# STUDEIS ON INDUSTRIAL LIGHTING SYSTEM- WAREHOUSE AND PHARMA CLEANROOM

A dissertation submitted in
partial fulfilment of the requirements for the degree of

**Master of Technology in**
**Illumination Technology & Design**

Submitted By


**Parijit Choudhury**

**Exam Roll no. M6ILT24009**
**Registration no. 160417 of 2021-2022**


Under the guidance of

**Dr. Biswanath Roy**
**Dr. Arindam Kumar Sil**

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**SCHOOL OF ILLUMINATION SCIENCE, ENGINEERING AND DESIGN JADAVPUR UNIVERSITY**



**Course affiliated to**
**Faculty of Engineering & Technology**
**Jadavpur University**
**Kolkata-700032**
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**M.Tech. (Illumination Technology and Design)**
**Course affiliated to**
**Faculty of Engineering & Technology**
**Jadavpur University**

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## CERTIFICATE OF RECOMMENDATION

This is to certify that the thesis entitles "Studies on Industrial Lighting System - Warehouse and Pharma Cleanroom" is a bonafide work carried out by PARIJIT CHOUDHURY (Examination Roll Number M6ILT24009) under our 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.

THESIS SUPERVISOR
Dr. Biswanath Roy
Professor
Electrical Engineering Department
Jadavpur University

THESIS SUPERVISOR
Dr. Arindam Kumar Sil
Associate Professor
Electrical Engineering Department
Jadavpur University

Dr. Parthasarathi Satvaya
DIRECTOR
School of Illumination Science, Engineering and Design,
Jadavpur University,

Dr. Ratan Mondal
Professor & DEAN -Faculty Council of Interdisciplinary Studies Law and Management Jadavpur University,

# M.Tech. (Illumination Technology and Design)

**course affiliated to**
**Faculty of Engineering and Technology**
**Jadavpur University**
**Kolkata, India**

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I hereby declare that this thesis contains literature survey and original research work by the undersigned candidate, as part of his M.Tech. (Illumination Technology and Design) studies during academic session 2023-24

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

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NAME: PARIJIT CHOUDHURY

EXAM. ROLL NUMBER: M6ILT24009

THESIS TITLE: STUDIES ON INDUSTRIAL LIGHTING SYSTEM – WAREHOUSE

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SIGNATURE: DATE:

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# Chapter 1
# **FOREWORD**

## 1.1 INTRODUCTION

### 1.1.1 PHARMA

The pharmaceutical industry is an industry in medicine where drugs are discovered, developed, produced and sold for patients to use. These drugs are used to cure, prevent or ease symptoms of diseases.

Pharmaceutical industry is one of the largest users of cleanrooms. A cleanroom is an interior where inside conditions of temperature, air ventilation, humidity and dust levels are controlled to reduce the availability of airborne particulates to an acceptable level. It is a defined area of space in which the air has to be so pure that even invisible particles twenty times smaller than the eye can see have to be filtered out. Everything in a cleanroom, including humidity, temperature, airflow and balance are closely monitored to ensure cleanliness. All people who occupy the space wear special clothing designed to prevent accumulation of particles. They pass through an air shower to further remove any microscopic particles before entering a cleanroom.

The need of this level of cleanliness arose over thirty years ago when NASA created white rooms, which were designed to filter out dust during process of communication systems for aerospace.

Controlled environments are becoming part of many manufacturers' plan for research and production construction. These businesses know the importance of preventing product and laboratory contamination by using high-tech controlled environments.

The pharmaceutical industry works with precise chemical compounds, worth hundreds of thousands of rupees per kilogram. Material contamination could gravely endanger patients and trace amount of previously manufactured compounds or can easily destroy an entire production run. Therefore, controlled clean space environments are normal in this industry.

In the world of pharmaceutical production, precision is not just a goal, it's a necessity. Every step, from research to packaging, needs careful attention to detail. One often-overlooked aspect of this precision is lighting. Pharmaceutical facilities require lighting solutions that does more than just light up – it must improve quality, keep things consistent, and follow strict rules.

Pharmaceutical lighting is not just about illuminating spaces; it's about creating the ideal conditions for precision and safety. Adequate lighting is crucial for various aspects of pharmaceutical production, including research, formulation, and quality control. It enables scientists and workers to accurately measure, mix, and evaluate substances, ensuring consistency and reliability in the process. Moreover, proper lighting is essential for minimizing errors and cross-contamination, both of which can be detrimental in pharmaceutical settings. From conducting intricate experiments to inspecting the final product, lighting forms the foundation of every pharmaceutical operation, and bad lighting can lead to costly mistakes and regulatory violations.

The link between lighting and product quality in pharmaceutical facilities is very much important. Variations in lighting conditions can cause lots of problems, ranging from inconsistent product appearance to more serious issues stability. How medicine look is very important because it shows if they are good quality. Inconsistent or inadequate lighting can make things look wrong and cause mistakes. Beyond aesthetics, proper lighting also affects the visibility of labels, barcodes, and text, which are crucial for tracking and tracing products. In this tightly regulated industry, even the smallest mistake can cause big trouble. So, it's really important for pharmaceutical places to have the right lighting solutions.

When it comes to pharmaceutical production, precision isn't a luxury—it's an absolute requirement. The industry's products directly impact the health and well-being of patients, leaving no room for errors or inconsistencies. To make sure everything is perfect, every part of making medicine, even the lighting, needs to be just right.

To make sure everything is accurate, pharmaceutical facilities are using LED lighting technology as the ideal solution. LED, stands for Light Emitting Diode, it is the best choice for lots of reasons. LEDs provide a consistent, stable, and high-quality light source that can be adjusted to the specific needs of pharmaceutical works. LED lighting offers exceptional color rendering properties, which is important for tasks where color matters. Moreover, LEDs are energy-efficient and have a longer lifespan compared to traditional lighting technologies, reducing maintenance costs. The ability to control LED lighting, including dimming and color temperature adjustments, makes them versatile and adaptable to the diverse tasks within a pharmaceutical facility. For a precise industry like pharmaceuticals, LED lights are very important.

### 1.1.2 WAREHOUSE

A warehouse is a building for storing goods. Warehouses are used by manufacturers, importers, exporters, wholesalers, transport businesses, customs etc. Warehouses are usually found in industrial areas on the edge of towns or cities. Indian warehouses, particularly, in the unorganized sector, were not really warehouses - they are godowns. During the rainy season, the roof might leak, and in summer, the heat can harm the things inside. Also, the floor of these warehouses isn't very good, which affects how quickly things can be moved around. Modern warehouses are water proof, have good ventilation, and insulation to reduce the temperature inside that make it comfortable for those working. They also have security cameras everywhere to prevent theft.

- **TYPES OF WAREHOUSES**

- **Private Warehouses**

Private warehouses are owned by private companies or people. They're only for storing goods owned or brought in by the owner or someone they have permission from. These warehouses are often built in important places to serve different factories, businesses, and services.

- **Public Warehouses**

Public warehouses are approved by the government for private companies, individuals, or cooperative societies to store items for the public. They charge a fee for renting space. Usually, this type of warehouses can be found at transportation spots like railway stations, highways, or near waterways. They offer services like receiving, sending, loading, and unloading goods. The government makes sure these warehouses run properly. They're mainly used by manufacturers, wholesalers, exporters, importers, and government agencies.

- **Bonded Warehouses**

Bonded warehouses are licensed by government to accept imported goods for storage until the payment of customs duty. They are located near the ports. They are either operated by the government or work under the control of customs authorities.

- **Container Freight Stations (CFS)/ Inland Container Depots (ICDS)**

CFSs/ICDs are special places approved by customs authorities where containers can be handled and stored.

- **Cold storage**

A cold storage is a place where the temperature is controlled to keep things cold. It's mostly used by agriculture and food industries. Cold stores are used for keeping perishable items like fruits, vegetables, dairy products, frozen foods like meat and ice cream, and medicines that need a specific temperature.

## ➢ STORAGE SYSTEMS

Different types of warehouses have various areas and storage systems for different tasks. The layout of the storage area decides how tasks are done and where shadows might be a problem.

- **High Rise** - Areas generally automated, where storage bins may be rotated so that unused bins are kept high up, and with storage levels rising to over 30.5 m (100 ft).
- **Fixed Racking** - In some parts of warehouses, there are fixed racks. They can be between 1 to 4 meters (3 to 12 feet) wide and 2.5 to 9 meters (8 to 30 feet) high. Things can be stored in bins, on racks, or in different types of containers. The labels on these racks, containers, or bins can vary from big black letters on white backgrounds to small, handwritten labels that are hard to read.
- **Mobile Racking -** A storage system now widely used in North America. Entire blocks of racking move on rails on the floor to open and close aisles when needed. In order to obtain maximum use from any lighting provided, the definition of the actual seeing task should be considered.
- **Stockroom Area -** Identification marks on the sides of bulky materials, rolls of paper, and crates or boxes require vertical illumination. Additional lighting should be provided over the aisles where high piles of stock interfere with general lighting.

## ➢ ROLE OF LIGHTING IN WAREHOUSING

- **Higher Productivity**

Under a proper illumination, workers experience better visibility and higher concentration, increasing their accuracy and work speed.

- **Reduce Picking Errors**

Warehouse lighting applications require optimal lighting levels with good horizontal and vertical Uniformity in order to avoid mistakes while reading labels and picking items for shipping. This can increase profits by reducing the cost of customer returns, refunds and expedited shipments caused by shipping the wrong item.

- **Safer Warehouse**

In warehouses and distribution centers, walking and driving forklit trucks represent a high risk if employees cannot see the floor or obstacles properly due to inadequate lighting.

- **Reduced Cost**

After manpower cost, lighting is the second highest contributor in the operational cost of a warehouse.

Energy free and maintenance free lighting can help to keep cost in control.

## 1.2 MOTIVATION

The primary purpose of artificial lighting is to provide illumination in areas where natural light is insufficient or unavailable. It allows us to see and perform various tasks in both indoor and outdoor environments, regardless of the time of day or prevailing weather conditions. Adequate lighting levels are essential for creating optimal working or learning environments. Properly lit spaces enhance productivity, focus, and overall performance.

As we all agree to the fact that LEDs are the most energy efficient option for artificial lighting today and can help achieve in maximum energy savings over conventional lighting technologies. By consuming less energy, LED lighting contributes to a significant reduction in carbon dioxide (CO2) emissions. CO2 is a major greenhouse gas responsible for climate change. Switching to LED lighting helps in mitigating climate change by reducing the overall carbon emissions associated with lighting operations.

According to the U.S. Department of Energy (DOE), replacing traditional lighting with LED lighting can save about 75 percent of the electricity used for lighting purposes. This translates into a corresponding reduction in CO2 emissions from electricity generation.

LED lights provide bright and focused illumination, improving visibility and making it easier to see objects and details in the visual field. The high-quality light output of LEDs allows for accurate color rendering and better contrast, resulting in a clearer and more vibrant visual experience. LED lighting systems can be easily integrated with dimming controls and lighting management systems. This allows for adjustable lighting levels, enabling users to customize the lighting intensity according to their preferences or specific visual tasks. Dimming capabilities also contribute to energy savings by reducing lighting output when full brightness is not necessary.

## 1.3 OBJECTIVES

The objectives of the thesis are as follows:

- To study about Pharma Industry and Warehouse
- Illumination design of Warehouse and different rooms of Pharma Industry.

Chapter 2
# TECHNICAL FEATURES OF LED LUMINAIRES

LED stands for Light Emitting Diode, it is a solid-state lamp. LED lighting products produce light up to 90% more efficiently than incandescent light bulbs. LED works by an electrical current pass through a microchip, which illuminates the tiny light sources we call LEDs and the result is visible light. To prevent performance issues, the heat LEDs produce is absorbed into a heat sink.

- **LIFETIME OF LED LIGHTING PRDUCTS**

The useful life of LED lighting products is defined differently than that of other light sources, such as incandescent or compact fluorescent lighting (CFL). LEDs typically do not burn out or fail. Instead, they experience **lumen depreciation**, wherein the brightness of the LED dims slowly over time. Although average expected lifetimes of around 50,000 hours.

