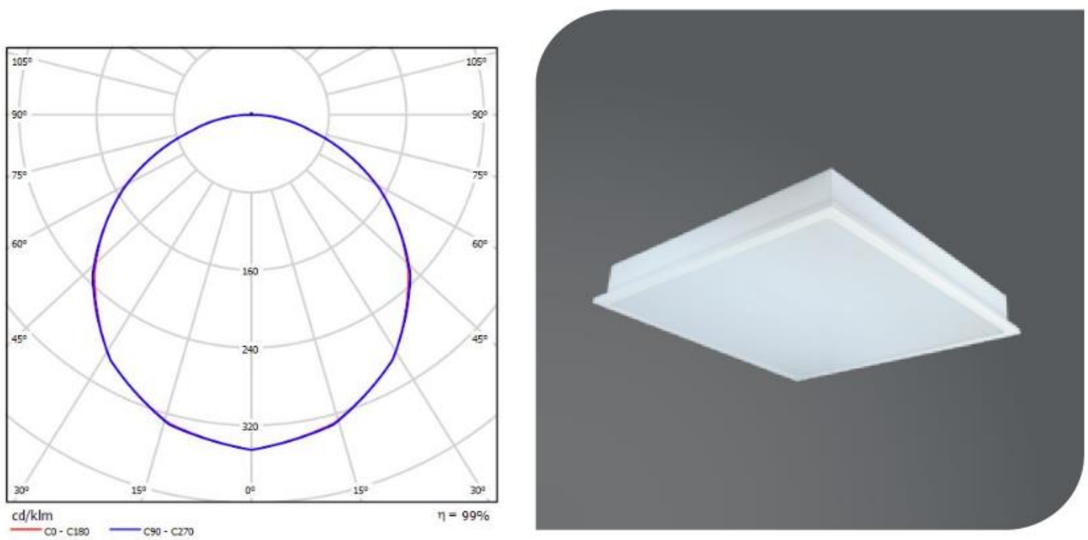


Fig: Intensity distribution curve & Image of the luminaire

Technical Specification of Selected Luminaires:

1. Luminaire Catalog Reference: **LCTLRNE-30-FO-CDL**

- **Type:** LED Recessed Full Lit Luminaire
- **Dimensions:** 2x2 Ft

- **Luminous Efficacy:** >100 lm/W
- **Color Temperature:** Available in Warm White and Natural White
- **Power Consumption:** 30W
- **Luminous Flux:** Approximately 3000 lumens
- **CRI (Color Rendering Index):** >80
- **Glare Control:** Glare-free uniform illumination
- **Lifespan:** 50,000 hours
- **Maintenance:** Low maintenance
- **Additional Features:** Uniform illumination, suitable for general hospital lighting needs

2.Luminaire Catalog Reference: **LCTLRNE-36-FO-CDL**

- **Type:** LED Recessed Full Lit Luminaire
- **Dimensions:** 2x2 Ft
- **Luminous Efficacy:** >100 lm/W
- **Color Temperature:** Available in Warm White and Natural White
- **Power Consumption:** 36W
- **Luminous Flux:** Approximately 3600 lumens
- **CRI (Color Rendering Index):** >80
- **Glare Control:** Glare-free uniform illumination
- **Lifespan:** 50,000 hours
- **Maintenance:** Low maintenance
- **Additional Features:** Higher luminous output, suitable for areas requiring more intense lighting

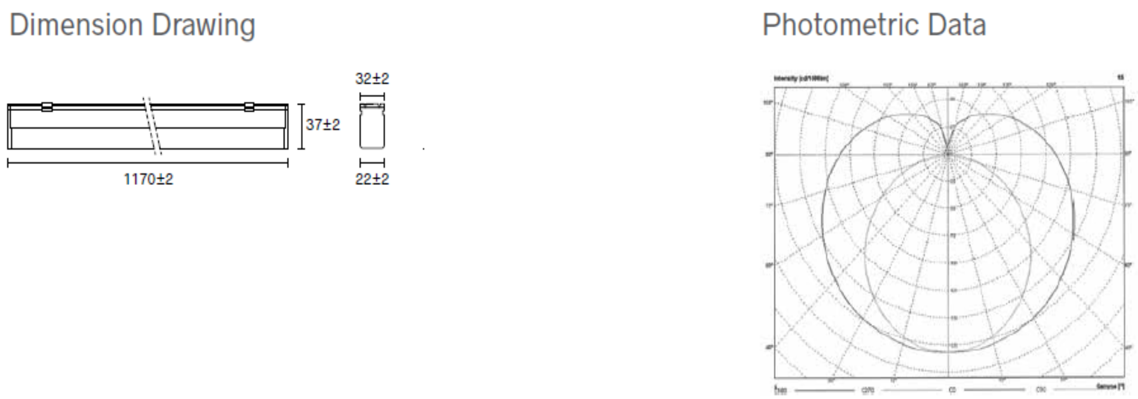


Fig: Dimensions & photometric dimensions of luminaires

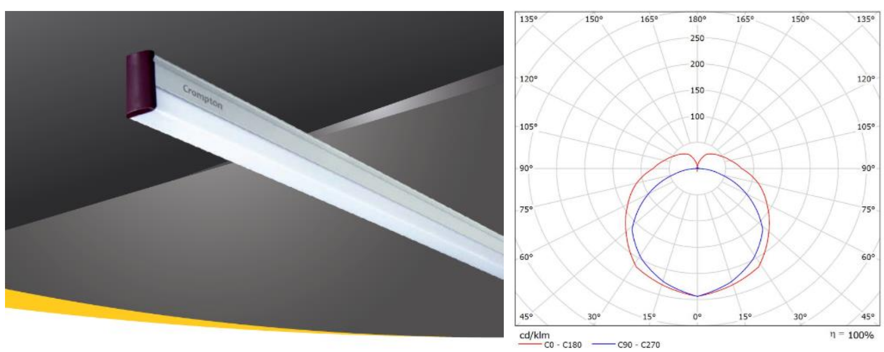


Fig: Image & polar curve of the luminaire (CCS-103-20-65-HL2-DP-NWH)

3.Luminaire Catalog Reference: **CCS-103-20-65-HL2-DP-NWH**

- **Type:** High Lumen Package LED Luminaire
- **Power Consumption:** 20W
- **Luminous Flux:** Approximately 2000 lumens
- **Color Temperature:** 6500K (Natural White)
- **CRI (Color Rendering Index):** >80
- **Glare Control:** Designed for minimal glare
- **Lifespan:** 50,000 hours
- **Dimensions:** Standard commercial size (specify if needed)
- **Uniformity:** High uniformity in light distribution

- **Energy Efficiency:** Designed for high energy efficiency
- **Maintenance:** Low maintenance
- **Additional Features:** Suitable for applications requiring high lumen output with low power consumption.

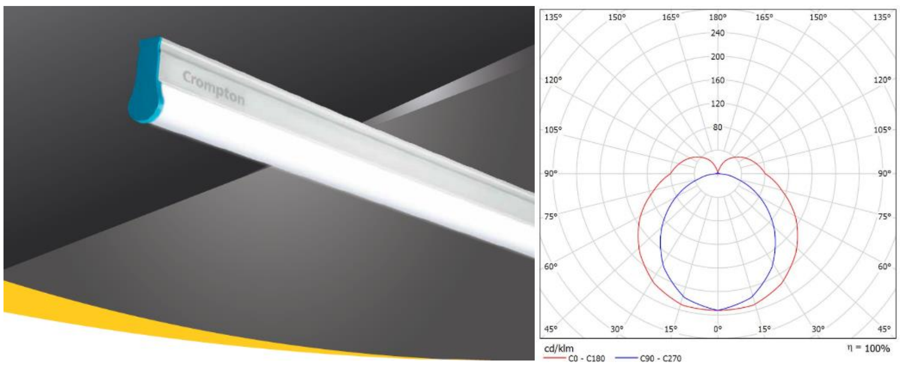


Fig: Image & polar curve of the luminaire (CCS-100-40-65-SL-DP-NWH)

4. Luminaire Catalog Reference: **CCS-100-40-65-SL-DP-NWH**

- **Type:** Standard Lumen LED Luminaire
- **Power Consumption:** 40W
- **Luminous Flux:** Approximately 4000 lumens
- **Color Temperature:** 6500K (Natural White)
- **CRI (Color Rendering Index):** >80
- **Glare Control:** Designed to minimize glare
- **Lifespan:** 50,000 hours
- **Dimensions:** Standard commercial size (specify if needed)
- **Uniformity:** Moderate uniformity in light distribution
- **Energy Efficiency:** Designed for moderate energy efficiency
- **Maintenance:** Low maintenance
- **Additional Features:** Suitable for general applications where a balance of lumen output and power consumption is desired.

10.5. Detailed Analysis of Hospital Patient ward Room Lighting Using Two Configurations

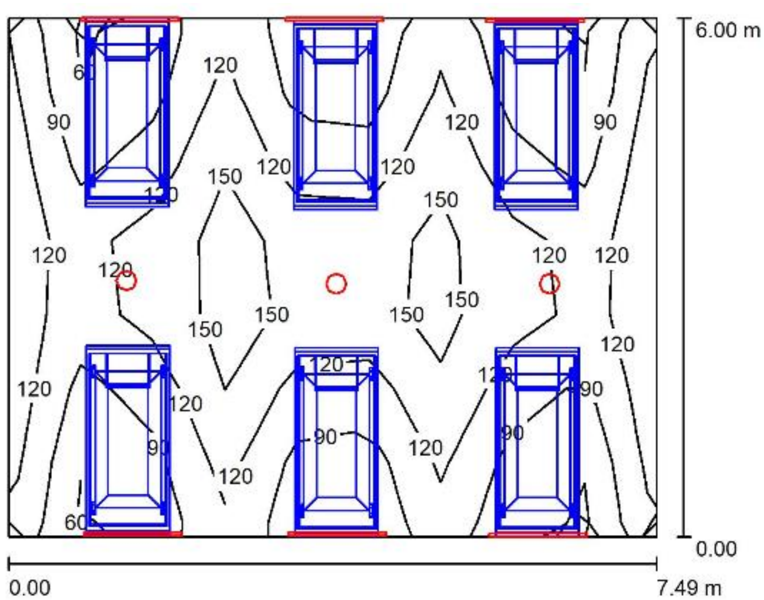
Effective lighting in hospital patient ward rooms is crucial for patient comfort, safety, and recovery. Proper lighting enhances visibility for both patients and healthcare professionals, contributing to a better healing environment and more efficient medical care. The assessment of lighting includes evaluating both the lux level, which measures the intensity of light, and uniformity, which assesses how evenly the light is distributed across the room. This analysis compares two lighting configurations in a hospital patient ward room against established standards from authoritative bodies such as the Illuminating Engineering Society of North America (IESNA), Indian Standards (IS 3646), the National Building Code of India (NBC), the Central Board of Irrigation and Power (CBIP), and the National Lighting Code (NLC).

Detailed Analysis of Hospital Patient Ward Room Lighting

Configuration 1

- **Lighting Fixtures**: Three LCDSPLN-R-18-CDL (1.000) and Six CCS-100-40-65-SL-DP-NWH (1.000)
- **Lux Level**: 106 lux
- **Uniformity**: 0.226
- **Power Consumption**: 274 watts

Dialux Output:



Luminaire Parts List

No.	Pieces	Designation (Correction Factor)	Φ (Luminaire) [lm]	Φ (Lamps) [lm]	P [W]
1	6	Crompton Greaves Consumer Electricals Ltd 01 CCS-100-40-65-SL-DP-NWH (1.000)	3990	4007	37.3
2	3	Crompton Greaves Consumer Electricals Ltd 01 LCDSPLN-R-18-CDL (1.000)	1716	1715	16.8
			Total: 29090	Total: 29185	274.0

Specific connected load: 6.32 W/m² = 2.48 W/m²/100 lx (Ground area: 43.39 m²)

Surface	ρ [%]	E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0
Workplane	/	106	24	164	0.226
Floor	20	105	21	175	0.195
Ceiling	70	120	87	1576	0.728
Walls (4)	50	137	25	14433	/

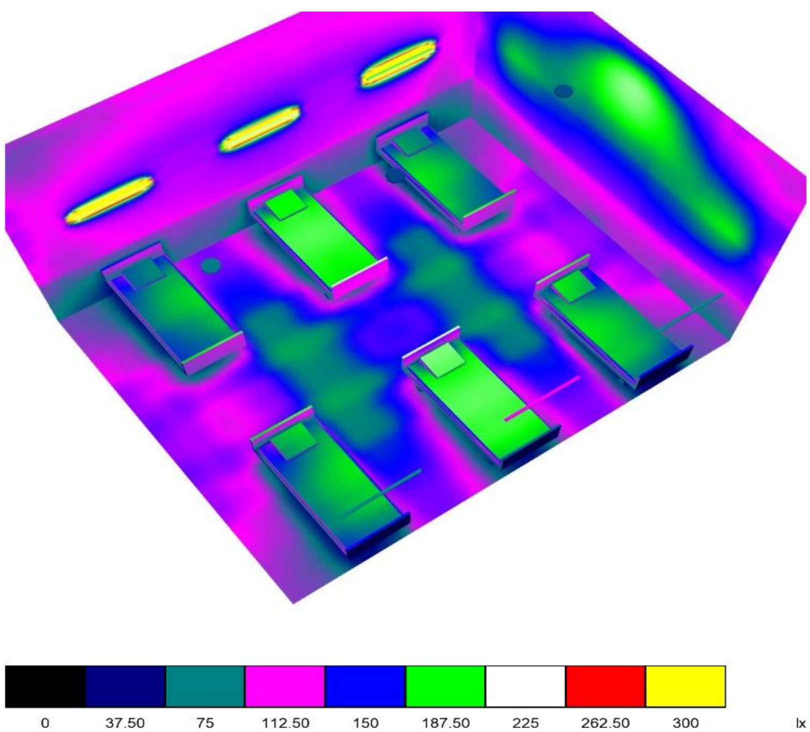


Fig:

Fig:false color rendering of patient ward room(Confi. 1)

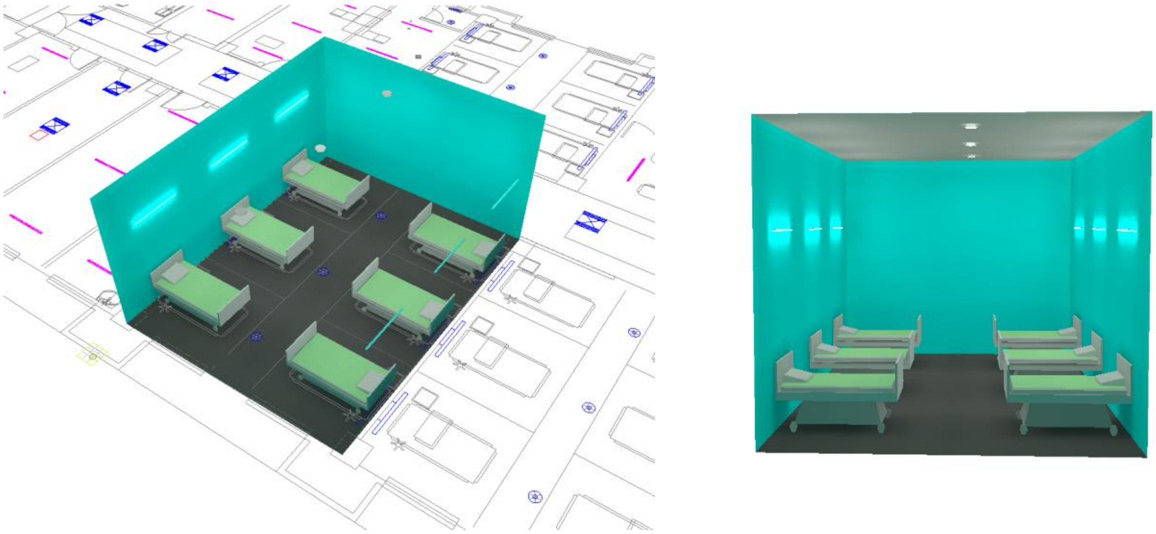
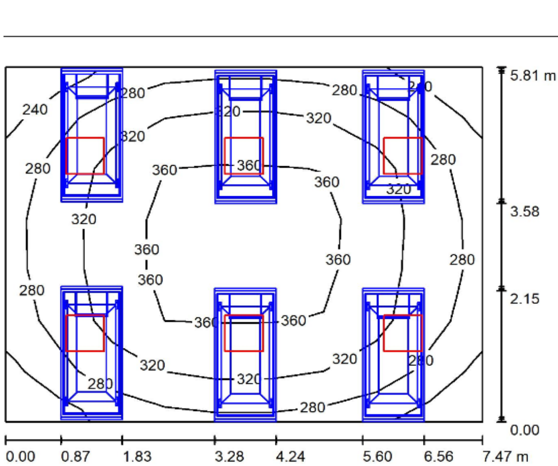


