STUDIES AND ANALYSIS OF ENERGY EFFICIENT LIGHTING DESIGN OF THERMAL POWER PLANT

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE DEGREE OF

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ILLUMINATION ENGINEERING

SUBMITTED BY

SOUMYA SAHA

Roll No. M4ILN23008

Registration No. 163505 OF 2022-23

UNDER THE SUPERVISION OF Prof. (Dr.) Saswati Mazumdar

ELECTRICAL ENGINEERING DEPARTMENT FACULTY OF ENGINEERING AND TECHNOLOGY JADAVPUR UNIVERSITY KOLKATA-700032

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JADAVPUR UNIVERSITY FACULTY OF ENGINEERING AND TECHNOLOGY ELECTRICAL ENGINEERING DEPARTMENT

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This is to certify that the thesis entitled "**STUDIES AND ANALYSIS OF ENERGY EFFICIENT LIGHTING DESIGN OF THERMAL POWER PLANT**" submitted by **SOUMYA SAHA** Roll no **M4ILN23008** Regin No. 163505 of 2022-23 of this university in partial fulfillment of requirements for the award of degree of **Master of Engineering in Illumination Engineering**, Electrical Engineering Dept. is a bonafide record of the work carried out by him under our guidance and supervision.

THESIS SUPERVISOR

Prof. (Dr.) SASWATI MAZUMDAR

ILLUMINATION ENGINEERING

ELECTRICAL ENGINEERING DEPARTMENT

JADAVPUR UNIVERSITY

Prof. (Dr.) BISWANATH ROY

HEAD OF THE DEPARTMENT

ELECTRICAL ENGINEERING DEPARTMENT

JADAVPUR UNIVERSITY

Prof. (Dr.) DIPAK LAHA

DEAN

FACULTY OF ENGINEERING AND TECHNOLOGY

JADAVPUR UNIVERSITY

JADAVPUR UNIVERSITY FACULTY OF ENGINEERING AND TECHNOLOGY ELECTRICAL ENGINEERING DEPARTMENT

CERTIFICATE OF APPROVAL

This foregoing thesis is hereby approved as a creditable study in the area of Illumination Engineering, carried out and presented by **SOUMYA SAHA**, in a manner of satisfactory warrant its acceptance as a pre-requisite to the degree for which it has been submitted. It is notified to be understood that by this approval, the undersigned do not necessarily endorse or approved the thesis only for the purpose for which it has been submitted.

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I hereby declare that this thesis contains literature survey and original research work by the undersigned candidate, as part of my Master of Engineering in Illumination Engineering studies.

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

I also declare that, as required by thesis rules and conduct, I have fully cited and referenced all material and results which are not original to this work.

NAME : SOUMYA SAHA

ROLL NUMBER : M4ILN23008

THESIS TITLE: STUDIES AND ANALYSIS OF ENERGY EFFICIENT LIGHTING DESIGN OF THERMAL POWER PLANT

SIGNATURE WITH DATE

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SOUMYA SAHA

Date……………… Roll NO M4ILN23008

ABSTRACT

Lighting is an essential element in our daily life. Based on the modern-day research on lighting, design related to lighting, it is proven that inadequate lighting gives us bad visual effects, poor viewing environment, uncomfortable visuals, low feeling, low attention towards our job, stress and mostly it affects our circadian rhythm. We need good lighting design toovercome these affects and to keep our eyes safe.

With rapid industrialization, energy consumption has been increased drastically. As most of the industries prefer conventional lighting scheme, which is both unhealthy and consumes considerable amount of lighting load, therefore light emitting diodes (LEDs) are used for industrial lighting designs as a solution to reduce the energy consumption.

This project is based on the energy efficient lighting solution for industrial lighting. Case studies have been carried out for different industries and the best possible lighting scheme has been proposed. The illumination level for the different areas are selected as per the IS 3646:1992 Part I and Part II where lighting levels are mentioned for different industries.

Lighting simulation has been carried out using lighting simulation software DIALux 4.12. A small section of this thesis work has been dedicated to compare the cost analysis of LEDs with conventional fixtures by comparing their Payback Period.