- **HOW ARE LEDS USED IN LIGHTING**

LED lamps are used for both general and special-purpose lighting. Small in size, LEDs provide unique design opportunities. Some LED bulbs look like traditional bulbs. Some fixtures have LEDs built-in as the main light. LEDs are commonly used in street lights, parking garages, walkways, and other outdoor areas. They can also be used in gardens for ambient lighting. LEDs can be used in large numbers for commercial purposes, such as in buildings and signs. LEDs are also used in TV and smartphone backlighting, LED displays, automotive lighting, and dimming of lights.

- **LEDS AND HEAT**

LEDs use heat sinks to absorb the heat produced by the LED and dissipate it into the surrounding environment. This keeps LEDs from overheating and burning out. Thermal management is generally the single most important factor in the successful performance of an LED over its lifetime. The higher the temperature at which the LEDs are operated, the more quickly the light will degrade, and the shorter the useful life will be. LED products use a variety of unique heat sink designs and configurations to manage heat.

- **COLOR OF LED LIGHT**

The color is characteristic of the energy bandgap of the semiconductor material used to make the LED. To emit white light from LEDs requires either mixing light from red, green, and blue LEDs, or using a phosphor to convert some of the light to other colors.
The first method (RGB-LEDs) uses multiple LED chips each emitting a different wavelength in close proximity, to form the broad white light spectrum.
The second method, phosphor converted LEDs uses one short wavelength LED (usually blue or ultraviolet) in combination with a phosphor, which absorbs a portion of the blue light and emits a broader spectrum of white light.

## 2.1 OPTICAL FEATURE

### 2.1.1 LED CHIP

A LED chip, also known as a light-emitting diode chip, is a semiconductor device that emits light when an electric current passes through it. It is the core component of an LED (light-emitting diode). LED chips are typically made from semiconducting materials such as gallium arsenide (GaAs) or gallium nitride (GaN). LED chips are typically mounted on a substrate and enclosed within an epoxy resin or ceramic package to protect the chip and provide electrical connections.

These packaged LED chips can then be integrated into various lighting fixtures and electronic devices for practical use. Led chips are basically of three types. They are:

- DIP Chip
- SMD LED Chip
- COB LED Chip

**Dip Chip:**

DIP (Dual In-line Package) LEDs are the traditional LED lights. DIP LEDs have a distinctive package design characterized by two parallel rows of pins or leads extending from the bottom of the chip. These pins are used for electrical connections and mechanical mounting.

DIP LED chips are typically larger in size compared to other LED chip packages, such as surface-mount device (SMD) LEDs. The larger size allows for easier handling and soldering, making them suitable for applications where simplicity and durability are important.

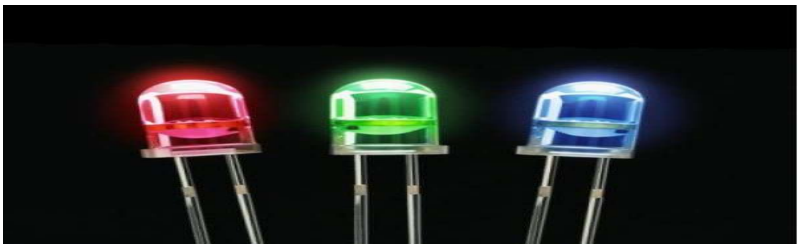


Fig. 2.1: DIP LED Chip

**SMD:**

Surface mounted device light emitting diodes (SMD LEDs) are the most common type of LED lights right now - these consist of a LED chip that is permanently fused to a printed circuit board, resulting in solid units that can be connected in a simple circuit to create various lighting configurations.
Up to 3 diodes can be fused onto a single SMD chip - this gives SMD LEDs the ability to output a huge range of colors when a chip is built using blue, red and green diodes.
SMD LEDs are available in a range of dimensions - two most common sizes are - SMD 3528 and SMD 5050, those are the two most common sizes used for 12V LED light strips.

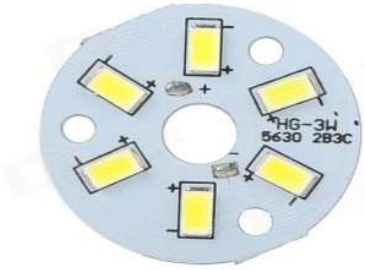



Fig. 2.2: SMD LED Chip

**COB:**

Chip on Board (COB) is the most recent development in LED. Like SMD LEDs, COB LEDs consist of multiple diodes that are soldered directly onto a microchip, however, unlike SMDs, COBs typically use 9 or more diodes per chip - this produces a light that looks like a glowing panel.

COB LEDs are extremely heat efficient, they give the best conditions for optimal cooling, which in turn will increase efficiency and lengthen the overall life of the lamp.

Unlike SMD LEDs, COB LEDs do not have the ability to emit different light colours, however, the colour temperature (such as warm or cool) can be controlled. COB LEDs can produce a higher lumen-per-watt ratio in comparison to both SMD and DIP LEDs.

Fig. 2.3: COB LED Chip

### 2.1.2 OPTICAL LENS

Lens is an important part of LED lights. The lens control and manipulate the light emitted by LEDs, they determine how the emitted light is distributed. They help to shape and direct the light output, optimizing its distribution and achieving specific lighting effects. In other words, it determines the optics of the light. Several factors are very important here. The convexity of the lens, the surface area and, of course, the thickness of the glass. The lens in combination with the reflector and the emitted light ensure the distribution and intensity of the light beam.

The most common LED lens is the convex lens that is placed around the LED. However, as technology advances, other types of lenses are also becoming more common. There are square lenses, high dome lenses, medium dome lenses and flat lenses. Each with its own light distribution and mounting over the LED diode. They can shape the light beam by focusing or diffusing it, or by creating specific beam angles, such as narrow spot, wide flood, or even asymmetric distributions.

- **OPTICAL PROPERTIES OF DIFFERENT LED LENSES**

**ROUNDED LENS**

The rounded lenses in LEDs often create an evenly distributed beam of light. If the lens curve is high and long, you'll the beam of light would be more focused on one specific point. This creates a focused light pattern.

**FLAT LENS**

Flat lens is found on both the inside and the outside. Because of this the light distribution is not or hardly affected by the present lens. Therefore, this as a protection for the LED diode rather than an actual optically changing component.

The image below is showing the optical property of different types of lenses.

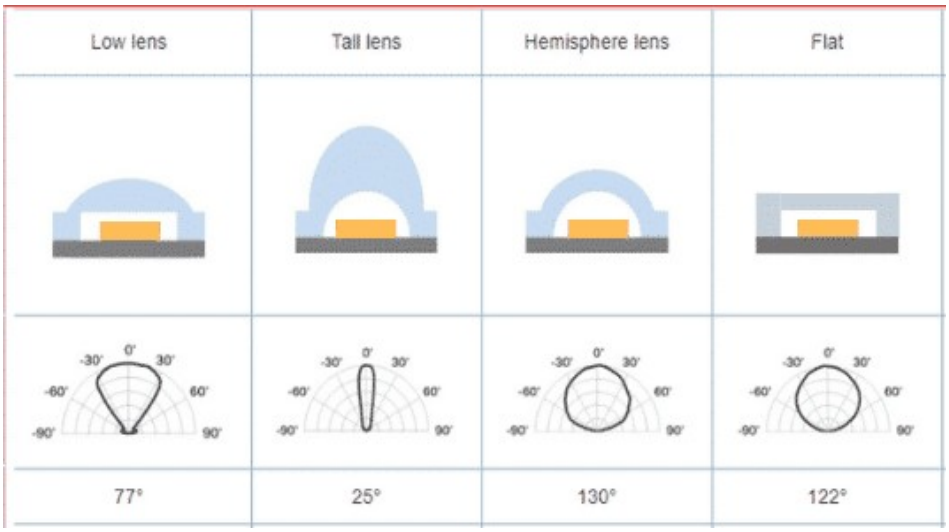



Fig 2.4

## 2.2 PHOTOMETRIC FEATURES

### 2.2.1 Beam Angle

Beam angle is a photometric feature of any luminaire. Technically beam angle is an angle over which luminous intensity drops to 50% of its peak intensity.

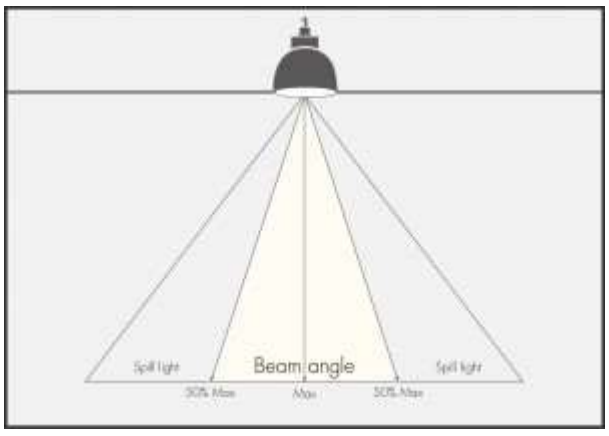



Fig 2.5: Beam Angle

**Types of Different Beam Angles:**
There are different types of beam angles that are suited to achieve the desired illuminating effect.

- **Narrow Beam Angle**

These angles refer to the range of beam angles, which is approximately between 15 and 30 degrees. They are usually employed in areas that demand focused light on a particular object. For example, in retail shops to focus on a particular product, in museums to draw attention to artwork, etc.

- **Medium Beam Angle:**

Ranging from 30 to 60 degrees, medium beam angles are used in environments that require a greater distribution of light than narrow beam angles. They are also called general-purpose lighting angles and are found in restaurants, parking lots, and similar spaces.

- **Wider Beam Angle:**

Wider beam angles are angles that are greater than 60 degrees. The areas of application are large indoor and outdoor areas like warehouses, factories, and other public spaces.

### 2.2.2 Luminous Flux

The total quantity of light energy emitted per second from a luminous body in the from of light waves is called luminous flux. It is represented by the symbol 'Φ' and measured in Lumens.

$$\Phi = dQ/dt$$

### 2.2.3 CCT

CCT (Correlated Color Temperature) of a LED luminaire refers to the color appearance of the light emitted by the luminaire. In order to define Color Temperature, we must first understand the term **Blackbody Radiator.** A blackbody is a theoretical object which is preferred radiator. As the temperature of a blackbody radiator is raised, it radiates energy in the visible range, first red, changing to orange, yellow, bluish white and then finally white. These colors plot a curve line on the CIE chromaticity diagram. The curve is known as the **blackbody locus**.

Color Temperature then is used to describe the color of light source by comparing it to color of a blackbody radiator. For example, the color appearance of an incandescent lamp is similar to a blackbody radiator heated to about 3000 K. Therefore, it is said that the incandescent lamp has a color temperature of 3000 K.

### 2.2.4 CRI

The CRI (Color Rendering Index) of a LED refers to its ability to accurately render colors compared to a reference light source. It is a numerical value on a scale from 0 to 100, with higher values indicating better color rendering capabilities.
The CRI is determined by comparing the appearance of a set of standard color samples under the LED light source with their appearance under a reference light source of the same color temperature.

## 2.3 ELECTRICAL FEATURES

The electrical features of a LED luminaire refer to the electrical characteristics and specifications of the luminaire. Some Electrical Features are –

### 2.3.1 V-I Characteristics

The working principle of the Light-emitting diode is based on the quantum theory. The quantum theory says that when the electron comes down from the higher energy level to the lower energy level then, the energy emits from the photon. The photon energy is equal to the energy gap between these two energy levels.

When the diode is forward biased, then the electrons & holes are moving fast across the junction and they are combined constantly, removing one another out. Soon after the electrons are moving from the n-type to the p-type silicon, it combines with the holes, then it disappears. Hence it makes the complete atom & more stable and it gives the little burst of energy in the form of a tiny packet or photon of light.