Fig:3d side and top view of ward room

Configuration 2

- **Lighting Fixtures**: Six LCTLRNE-36-FO-CDL
- **Lux Level**: 317 lux
- **Uniformity**: 0.862
- **Power Consumption**: 205.2 watts

Dialux Output:



Surface	ρ [%]	E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0
Workplane	/	317	274	368	0.862
Floor	20	183	22	324	0.121
Ceiling	70	90	68	133	0.751
Walls (4)	50	187	28	325	/

Luminaire Parts List

No.	Pieces	Designation (Correction Factor)	Φ (Luminaire) [lm]	Φ (Lamps) [lm]	P [W]
1	6	Crompton Greaves Consumer Electricals Ltd 05 LCTLRNE-36-FO-CDL (1.000)	3906	3946	34.2
			Total: 23434	Total: 23675	205.2

Specific connected load: 4.73 W/m² = 1.49 W/m²/100 lx (Ground area: 43.39 m²)

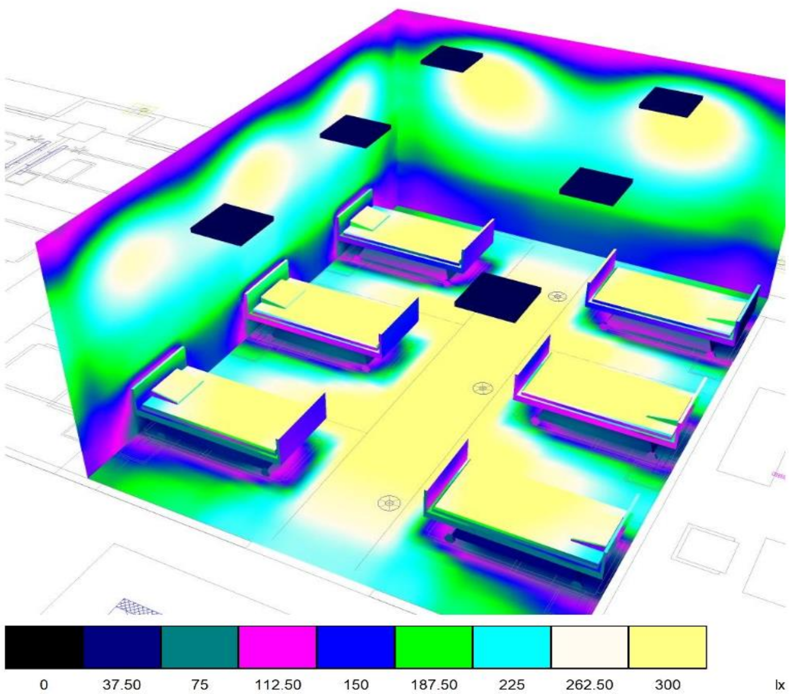


Fig: false color rendering of patient ward room(confi.2)

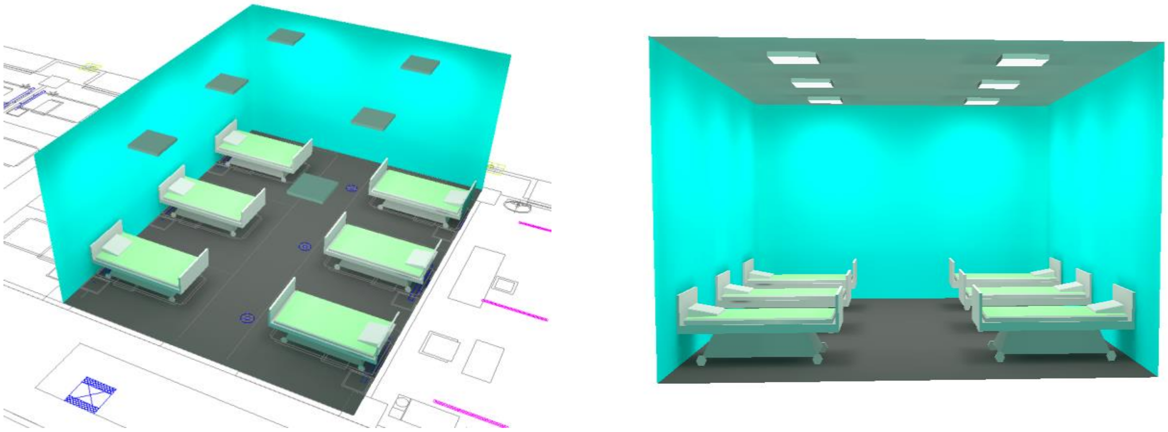


Fig:3d side and top view of ward room

Lighting Configurations Comparison

Parameter	Configuration 1	Configuration 2	IESNA Standard	IS 3646 Standard	NBC Standard	NLC Standard
Lighting Fixtures	Three LCDSPLN-R-18-CDL (1.000) and Six CCS-100-40-65-SL-DP-NWH (1.000)	Six LCTLRNE36-FO-CDL	-	-	-	-
Lux Level	106 lux	317 lux	200-300 lux	150-300 lux	150-300 lux	200-300 lux
Uniformity	0.226	0.862	≥ 0.8	≥ 0.7	≥ 0.7	≥ 0.7
Power Consumption	274 watts	205.2 watts	-	-	-	-
Compliance with Lux Level	No	Yes	No	Yes	Yes	Yes
Compliance with Uniformity	No	Yes	No	Yes	Yes	Yes
Energy Efficiency	Higher power consumption	Lower power consumption	-	-	-	-

- ✓ **Standards for Hospital Patient Ward Room Lighting**

1. **IESNA (Illuminating Engineering Society of North America)**
   - Recommended Lux Level: 200-300 lux for patient rooms.
   - Uniformity: Ideally, uniformity ratios should be close to 0.8 or higher for comfort and safety.
2. **IS 3646 (Indian Standards)**
   - Recommended Lux Level: 150-300 lux for general wards.
   - Uniformity: Preferably above 0.7.
3. **NBC (National Building Code of India)**
   - Recommended Lux Level: 150-300 lux for patient wards.
   - Uniformity: Should ensure minimal glare and good uniformity, typically above 0.7.
4. **CBIP (Central Board of Irrigation and Power)**
   - Recommended Lux Level: 200-300 lux for patient wards.
   - Uniformity: Aiming for ratios around 0.8 for better visual comfort.
5. **NLC (National Lighting Code)**
   - Recommended Lux Level: 200-300 lux for patient wards.
   - Uniformity: Should strive for a uniformity ratio of 0.7 or higher.

Configuration 1 Analysis

- **Lux Level**: At 106 lux, this configuration is below the recommended range of all standards.
- **Uniformity**: At 0.226, this is significantly below the ideal uniformity ratio recommended by IESNA and other standards, which suggest values above 0.7 or 0.8.
- **Power Consumption**: 274 watts, which is higher compared to Configuration 2.

Configuration 2 Analysis

- **Lux Level**: At 317 lux, this configuration slightly exceeds the upper limit of the recommended range but is generally acceptable as it provides better visibility.

- **Uniformity**: At 0.862, this configuration meets and exceeds the recommended uniformity ratios, providing more even light distribution.
- **Power Consumption**: 205.2 watts, which is significantly lower, making it more energy-efficient.

Conclusion

- **Configuration 2** is clearly preferable due to its compliance with the recommended lux levels, superior uniformity, and lower power consumption. It aligns well with the standards provided by IESNA, IS 3646, NBC, CBIP, and NLC.
- **Configuration 1** falls short on both lux level and uniformity, despite consuming more power, making it a less desirable option for hospital patient ward room lighting.

❖ Luminaire Selection Criteria for Hospital LED Lighting

Selecting the appropriate luminaires for hospital LED lighting is essential for ensuring optimal illumination, energy efficiency, patient comfort, and compliance with standards. Here are the key criteria to consider:

1. Lighting Quality

- **Lux Levels:** Ensure that the luminaires provide adequate illumination levels for different areas:
  - **Consultation Rooms:** 300-500 lux
  - **Corridors and Waiting Areas:** 100-200 lux
  - **Operation Theaters and ICUs:** 1000-1500 lux
- **Uniformity:** Aim for high uniformity (≥ 0.6) to ensure even light distribution and prevent shadows, which is critical for medical tasks.
- **Color Rendering Index (CRI):** A CRI of 80 or higher is recommended for accurate color rendering, important for medical diagnostics and patient care.
- **Color Temperature:** Select suitable color temperatures:
  - **Warm White (3000K-3500K):** For patient rooms and waiting areas to create a comfortable and calming environment.

- **Natural White (4000K-4500K):** For examination and operating rooms to provide clear visibility and reduce eye strain.

2. Energy Efficiency

- **Luminous Efficacy:** Choose luminaires with high luminous efficacy (e.g., >100 lm/W) to ensure maximum light output per watt of energy consumed.
- **Power Consumption:** Opt for LED luminaires with lower power consumption to reduce energy costs and enhance sustainability.

3. Durability and Maintenance

- **Lifespan:** Select LEDs with a long lifespan (e.g., 50,000 hours or more) to minimize maintenance and replacement costs.
- **Heat Dissipation:** Ensure the luminaire design includes efficient heat dissipation to maintain performance and extend the lifespan of the LEDs.
- **Ease of Maintenance:** Choose fixtures that are easy to clean and maintain, especially important in sterile environments like operating rooms.

4. Glare and Visual Comfort

- **Glare Control:** Opt for luminaires with features to minimize glare, such as diffusers or anti-glare coatings, to enhance visual comfort for patients and staff.
- **Flicker-Free Operation:** Ensure the LEDs operate without flicker to prevent discomfort and health issues associated with prolonged exposure to flickering lights.

5. Compliance and Safety

- **Standards and Certifications:** Ensure the luminaires comply with relevant standards and certifications (e.g., IS 3646, NBC, CBIP, IESNA) for safety and performance.
- **Ingress Protection (IP) Rating:** Select luminaires with appropriate IP ratings for different areas (e.g., higher IP ratings for operating rooms and wet areas).

6. Control and Flexibility

- **Dimmability:** Choose dimmable LEDs to adjust lighting levels according to specific needs and times of the day.

- **Smart Controls:** Consider luminaires compatible with smart control systems for automated lighting management, improving energy efficiency and flexibility.

7. Cost and Budget

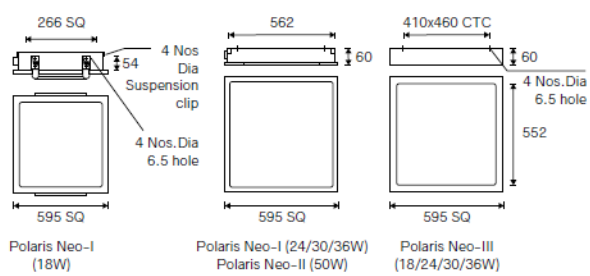
- **Initial Cost vs. Total Cost of Ownership:** Evaluate the initial purchase cost against the total cost of ownership, including energy savings, maintenance, and lifespan.

8. Aesthetic and Integration

- **Design and Aesthetics:** Select luminaires that complement the interior design of the hospital, contributing to a pleasant environment.
- **Ease of Installation:** Ensure the luminaires are easy to install and integrate with the existing electrical and architectural setup.

Technical details of luminaire:

Dimension Drawing



Photometric Data

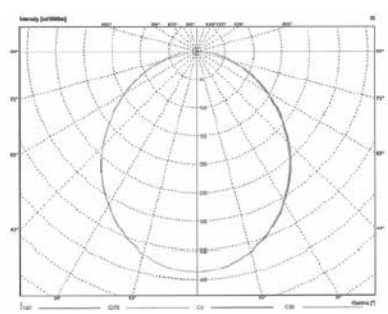


Fig: Dimensions & photometric curve of luminaires

Technical Specifications :

Luminaire Catalog Reference: LCTLRNE-36-FO-CDL

- **Type:** LED Recessed Full Lit Luminaire
- **Dimensions:** 2x2 Ft

- **Luminous Efficacy:** >100 lm/W
- **Color Temperature:** Available in Warm White and Natural White
- **Power Consumption:** 36W
- **Luminous Flux:** Approximately 3600 lumens
- **CRI (Color Rendering Index):** >80
- **Glare Control:** Glare-free uniform illumination
- **Lifespan:** 50,000 hours
- **Maintenance:** Low maintenance
- **Additional Features:** Higher luminous output, suitable for areas requiring more intense lighting

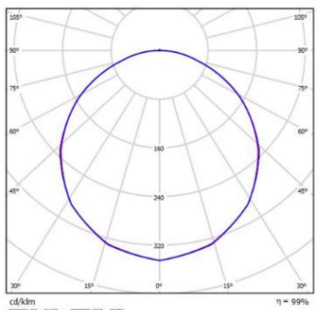
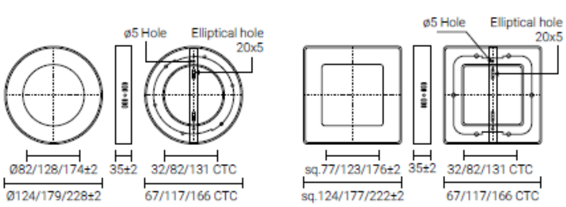



Fig: Intensity distribution curve & Image of the luminaire

Dimension Drawing



Photometric Data

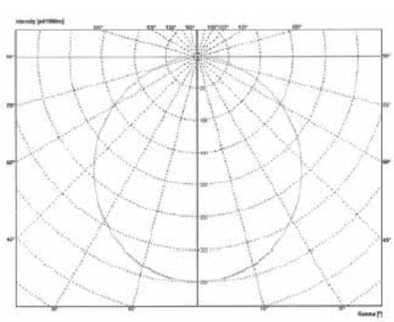


Fig: Dimensions & photometric curve of luminaires

✓ **Luminaire Catalog Reference:** LCDSPLN-R-18-CDL

- **Power:** 18W
- **Voltage:** 240V
- **Color Temperature**: 3000K / 4000K / 5700K
- **CRI:** ≥ 80 (ANSI standard)
- **Luminous Flux:** Approximately 1800-2000 lumens
- **Lifespan:** 50,000 hours
- **Maintenance:** Low maintenance with minimal lumen depreciation over time
- **Additional Features:**
- **Build Quality:** Durable construction with efficient heat dissipation
- **Installation:** Easy to install with standard fittings
- **Design:** Sleek design suitable for modern interiors
- **Compliance:** Meets ANSI standards for lighting quality and performance
- **Energy Efficiency:** High energy efficiency with lower power consumption