The findings of this research contribute to the advancement of Power Plant lighting design, providing valuable insights for engineers, lighting designers, and stakeholders involved in the construction and renovation of Thermal Power Plant Ultimately, the goal is to create a well-lit environment that enhances safety, performance, and enjoyment for both athletes and spectators alike.

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1. Introduction:

In modern day Industries to achieve sufficient energy savings, Provision of Energy efficient lighting has become an important topic. There has a significant role of lights in industry to run continuously. In present day India is shifting towards energy efficient lighting as to improvise the efficiency and more precisely to reduce cost. By proper designing and implementation of lighting layouts we can achieve maximum energy efficiency. Energy efficient lighting means the use of LED lamps, High efficacy lamps, use of daylights, High CRI lamps, Sensors to save energy. Energy efficient lighting means to obtain required lighting and consume less electricity and should be free from polluting the environment.

In Thermal power plant for proper visualization and to perform detailed work various types of lamps are used i.e. (High Mast, LED), also lights are very crucial in accident prone zone and emergency exit areas. As the plants are mainly constructed in remote areas, with vast areas there needs huge amount light basically in outdoor (Switchyard, Construction area etc.) and in case of indoor (Circulating Water Pump House, DM plant, Boiler Area, Turbine Room, Battery room etc.). So, it can be seen that light (lamps) is most important part of plant. However, In Plants Production of Electrical power is generally considered. Thus Energy efficient lights are mainly neglected in discussion with Power Generation. By using the energy efficient lighting scheme cost is reduced thus reducing the overall running cost of the Plant and there will be more profit.

Green lighting design matches the amount of quality of light to the function of a space. Sections of lighting for different areas or different functions should be on separate controls, to allow users of a space to decide how much light is needed. This lighting design save energy, reduce CO_2 emissions.

This chapter deals with present day scenario of energy demand and how lighting can be implemented to improve it. This chapter discussed a brief description about energy efficient lighting.

1.1 Chapter Preview

This thesis is divided into 7 chapters

Chapter 2 is the **"Literature Survey".** In this chapter the summary of research papers related to this thesis are discussed

Chapter 3 is the **“Standards and parameters of Industrial Lighting Design”** deals with the different criteria for industry lighting and their standards and basic parameters of illuimination are discussed.

Chapter 4 is the **“Lighting design process and design parameters”.** In this chapter different types of lamps and different types of LED technologies are described.

Chapter 5 **“Light Sources for Industrial Lighting”** deals with different types of lamps and luminaire used for industrial lighting**.**

Chapter 6 is the **“Study on Thermal Power Plant Lighting Scheme”** where DIALux simulation results of different areas of Thermal Power Plant has been shown.

Chapter 7 is the "**Conclusion**" where conclusion and future possible scope are highlighted

2. Literature Survey

1. **“Research and Application of Green Lighting in Power Plant”** by Zixia Cheng, Bingbing Du, Yu Wang, Zhenzhen Niu, Xiu Zheng is based on the analysis and comparison of the technical and economic of lighting source and energy-saving lamps and accessories, recommended the use of high luminous efficiency of lamps and lanterns, to achieve energy-saving effect. To study the application of green lighting in power plant, this paper is discussed from the point of lighting design, through the calculation of the illumination value and the use of reasonable lighting control to achieve the effect of green lighting. By adopting the new energy saving lamps and light sources, the operation cost of the power plant and the lighting energy consumption can be reduced, the project investment and operation cost can be saved, and the social and economic benefits will be obtained**.[1]**

2. In the journal paper **“Preferred task-lighting levels in an industrial work area without daylight”,** by HT Juslén, MCHM Wouters and AD Tenner, an experiment is carried out to compare the level of illumninance required for different age people. In a luminaire factory an experiment was performed to determine the preferred lighting levels in an industrial work environment. A dimmable task-lighting system was installed above 10 individual assembly workstations. The illuminances selected by the users (regular workers) were recorded. were large. Weak, but significant trends in using different lighting the differences between the individual settings levels at different times during the working day were found. Subjects exhibited different weekly rhythms in their preferred illuminance, and as a group they showed a tendency to use lower lighting levels on Fridays than on Thursdays during the summer, and the reverse during the winter. There was also a trend towards using lower illuminances on the task in the summer than in the winter**.[2]**