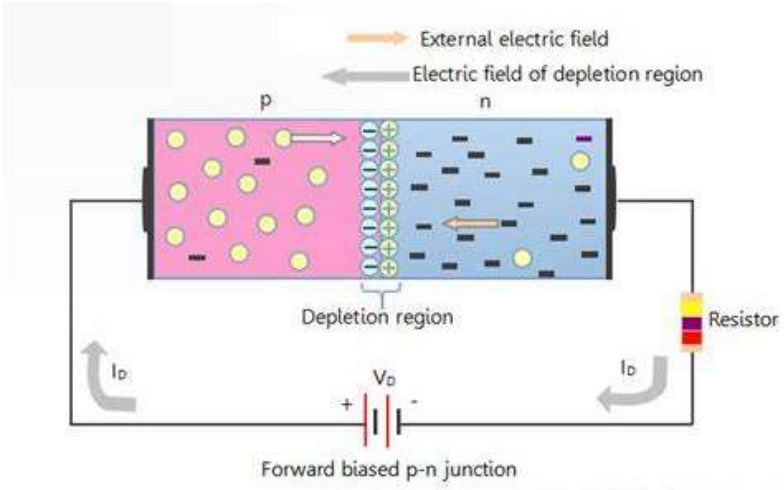
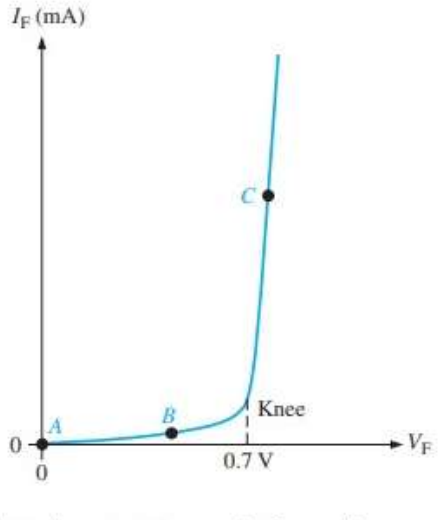



Fig 2.6: p-n junction diode

The power supply across the p-n junction makes the diode forward biased and pushing the electrons from n-type to p-type. Pushing the holes in the opposite direction. Electron and holes at the junction are combined. The photons are given off as the electrons and holes are recombined.




a). V-I characteristic curve for forward bias.

Fig 2.7: V-I curve

### 2.3.2 Power Consumption

LED luminaires are known for their energy efficiency. The power consumption of a luminaire is typically specified in watts (W) and indicates the electrical power required to operate the luminaire at its rated performance.

### 2.3.3 Power Factor

Power factor is a measure of how effectively a luminaire converts the incoming electrical power into useful work. It is a value between 0 and 1, with 1 representing ideal power factor. A higher power factor indicates better utilization of electrical power and is desirable to minimize power losses.

P.F = True Power/ Apparent power

### 2.3.4 Surge Protection

LED luminaires may incorporate surge protection devices or circuitry to safeguard against voltage spikes or transient overvoltage events. Surge protection is important to ensure the longevity and reliability of the luminaire, especially in areas prone to power surges or electrical disturbances.

Understanding the electrical features of a LED luminaire is crucial for proper installation, compatibility with the electrical infrastructure, energy efficiency considerations, and ensuring compliance with electrical regulations.

## 2.4 MECHANICAL FEATURE

The mechanical features of a LED luminaire refer to the physical characteristics and components that contribute to its structural integrity, installation, and overall functionality.

The mechanical characteristics of a luminaire has two major functions – lit accommodates various components of luminaire, such as optical system, electrical system; provides against external foreign body influences.

### 2.4.1 IK Rating

The **IK rating** evaluates the ability of a luminaire to withstand external mechanical impacts or shocks. It consists of two digits (00 to 10) following the term “IK”. The higher ratings describe a higher tolerance for impact. Here’s what each digit represents:
IK00: No protection against shock.

**IK01:** Protected against 0.14 joules of impact (equivalent to a 0.25 kg mass dropped from 5.6 cm above the impacted surface).

**IK02:** Protected against 0.2 joules of impact (equivalent to a 0.25 kg mass dropped from 8 cm above the impacted surface).

**IK03:** Protected against 0.35 joules of impact (equivalent to a 0.2 kg mass dropped from 14 cm above the impacted surface).

**IK04:** Protected against 0.5 joules of impact (equivalent to a 0.25 kg mass dropped from 20 cm above the impacted surface).

**IK05:** Protected against 0.7 joules of impact (equivalent to a 0.25 kg mass dropped from 28 cm above the impacted surface).

**IK06:** Protected against 1 joule of impact (equivalent to a 0.5 kg mass dropped from 20 cm above the impacted surface).

**IK07**: Protected against 2 joules of impact (equivalent to a 0.5 kg mass dropped from 40 cm above the impacted surface).

**IK08**: Protected against 5 joules of impact (equivalent to a 1.7 kg mass dropped from 29.5 cm above the impacted surface).

**IK09**: Protected against 10 joules of impact (equivalent to a 5 kg mass dropped from 20 cm above the impacted surface).

**IK10**: Protected against 20 joules of impact (equivalent to a 5 kg mass dropped from 40 cm above the impacted surface).

### 2.4.2 IP Rating

An **IP rating** (Ingress Protection) for a luminaire indicates the level of protection it offers against dust and water. It consists of two digits: the first digit represents protection against solid objects (like dust), and the second digit represents protection against liquids (such as water). The higher the value of either digit, the greater the protection. Here's a breakdown of IP Rating –

**Lower IP Ratings (below IP44):**
These are mostly suited for indoor use in spaces with minimal exposure to dust or water, such as your living room or bedroom.
Most light fixtures inside your home will have an IP20 rating, which is sufficient for most indoor purposes.

**Mid-Range IP Ratings (between IP44 and IP65):**
These are acceptable for both indoor and general outdoor use, provided they are installed in a sheltered location and protected from harsh weather conditions.

**Higher IP Ratings (IP65 and above):**
These are more suitable for areas exposed to harsh weather conditions.
IP65 lights can withstand water projected directly onto the fixture but are not completely waterproof.
IP66 lights can withstand water being sprayed forcefully from any direction but should not be submerged in water.

Chapter 3

# BENEFITS AND CHALLENGES OF LEDs IN INDUSTRIAL LIGHTING APPLICATION

## 3. BNEFITS AND CHALLENGES OF LEDs IN INDUSTRIAL LIGHTING APPLICATION

### 3.1 Benefits

Due to the unique characteristics of LED lights, they are becoming popular for commercial and industrial applications. Despite its higher cost than conventional light sources, LEDs are more durable, reliable, and do not need any maintenance. The most advantageous factor is their long lifespan, which can last for as long as 50,000 - 100,000 hours. With properly designed fixtures, LEDs can operate well in all temperature environments and are much more energy-efficient than conventional light sources. Some key benefits of LED Lighting for Industrial Application are -

- **Return on Investment of LED Lighting for Industrial Applications**

Industries should be aware that LED lighting is a cost-effective replacement for fluorescents, HIDs, and all other types of industrial lighting. While initial purchase costs for LED lights are a little higher than fluorescents, the price difference is just a one-time issue. Moreover, they are energy-efficient, meaning industries that use LED lighting will have a lesser electricity bill. From a purely financial perspective, it makes sense to go for LED lights due to the long life and maintenance savings.

- **LED Lights Don’t Require Maintenance**

LED lights have electronic drivers, which don't require replacement. Nowadays, these drivers are built to handle tough conditions. On the other hand, a magnetic ballast used in traditional industrial lighting such as HID, HIF, HPS, and metal halide wears out quickly, needing servicing or replacement.

- **LED Lights Don’t Contain Hazardous Material**

Like other conventional Luminaires LED lights are free from any hazardous material. They work well in high-temperature environments. In fact, well-designed LEDs work well in any type of environment. A well-designed lighting system that manages heat dissipation well can operate at any temperature—hot, cold, or anywhere in-between.

### 3.2 Challenges

In this practical world every technology or product or service have some challenges. Despite of its huge benefits LEDs also comes with some challenges that are unavoidable. These challenges are discussed below –

- **Performance Consistency**

For most applications it is hard for the user of the LEDs to set a tight specification on flux and color; generally, a range of a color is used. Challenges lie in the 19 matter that LEDs, when manufactured, are produced in a distribution of colors (wavelengths or color corrected temperatures, CCT), light output (intensity or luminous flux), and efficacy (lumens per watt). Generating a matching color and light output in multiple fixtures is extremely important; it is critical both in the occasion of fixed or permanent installations. Color variations in LED arrays are a fundamental design consideration, particularly for applications such as wall washing, where disparities in adjacent LEDs can create unexpected color effects on the target surface.

- **Operating Temperature:**

LED performance predominantly relies on the ambient temperature of the operating environment. This criticality is especially noticeable in high power LED applications. In spite of the remarkable improvement in energy efficiency over currently established light sources, light sources employing light emitting diodes (LEDs) still convert between 20 to 50% of the power they are fed into heat. Heat can often lead to permanently damages to the LED, degrades LED

performance by causing reduced light output, and ends up in a premature device failure. As a result, adequate heat-sinking or cooling essential to maintain a long lifetime for the LED, which is extremely important in applications where the LED must operate over a broad range of temperatures.

- **LED Driver Failure:**

LED system is consisting of some components which are: LED Chip, Lens, LED module, Driver Circuit, Luminaire Housing, Heat Sink and Mounting arrangement. Among them LED Driver Circuits are considered as the weakest link in the solid-state luminaire so LED driver can have life span less than that of LED itself. According to studies the life of LED driver is decided by Electrolytic capacitors at the output stage of LED driver and 50% SMPS failures are also caused by Electrolytic capacitors malfunction.

- **Product Cost**

LEDs unlike conventional light sources for example incandescent bulbs cannot effectively cool themselves. For this reason, additional heatsinking or cooling means are needed to prevent overheating. While high thermal conductivity materials are often used to propagate the heat out over a substantial area, these high thermal conductivity materials come with the addition of significant weight and cost. This raises the cost of not only the light sources as a result of shipping costs and materials costs but also the fixtures which use those light sources. Additionally, for driving an illumination system, the LED driver is commonly designed as general-purpose circuitry for use with a wide selection of LEDs. This further increases the overall cost.

Chapter 4

# OVERVIEW OF WAREHOUSE AND DIFFERENT ROOMS OF PHARMA INDUSTRY

### 4.1 **Warehouse**

Warehouse is a space where materials are properly stored retrieving and loading / unloading are done.

Warehousing plays a pivotal role in modern business operations, serving as the backbone of supply chain management and influencing overall organizational efficiency. By providing a centralized location for inventory storage, warehouses enable businesses to optimize their logistics processes and ensure timely delivery of products to customers.

For example, an e-commerce company relies heavily on warehousing not only for storing its wide assortment of products but also for fulfilling customer orders efficiently.

Through proper planning and organization of warehouse space, effective use of technology such as a warehouse management system, along with streamlined picking and packing procedures, businesses can achieve faster order processing times while reducing operational costs.

Warehousing further ensures the safety and security of valuable inventory assets by incorporating climate-controlled environments tailored for temperature-sensitive goods or employing advanced tracking systems to closely monitor stock levels.

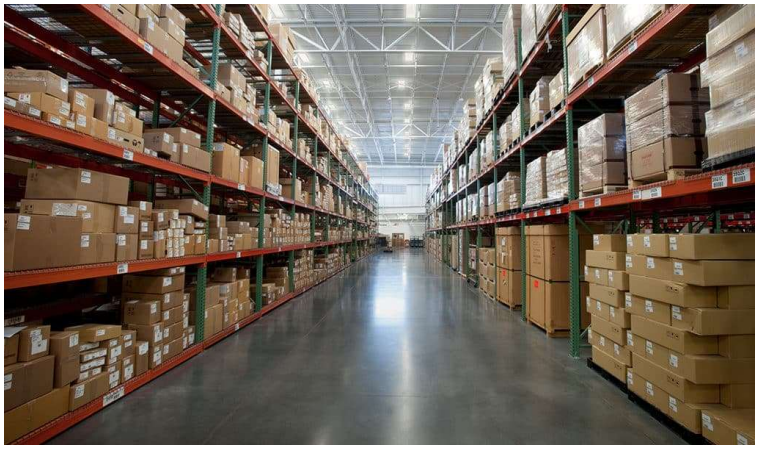


Fig 4.1: Warehouse

### 4.2 **Personnel Airlocks**

Airlock helps to protect the classified area from the contamination that may occur during the entry and exit of personnel and material.
For the movement of a person PAL (Personnel Airlock) is used and for the movement of material (example: Raw Material, Packed Material etc.) MAL (Material Airlock) is used.