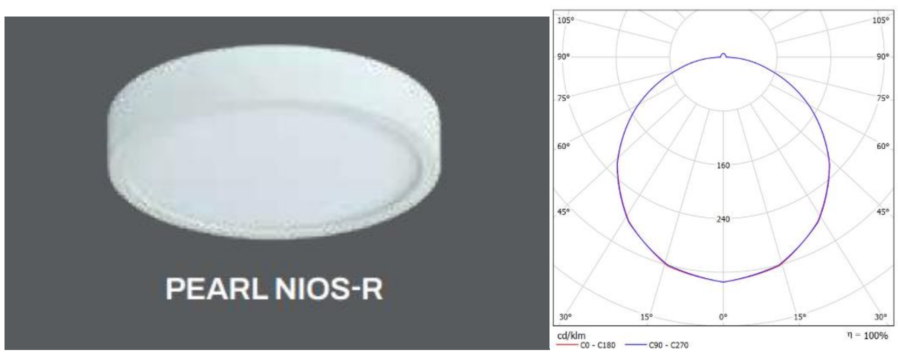


Fig: Intensity distribution curve & Image of the luminaire (LCDSPLN-R-18-CDL)

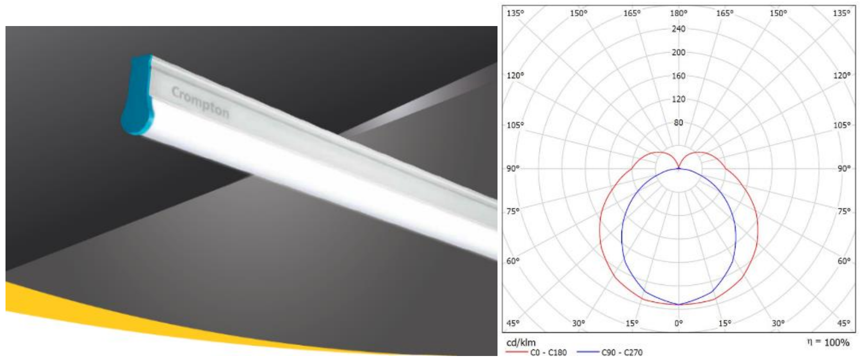


Fig: Image & polar curve of the luminaire (CCS-100-40-65-SL-DP-NWH)

✓ **Luminaire Catalog Reference:** CCS-100-40-65-SL-DP-NWH

- **Type:** Standard Lumen LED Luminaire
- **Power Consumption:** 40W
- **Luminous Flux:** Approximately 4000 lumens
- **Color Temperature:** 6500K (Natural White)
- **CRI (Color Rendering Index):** >80
- **Glare Control:** Designed to minimize glare
- **Lifespan:** 50,000 hours
- **Dimensions:** Standard commercial size (specify if needed)
- **Uniformity:** Moderate uniformity in light distribution
- **Energy Efficiency:** Designed for moderate energy efficiency
- **Maintenance:** Low maintenance
- **Additional Features:** Suitable for general applications where a balance of lumen output and power consumption is desired.

10.6. Detailed Analysis of Lighting Configurations for Patient Examination Rooms ;

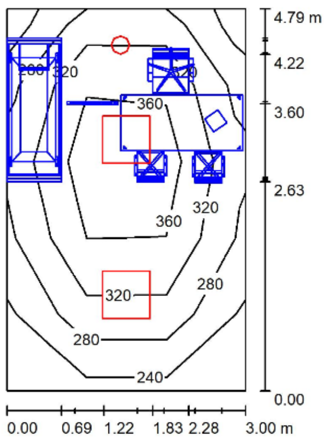
Introduction:

The patient examination room is a critical area in hospitals and healthcare facilities where medical professionals perform detailed assessments and procedures. Proper lighting in these rooms is essential for ensuring that healthcare providers can conduct accurate examinations, diagnoses, and treatments. The quality of lighting directly impacts the ability to see fine details, which is crucial for patient care.

Importance of Proper Lighting

1. **Accurate Diagnosis**:
    - Adequate lighting is crucial for medical professionals to observe and assess patient conditions accurately. Good lighting helps in identifying subtle symptoms, skin conditions, and other physical signs that are essential for diagnosis.
2. **Patient Comfort**:
    - The lighting in examination rooms should be comfortable for patients, reducing glare and avoiding harsh shadows. Proper lighting creates a welcoming environment, helping to ease patient anxiety during examinations.
3. **Safety**:
    - Proper illumination ensures that both patients and healthcare providers can navigate the examination room safely, reducing the risk of accidents and enhancing overall safety.
4. **Efficiency**:
    - Good lighting improves the efficiency of medical procedures and examinations, allowing healthcare professionals to work more effectively and swiftly. It ensures that instruments and equipment are easily visible and accessible.
5. **Compliance with Standards**:
    - Adhering to lighting standards set by organizations such as IESNA, IS 3646, NBC, CBIP, and NLC ensures that the lighting in examination rooms meets the required levels for optimal performance and patient care.

1. **Configuration 1**:
    - Lighting fixtures: Two LCTLRNE 30-FO-CDL and one CDR-18-57-SL-NWH
    - Lux level: 327 lux
    - Uniformity: 0.729
    - Power consumption:81.4 watts



Height of Room: 3.000 m, Mounting Height: 3.000 m, Light loss factor: 0.85

Values in Lux, Scale 1:62

Surface	ρ [%]	E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0
Workplane	/	327	238	437	0.729
Floor	20	188	18	302	0.095
Ceiling	70	88	54	286	0.615
Walls (4)	50	182	16	950	/

Workplane:

Height:	0.760 m
Grid:	3 x 5 Points
Boundary Zone:	0.000 m

Illuminance Quotient (according to LG7): Walls / Working Plane: 0.648, Ceiling / Working Plane: 0.276.

Luminaire Parts List

No.	Pieces	Designation (Correction Factor)	Φ (Luminaire) [lm]	Φ (Lamps) [lm]	P [W]
1	1	Crompton Greaves Consumer Electricals Ltd 01 CDR-206-18-57-SL-NWH (1.000)	1983	2005	18.4
2	2	Crompton Greaves Consumer Electricals Ltd 01 LCTLRNE-30-FO-CDL (1.000)	3551	3553	31.5
			Total: 9086	Total: 9111	81.4

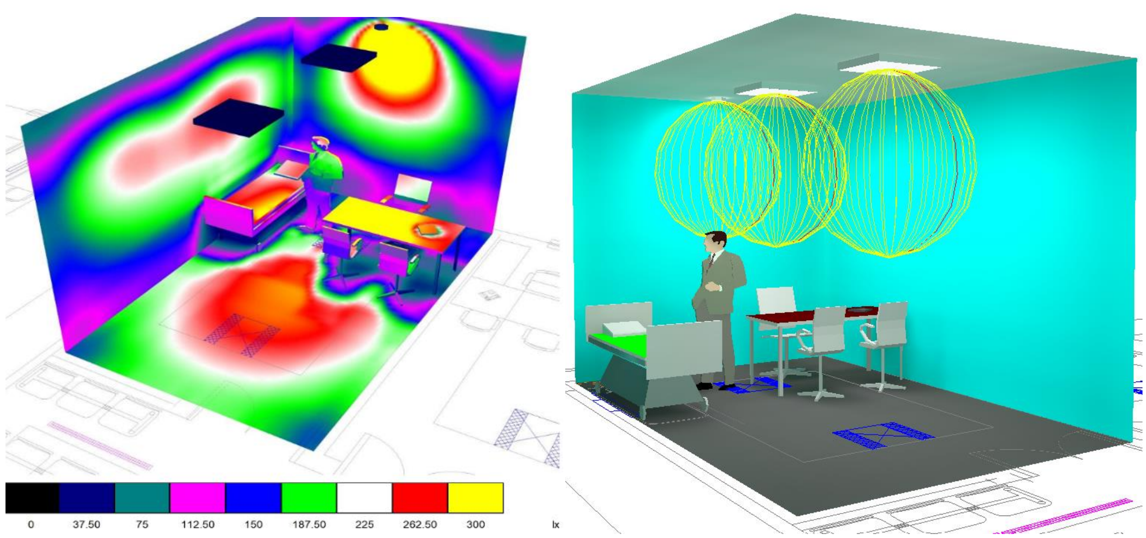
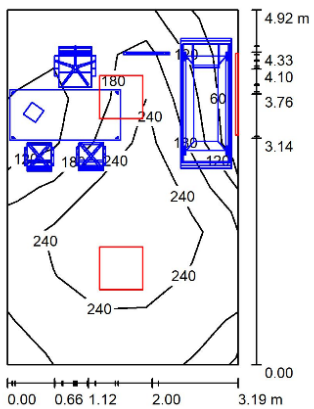


Fig: false color rendering and 3d view of patient examination room

2. **Configuration 2**:
    - Lighting fixtures: Two LCTLRNE 36-FO-CDL and one CCS-102-20-HL2-DP-NWH
    - Lux level: 195 lux
    - Uniformity: 0.127
    - Power consumption: 85.9 watts

PATIENT EXAMINATION ROOM - 04 / Summary



Height of Room: 3.000 m, Light loss factor: 0.85

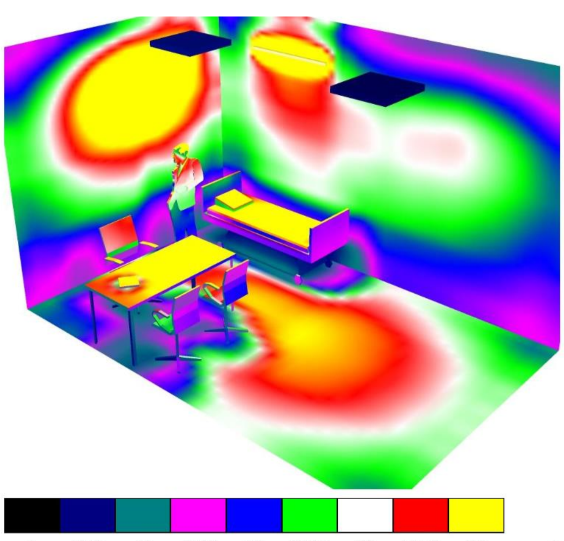
Values in Lux, Scale 1:64

Surface	ρ [%]	E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0
Workplane	/	195	25	301	0.127
Floor	20	192	28	302	0.146
Ceiling	70	135	61	618	0.451
Walls (4)	50	194	27	15940	/

Luminaire Parts List

No.	Pieces	Designation (Correction Factor)	Φ (Luminaire) [lm]	Φ (Lamps) [lm]	P [W]
1	1	Crompton Greaves Consumer Electricals Ltd 01 CCS-103-20-65-HL2-DP-NWH (1.000)	2303	2313	17.5
2	2	Crompton Greaves Consumer Electricals Ltd 05 LCTLRNE-36-FO-CDL (1.000)	3906	3946	34.2
			Total: 10114	Total: 10205	85.9

Specific connected load: 5.47 W/m² = 2.80 W/m²/100 lx (Ground area: 15.70 m²)



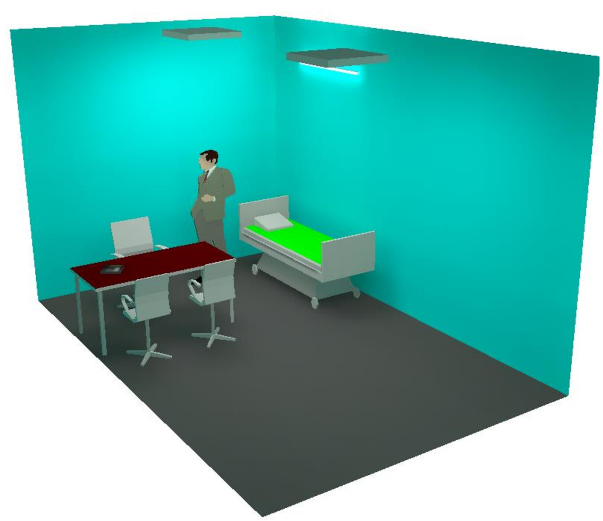


Fig: false color rendering and 3d view of patient examination room

Given that the lux level and uniformity of the lighting are critical factors in patient examination rooms, we need to evaluate which configuration best meets the required standards.

Criteria	Configuration 1	Configuration 2	Recommended Standards
Fixtures	**2**X LCTLRNE 30-FO-CDL and **1**X CDR-18-57-SL-NWH	**2**X LCTLRNE 36-FO-CDL and **1**X CCS-102-20-HL2-DP-NWH	N/A
Total Power Consumption	81.4W	85.9W	Lower is better for energy efficiency
Achieved Lux Level	327lux	195lux	>=300lux (IS 3646, NBC, CBIP, IESNA)
Uniformity	0.729	0.127	≥ 0.7
Meets Lux Level Standard	Yes	No	Yes
Meets Uniformity Standard	Yes	No	Yes
Energy Efficiency	More efficient	Less efficient	N/A

Analysis:

1. **Lux Level**: Configuration 1 provides a higher lux level (327 lux) compared to Configuration 2 (195 lux). Higher lux levels generally provide better visibility and are preferred in examination rooms to ensure accurate assessment.
2. **Uniformity**: Configuration 1 also has higher uniformity (0.718) compared to Configuration 2 (0.127). Higher uniformity means that the light distribution across the room is more consistent, reducing the

likelihood of unevenly lit areas, which is crucial for patient comfort and staff efficiency.

3. **Power Consumption**: Configuration 1 consumes less power (81.4 watts) compared to Configuration 2 (85.9 watts). While power efficiency is important for cost-saving and sustainability, it should be balanced with the need for adequate lighting levels and uniformity.

Conclusion:

Considering the requirements for patient examination rooms, Configuration 1 with two LCTLRNE 30-FO-CDL fixtures and one CDR-18-57-SL-NWH fixture appears to be the better choice. It provides higher lux levels and better uniformity while consuming less power, meeting both lighting standards and energy efficiency goals.

❖ **Luminaire Selection Criteria for Hospital LED Lighting**

Selecting the appropriate luminaires for hospital LED lighting is essential for ensuring optimal illumination, energy efficiency, patient comfort, and compliance with standards. Here are the key criteria to consider:

1. Lighting Quality

- **Lux Levels:** Ensure that the luminaires provide adequate illumination levels for different areas:
  - **Consultation Rooms:** 300-500 lux
  - **Corridors and Waiting Areas:** 100-200 lux
  - **Operation Theaters and ICUs:** 1000-1500 lux
- **Uniformity:** Aim for high uniformity (≥ 0.6) to ensure even light distribution and prevent shadows, which is critical for medical tasks.
- **Color Rendering Index (CRI):** A CRI of 80 or higher is recommended for accurate color rendering, important for medical diagnostics and patient care.
- **Color Temperature:** Select suitable color temperatures:
  - **Warm White (3000K-3500K):** For patient rooms and waiting areas to create a comfortable and calming environment.
  - **Natural White (4000K-4500K):** For examination and operating rooms to provide clear visibility and reduce eye strain.

2. Energy Efficiency

- **Luminous Efficacy:** Choose luminaires with high luminous efficacy (e.g., >100 lm/W) to ensure maximum light output per watt of energy consumed.
- **Power Consumption:** Opt for LED luminaires with lower power consumption to reduce energy costs and enhance sustainability.