3. The **“Guide for Virtual Power Plant Functional Specification for Alternate and Multi-Source Generation”,** relates to virtual power plants (VPPs). This guide defines the VPP as an electric power plant capable of supplying electrical power to the electric grid and local loads. This document provides guidance for the development of a functional specification for a VPP. The VPP specification covers local energy management and grid interaction functions. The VPP incorporates local controllable and dispatchable power generation, such as combined heat and power (CHP) units and the newer micro reactors (based on small modular reactor (SMR) technology). It may integrate local renewable energy resources (solar photovoltaics and wind generation), and electric energy storage (battery energy storage) and thermal storage systems. The implementation of VPPs and VPP control systems, addresses their basic functional requirements, and proposes a set of core functions is discussed in this guide for the control systems. These functions include generation production estimation and scheduling from all sources; local load estimation and management; the provision of grid services (energy, capacity) and ancillary services (voltage and frequency control/support) to the electric power system (EPS). Generic requirements for grid interconnection and integration, and for interoperability with other EPS systems are addressed. Islanded operation of a VPP feeding local loads and operating as a microgrid for enhancing energy supply security and resilience is discussed, within the context of existing IEEE Microgrid standards**.[3]**

4. Marc Elliott, Asiri Jayawardena in their paper "**The Advancement of Industrial LED Lighting and Its Future Applications"** discussed key factors to consider in designing an industrial lighting space. Key lighting technologies used in industrial facilities with special focus on light emitting diode (LED) is discussed and compared. This paper will discuss in detail attributes that needs to be considered in selecting a luminaire with emphasis on LED technology. How these attributes impact safety, sustainability, light pollution, and digitalization is discussed. A framework to consider when selecting luminaire is presented as a conclusion.**[4]**

5. S. Ghosh, S. C. Basu and P. P. Sengupta, in their paper **"Improvement of financial efficiency and cost effectiveness in energy sector: A case study from Indian thermal power plant,"** discussed on Electricity, which is generated based on potential resources like coal, crude oil, water, wind, solar and nuclear energy. India depends largely on thermal power using coal as raw material despite the reality that indigenous stock of this raw material is depleting fast. At the same time coal based thermal stations are losing out financial viability gradually in terms of deteoriating efficiency, transmission & distribution loss as well as auxiliary consumption of power**.[5]** In order to maintain financial viability and ensure steady supply of thermal power within available limited resources, only option left for India is to minimize wastage of electricity at the source of generation & supply line and maximize sales & profit. This hypothesis has been tasted on the basis of analysis of secondary data of a coal based thermal power plant at West Bengal, India by using Multi-objective Fuzzy Non-linear Goal Programming. In case the resources are optimally utilized, wastage and auxiliary consumption are controlled; thermal station will be able to generate electricity at a controlled cost which in turn can maximize its sales & profit.

3. Standards and parameters of Industrial Lighting Design

Instead of rapid growth of industry developments in industry lightings are very as compared to Interior/Indoor lighting. In industrial lighting energy efficiency is more crucial. As more of numbers of lamps are required thus energy losses are more. Industrial lighting schemes are installed for energy efficient illumination in quantity and quality sufficient for safety and to enhance visibility and productivity. In this chapter energy efficient lighting installations are discussed.

3.1 GENERAL FEATURES OF INDUSTRIAL LIGHTING

Industrial facilities encompass a wide variety of working conditions and seeing tasks. There are different types of lighting of arrangements based on the working purpose, Room size, Cleanliness etc. For high precision or detailed work the required illuminance is high. Visual tasks may be classified either small or very large; dark or light; opaque, translucent surfaces; flat or contoured shapes. R arent or translucent; specular of diffuse. With each of the various task conditions, lighting should be suitable for adequate visibility in developing raw materials into finished products. Physical hazards exist in manufacturing processes and, therefore, lighting should contribute to the utmost as a safety factor in preventing accidents. The speed of operations may be such as to allow only minimum time for visual perception and, therefore, lighting should be a compensating factor to increase the speed of vision.