Personnel Airlock can be further classified into three types:

- **Cascade Airlock:** These airlocks maintain higher pressure on one side and lower pressure on the other. This design prevents dust and contaminants from entering the airlock from outside and from the airlock to the inner side.
- **Bubble Airlock:** Bubble airlocks have higher pressure inside the airlock and lower pressure on both sides. This configuration creates a pressure barrier, preventing air flow between two adjacent areas through the airlock.

- **Sink Airlock:** In sink airlocks, the pressure inside the airlock is lower than that on both sides. As a result, air is drawn from both adjacent areas, creating a low-pressure barrier.

Fig 4.2: Airlock Room

### 4.3 **Vibro Shifter Room**

Vibro sifter is one of the needed types of machinery in many laboratory and industrial processes. It is used for the gradation of raw materials by separating materials based on their particle size.

Shifting is done to remove lumps that might have formed on the materials after being stored for a longer period and materials are passed through a mesh that opens, which leads to fine the materials. It also removes the unrequired particles and separate the materials according to size.

*Vibro Sifter* is one of the crucial components for the pharmaceutical company as it is used in the end process. Vibro sifter ensures that there is no contamination and offers assured particles in the end product.

We all know that preciseness is a must while we are manufacturing medicines as a slight increase or decrease in the quantity of the raw ingredient will alter the efficacy of the medicines. So, not only in end processes, but it can also be used while separating two or more ingredients from a mixture in order to weigh and create pellets. Thus, there is a need for such equipment in pharma companies.

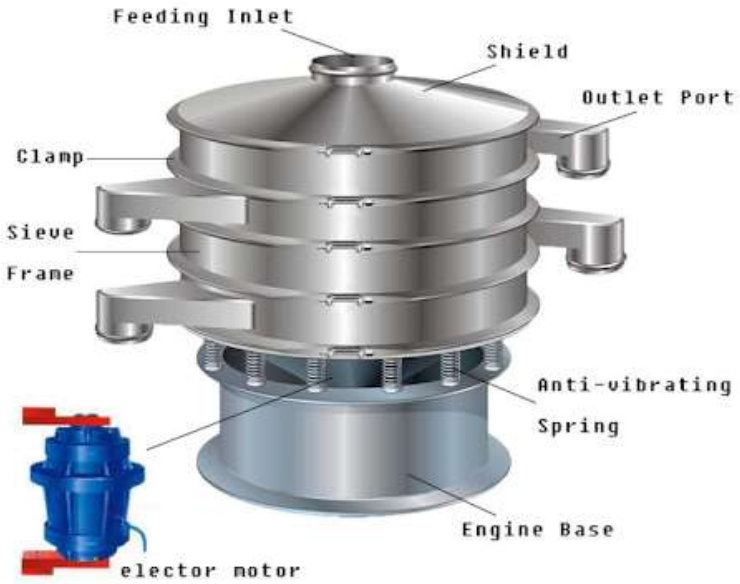



Fig 4.3: Vibro Shifter

### 4.4 **Liquid Preparation Room**

In Liquid Preparation Room Oral Liquid is produced. The process consists of Sugar Syrup preparation, Ingredient mixing and storage with product distribution piping. In Liquid Preparation Room following equipments are used –

- Sugar Syrup Vessel
- Filter Press
- Manufacturing Vessel
- Transfer Pump
- Storage Vessel
- Transfer Pump
- Piping To Connect all above Equipments
- Working Platform
- Control Pump

Fig.4.4: Liquid Preparation Room

### 4.5 **In Process Quality Assurance (IPQA)**

Manufacturers face continuous challenges when it comes to maintaining **Manufacturing Quality.** Manufacturers need Quality to differentiate themselves and gain a Competitive Advantage.

In Process Quality Assurance, IPQA is very important in any manufacturing environment, but it is critical for certain types of manufacturers like Pharmaceuticals, Medical Devices, Food & Beverage, Automotive and high-precision parts manufacturers. A well-defined and well-organized IPQA Framework can help manufacturers keep their processes on track and manufacture to their highest capacity with greater Quality.

IPQA department in Pharma Industry plays a very important role. IPQA professionals are responsible for carrying out all the process as per standard operating procedures during manufacturing to ensure quality by performing IPQA checks during Sampling, Line clearance, manufacturing packing of products. They check quality of products. It helps in identifying and correcting any defects from standard procedures. IPQA ensures that the final product meets the required quality standards.
Examples of IPQA activities include visual inspection, measurement and testing of products.

Fig 4.5: IPQA Room

### 4.6 **Quarantine Area**

Quarantine room is a place, where raw material, packing material. Intermediate, finished products are isolated physically or by other effective means while a decision is awaited on their release rejection or reprocessing.
Following items are stored in quarantine room:

- Empty ampoules/ vials/plugs etc.
- Raw material
- Semi-finished goods to be labeled or to be packed.
- Filled goods needing any sort of process are kept in quarantine room.

Fig 4.6: Quarantine Room

Chapter 5
# LIGHTING DESIGN METHODOLOGY

Lighting design methodology refers to the systematic approach and process followed by lighting designers to create effective and visually appealing lighting schemes for various spaces and applications. While different designers may have their own variations, here is a general outline of the steps involved in lighting design methodology:

## 5.1 INPUT DATA

### 5.1.1 Drawing of the area given plan and elevation

To initiate any lighting design for an area, it is essential to build/design the virtual structure on software, and that structure should be built/designed with exact dimensions as the original space. For this we need AutoCAD layouts. This detail helps in deciding the length, width and height of the area. It also gives information about the type and any constraints in locating the luminaires. If AutoCAD layout is not available in that case direct site survey can/should be conducted to get these details.

### 5.1.2 Reflection Properties of Surroundings

Reflection Properties helps in deciding the reflection factors of the ceiling, walls and floor. Normally the client does not specify this data. In such cases, the environmental condition prevailing in the area and experience of the designer helps in deciding the reflection properties.

### 5.1.3 Required Illumination Level

Another important criterion before designing is to know what the client wants for this space. Tender documents contain the requirements of the client, i.e., Pharma and Warehouse here. Some of the requirements are certain maintained lux level values, uniformity ratio, design parameters, plan and profile of the project etc.

### 5.1.4 Layout and Heights of Machine and Tools

This will help in location of luminaires such that light is not obstructed by them and design becomes much more practical optimized. From AutoCAD layout we have idea of elevation. It also helps determining the work plane height considerations for any particular area.

## 5.2 Method of Lighting

The method of lighting design involves a systematic approach to create effective and visually appealing lighting schemes. During the actual lighting design phase of a lighting project, a lighting engineer has to perform lighting calculations in order to arrive at solutions that will satisfy the relevant lighting requirements. Lighting simulation software are being used to simulate and visualize any design virtually. At this stage, consideration is given to how the light is to be delivered. The fixtures may be recessed, surface mounted, wall mounted direct or indirect.

## 5.3 Selection the Lighting Equipment

Once the method of lighting has been selected, the most appropriate light source can then be chosen followed by the luminaire.

The following attributes should be studied when choosing the light source:

• Light output (lumens)
• Total input wattage
• Efficacy (lumen per watt)
• Surface brightness / glare
• Colour characteristics
• Electrical characteristics
• Photometric attributes
• Requirement for control gear

Apart from these there are also some other factors which affect the luminaire choice. These are:

• Characteristics of light source and control gear
• Luminaire efficacy
• Light distribution
• Glare control
• Finish and appearance
• Size • Accessibility of components for maintenance
• Ability to handle adverse operating conditions
• Aesthetics
• Thermal management

## 5.4 Choice of Luminaire

The performance of a luminaire should be considered just as carefully as its cost. In the long term a well-designed, well-constructed luminaire will be cheaper than a poor-quality unit; and the salient features of a good quality luminaire are:

• Sound electrical and mechanical construction with durable finish.

• Adequate screening of high luminance lamps to minimize discomfort and glare.

• Adequate heat dissipation to prevent over-heating of the lamp, wiring and ancillary equipment.

• High light output ratio with the appropriate light distribution.

• Ease of installation, cleaning and maintenance.

## 5.5 Design Tools

### 5.5.1 AutoCAD

AutoCAD is an architectural tool which provides complete information on the dimensions of the room like length, width and height of the room. And after the completion of the design, the same can be used to provide the lighting layout as well. AutoCAD drawings are saved using the DWG extension, and over the years this has become a standard format for exchanging technical drawings, to the extent that even programs such as Adobe Illustrator will recognize DWG files. AutoCAD also supports an even more widely recognized format called DXF which was specifically designed as an interchange format.

### 5.5.2 DIALux

DIALux is a user-friendly lighting simulation software which is used to calculate the luminaire quantity required to achieve the illumination level on the area as per the standard. It also gives information on the total power consumption by the lighting load for the given area and also calculates the LPD value of the proposed lighting scheme which helps in identifying the most efficient lighting scheme. DIALux enables us to enjoy complete freedom for designing, whether it is an Indoor Area, or an Industrial Shed or an Exterior area.

## 5.6 Design Methodology

### 5.6.1 Client Meet and Discussion

For any lighting designer, the first and foremost step is to have a formal discussion with the client or end user and other members of the design team, so as to get the essence of what function the area or space would serve for, and hence to have an idea about what design needs to be done.

### 5.6.2 Obtaining the AutoCAD Layout

After client meeting, we need AutoCAD file of the project. AutoCAD layout provides us the exact length, width and height of particular area which helps in proper selection and arrangement of the luminaire. The more accurate/detailed the AutoCAD layout the more accurate will be the lighting design output.

### 5.6.3 Study of Guidelines

Now being a lighting designer, it is a responsibility to study the relevant standard codes, guidelines in detail. For this particular project work relevant standards and guidelines which needs to be followed in the previous chapter.

### 5.6.4 Design Simulation with Site Layout

After studying the guidelines, we have to import the AutoCAD layout in the lighting design software. During this import, one should take care about the dimension unit in the AutoCAD File.

### 5.6.5 Illumination Design

Illumination design is done by DIALux. The following steps are involved in indoor illumination design:

**STEP I – Deciding the type of area and type of task to be performed In the first step after having**

AutoCAD layout, we have to identify the type of work to be done e.g., whether it is office area, industry shed area etc.

**STEP II – Deciding the illuminance level required**

Once the area type and task to be performed decided then as per relevant code or guideline or tender document recommendation illuminance level required can be found out.

**STEP III – Finding out the dimension of the room**

After importing the AutoCAD, we can find the length, width and height. Once of the dimension of the area is found out, then the type of lighting arrangement can be decided.

**STEP IV – Finding out the ceiling type**

In this step we have to decide whether true ceiling or false ceiling is there. If it is true ceiling surface/ suspended mounted luminaires are chosen. In case of false ceiling recess mounted luminaire should be chosen. In case of Industries, Plants, Factories most of the cases luminaires are mounted on the truss. So, we have to be careful while mounting the luminaires.

**STEP V – Selecting the luminaire**

Luminaire is chosen based upon the task performed in the area, illumination level required, type of ceiling and level of protection required for the specified area.

**STEP VI – Selecting Maintenance Factor**

In any lighting design calculation, an appropriate maintenance factor has to be included to allow for depreciation. The magnitude of the maintenance factor significantly affects the number of luminaires needed to produce the specified illuminance. Maintenance factor is chosen as per design requirement otherwise mentioned by the client. Generally, for conventional light sources we consider maintenance factor 0.7 (for indoor) and for LED light sources 0.8.

**STEP VII – Finding out the work plane height**

Depending upon the application of task area work plane height is to be considered for office area we consider table height say 0.76 meter above the floor and for industrial shed area we consider null value, i.e., measurement to be performed at finished ground level.