3. Durability and Maintenance

- **Lifespan:** Select LEDs with a long lifespan (e.g., 50,000 hours or more) to minimize maintenance and replacement costs.
- **Heat Dissipation:** Ensure the luminaire design includes efficient heat dissipation to maintain performance and extend the lifespan of the LEDs.
- **Ease of Maintenance:** Choose fixtures that are easy to clean and maintain, especially important in sterile environments like operating rooms.

4. Glare and Visual Comfort

- **Glare Control:** Opt for luminaires with features to minimize glare, such as diffusers or anti-glare coatings, to enhance visual comfort for patients and staff.
- **Flicker-Free Operation:** Ensure the LEDs operate without flicker to prevent discomfort and health issues associated with prolonged exposure to flickering lights.

5. Compliance and Safety

- **Standards and Certifications:** Ensure the luminaires comply with relevant standards and certifications (e.g., IS 3646, NBC, CBIP, IESNA) for safety and performance.
- **Ingress Protection (IP) Rating:** Select luminaires with appropriate IP ratings for different areas (e.g., higher IP ratings for operating rooms and wet areas).

6. Control and Flexibility

- **Dimmability:** Choose dimmable LEDs to adjust lighting levels according to specific needs and times of the day.
- **Smart Controls:** Consider luminaires compatible with smart control systems for automated lighting management, improving energy efficiency and flexibility.

7. Cost and Budget

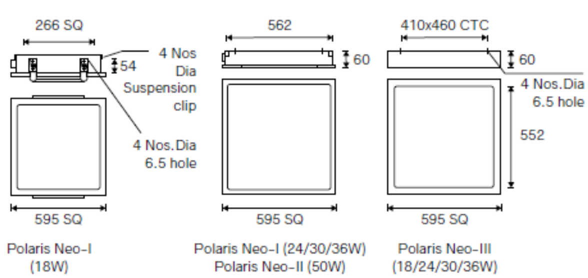
- **Initial Cost vs. Total Cost of Ownership:** Evaluate the initial purchase cost against the total cost of ownership, including energy savings, maintenance, and lifespan.

8. Aesthetic and Integration

- **Design and Aesthetics:** Select luminaires that complement the interior design of the hospital, contributing to a pleasant environment.
- **Ease of Installation:** Ensure the luminaires are easy to install and integrate with the existing electrical and architectural setup.

Technical details of luminaire:

Dimension Drawing



Photometric Data

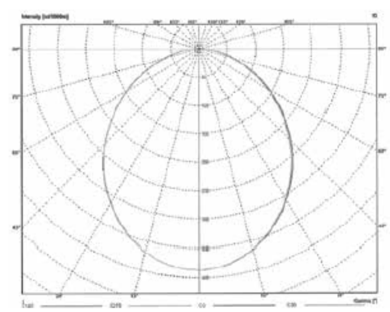


Fig: Dimensions & photometric curve of luminaire (LCTLRNE-36-FO-CDL)

Technical Specifications :

Luminaire Catalog Reference: LCTLRNE-36-FO-CDL

- **Type:** LED Recessed Full Lit Luminaire
- **Dimensions:** 2x2 Ft
- **Luminous Efficacy:** >100 lm/W
- **Color Temperature:** Available in Warm White and Natural White
- **Power Consumption:** 36W
- **Luminous Flux:** Approximately 3600 lumens
- **CRI (Color Rendering Index):** >80
- **Glare Control:** Glare-free uniform illumination
- **Lifespan:** 50,000 hours
- **Maintenance:** Low maintenance
- **Additional Features:** Higher luminous output, suitable for areas requiring more intense lighting

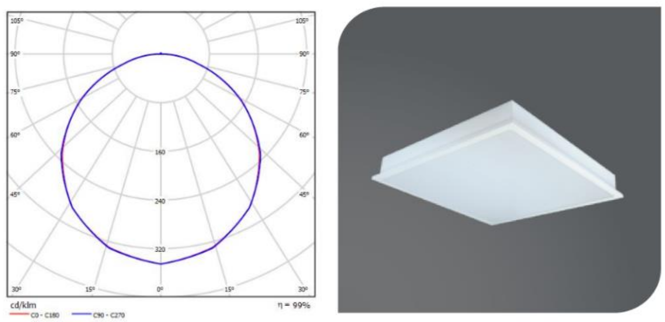
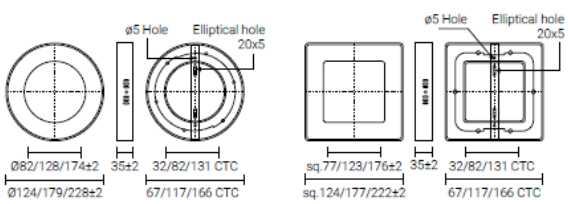


Fig: Intensity distribution curve & Image of the luminaire

Dimension Drawing



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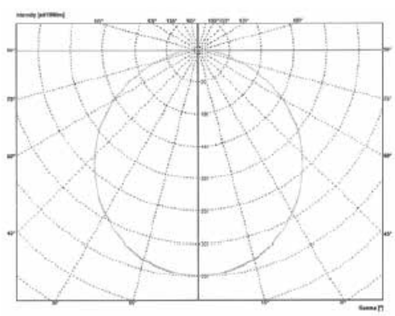


***Fig: Dimensions & photometric curve of luminaire (*LCDSPLN-R-18-CDL)**

Luminaire Catalog Reference: LCDSPLN-R-18-CDL

- **Power:** 18W
- **Voltage:** 240V
- **Color Temperature**: 3000K / 4000K / 5700K
- **CRI:** ≥ 80 (ANSI standard)
- **Luminous Flux:** Approximately 1800-2000 lumens
- **Lifespan:** 50,000 hours
- **Maintenance:** Low maintenance with minimal lumen depreciation over time
- **Additional Features:**
- **Build Quality:** Durable construction with efficient heat dissipation
- **Installation:** Easy to install with standard fittings
- **Design:** Sleek design suitable for modern interiors

- **Compliance:** Meets ANSI standards for lighting quality and performance
- **Energy Efficiency:** High energy efficiency with lower power consumption

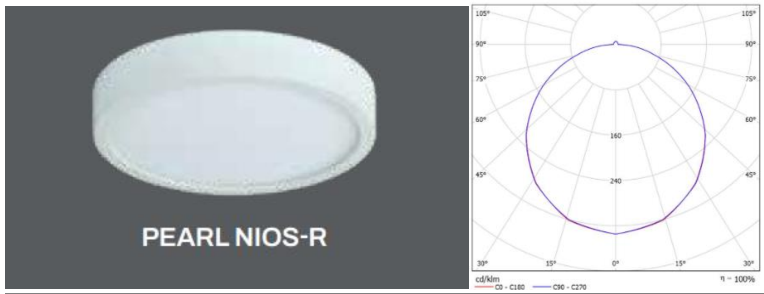


Fig: Intensity distribution curve & Image of the luminaire (LCDSPLN-R-18-CDL)

Luminaire Catalog Reference: **CCS-103-20-65-HL2-DP-NWH**

- **Type:** High Lumen Package LED Luminaire
- **Power Consumption:** 20W
- **Luminous Flux:** Approximately 2000 lumens
- **Color Temperature:** 6500K (Natural White)
- **CRI (Color Rendering Index):** >80
- **Glare Control:** Designed for minimal glare
- **Lifespan:** 50,000 hours
- **Dimensions:** Standard commercial size (specify if needed)
- **Uniformity:** High uniformity in light distribution
- **Energy Efficiency:** Designed for high energy efficiency
- **Maintenance:** Low maintenance
- **Additional Features:** Suitable for applications requiring high lumen output with low power consumption.

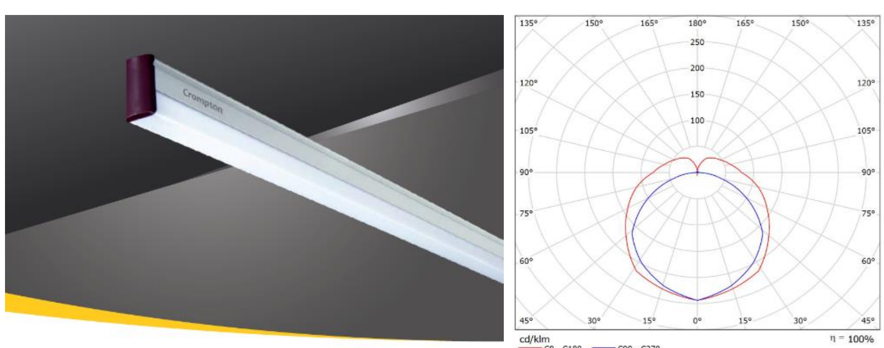


***Fig: Intensity distribution curve & Image of the luminaire* (CCS-103-20-65-HL2-DP-NWH)**

10.7. Detailed Analysis of Hospital Nurse station Lighting design Using Two Configurations:

Introduction

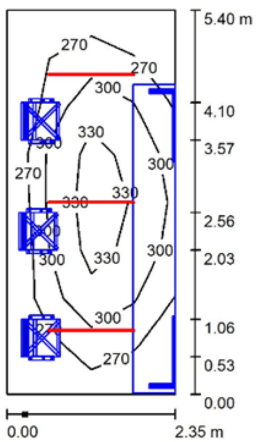
The nurse station is a critical hub within a hospital, serving as the central point for coordinating patient care, documentation, and communication among medical staff. Effective lighting at the nurse station is essential to ensure that nurses can perform their tasks efficiently, comfortably, and safely. Different types of luminaires can be employed to achieve the desired lighting quality. This analysis evaluates the performance of various luminaires in terms of illuminance, uniformity, glare, energy efficiency, user satisfaction, and compliance with industry standards.

Detailed Analysis of Nurse Station Lighting :

Luminaire Configurations

- **Configuration 1**:
  - Luminaires: 3 x CCS-100-40-SL-DP-NWH
  - Lux Level: 301 lux
  - Uniformity: 0.815
  - Power Consumption: 111.8 watts

Dialux Output:



Height of Room: 3.650 m, Mounting Height: 3.650 m, Light loss factor: 0.85

Values in Lux, Scale 1:70

Surface	ρ [%]	E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0
Workplane	/	301	245	346	0.815
Floor	20	169	43	244	0.256
Ceiling	70	282	122	6817	0.432
Walls (4)	50	237	11	564	/

Workplane:

Height:	0.760 m
Grid:	4 x 8 Points
Boundary Zone:	0.000 m

Illuminance Quotient (according to LG7): Walls / Working Plane: 0.942, Ceiling / Working Plane: 0.963.

Luminaire Parts List

No.	Pieces	Designation (Correction Factor)	Φ (Luminaire) [lm]	Φ (Lamps) [lm]	P [W]
1	3	Crompton Greaves Consumer Electricals Ltd 01 CCS-100-40-65-SL-DP-NWH (1.000)	3990	4007	37.3
			Total: 11971	Total: 12020	111.8

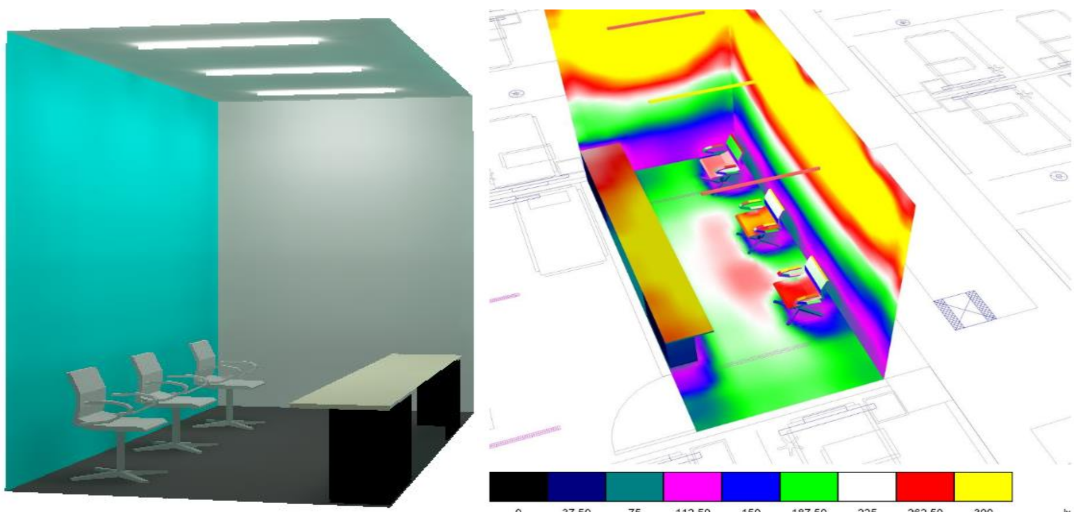
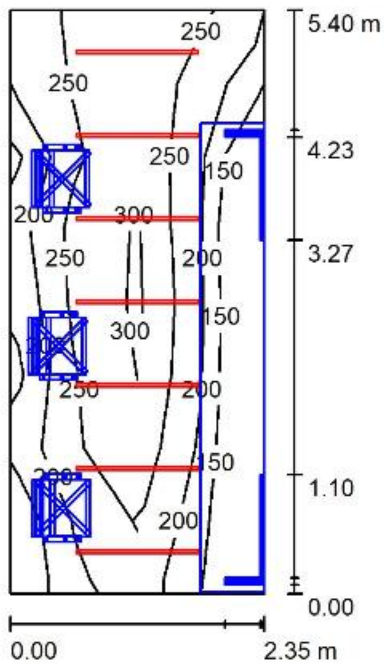


Fig: 3d image and flse color rending of nursing station (Confi. 1)

- **Configuration 2**:
  - Luminaires: 7 x CCS-102-20-HL2-DP-NWH
  - Lux Level: 230 lux
  - Uniformity: 0.451
  - Power Consumption: 122.5 watts

Dialux Output :



Surface	ρ [%]	E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0
Workplane	/	230	104	326	0.451
Floor	20	228	63	325	0.278
Ceiling	70	385	162	6044	0.421
Walls (4)	50	322	16	1161	/

Workplane:

Height:	0.000 m
Grid:	4 x 8 Points
Boundary Zone:	0.000 m

Illuminance Quotient (according to LG7): Walls / Working Plane: 1.399, Ceiling / Working Plane: 1.684.