Lighting layouts should be designed according to the operating conditions, site application and visual tasks for which illumination is required. Energy efficient lighting is the main challenge for industry area, in order to achieve it some steps should be taken viz.

i. Quality and quantity of illumination as per requirement in different industrial area.
ii. Color rendering index and Correlated color temperature for tasks.
iii. Selection of suitable lamps, fixtures, luminaires, for performing tasks.
iv. Maintenance factor, Reflection factor, absorption factor calculation
v. Special protection for lamps in hazardous zones or Special types of glass lamps are required
vi. Proper installation of fixtures to achieve maximum amount of light by using less number of lamps hence in order to save cost.

vii. Review the energy, economic and operation characteristics of lighting system.

i. A good lighting system should produce

a) Adequate amount of light with max visible sensation with no or less glare.
b) Standard quality of lights

3.2 Basic terms of Illumination [6]

Nowadays, the electrically produced light is preferred to the other source of illumination because of an account of its cleanliness, ease of control, steady light output, low cost, and reliability. The best illumination is that it produces no strain on the eyes. Apart from its esthetic and decorative aspects, good lighting has a strictly utilitarian value in reducing the fatigue of the workers, protecting their health, increasing production, etc

ii. **ILLUMINANCE** (symbol E): when light falls on a surface, the level of illumination on that surface is referred to as illuminance. The unit of measurement is lux. (Lumens per square meter)

iii. **LUMINANCE** (symbol L) – The fourth stage of this process is the light leaving the surface which has been illuminated by the source.

Luminance is usually be measured in candela per square meter, the illuminated surface being considered a secondary light source.

- $1Cd/m^2=3.14\ lm/m^2$ (Cd=Candela)

iv. When light falls on a surface, one or more of the following may occur:

a) 1. Light is transmitted through it;
b) 2. Light is reflected from it;
c) 3. Light is absorbed as heat.

i. **Transmittance** Most surfaces will not allow light pass through them but surfaces which do, are referred to as translucent

ii. **Reflectance** We have already seen that the luminance of a surface is the illuminance on it multiplied by the surface reflectance. It therefore follows that:

$$Reflectance = \frac{Reflected\ Light}{Incident\ Light}$$

Table 1 Percentage of reflectance [7]

Reflectance	Surface
80-90	Ceiling
40-60	Wall
25-45	Desk bench tops, machine and equipment
Less than 20	Floor

iii. **Absorption** The light which is not transmitted or reflected is absorbed as heat. This is the reason light colored high reflectance clothing is preferred in summer.

v. UTILISATION FACTOR Utilization factor (U.F) takes account of the loss of light due to absorption on room surfaces.

$$\mathbf{U.F} = \frac{\boldsymbol{Lumens\ Received\ on\ work\ Plane}}{\boldsymbol{Lumen\ output\ of\ luminaires}}$$

i. **Type of Luminaire:** A luminaire with a concentrated light output directed on the working plane will have a higher UF than a luminaire with a dispersed light output.

ii. **Room index (R.I)**: This takes account of the length (L) and width (W) of the room and the height of the luminaires above the working plane (H_m).

$$\mathbf{R.I} = \frac{\boldsymbol{L \times W}}{(\boldsymbol{L + W})\mathbf{Hm}}$$

iii. **Reflectance of Room Surfaces**. Bright colors with high reflectance result in a higher UF. A high utilization factor will mean fewer lamps are needed resulting in a more efficient energy usage and a lower capital cost.

iv. **SPACE: HEIGHT RATIO (SHR)** This is the ratio of space between luminaires (S) to their height above the working plane (Hm). Manufacturers will specify a recommended SHR for each of their luminaires.

$$\textbf{SHR} = \frac{\boldsymbol{Horizontal\ distance\ between\ two\ lamps}}{\boldsymbol{Mounting\ height\ of\ lamps}}$$

Ensuring that luminaires are spaced within the recommended value will mean an acceptable variation in illuminance across the working plane. This is expressed in terms of the Uniformity Ratio.