**STEP VIII – Selecting the reflectance factors**

Depending upon the area we have to select the reflectance factors of the room. For office area reflectance factors for ceiling, walls and floor are to be considered 50%, 30% and 20% respectively. For industry shed area reflectance factors for ceiling, walls and floor 30%, 20% and 10%.

**STEP IX – Software simulation**

To find out luminaire quantity we have to simulate DIALux software after all the above steps done. In DIALux to simulate the software we have to select calculate option.

**STEP X – Output**

After software simulation done, we have to select output option in DIALux. In output we have to choose summary option to find out required illuminance levels and luminaire quantity for a particular task.

Chapter 6

# CASE STUDY OF WAREHOUSE AND DIFFERENT ROOMS OF PHARMA

The objective of Warehouse Illumination design is to reduce costs, maximizing productivity and safety. These are the biggest challenge for the Warehouse facility owners and managers. Warehouse is a space where materials are properly stored retrieving and loading / unloading are done. Early days Warehouse illumination was done by Fluorescent Lamps. Nowadays proper illumination design is required considering following factors:

- Lux Level calculation based on the dimensions of the aisle space rather than the overall building size parameters
- Lighting Fixtures to be placed over aisle (generally in the Middle), regardless of the overall building configuration.
- To help ensure a productive work environment, glare from light sources should be minimized.
- **Vertical Illuminance:**

Most of the tasks performed in the Warehouse, majority critical viewing tasks occur in vertical plane.

Illuminance should be distributed uniformly over the entire vertical seeing surface, from top to bottom and along the entire length of storage aisle.

- **Horizontal Illuminance:**

While not as critical as the Vertical Illuminance, adequate horizontal illuminance must be provided for safety and navigation in the aisles.

In pharma Industry Cleanroom is Used. The work done in cleanrooms is sensitive to even invisible airborne particles and selection of lighting fixtures plays an important role in the contamination control. Of course, these products become even more critical, if these are used in the environments where lifesaving drugs, food etc. are being processed. For example: Pharmaceutical Industries, food processing units.

There are two types of Luminaires used in Cleanroom:

**Bottom Opening Cleanroom Luminaires:** The LED and control gear fixtures are accessible from the bottom side. These luminaires are available in both surface mounted and recess mounted form.

**Top Opening Cleanroom Luminaires:** The lamp and the control gear tray are accessible from the top side. These luminaires are used where entry in the clean space is restricted and luminaires can be accessed only from the bay area. These are also available in both surface mounted and recess mounted form.

## 1.1 Warehouse

A warehouse is a place where products or materials can get stored before they move to another location. It's a crucial element to supply chain management.

There are some considerations to lighting design a Warehouse:

a) There is the necessity to viewing on a vertical surface rather than on a horizontal plan.

b) Lux Level calculation should be based on the dimensions of the aisle space rather than the overall building size parameters.

c) Work Environment should be glare free.

**Design AIM:**

The primary goal is to ensure clear visibility with good horizontal and vertical uniformity to avoid mistakes while reading labels or picking items for shipping, increase productivity, create safe working environment.

Required Illumination Level:

Horizontal Illuminance (Eh): 200 lux (at floor)
Vertical Illuminance (Ev): 75 lux (at 1.5 m height)

**Layout and Description of Warehouse:**

Considering one of the Warehouse for better understanding of lighting design, analysing software DIIALux has been used for describing and achieving the recommended values as per standard.

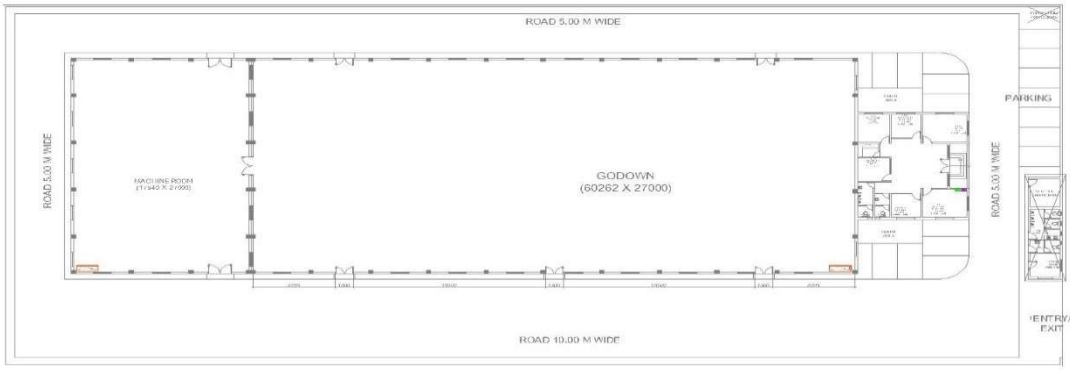



Fig 6.1

**Luminaire Used:**

32 number of 150 W Highbay Luminaires has been used for this Project.

- Luminous Flux: 23563 Lumen
- Wattage: 150 W
- Efficacy: 150 Lumen/Watt
- Beam Angle: 120 Degree
- CCT: 5000 K
- CRI: 70
- IP66 Protected

Fig. 6.2: High Bay Luminaire

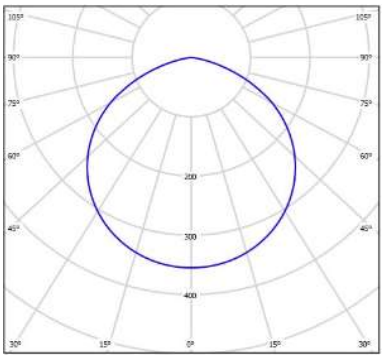


Fig. 6.3: Polar Curve

**Design Consideration for the Lighting Implementation:**
Number of Luminaire: 32
Mounting Height: 12M (At ceiling)
Maintenance Factor: 0.8
Refection Factor: Ceiling - 30
Wall - 20
Floor – 10

**DIALux Simulation:**

DIALux simulation of the Warehouse is based on positioning the light fixture and selecting proper beam angle, wattage and photometry to achieve recommended illumination level, Uniformity on the calculation surface. The lighting level on this area must meet the recommended illuminance value. Below Figure shows the simulation view of Warehouse:

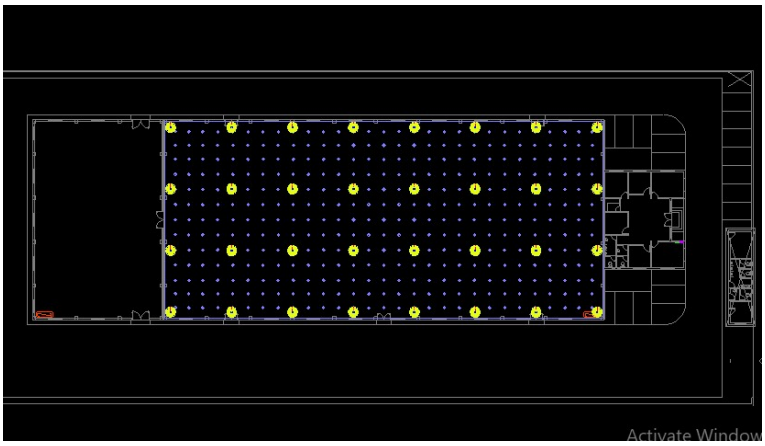


Fig. 6.4

**Result Overview:**

Here the value of average and vertical illumination level of 216 Lux and 75 lux respectively and overall horizontal uniformity of 0.4 and vertical uniformity 0.3 at 1.5 m height is achieved.

**Results overview**

| No. | Type | $E_{av}$ [lx] | $E_{min}$ [lx] | $E_{max}$ [lx] | u0 | $E_{min}$ / $E_{max}$ | $E_{h\,m}/E_m$ | H [m] | Camera |
|---|---|---|---|---|---|---|---|---|---|
| 1 | horizontal | 216 | 152 | 246 | 0.71 | 0.62 | / | 0.000 | / |
| 2 | vertical, 90.0° | 75 | 22 | 105 | 0.30 | 0.21 | 2.89 | 1.500 | / |

**3D View of the Warehouse:**

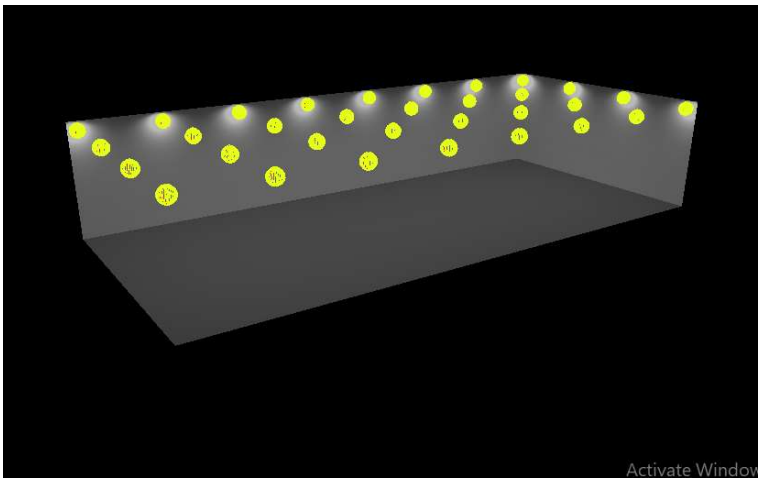


Fig. 6.5

**PHARMA INDUSTRY:**

The pharmaceutical industry is an industry in medicine that discovers, develops, produces, and markets pharmaceutical drugs for use as medications with the aim to cure and prevent diseases, or alleviate symptoms.

**Layout of Pharma Industry:**

Below Autocad drawing is considered for better understanding of lighting design of Pharma Industry. Analyzing software DIIALux has been used for describing and achieving the recommended values as per standard.

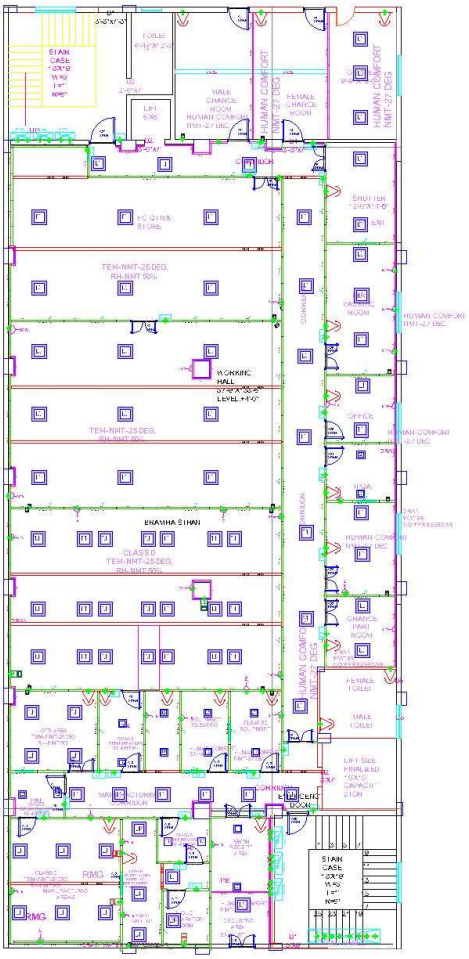


Fig. 6.6

Here we have studied about some important rooms:

### 1.2 **Personnel Airlocks**

Airlock is a transition space that typically has two doors in series to separate controlled environments such as a cleanroom, lab, operating room, isolation room etc.
The Airlock through which persons move, is called PAL (Personnel Airlock).

**Luminaires Used:**

One 40 W Cleanroom Luminaire has been used to illuminate this room.