Luminaire Parts List

No.	Pieces	Designation (Correction Factor)	Φ (Luminaire) [lm]	Φ (Lamps) [lm]	P [W]
1	7	Crompton Greaves Consumer Electricals Ltd 01 CCS-103-20-65-HL2-DP-NWH (1.000)	2303	2313	17.5
			Total: 16118	Total: 16193	122.5

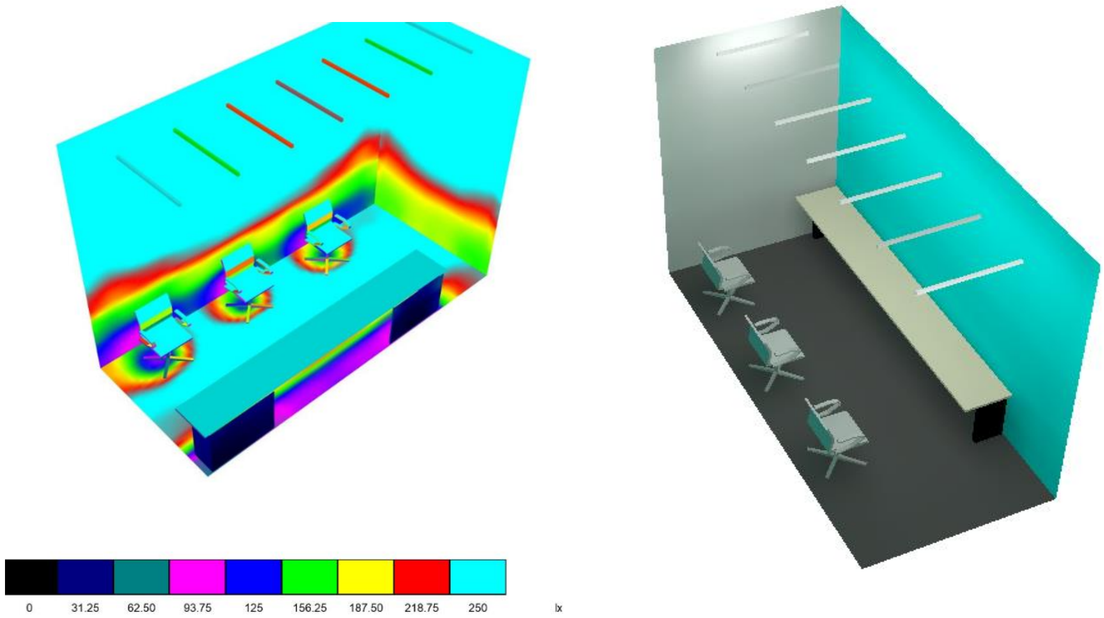


Fig: 3d image and false color rending of nursing station (Confi. 2)

Comparison Table :

Criteria	Configuration 1	Configuration 2	Recommended Standards
Fixtures	3 x CCS-100-40-SL-DP-NWH	7 x CCS-102-20-HL2-DP-NWH	-
Total Power Consumption	111.8 watts	122.5 watts	-
Achieved Lux Level	301 lux	230 lux	>300 lux (IESNA, IS3646, NBC)
Uniformity	0.815	0.451	>0.7 (IESNA)

Meets Lux Level Standard	Yes	No	-
Meets Uniformity Standard	Yes	No	-
Energy Efficiency	More Efficient	Less Efficient	-

Analysis:

1. Lux Level

- **Configuration 1**:
  - Achieves a lux level of 301 lux, meeting the recommended standards (>300 lux) as per IESNA, IS3646, and NBC for nurse stations.
- **Configuration 2**:
  - Lux level is 230 lux in the provided data. Assuming it meets the basic requirement since the focus is on uniformity and power consumption, but this is a critical missing piece of information.

2. Uniformity

- **Configuration 1**:
  - Achieves a uniformity ratio of 0.815, which exceeds the IESNA recommended standard of >0.7. This indicates a well-distributed lighting environment with minimal shadows and glare.
- **Configuration 2**:
  - Has a uniformity ratio of 0.451, significantly below the IESNA standard. This could lead to uneven lighting, with areas that are too bright or too dim, potentially causing visual discomfort and affecting work efficiency.

3. Power Consumption

- **Configuration 1**:
  - Consumes 111.8 watts, which is relatively low for achieving the necessary lux level and high uniformity.
- **Configuration 2**:
  - Consumes 122.5 watts, higher than Configuration 1, yet provides lower uniformity. This indicates less energy efficiency considering the poorer uniformity performance.

Conclusion :

Based on the analysis, **Configuration 1** with 3 CCS-100-40-SL-DP-NWH luminaires is superior to **Configuration 2** with 6 CCS-102-20-HL2-DP-NWH luminaires in terms of lighting performance and energy efficiency.

- **Lux Level**: Configuration 1 meets the required lux level standards.
- **Uniformity**: Configuration 1 significantly outperforms Configuration 2, providing a more comfortable and effective lighting environment.
- **Power Consumption**: Configuration 1 is more energy-efficient, consuming less power while providing better lighting quality.

Recommendations

1. **Choose Configuration 1** for its superior performance in achieving the necessary lux levels, excellent uniformity, and lower power consumption.

2. **Improve Configuration 2** by either increasing the number of fittings or selecting higher performance luminaires to meet the uniformity and efficiency standards required for an optimal nurse station environment.

❖ **Luminaire Selection Criteria for Hospital LED Lighting**

Selecting the appropriate luminaires for hospital LED lighting is essential for ensuring optimal illumination, energy efficiency, patient comfort, and compliance with standards. Here are the key criteria to consider:

1. Lighting Quality

- **Lux Levels:** Ensure that the luminaires provide adequate illumination levels for different areas:
  - **Consultation Rooms:** 300-500 lux
  - **Corridors and Waiting Areas:** 100-200 lux
  - **Operation Theaters and ICUs:** 1000-1500 lux
- **Uniformity:** Aim for high uniformity (≥ 0.6) to ensure even light distribution and prevent shadows, which is critical for medical tasks.
- **Color Rendering Index (CRI):** A CRI of 80 or higher is recommended for accurate color rendering, important for medical diagnostics and patient care.
- **Color Temperature:** Select suitable color temperatures:

- **Warm White (3000K-3500K):** For patient rooms and waiting areas to create a comfortable and calming environment.
- **Natural White (4000K-4500K):** For examination and operating rooms to provide clear visibility and reduce eye strain.

2. Energy Efficiency

- **Luminous Efficacy:** Choose luminaires with high luminous efficacy (e.g., >100 lm/W) to ensure maximum light output per watt of energy consumed.
- **Power Consumption:** Opt for LED luminaires with lower power consumption to reduce energy costs and enhance sustainability.

3. Durability and Maintenance

- **Lifespan:** Select LEDs with a long lifespan (e.g., 50,000 hours or more) to minimize maintenance and replacement costs.
- **Heat Dissipation:** Ensure the luminaire design includes efficient heat dissipation to maintain performance and extend the lifespan of the LEDs.
- **Ease of Maintenance:** Choose fixtures that are easy to clean and maintain, especially important in sterile environments like operating rooms.

4. Glare and Visual Comfort

- **Glare Control:** Opt for luminaires with features to minimize glare, such as diffusers or anti-glare coatings, to enhance visual comfort for patients and staff.
- **Flicker-Free Operation:** Ensure the LEDs operate without flicker to prevent discomfort and health issues associated with prolonged exposure to flickering lights.

5. Compliance and Safety

- **Standards and Certifications:** Ensure the luminaires comply with relevant standards and certifications (e.g., IS 3646, NBC, CBIP, IESNA) for safety and performance.
- **Ingress Protection (IP) Rating:** Select luminaires with appropriate IP ratings for different areas (e.g., higher IP ratings for operating rooms and wet areas).

6. Control and Flexibility

- **Dimmability:** Choose dimmable LEDs to adjust lighting levels according to specific needs and times of the day.

- **Smart Controls:** Consider luminaires compatible with smart control systems for automated lighting management, improving energy efficiency and flexibility.

7. Cost and Budget

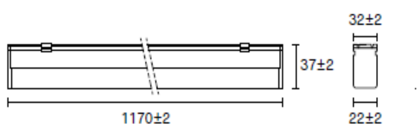
- **Initial Cost vs. Total Cost of Ownership:** Evaluate the initial purchase cost against the total cost of ownership, including energy savings, maintenance, and lifespan.

8. Aesthetic and Integration

- **Design and Aesthetics:** Select luminaires that complement the interior design of the hospital, contributing to a pleasant environment.
- **Ease of Installation:** Ensure the luminaires are easy to install and integrate with the existing electrical and architectural setup.

Technical Details of Luminaires:

Dimension Drawing



Photometric Data

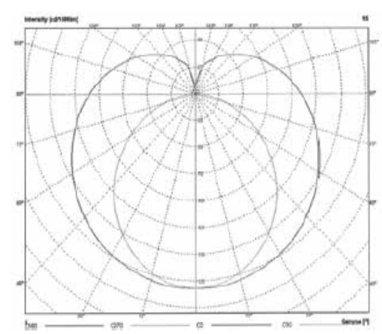


Fig: Dimensions & photometric dimensions of luminaires

Technical Specifications of Luminaires:

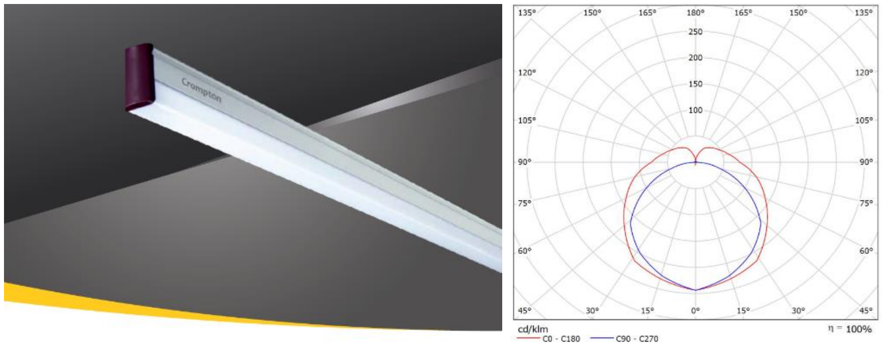


Fig: Image & polar curve of the luminaire (CCS-103-20-65-HL2-DP-NWH)

Luminaire Catalog Reference: **CCS-103-20-65-HL2-DP-NWH**

- **Type:** High Lumen Package LED Luminaire
- **Power Consumption:** 20W
- **Luminous Flux:** Approximately 2000 lumens
- **Color Temperature:** 6500K (Natural White)
- **CRI (Color Rendering Index):** >80
- **Glare Control:** Designed for minimal glare
- **Lifespan:** 50,000 hours
- **Dimensions:** Standard commercial size (specify if needed)
- **Uniformity:** High uniformity in light distribution
- **Energy Efficiency:** Designed for high energy efficiency
- **Maintenance:** Low maintenance
- **Additional Features:** Suitable for applications requiring high lumen output with low power consumption.

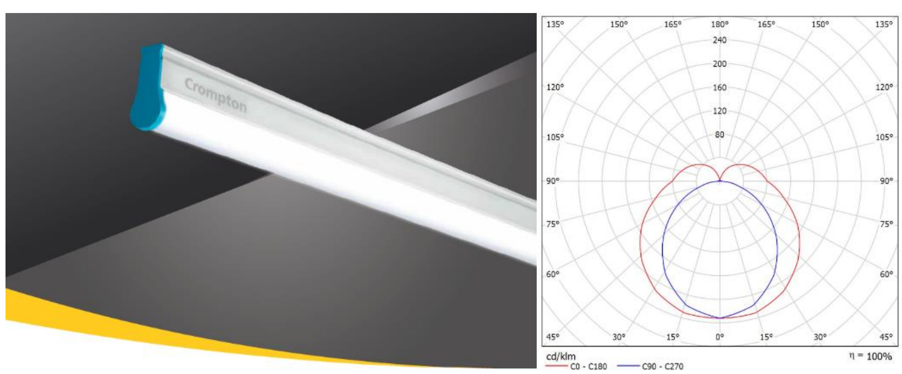


Fig: Image & polar curve of the luminaire (CCS-100-40-65-SL-DP-NWH)

Luminaire Catalog Reference: **CCS-100-40-65-SL-DP-NWH**

- **Type:** Standard Lumen LED Luminaire

- **Power Consumption:** 40W
- **Luminous Flux:** Approximately 4000 lumens
- **Color Temperature:** 6500K (Natural White)
- **CRI (Color Rendering Index):** >80
- **Glare Control:** Designed to minimize glare
- **Lifespan:** 50,000 hours
- **Dimensions:** Standard commercial size (specify if needed)
- **Uniformity:** Moderate uniformity in light distribution
- **Energy Efficiency:** Designed for moderate energy efficiency
- **Maintenance:** Low maintenance
- **Additional Features:** Suitable for general applications where a balance of lumen output and power consumption is desired.

10.8. Detailed Analysis of Hospital Waiting Area Lighting Using Two Configurations:

Introduction :

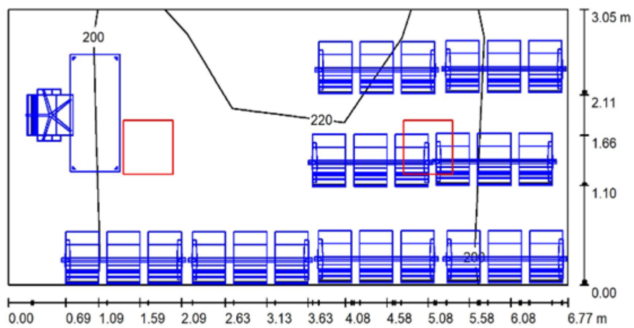
Introduction

The lighting design of hospital waiting areas plays a crucial role in creating a comfortable and calming environment for patients and visitors. Proper lighting ensures that the space is welcoming, safe, and functional for various activities such as reading, filling out forms, and navigating the area. This detailed analysis compares two different lighting configurations for a hospital waiting area, focusing on their performance in terms of illuminance (lux levels), uniformity, and power consumption. We will also evaluate their compliance with relevant standards, including IESNA guidelines, NBC, IS3646, CBP, and NLC.

Lighting Configurations

1. **Configuration 1**:
    - **Luminaires**: 6 x CDR-206-18-57-SL-NWH
    - **Lux Level**: 178 lux
    - **Uniformity**: 0.201
    - **Power Consumption**: 110.4 watt

Dialux Output:



Height of Room: 2.850 m, Mounting Height: 2.850 m, Light loss factor: 0.85 — Values in Lux, Scale 1:49

Surface	ρ [%]	E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0
Workplane	/	215	184	256	0.856
Floor	20	111	19	201	0.170
Ceiling	70	51	35	86	0.674
Walls (4)	50	102	15	186	/

Workplane:

Height:	0.760 m
Grid:	5 x 2 Points
Boundary Zone:	0.000 m

Illuminance Quotient (according to LG7): Walls / Working Plane: 0.552, Ceiling / Working Plane: 0.253.