- Luminous Flux: 3500 Lumen
- Wattage: 40 W
- Efficacy: 87 Lumen/Watt
- Beam Angle: Diffused Luminaire
- CCT: 5700 K
- CRI: 80
- IP54 Protected

Fig. 6.7: Cleanroom Luminaire

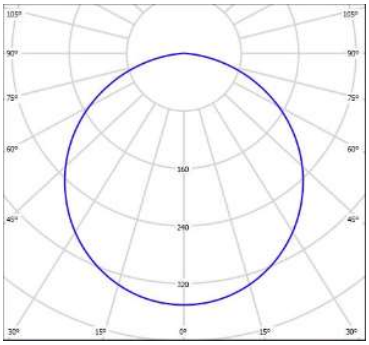


Fig. 6.8: Polar Curve

**Design Consideration for the Lighting Implementation:**
Number of Luminaire: 1
Mounting Height: 2.7 M (At ceiling, Recess Mounted)
Maintenance Factor: 0.85
Refection Factor: Ceiling - 50
Wall - 30
Floor – 20

**DIALux Simulation:**

DIALux simulation of the PAL is based on positioning the light fixture and selecting proper beam angle, wattage and photometry to achieve recommended illumination level, Uniformity on the calculation surface. The lighting level on this area must meet the recommended illuminance value. Below Figure shows the simulation view of PAL:

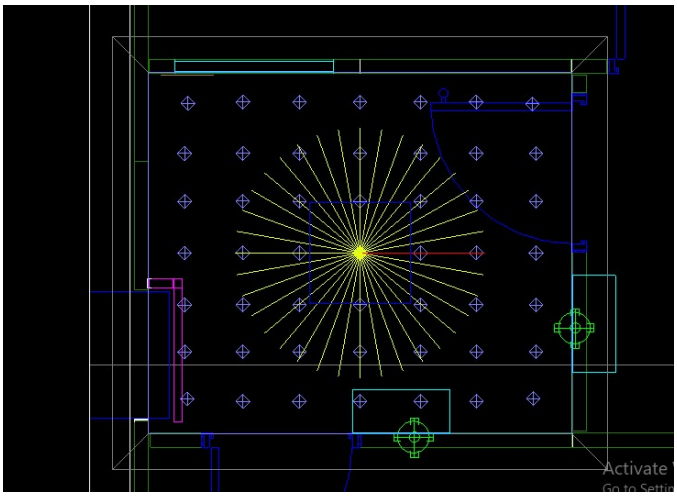


Fig. 6.9

**Result Overview:**

Here the value of average illumination level of 233 Lux and overall uniformity of 0.71 is achieved at 0.76 m work-plane height.

**Results overview**

| No. | Type | $E_{av}$ [lx] | $E_{min}$ [lx] | $E_{max}$ [lx] | u0 | $E_{min}$ / $E_{max}$ | $E_{h\,m}/E_m$ | H [m] | Camera |
|---|---|---|---|---|---|---|---|---|---|
| 1 | horizontal | 233 | 165 | 311 | 0.71 | 0.53 | / | 0.760 | / |

**3D View of PAL:**

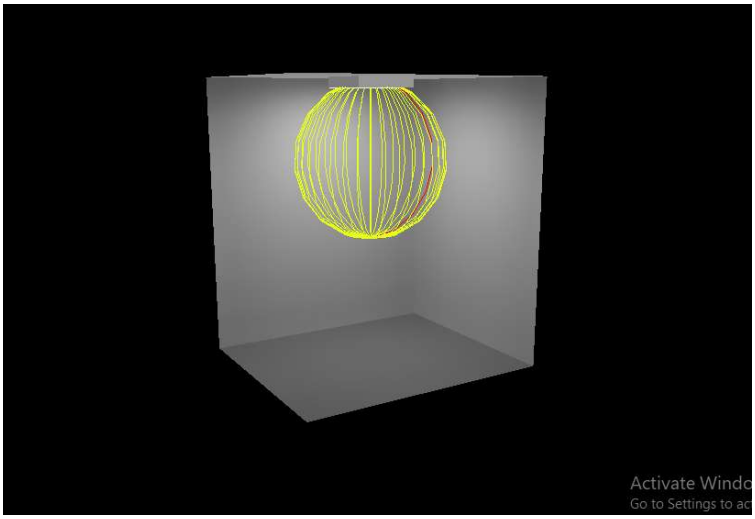



Fig. 6.10

### 1.3 Vibro Shifter Room

In Vibro Shifter Room Vibro Shifter Machine is kept. It is device used for sifting or separating various types of materials based on their sizes. Vibro Shifter make use of vibratory motion to deliver a separation, scalping and grading process.

Shifting is done to remove lumps that might have formed on the materials after being stored for a longer period and materials are passed through a mesh that opens, which leads to fine the materials.

**Luminaires Used:**

Four 40 W Cleanroom Luminaire has been used to illuminate this room.

- Luminous Flux: 3500 Lumen
- Wattage: 40 W
- Efficacy: 87 Lumen/Watt
- Beam Angle: Diffused Luminaire
- CCT: 5700 K
- CRI: 80
- IP54 Protected

Fig. 6.11: Cleanroom Luminaire

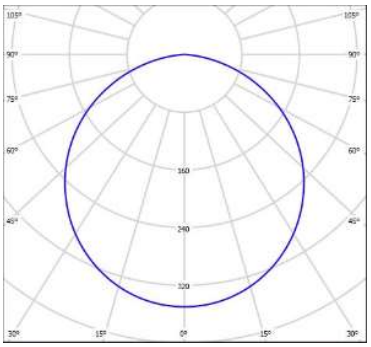


Fig. 6.12: Polar Curve

**Design Consideration for the Lighting Implementation:**
Number of Luminaire: 4
Mounting Height: 2.7 M (At ceiling, Recess Mounted)
Maintenance Factor: 0.85
Refection Factor: Ceiling - 50
Wall - 30
Floor – 20

**DIALux Simulation:**

DIALux simulation of the Vibro Shifter is based on positioning the light fixture and selecting proper beam angle, wattage and photometry to achieve recommended illumination level, Uniformity on the calculation surface. The lighting level on this area must meet the recommended illuminance value. Below Figure shows the simulation view of Vibro Shifter:

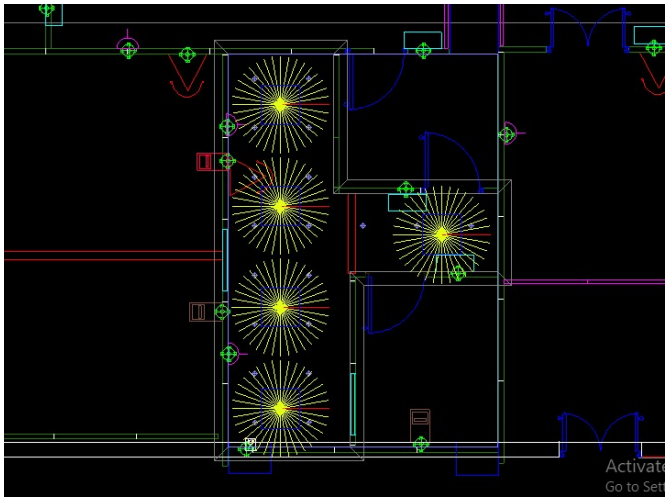


Fig. 6.13

**Result Overview:**

Here the value of average illumination level of 404 Lux and overall uniformity of 0.7 is achieved at 0.76 m work-plane height.

**Results overview**

| No. | Type | $E_{av}$ [lx] | $E_{min}$ [lx] | $E_{max}$ [lx] | u0 | $E_{min}$ / $E_{max}$ | $E_{h\,m}/E_m$ | H [m] | Camera |
|---|---|---|---|---|---|---|---|---|---|
| 1 | horizontal | 505 | 351 | 621 | 0.70 | 0.57 | / | 0.760 | / |

**3D View of Vibro Shifter:**

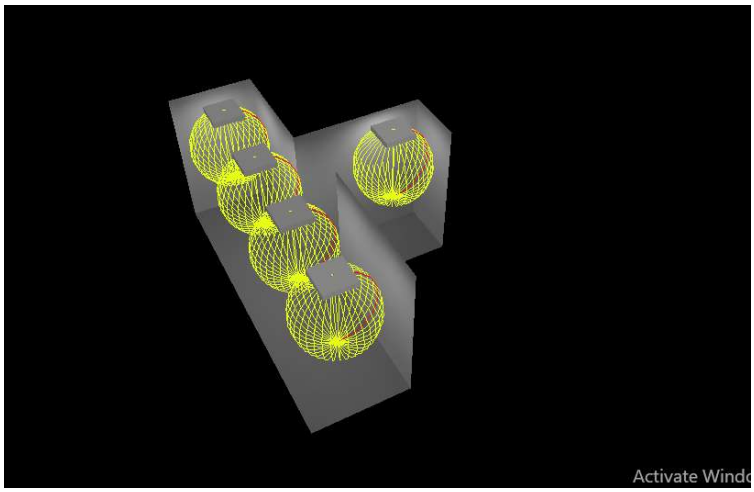



Fig. 6.14

### 1.4 Liquid Preparation Room

In Pharmaceutical Industry Liquid Preparation Room in used to make oral liquid Medicine. This process consists of Sugar Syrup preparation, Ingredient mixing and storage with product distribution piping.

**Luminaires Used:**

Four 30 W Cleanroom Luminaire has been used to illuminate this room.

- Luminous Flux: 2624 Lumen
- Wattage: 30 W
- Efficacy: 87 Lumen/Watt
- Beam Angle: Diffused Luminaire
- CCT: 5700 K
- CRI: 80
- IP54 Protected

Fig. 6.15: Cleanroom Luminaire

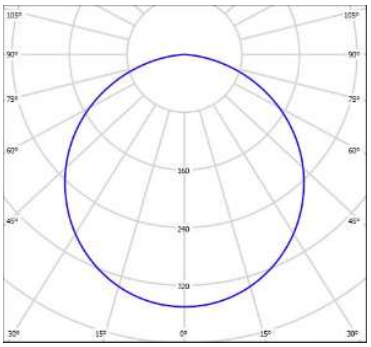


Fig. 6.16: Polar Curve

**Design Consideration for the Lighting Implementation:**
Number of Luminaire: 4
Mounting Height: 2.7 M (At ceiling, Recess Mounted)
Maintenance Factor: 0.85
Refection Factor: Ceiling - 50
Wall - 30
Floor – 20

**DIALux Simulation:**

DIALux simulation of the Liquid Preparation Room is based on positioning the light fixture and selecting proper beam angle, wattage and photometry to achieve recommended illumination level, Uniformity on the calculation surface. The lighting level on this area must meet the recommended illuminance value. Below Figure shows the simulation view of Liquid Preparation Room:

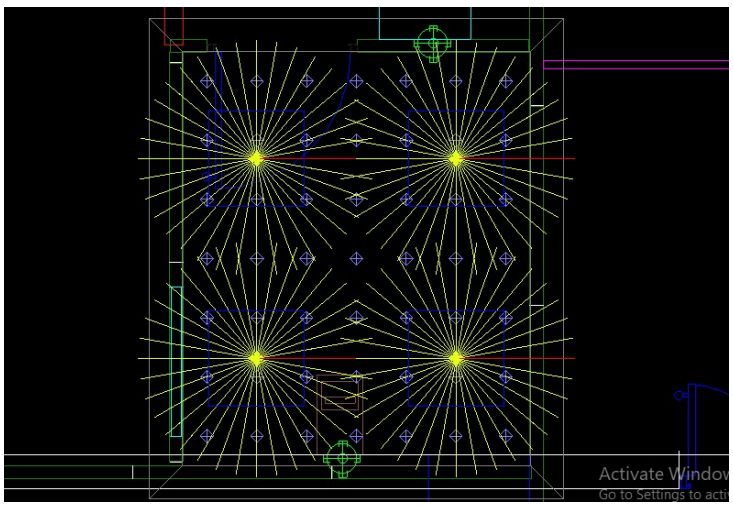



Fig. 6.17

**Result Overview:**

Here the value of average illumination level of 572 Lux and overall uniformity of 0.77 is achieved at 0.76 m work-plane height.