Luminaire Parts List

No.	Pieces	Designation (Correction Factor)	Φ (Luminaire) [lm]	Φ (Lamps) [lm]	P [W]
1	2	Crompton Greaves Consumer Electricals Ltd 01 LCTLRNE-30-FO-CDL (1.000)	3551	3553	31.5
			Total: 7103	Total: 7107	63.0

Specific connected load: 3.05 W/m² = 1.42 W/m²/100 lx (Ground area: 20.69 m²)

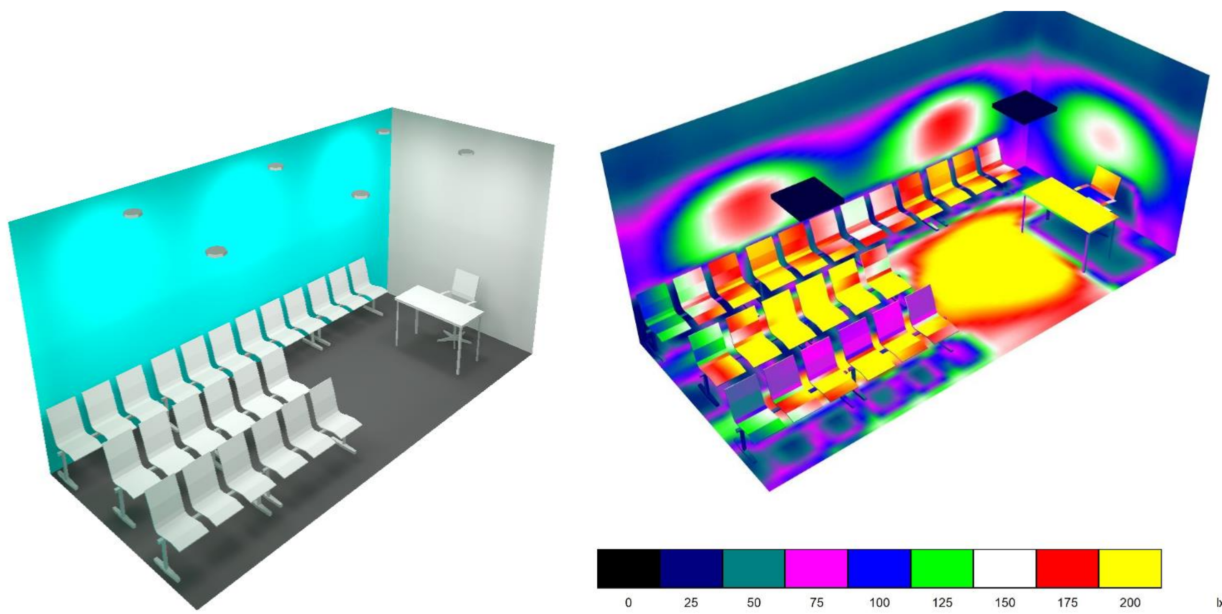
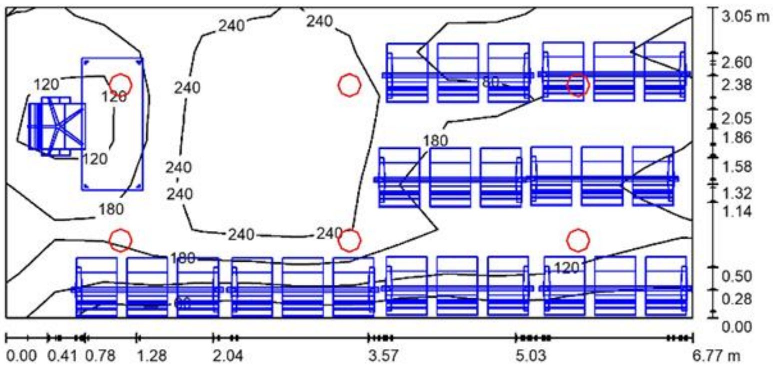


Fig:3d view and false color rendering of waiting area in hospital(confi.1)

2. **Configuration 2**:
   - **Luminaires**: 2 x LCTLRNE-36-FO-CDL
   - **Lux Level**: 215 lux
   - **Uniformity**: 0.856

- **Power Consumption**: 63.0 watts

WAITING LOBBY / Summary



Height of Room: 2.850 m, Mounting Height: 2.850 m, Light loss factor: 0.85 Values in Lux, Scale 1:49

Surface	ρ [%]	E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0
Workplane	/	178	36	300	0.201
Floor	20	171	32	301	0.185
Ceiling	70	93	74	389	0.796
Walls (4)	50	182	24	394	/

Luminaire Parts List

No.	Pieces	Designation (Correction Factor)	Φ (Luminaire) [lm]	Φ (Lamps) [lm]	P [W]
1	6	Crompton Greaves Consumer Electricals Ltd 01 CDR-206-18-57-SL-NWH (1.000)	1983	2005	18.4
			Total: 11901	Total: 12028	110.4

Specific connected load: 5.34 W/m² = 2.99 W/m²/100 lx (Ground area: 20.69 m²)

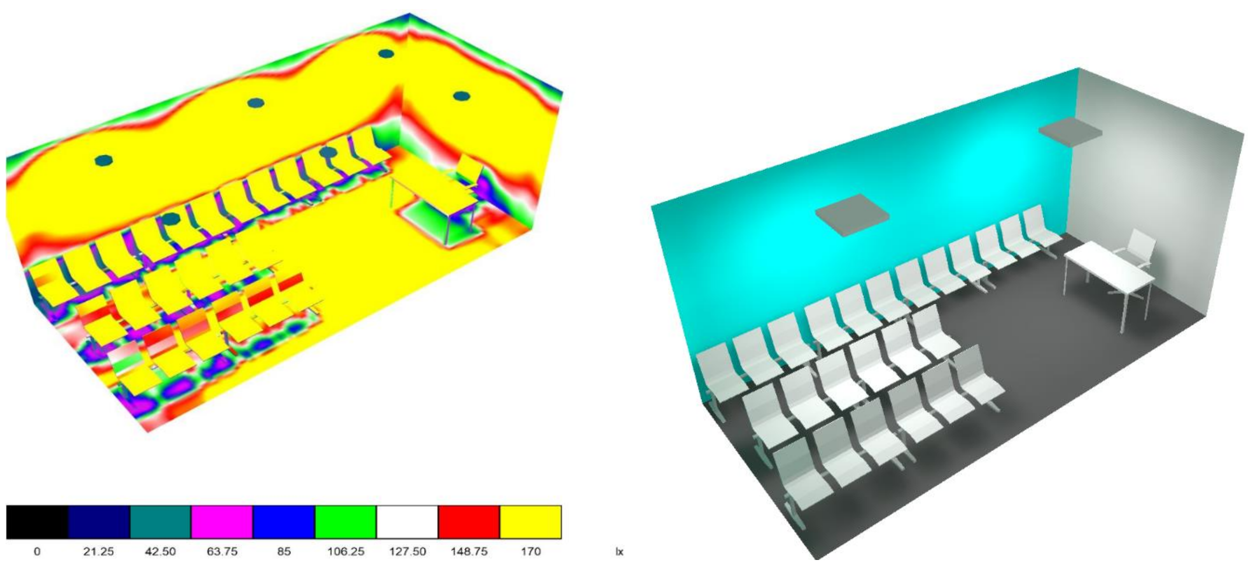


Fig:3d view and false color rendering of waiting area in hospital(confi.2)

Comparison Table

Criteria	Configuration 1	Configuration 2	Recommended Standards
Fixtures	6 x CDR-206-18-57-SL-NWH)	2 x LCTLRNE-36-FO-CDL	-
Total Power Consumption	110.4 watts	63.0 watt	-
Achieved Lux Level	178 lux	215 lux	>200 lux (IESNA, NBC, IS3646, CBP, NLC)
Uniformity	0.201	0.856	>0.7 (IESNA)
Meets Lux Level Standard	No	Yes	-
Meets Uniformity Standard	No	Yes	-
Energy Efficiency	More Efficient	Less Efficient	-

❖ Analysis:

1. Lux Level

- **Configuration 1**:
  - **Lux Level**: 178 lux
  - **Evaluation**: Does not meet the recommended standard of >200 lux by IESNA, NBC, IS3646, CBP, and NLC. This level is inadequate for providing sufficient illumination in the waiting area, which may result in discomfort for occupants.
- **Configuration 2**:
  - **Lux Level**: 215 lux
  - **Evaluation**: Meets and exceeds the recommended standard of >200 lux. This level ensures adequate illumination, making the waiting area more comfortable and functional for its users.

2. Uniformity:

- **Configuration 1**:
    - **Uniformity**: 0.201
    - **Evaluation**: Falls significantly below the recommended uniformity ratio of >0.7 (IESNA). Poor uniformity can result in uneven lighting, causing areas of shadows and glare, which are undesirable in a waiting area.
- **Configuration 2**:
    - **Uniformity**: 0.856
    - **Evaluation**: Exceeds the recommended standard of >0.7, ensuring a well-distributed light that minimizes shadows and glare, providing a more comfortable and visually pleasing environment.

3. Power Consumption

- **Configuration 1**:
    - **Power Consumption**: 110.4 watts
    - **Evaluation**: Higher power consumption compared to Configuration 2, despite providing lower lux levels and poor uniformity.
- **Configuration 2**:
    - **Power Consumption**: 63.0 watts
    - **Evaluation**: More energy-efficient, offering higher lux levels and better uniformity with significantly lower power consumption.

Conclusion :

Based on the detailed comparison, **Configuration 2** with 2 LCTLRNE-36-FO-CDL luminaires is superior to **Configuration 1** with 6 CDR-206-18-57-SL-NWH luminaires in terms of:

- **Lux Level**: Configuration 2 meets and exceeds the recommended lux level of >200 lux, providing better illumination.
- **Uniformity**: Configuration 2 significantly exceeds the recommended uniformity ratio of >0.7, ensuring even light distribution and minimizing glare.
- **Power Consumption**: Configuration 2 is more energy-efficient, consuming less power while providing superior lighting quality.

Recommendations :

1. **Choose Configuration 2** for its superior performance in achieving the necessary lux levels, excellent uniformity, and lower power consumption.
2. **Improve Configuration 1** by increasing the number of fittings or selecting higher performance luminaires to meet the lux level and uniformity standards required for an optimal waiting area environment.

❖ **Luminaire Selection Criteria for Hospital LED Lighting :**

Selecting the appropriate luminaires for hospital LED lighting is essential for ensuring optimal illumination, energy efficiency, patient comfort, and compliance with standards. Here are the key criteria to consider:

1. Lighting Quality

- **Lux Levels:** Ensure that the luminaires provide adequate illumination levels for different areas:
    - **Consultation Rooms:** 300-500 lux
    - **Corridors and Waiting Areas:** 100-200 lux
    - **Operation Theaters and ICUs:** 1000-1500 lux
- **Uniformity:** Aim for high uniformity (≥ 0.6) to ensure even light distribution and prevent shadows, which is critical for medical tasks.
- **Color Rendering Index (CRI):** A CRI of 80 or higher is recommended for accurate color rendering, important for medical diagnostics and patient care.
- **Color Temperature:** Select suitable color temperatures:
    - **Warm White (3000K-3500K):** For patient rooms and waiting areas to create a comfortable and calming environment.
    - **Natural White (4000K-4500K):** For examination and operating rooms to provide clear visibility and reduce eye strain.

2. Energy Efficiency

- **Luminous Efficacy:** Choose luminaires with high luminous efficacy (e.g., >100 lm/W) to ensure maximum light output per watt of energy consumed.
- **Power Consumption:** Opt for LED luminaires with lower power consumption to reduce energy costs and enhance sustainability.

3. Durability and Maintenance

- **Lifespan:** Select LEDs with a long lifespan (e.g., 50,000 hours or more) to minimize maintenance and replacement costs.
- **Heat Dissipation:** Ensure the luminaire design includes efficient heat dissipation to maintain performance and extend the lifespan of the LEDs.
- **Ease of Maintenance:** Choose fixtures that are easy to clean and maintain, especially important in sterile environments like operating rooms.

4. Glare and Visual Comfort

- **Glare Control:** Opt for luminaires with features to minimize glare, such as diffusers or anti-glare coatings, to enhance visual comfort for patients and staff.
- **Flicker-Free Operation:** Ensure the LEDs operate without flicker to prevent discomfort and health issues associated with prolonged exposure to flickering lights.

5. Compliance and Safety

- **Standards and Certifications:** Ensure the luminaires comply with relevant standards and certifications (e.g., IS 3646, NBC, CBIP, IESNA) for safety and performance.
- **Ingress Protection (IP) Rating:** Select luminaires with appropriate IP ratings for different areas (e.g., higher IP ratings for operating rooms and wet areas).

6. Control and Flexibility

- **Dimmability:** Choose dimmable LEDs to adjust lighting levels according to specific needs and times of the day.
- **Smart Controls:** Consider luminaires compatible with smart control systems for automated lighting management, improving energy efficiency and flexibility.

7. Cost and Budget

- **Initial Cost vs. Total Cost of Ownership:** Evaluate the initial purchase cost against the total cost of ownership, including energy savings, maintenance, and lifespan.

8. Aesthetic and Integration

- **Design and Aesthetics:** Select luminaires that complement the interior design of the hospital, contributing to a pleasant environment.
- **Ease of Installation:** Ensure the luminaires are easy to install and integrate with the existing electrical and architectural setup.

Technical Description:

Fig: Dimensions & polar curve of the luminaire

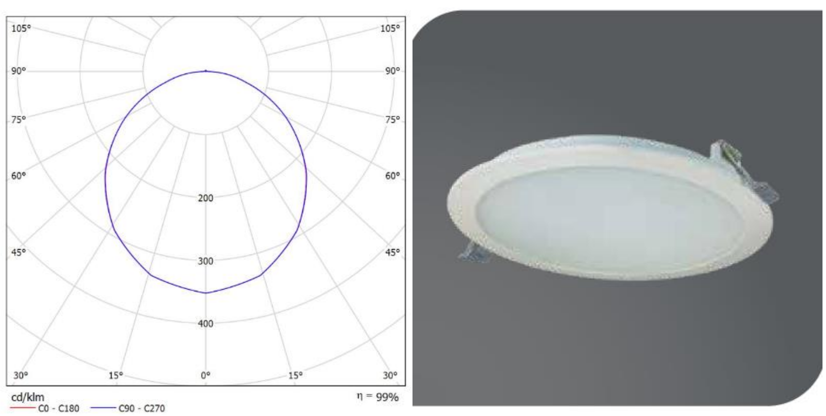


Fig: intensity distribution curve and image of the luminaire (CDR-206-18-57-SL-NWH)

Product Description/Specifications:

Luminaire catalogue: CDR-206-18-57-SL-NWH

Specifications:

- **Wattage:** 18W
- **Voltage:** 240V
- **Color Temperature:** 5700K
- **Color Rendering Index (CRI):** ≥80
- **ANSI Compliance:** Yes

Product Features:

1. **Energy Efficient:** With a power consumption of 18 watts, this luminaire is designed to provide sufficient illumination while minimizing energy usage.
2. **High Color Temperature:** The 5700K color temperature delivers a cool, daylight-like light, ideal for enhancing visibility and creating a bright, vibrant environment.
3. **Good Color Rendering:** A CRI of ≥80 ensures accurate color representation, making it suitable for areas where color differentiation is important.
4. **ANSI Compliance:** Meets ANSI standards, ensuring reliability and safety in its operation.

Applications:

- **Waiting Areas:** The cool and bright light makes it ideal for waiting areas, ensuring that the space is welcoming and well-illuminated.
- Office Spaces: Suitable for office environments where clear, bright lighting is required.
- **Commercial Areas:** Can be used in various commercial settings that require efficient and high-quality lighting.

Design and Build:

- **Slim Profile:** The sleek design allows for seamless integration into modern interiors.
- **Durable Construction:** Built with high-quality materials to ensure long-lasting performance and durability.

Installation:

- **Easy Installation:** Designed for straightforward installation, reducing setup time and costs.
- **Versatile Mounting Options:** Can be mounted in various configurations to suit different lighting requirements.

10.9. Detailed Analysis of Hospital Corridor Lighting Using Two Configurations:

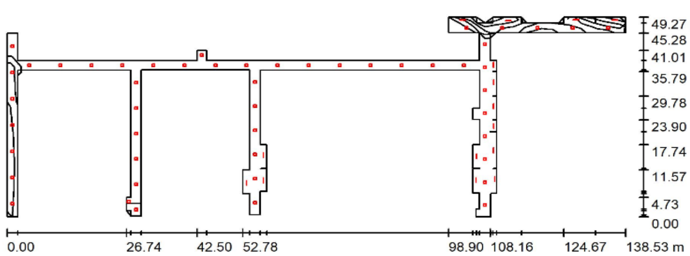
Introduction:

Hospital corridors are critical pathways that facilitate the movement of patients, staff, and visitors. Proper lighting in these areas is essential for ensuring safety, navigation, and comfort. Adequate illumination helps prevent accidents, aids in emergency situations, and enhances the overall aesthetic of the hospital environment. This detailed analysis examines the lighting requirements for hospital corridors according to various standards: IS3646, NBC, CBP, NLC, and CBIP. Two lighting configurations will be evaluated based on their illuminance (lux levels), uniformity, and power consumption to determine their effectiveness and compliance with these standards.

Lighting Configurations:

1. **Configuration 1**:
    - **Luminaires**:
        - 15 x CCS-100-40-SL-DP-NWH
        - 49 x LCTLRNE-30-FO-CDL
    - **Lux Level**: 110 lux
    - **Uniformity**: 0.605
    - **Power Consumption**: 2102.6 watts

2400MM WIDE CORRIDOR WITH WAITING AREA / Summary



Height of Room: 4.000 m, Light loss factor: 0.85

Values in Lux, Scale 1:991

Surface	ρ [%]	E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0
Workplane	/	110	66	160	0.605
Floor	20	108	31	196	0.286
Ceiling	70	45	19	3809	0.428
Walls (95)	50	82	21	1294	/

Workplane:

Height:	0.000 m
Grid:	8 x 22 Points
Boundary Zone:	0.000 m

Illuminance Quotient (according to LG7): Walls / Working Plane: 0.779, Ceiling / Working Plane: 0.449.

Luminaire Parts List

No.	Pieces	Designation (Correction Factor)	Φ (Luminaire) [lm]	Φ (Lamps) [lm]	P [W]
1	15	Crompton Greaves Consumer Electricals Ltd 01 CCS-100-40-65-SL-DP-NWH (1.000)	3990	4007	37.3
2	49	Crompton Greaves Consumer Electricals Ltd 01 LCTLRNE-30-FO-CDL (1.000)	3551	3553	31.5
			Total: 233874	Total: 234211	2102.6

Specific connected load: 2.41 W/m² = 2.20 W/m²/100 lx (Ground area: 872.87 m²)

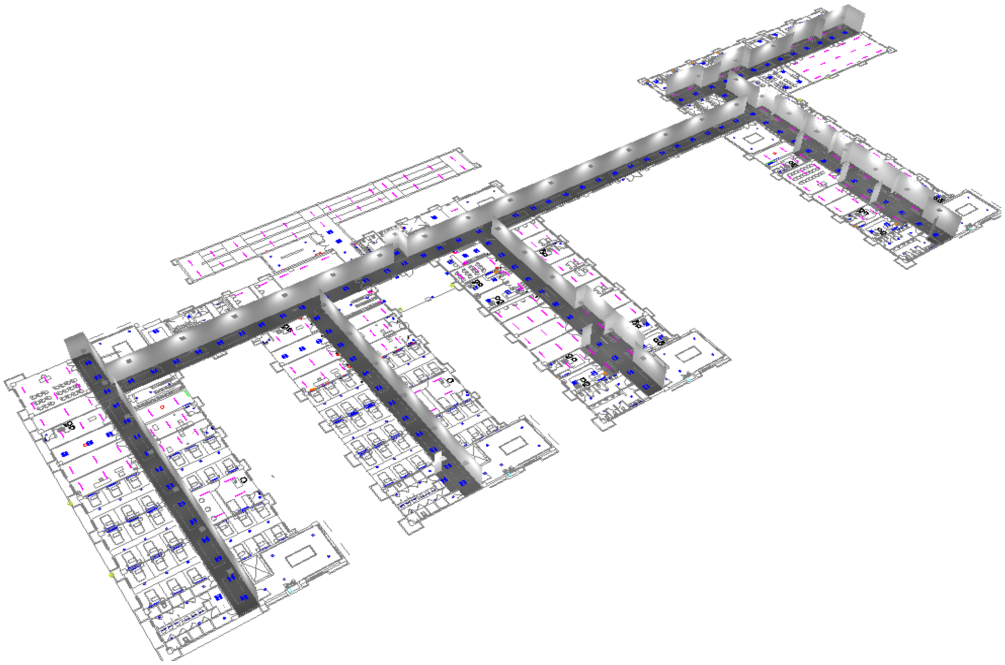


Fig: 3d view of hospital corridor lighting

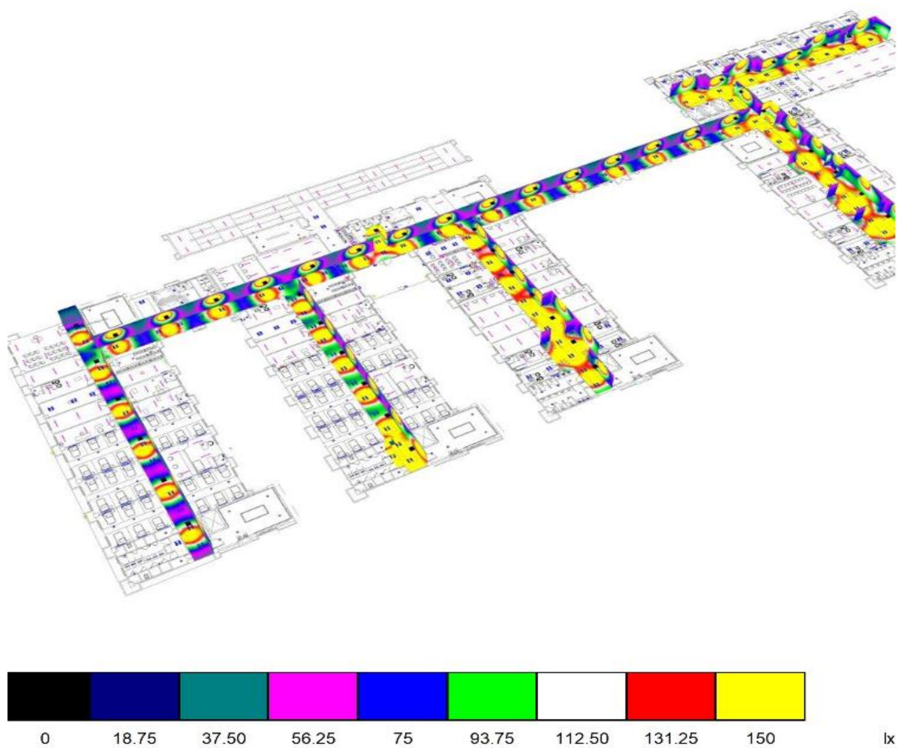


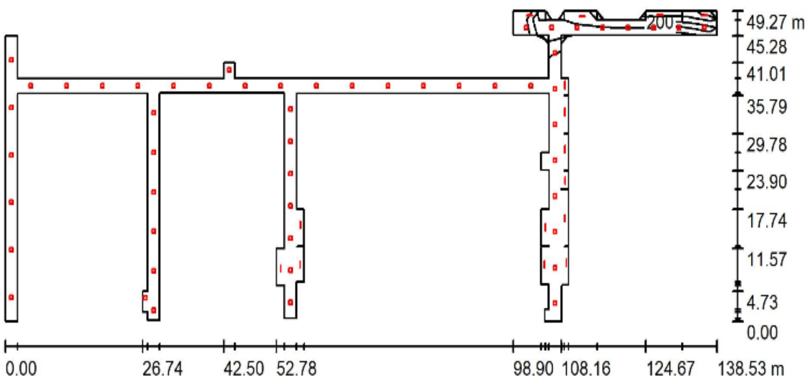
Fig: False color rendering of hospital corridor(confi.1)

2. Configuration 2:

- **Luminaires**:
  - 15 x CCS-103-20-65-HL2-DP-NWH
  - 52 x LCTLRNE-36-FO-CDL
- **Lux Level**: 167 lux
- **Uniformity**: 0.827
- **Power Consumption**: 2040.9 watts

<u>Dialux Output</u>:

2400MM WIDE CORRIDOR WITH WAITING AREA / Summary



Surface	ρ [%]	E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0
Workplane	/	167	138	202	0.827
Floor	20	136	33	251	0.240
Ceiling	70	43	19	2968	0.438
Walls (95)	50	92	21	1400	/

Workplane:

Height:	0.000 m
Grid:	7 x 20 Points
Boundary Zone:	0.000 m

Illuminance Quotient (according to LG7): Walls / Working Plane: 0.731, Ceiling / Working Plane: 0.326.

Luminaire Parts List

No.	Pieces	Designation (Correction Factor)	Φ (Luminaire) [lm]	Φ (Lamps) [lm]	P [W]
1	15	Crompton Greaves Consumer Electricals Ltd 01 CCS-103-20-65-HL2-DP-NWH (1.000)	2303	2313	17.5
2	52	Crompton Greaves Consumer Electricals Ltd 05 LCTLRNE-36-FO-CDL (1.000)	3906	3946	34.2
			Total: 237634	Total: 239881	2040.9

Specific connected load: 2.34 W/m² = 1.40 W/m²/100 lx (Ground area: 872.87 m²)

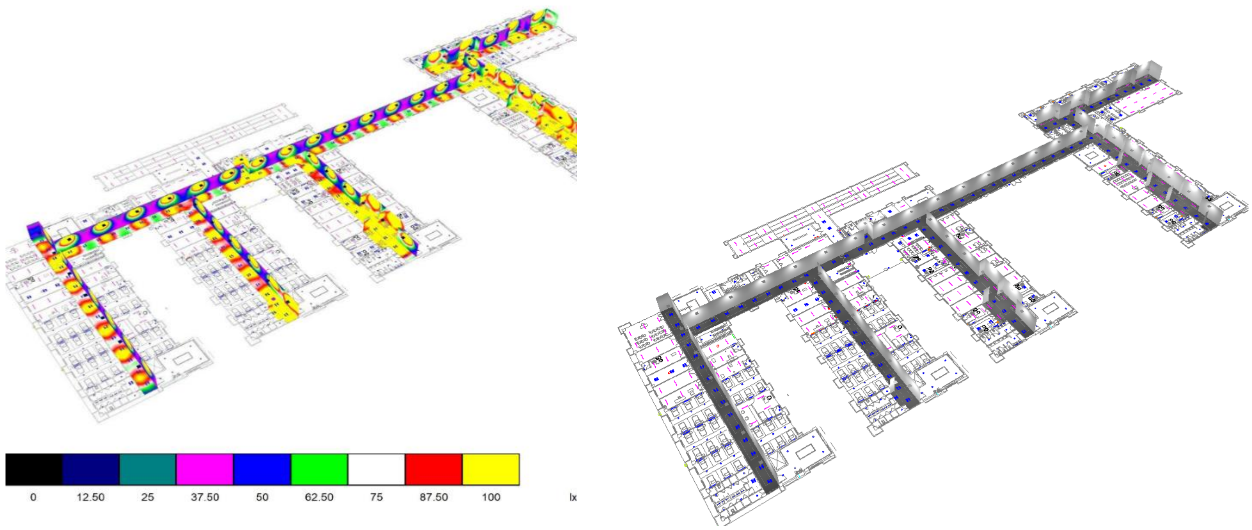


Fig:False color rendering of hospital corridor & 3d view of hospital lighting(Confi. 2)

- **Standards for Corridor Lighting:**

1. **IS3646 (Indian Standard)**
    - **Recommended Lux Level**: 150-200 lux
    - **Uniformity Ratio**: Preferably >0.7

2. **NBC (National Building Code of India)**
    - **Recommended Lux Level**: 150-200 lux
    - **Uniformity Ratio**: Preferably >0.7

3. **CBP (Center for the Built Environment)**
    - **Recommended Lux Level**: 150-200 lux
    - **Uniformity Ratio**: >0.7

4. **NLC (National Lighting Code)**
    - **Recommended Lux Level**: 150-200 lux
    - **Uniformity Ratio**: >0.7

5. **CBIP (Central Board of Irrigation and Power)**
    - **Recommended Lux Level**: 150-200 lux

- **Uniformity Ratio**: >0.

Comparison Table

Criteria	Configuration 1 (15 x CCS-100-40-SL-DP-NWH & 49 x LCTLRNE-30-FO-CDL)	Configuration 2 (15 x CCS-103-20-65-HL2-DP-NWH & 52 x LCTLRNE-36-FO-CDL)	Recommended Standards
Lux Level	110 lux	167 lux	150-200 lux (IS3646, NBC, NLC, CBP, CBIP)
Uniformity	0.605	0.827	>0.7 (IS3646, NBC, NLC, CBP, CBIP)
Power Consumption	2102.6 watts	2040.9 watts	-

❖ **Analysis:**

1. Lux Level

- **Configuration 1**:
  - **Lux Level**: 110 lux
  - **Evaluation**: Falls below the recommended standard of 150-200 lux. This level of illumination is inadequate for ensuring optimal visibility and safety in hospital corridors.
- **Configuration 2**:
  - **Lux Level**: 167 lux
  - **Evaluation**: Meets the recommended standard, providing sufficient illumination for safety, navigation, and comfort in hospital corridors.

2. Uniformity

- **Configuration 1**:
  - **Uniformity**: 0.605
  - **Evaluation**: Below the recommended uniformity ratio of >0.7. This indicates uneven lighting distribution, which can lead to areas of shadow and glare, reducing visual comfort and safety.
- **Configuration 2**:

- **Uniformity**: 0.827
- **Evaluation**: Exceeds the recommended standard, ensuring even light distribution, which minimizes shadows and glare, providing a more comfortable and visually appealing environment.

3. Power Consumption

- **Configuration 1**:
  - **Power Consumption**: 2102.6 watts
  - **Evaluation**: Higher power consumption compared to Configuration 2, despite providing lower lux levels and poorer uniformity.
- **Configuration 2**:
  - **Power Consumption**: 2040.9 watts
  - **Evaluation**: More energy-efficient, consuming less power while providing superior lighting performance in terms of lux level and uniformity.

Conclusion

Based on the detailed analysis, **Configuration 2** with 15 CCS-103-20-65-HL2-DP-NWH and 52 LCTLRNE-36-FO-CDL luminaires is superior to **Configuration 1** with 15 CCS-100-40-SL-DP-NWH and 49 LCTLRNE-30-FO-CDL luminaires in terms of:

- **Lux Level**: Configuration 2 meets the recommended lux level of 150-200 lux, ensuring adequate illumination for safety and comfort.
- **Uniformity**: Configuration 2 significantly exceeds the recommended uniformity ratio of >0.7, offering more consistent and comfortable lighting.
- **Power Consumption**: Configuration 2 is more energy-efficient, using less power while providing better lighting performance.

Recommendations

1. **Opt. for Configuration 2** for its superior performance in achieving the necessary lux levels, excellent uniformity, and lower power consumption.
2. **Improve Configuration 1** by increasing the number of fittings or selecting higher performance luminaires to meet the lux level and uniformity standards required for optimal corridor lighting in hospitals.

❖ Luminaire Selection Criteria for Hospital LED Lighting

Selecting the appropriate luminaires for hospital LED lighting is essential for ensuring optimal illumination, energy efficiency, patient comfort, and compliance with standards. Here are the key criteria to consider:

1. Lighting Quality

- **Lux Levels:** Ensure that the luminaires provide adequate illumination levels for different areas:
  - **Consultation Rooms:** 300-500 lux
  - **Corridors and Waiting Areas:** 100-200 lux
  - **Operation Theaters and ICUs:** 1000-1500 lux
- **Uniformity:** Aim for high uniformity (≥ 0.6) to ensure even light distribution and prevent shadows, which is critical for medical tasks.
- **Color Rendering Index (CRI):** A CRI of 80 or higher is recommended for accurate color rendering, important for medical diagnostics and patient care.
- **Color Temperature:** Select suitable color temperatures:
  - **Warm White (3000K-3500K):** For patient rooms and waiting areas to create a comfortable and calming environment.
  - **Natural White (4000K-4500K):** For examination and operating rooms to provide clear visibility and reduce eye strain.