**Results overview**

| No. | Type | $E_{av}$ [lx] | $E_{min}$ [lx] | $E_{max}$ [lx] | u0 | $E_{min}$ / $E_{max}$ | $E_{h\,m}/E_m$ | H [m] | Camera |
|---|---|---|---|---|---|---|---|---|---|
| 1 | horizontal | 572 | 440 | 691 | 0.77 | 0.64 | / | 0.760 | / |

**3D View of Liquid Preparation Room:**

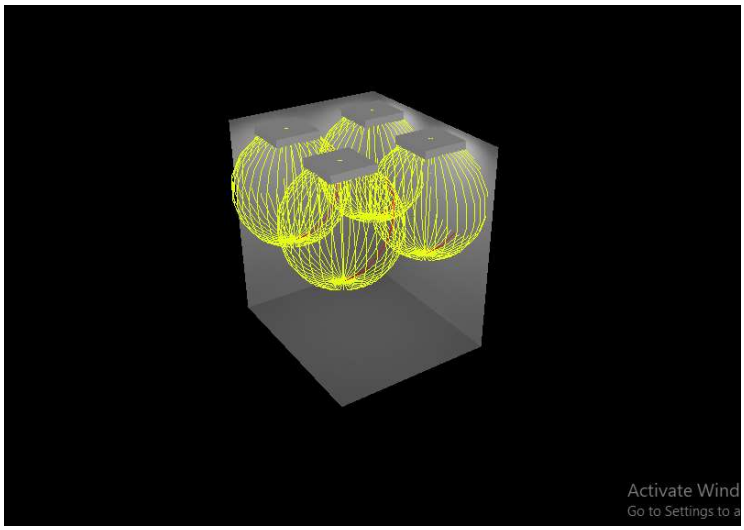



Fig. 6.18

## 1.5 In Process Quality Assurance (IPQA)

IPQA room is for IPQA professionals. IPQA professionals check all the process as per standard to ensure quality by performing IPQA check.

**Luminaires Used:**

Two 40 W Cleanroom Luminaire has been used to illuminate this room.

- Luminous Flux: 3500 Lumen
- Wattage: 40 W
- Efficacy: 87 Lumen/Watt
- Beam Angle: Diffused Luminaire
- CCT: 5700 K
- CRI: 80

- IP54 Protected

Fig. 6.19: Cleanroom Luminaire

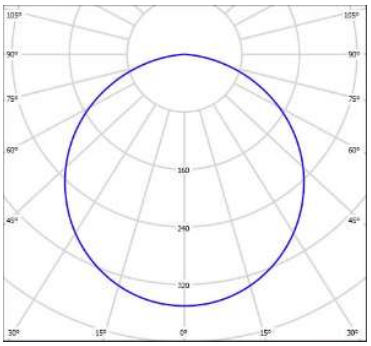


Fig. 6.20: Polar Curve

**Design Consideration for the Lighting Implementation:**
Number of Luminaire: 2
Mounting Height: 2.7 M (At ceiling, Recess Mounted)
Maintenance Factor: 0.85
Refection Factor: Ceiling - 50
Wall - 30
Floor – 20

**DIALux Simulation:**

DIALux simulation of the IPQA Room is based on positioning the light fixture and selecting proper beam angle, wattage and photometry to achieve recommended illumination level, Uniformity on the calculation surface. The lighting level on this area must meet the recommended illuminance value. Below Figure shows the simulation view of IPQA Room:

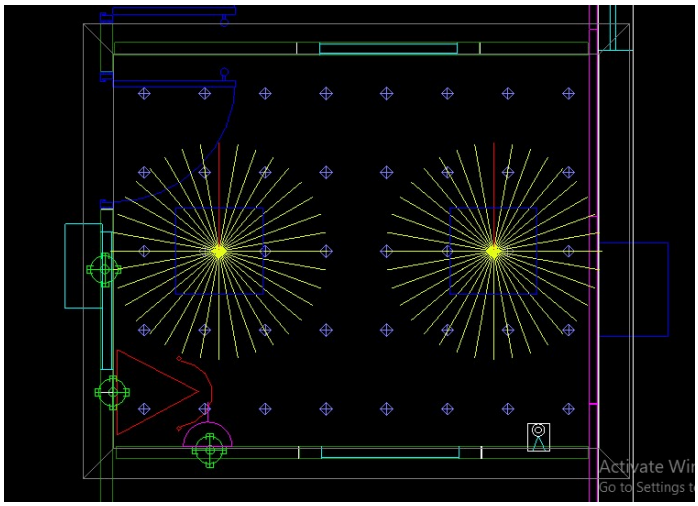


Fig. 6.21

**Result Overview:**

Here the value of average illumination level of 327 Lux and overall uniformity of 0.71 is achieved at 0.76 m work-plane height.

**Results overview**

| No. | Type | $E_{av}$ [lx] | $E_{min}$ [lx] | $E_{max}$ [lx] | u0 | $E_{min}$ / $E_{max}$ | $E_{h\,m}/E_m$ | H [m] | Camera |
|---|---|---|---|---|---|---|---|---|---|
| 1 | horizontal | 327 | 232 | 418 | 0.71 | 0.56 | / | 0.760 | / |

**3D View of IPQA Room:**

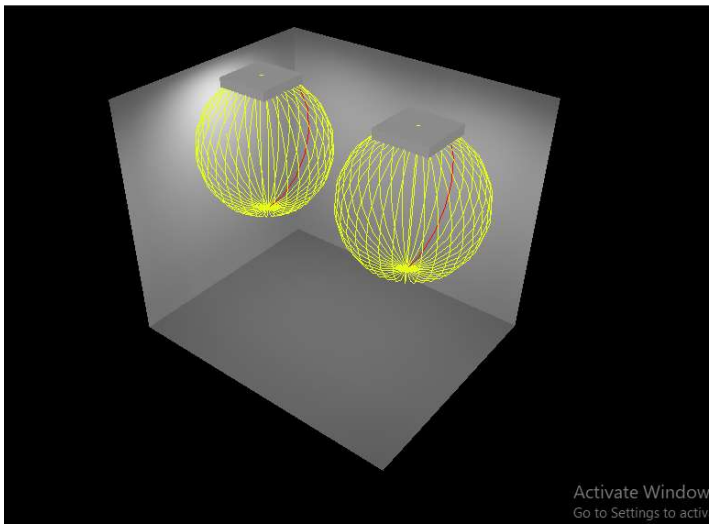



Fig. 6.22

### 1.6 Quarantine Area

Quarantine Room is a place where raw material, Packing Material, Intermediate and Finished Products are isolated physically or by other effective means while a decision is awaited on their release rejection or reprocessing.

**Luminaires Used:**

Four 30 W Cleanroom Luminaire has been used to illuminate this room.

- Luminous Flux: 2624 Lumen
- Wattage: 30 W
- Efficacy: 87 Lumen/Watt
- Beam Angle: Diffused Luminaire
- CCT: 5700 K
- CRI: 80

- IP54 Protected

Fig. 6.23: Cleanroom Luminaire

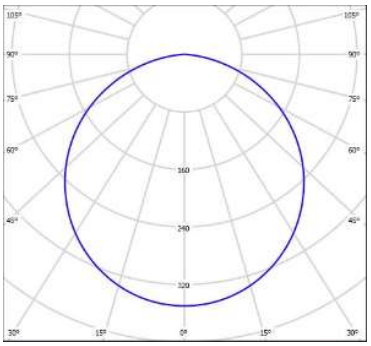


Fig. 6.24: Polar Curve

**Design Consideration for the Lighting Implementation:**
Number of Luminaire: 4
Mounting Height: 2.7 M (At ceiling, Recess Mounted)
Maintenance Factor: 0.85
Refection Factor: Ceiling - 50
Wall - 30
Floor – 20

**DIALux Simulation:**

DIALux simulation of the Quarantine Area is based on positioning the light fixture and selecting proper beam angle, wattage and photometry to achieve recommended illumination level, Uniformity on the calculation surface. The lighting level on this area must meet the recommended illuminance value. Below Figure shows the simulation view of Quarantine Area:

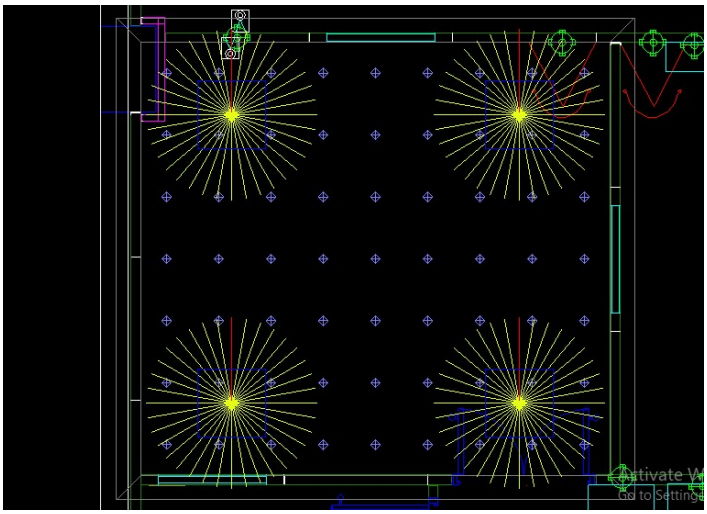


Fig. 6.25

**Result Overview:**

Here the value of average illumination level of 303 Lux and overall uniformity of 0.77 is achieved at 0.76 m work-plane height.

**Results overview**

| No. | Type | $E_{av}$ [lx] | $E_{min}$ [lx] | $E_{max}$ [lx] | u0 | $E_{min}$ / $E_{max}$ | $E_{h\,m}/E_m$ | H [m] | Camera |
|---|---|---|---|---|---|---|---|---|---|
| 1 | horizontal | 303 | 257 | 335 | 0.85 | 0.77 | / | 0.760 | / |

## 3D View of Quarantine Area:

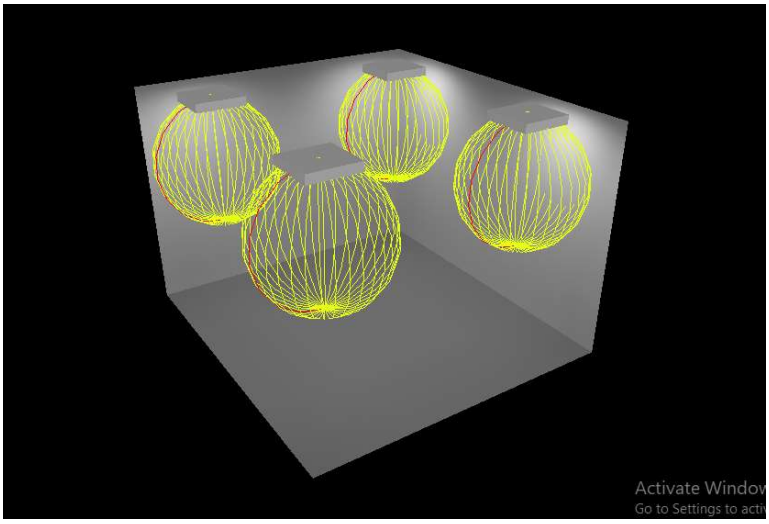



Fig. 6.26

## ELECTRICAL WIRING OF WAREHOUSE

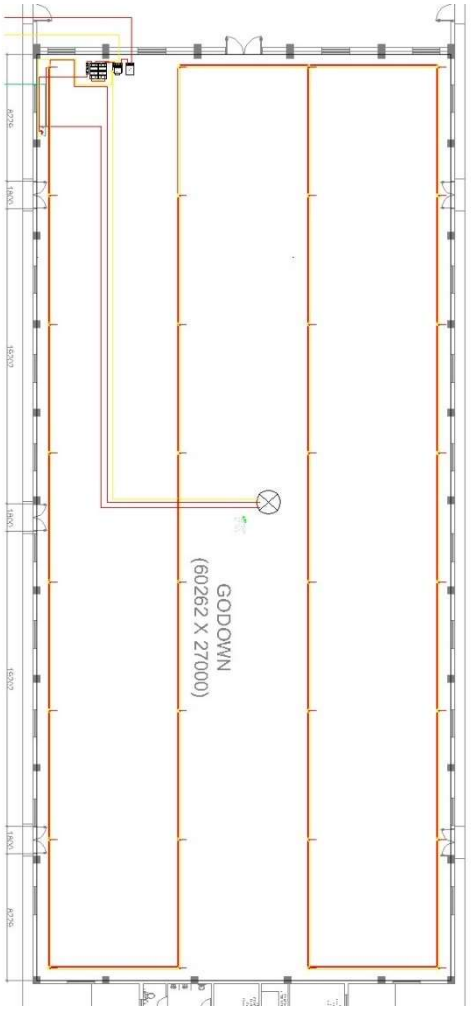



Fig. 6.27

## BOQ OF LUMINAIRE

| SL.NO. | LUMINAIRES | NO. OF LUMINAIRES | POWER OF EACH LUMINAIRE (W) | TOTAL POWER (W) | PRICE OF EACH LUMINAIRE (Rs.) | TOTAL PRICE (Rs.) |
|---|---|---|---|---|---|---|
| 1 | UHBD-S1-50K80-80H | 32 | 150 | 4800 | 19500 | 624000 |

TOTAL LOAD 4800W
V*I*Cos (Theta)= Total Power
230*I*0.85 = 4800
I= 25 A

To flow 25 A current 1.84 mm Diameter Wire is required.