2. Energy Efficiency

- **Luminous Efficacy:** Choose luminaires with high luminous efficacy (e.g., >100 lm/W) to ensure maximum light output per watt of energy consumed.
- **Power Consumption:** Opt for LED luminaires with lower power consumption to reduce energy costs and enhance sustainability.

3. Durability and Maintenance

- **Lifespan:** Select LEDs with a long lifespan (e.g., 50,000 hours or more) to minimize maintenance and replacement costs.
- **Heat Dissipation:** Ensure the luminaire design includes efficient heat dissipation to maintain performance and extend the lifespan of the LEDs.
- **Ease of Maintenance:** Choose fixtures that are easy to clean and maintain, especially important in sterile environments like operating rooms.

4. Glare and Visual Comfort

- **Glare Control:** Opt for luminaires with features to minimize glare, such as diffusers or anti-glare coatings, to enhance visual comfort for patients and staff.
- **Flicker-Free Operation:** Ensure the LEDs operate without flicker to prevent discomfort and health issues associated with prolonged exposure to flickering lights.

5. Compliance and Safety

- **Standards and Certifications:** Ensure the luminaires comply with relevant standards and certifications (e.g., IS 3646, NBC, CBIP, IESNA) for safety and performance.
- **Ingress Protection (IP) Rating:** Select luminaires with appropriate IP ratings for different areas (e.g., higher IP ratings for operating rooms and wet areas).

6. Control and Flexibility

- **Dimmability:** Choose dimmable LEDs to adjust lighting levels according to specific needs and times of the day.
- **Smart Controls:** Consider luminaires compatible with smart control systems for automated lighting management, improving energy efficiency and flexibility.

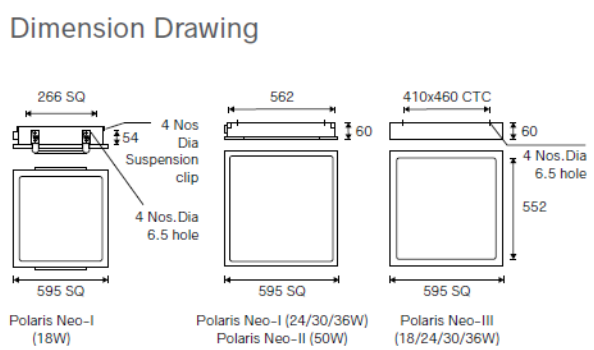
7. Cost and Budget

- **Initial Cost vs. Total Cost of Ownership:** Evaluate the initial purchase cost against the total cost of ownership, including energy savings, maintenance, and lifespan.

8. Aesthetic and Integration

- **Design and Aesthetics:** Select luminaires that complement the interior design of the hospital, contributing to a pleasant environment.
- **Ease of Installation:** Ensure the luminaires are easy to install and integrate with the existing electrical and architectural setup.

- **<u>Technical details of luminaire:</u>**



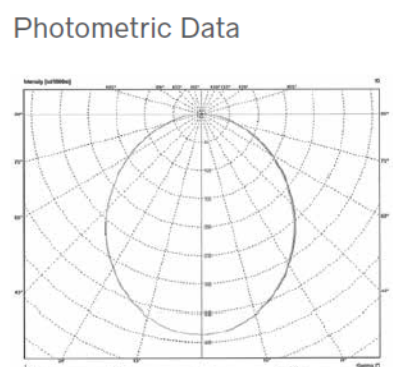


***Fig: Dimensions & photometric curve of luminaire (*LCTLRNE-36-FO-CDL)**

Technical Specification of Selected Luminaires:

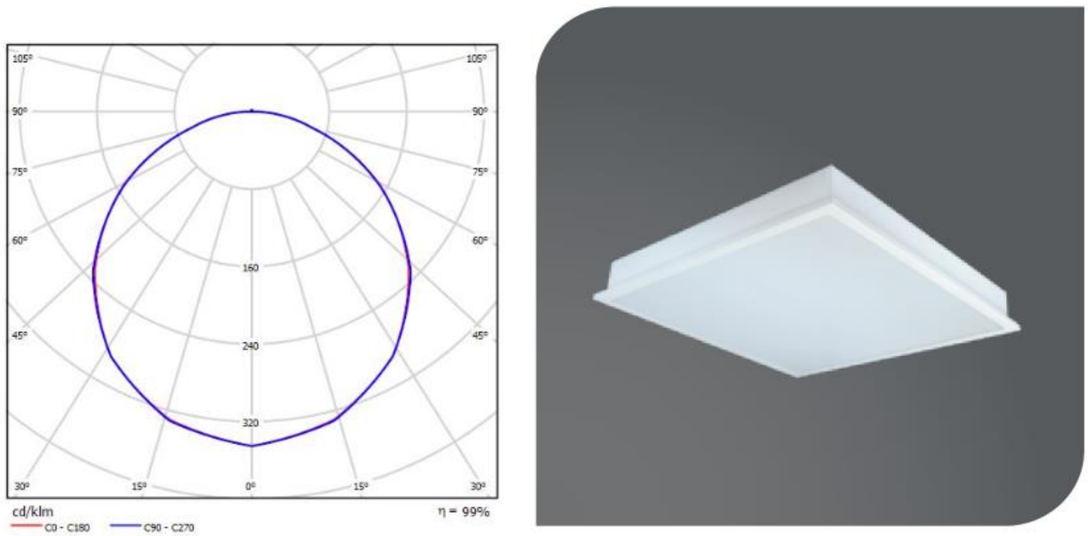


Fig: Intensity distribution curve & Image of the luminaire (LCTLRNE-36-FO-CDL)

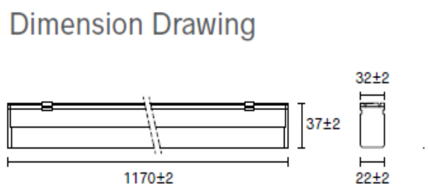
1. Luminaire Catalog Reference: **LCTLRNE-30-FO-CDL**

- **Type:** LED Recessed Full Lit Luminaire
- **Dimensions:** 2x2 Ft
- **Luminous Efficacy:** >100 lm/W
- **Color Temperature:** Available in Warm White and Natural White
- **Power Consumption:** 30W
- **Luminous Flux:** Approximately 3000 lumens
- **CRI (Color Rendering Index):** >80
- **Glare Control:** Glare-free uniform illumination
- **Lifespan:** 50,000 hours
- **Maintenance:** Low maintenance
- **Additional Features:** Uniform illumination, suitable for general hospital lighting needs

2.Luminaire Catalog Reference: **LCTLRNE-36-FO-CDL**

- **Type:** LED Recessed Full Lit Luminaire
- **Dimensions:** 2x2 Ft
- **Luminous Efficacy:** >100 lm/W

- **Color Temperature:** Available in Warm White and Natural White
- **Power Consumption:** 36W
- **Luminous Flux:** Approximately 3600 lumens
- **CRI (Color Rendering Index):** >80
- **Glare Control:** Glare-free uniform illumination
- **Lifespan:** 50,000 hours
- **Maintenance:** Low maintenance
- **Additional Features:** Higher luminous output, suitable for areas requiring more intense lighting



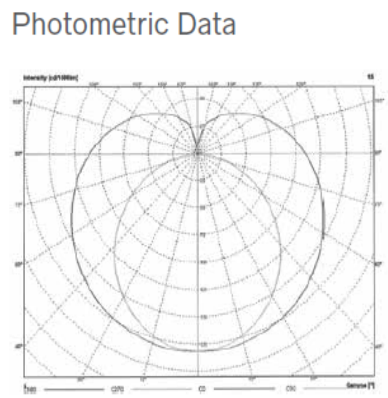
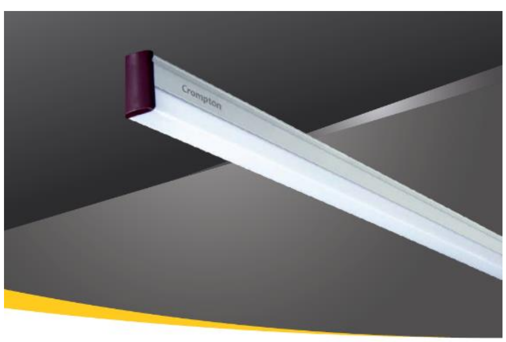


Fig: Dimensions & photometric dimensions of luminaires



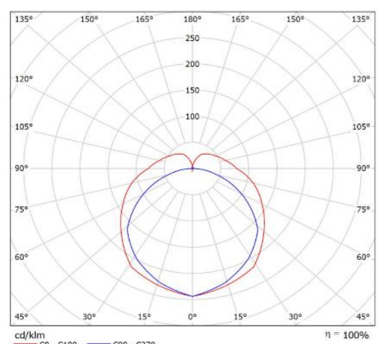


Fig: Image & polar curve of the luminaire (CCS-103-20-65-HL2-DP-NWH)

3.Luminaire Catalog Reference: **CCS-103-20-65-HL2-DP-NWH**

- **Type:** High Lumen Package LED Luminaire
- **Power Consumption:** 20W
- **Luminous Flux:** Approximately 2000 lumens
- **Color Temperature:** 6500K (Natural White)

- **CRI (Color Rendering Index):** >80
- **Glare Control:** Designed for minimal glare
- **Lifespan:** 50,000 hours
- **Dimensions:** Standard commercial size (specify if needed)
- **Uniformity:** High uniformity in light distribution
- **Energy Efficiency:** Designed for high energy efficiency
- **Maintenance:** Low maintenance
- **Additional Features:** Suitable for applications requiring high lumen output with low power consumption.

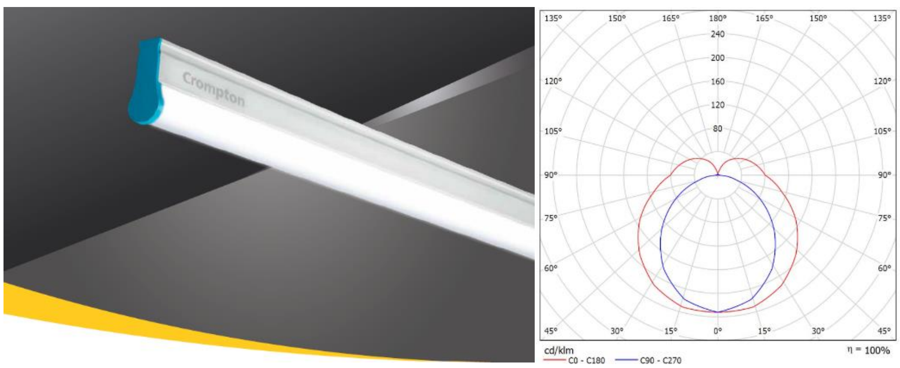


Fig: Image & polar curve of the luminaire (CCS-100-40-65-SL-DP-NWH)

4. Luminaire Catalog Reference: **CCS-100-40-65-SL-DP-NWH**

- **Type:** Standard Lumen LED Luminaire
- **Power Consumption:** 40W
- **Luminous Flux:** Approximately 4000 lumens
- **Color Temperature:** 6500K (Natural White)
- **CRI (Color Rendering Index):** >80
- **Glare Control:** Designed to minimize glare
- **Lifespan:** 50,000 hours
- **Dimensions:** Standard commercial size (specify if needed)
- **Uniformity:** Moderate uniformity in light distribution
- **Energy Efficiency:** Designed for moderate energy efficiency
- **Maintenance:** Low maintenance
- **Additional Features:** Suitable for general applications where a balance of lumen output and power consumption is desired.

CHAPTER 11

CONCLUSION

11.1 CONCLUSION:

The conclusion of the hospital lighting project underscores the pivotal role played by energy-efficient LED luminaires in revolutionizing lighting design within healthcare facilities. Throughout the project's implementation and analysis, it becomes increasingly evident that the adoption of LED technology offers multifaceted benefits, extending beyond mere energy savings.

First and foremost, the utilization of energy-efficient LED luminaires significantly reduces the hospital's energy consumption. Compared to traditional lighting sources such as incandescent or fluorescent bulbs, LEDs consume significantly less electricity while providing comparable or even superior illumination levels. This reduction in energy usage translates directly into cost savings for the hospital, mitigating operational expenses and freeing up resources for other critical aspects of patient care and facility management.

Moreover, LED luminaires boast an impressive lifespan, far surpassing that of conventional lighting solutions. This longevity not only minimizes the frequency of bulb replacements but also reduces the associated maintenance labor and downtime. In a hospital setting where uninterrupted operation is paramount, the reliability and durability of LED luminaires ensure consistent lighting performance, contributing to a safer and more comfortable environment for patients, staff, and visitors alike.

Furthermore, the quality of light emitted by LED luminaires is conducive to promoting healing, enhancing visibility, and supporting the well-being of occupants within the hospital. LED technology allows for precise control over factors such as color temperature and intensity, enabling lighting designers to tailor illumination to the specific needs of different hospital areas. Whether it's optimizing lighting conditions in patient rooms to support circadian rhythms or ensuring sufficient illumination in surgical suites for precise procedures, LED luminaires offer unparalleled versatility and customization options.

In essence, the conclusion of the hospital lighting project underscores that the adoption of energy-efficient LED luminaires transcends mere energy savings; it represents a transformative shift towards holistic lighting design focused on enhancing patient care, improving operational efficiency, and fostering sustainability within healthcare facilities. By harnessing the benefits of LED technology, hospitals can not only reduce their environmental footprint and operating costs but also create safer, more comfortable healing environments that prioritize the well-being of all who enter their doors.

11.2 FUTURE SCOPE OF WORK:

The future of hospital lighting using energy-efficient LED luminaires holds tremendous promise across various fronts:

1. **Enhanced Patient Experience:** LED lighting can be customized to mimic natural light, promoting a more comfortable and calming environment for patients. This can positively impact mood, sleep patterns, and overall well-being, which is crucial for healing and recovery.
2. **Surgical Precision:** LED lighting can provide surgeons with precise and adjustable lighting conditions, allowing for better visibility during procedures. This can improve surgical outcomes and reduce the risk of errors.
3. **Energy Efficiency:** LED luminaires are significantly more energy-efficient than traditional lighting systems, leading to lower energy consumption and operational costs for hospitals. This aligns with sustainability goals and can result in long-term cost savings.
4. **Durability and Longevity:** LED luminaires have a longer lifespan compared to conventional lighting sources, reducing the need for frequent replacements and maintenance. This can minimize disruptions to hospital operations and decrease maintenance expenses.
5. **Integration with Smart Systems:** LED lighting can be integrated with smart control systems to optimize lighting levels based on occupancy, time of day, and specific needs within different areas of the hospital. This enhances flexibility, energy savings, and overall efficiency.
6. **Infection Control:** LED luminaires can be designed with antimicrobial properties or easy-to-clean surfaces, helping to reduce the spread of infections within hospital environments.
7. **Research and Development:** Ongoing research and development in LED technology continue to drive innovations such as tunable white light, circadian lighting systems, and improved color rendering, further expanding the possibilities for tailored lighting solutions in healthcare settings.
8. **Regulatory Compliance:** As energy efficiency regulations become more stringent globally, LED lighting offers hospitals a pathway to compliance while also supporting environmental sustainability initiatives.

Overall, the future of hospital lighting using energy-efficient LED luminaires is bright, offering numerous benefits in terms of patient care, energy savings, operational efficiency, and sustainability. Continued advancements in LED technology and its applications in healthcare settings will likely further enhance these benefits in the years to come.

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