## ELECTRICAL WIRING OF PHARMACEUTICAL INDUSTRY

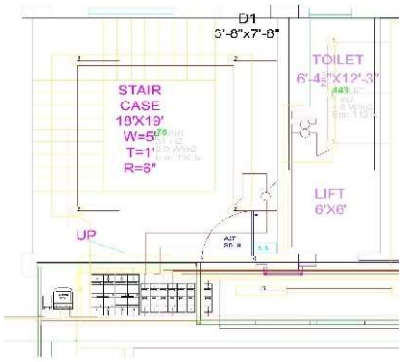



Fig. 6.28

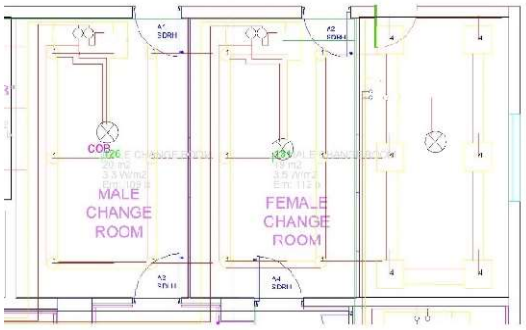



Fig. 6.29

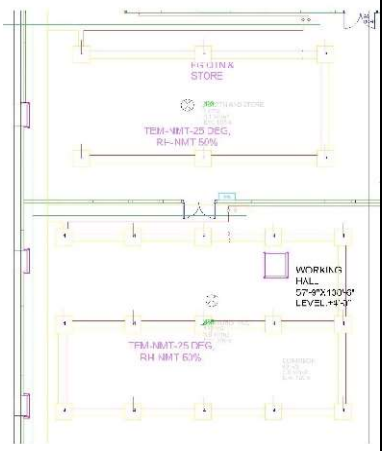



Fig. 6.30

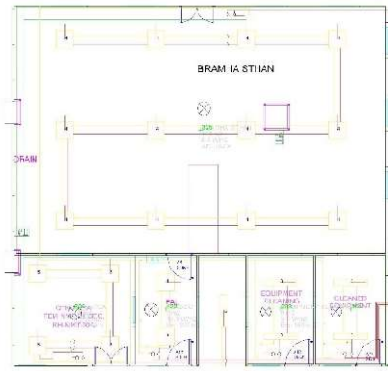



Fig. 6.31

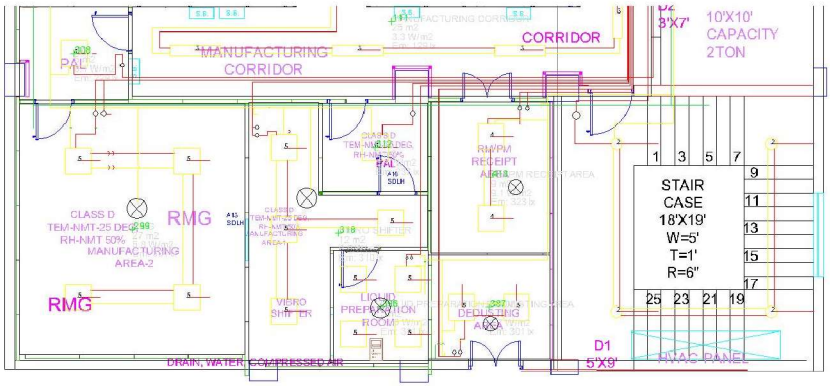



Fig. 6.32

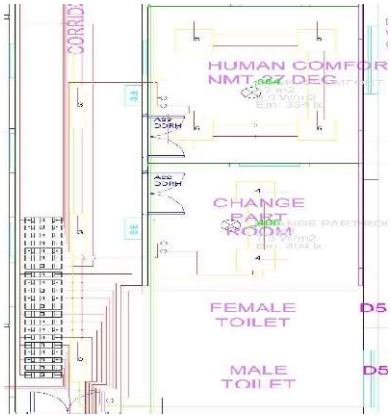



Fig. 6.33

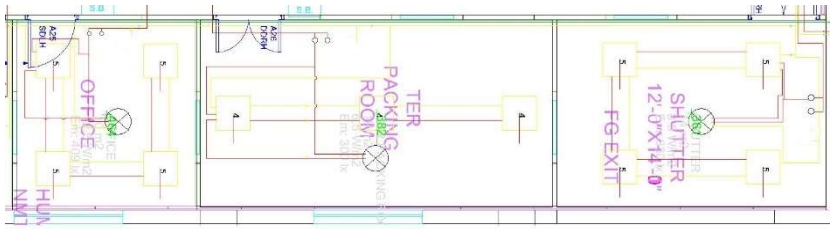



Fig. 6.34

**BOQ OF LUMINAIRE:**

| SL. NO. | LUMINAIRES | NO. OF LUMINAIRES | WATTAGE (W) | TOTAL POWER (W) | PRICE OF EACH LUMINARE (Rs.) | TOTAL PRICE (Rs.) |
|---|---|---|---|---|---|---|
| 1 | WF4C RD TUHW MW M6 | 15 | 11 | 165 | 1000 | 15000 |
| 2 | WF6 DREG SM ALO20 SWW5 | 8 | 15 | 120 | 1200 | 9600 |
| 3 | CR150B PSD W30L120 | 20 | 20 | 400 | 7000 | 140000 |
| 4 | CR150B PSD W60L60 | 54 | 40 | 2160 | 11000 | 594000 |
| 5 | CR150B PSD W60L60 | 30 | 30 | 900 | 10000 | 300000 |
| | | | **TOTAL** | **3745** | | 1058600 |

TOTAL LOAD = 3745W
V*I*Cos (Theta) = Total Power
230*I *0.85 = 3745
I = 19 A

Total 19 A Current is flowing.

In Personnel Airlock room a 40W luminaire is used.
Therefore [40/ (230*0.85)] = 0.2 A current is required for this room.
For 0.2 A current to flow 0.2 mm diameter wire is required.

In Vibro Shifter room four 40W luminaire is used.
Therefore [(40*4)/ (230*0.85)] = 0.8 A current is required for this room.
For 0.8 A current to flow 0.41 mm diameter wire is required.

In Liquid Preparation room four 30W luminaire is used.
Therefore [(30*4)/ (230*0.85)] = 0.6 A current is required for this room.
For 0.6 A current to flow 0.32 mm diameter wire is required.

In IPQA room two 40W luminaire is used.
Therefore [(40*2)/ (230*0.85)] = 0.4 A current is required for this room.
For 0.4 A current to flow 0.26 mm diameter wire is required.

In Quarantine Area four 30W luminaire is used.
Therefore [(30*4)/ (230*0.85)] = 0.6 A current is required for this room.
For 0.6 A current to flow 0.32 mm diameter wire is required.

# Chapter 7
# CONCLUSION AND FUTURE SCOPE

Light plays a crucial role in design and visual perception. It has the power to transform and enhance our perception of spaces, objects, and colors. Proper lighting design can enhance spatial perception and create a sense of depth in a room. By using various lighting techniques like uplighting, downlighting, and wall washing, designers can manipulate shadows and highlights to add dimensionality to a space, making it appear larger, more dynamic, or more intimate.

One of the primary challenges is achieving adequate illumination throughout a space. Designers must ensure that light levels are sufficient for the intended activities, whether it's reading, working, or performing specific tasks. Balancing the lighting requirements with energy efficiency considerations can be a complex task.

Achieving uniform lighting distribution can be challenging, especially in larger spaces. Uneven lighting levels or abrupt changes in illumination can lead to visual discomfort and difficulties in perceiving the environment. Designers must consider factors like the height and spacing of light fixtures, the reflective properties of surfaces, and the specific lighting requirements of each area to achieve a consistent and uniform lighting design.

Improperly placed light fixtures or fixtures with high glare can create discomfort for occupants and hinder visual tasks. Glare occurs when there is excessive brightness or contrast, making it difficult to see clearly. Designers need to consider glare control techniques such as shielding, diffusing, or using appropriate light levels to minimize glare. Conversely, achieving the right balance of light and shadows can add depth and visual interest to a space.

Designers face the challenge of balancing energy efficiency and sustainability goals with the desired lighting quality. Selecting energy-efficient lighting technologies, implementing lighting controls, and optimizing lighting layouts are necessary to reduce energy consumption. However, designers must ensure that energy-saving measures do not compromise visual comfort or the intended design concept.

## OVERALL CONCLUSION

This project is dealt with analyzing the processes and activities in warehouse and various rooms of Pharma Industry, so as to provide energy efficient lighting which will lead to efficient energy savings. The first task concept development has to deal with is the allocation of specific lighting qualities to the lighting tasks defined as a result of the project analysis; to define the lighting conditions that are to be achieved in specific locations. To begin with, this concerns the quantity and the various other criteria of the light in the individual areas, plus the order of importance of these individual aspects within the overall lighting concept. The allocation of lighting qualities to the individual lighting tasks in a project gives rise to a catalogue of design objectives, which takes into account the different requirements the lighting has to fulfil.

A practice-oriented design concept must therefore first describe how the desired lighting effects can be realized within the basic conditions and restrictions inherent to the project. The design concept may be required to correspond to specific standards, and it must keep within the budget with regard to both the investment costs and the operating costs. Lighting defines economic efficiency, safety and security. The lighting design should be designed in such a way that the energy consumption for particular area has to be optimized and light pollution problems have to be minimized. Hence the lighting concept must also be coordinated with other engineering work to be affected on the project.

The result of the project analysis is a series of lighting tasks that are allocated to specific areas within the Warehouse and Pharma Industry illumination project, all of which form a characteristic matrix of requirements for a visual environment. The next phase following the project analysis is the development of a qualitative lighting design concept that outlines an idea of the qualities the lighting should possess such that visual performance and comfort of an observer becomes enhanced.

## FUTURE SCOPRE OF WORK

Lighting, along with architectural infrastructure is improving the world regularly in terms of visualization. Lighting designers are trying their best to offer a dynamic world to the present and future generation, keeping in mind about energy efficient with smart handling lighting solution.

LED Lights consumes very less energy and control for the light output can be done very easily. With Pulse Width Modulation (PWM) Technology LEDs can be dimmed accurately makes it easy to integrate with daylight sensors. We know about the various advantages of smart lighting soutions, the extra benefits we are getting from smart applications. If the availability of Daylight is there, then the artificial luminaires can be dimmed to save more energy.

Besides the objective requirements which result from the activities performed in a visual environment, attention must also be paid to the demands that stem from the users themselves. Another psychological aspect that has to be fulfilled is highlighting of a clearly structured environment as this is especially important in areas that are potentially subjected to danger.

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(3) Electrical Estimation and Costing by J.B Gupta 9th Edition (2020): S.K Kataria, New Delhi.

(4) Lighting for energy-efficient luminous environment by Ronald N. Helms and M. Clay Belcher 2nd Edition (1991): Prentice-Hall.

(5) "Concept of Beam Angle." Online. **https://www.wiprolighting.com/blog/concept-of-beam-angle-in-lighting-design. (seen on 5th April, 2024)**

(6) "Concept of LED Lighting in Pharmaceutical Industry" Online. **https://safetysourcellc.com/blog/led-lighting-in-pharmaceutical-facilities/. (seen on 5th April, 2024)**