In industrial lighting some more terms are considered on the basis of the ambient temperature, continuous supply of lights, and lamp life for continuous duty. These factors determine the durability, luminous efficacy, efficiency etc. Those factors are:

Maintenance Factor: Maintenance factor indicates how much of the initial luminous flux remains available at the end of its service life. The maintenance factor must be determined by the planning lighting engineer and the new value of the luminous flux multiplied by it.

$$\boldsymbol{MF = LLMF \times LMF \times RSMF \times LSF}$$

Lamp lumen maintenance factor (LLMF): The lamp lumen maintenance factor LLMF takes into account the reduction of luminous flux due to the ageing of the lamp. It signifies the ratio of the lamp lumens at a specific time and the new value.

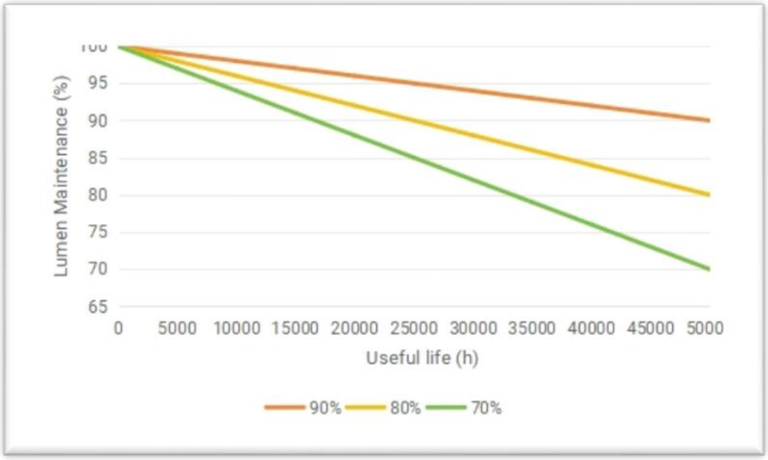

Fig. 1 Lamp lumen maintenance factor [6]

Luminaire maintenance factor: LMF is the ratio of the light output of a clean luminaire to that of a dirty one. It depends on the type and quality of the lamp and luminaire, as well as the amount of dirt and dust that can accumulate on them. The LMF can vary from 0.6 to 0.95, depending on the luminaire design and the environment.

Lamp survival factor (LSF): LSF is the ratio of the number of lamps that are still operating at a specific time to the initial number of lamps. LSF depends on the reliability and durability of the lamps, as well as the frequency and quality of maintenance. LSF is also influenced by the probability of lamp failure, which can be caused by various factors, such as voltage fluctuations, mechanical shocks, or vandalism.

Room surface maintenance factor (RSMF): RSMF is the ratio of the reflectance of the room surfaces before and after cleaning. It depends on the environment, cleaning frequency, and the impact of room surfaces on the lighting level. The RSMF is influenced by the surface material and the maintenance schedule.

In industrial lighting the calculation of Required Number of luminaires are must. This can be calculated from **"LUMEN METHOD OF LIGHT CALCULATION":** This method is most suitable for interior lighting design, where a high Proportion of light on the working plane is reflected by internal surfaces.

The lumen method, sometimes called the luminous flux method of calculation, is normally used to calculate the average illuminance on working planes, or to calculate the number of luminaires required to provide a specified average illuminance in rooms.

N = Number of luminaires required

E = Maintained Illuminance (lux)

φ = Initial lamp output (lumens)

n = Number of lamps in luminaire

MF = Maintenance factor

UF = Utilization factor

A = Area of room (m^2)

$$\boldsymbol{N = \frac{E \times A}{MF \times UF \times \varphi \times n}}$$

In industrial area the maintenance factor (MF) has effect of 3 factors which reduces the luminous efficacy also the maintenance factor (MF). Viz.

The factors comprise mostly of the

a) **Lamp Lumen Depreciation:** LLD is the loss of luminous flux with time due to repeated use.
b) **Luminaire Dirt Depreciation (LDD):** LDD is the accumulation of dirt over the surface of luminaires due to which luminous efficacy decreases with time. LDD is mainly dependent on the environment conditions (dirt, dust, mist, heat, fog) of that area
c) **Room Surface Dirt Depreciation (RSDD):** RSDD accounts for dirt or dust that accumulates on all the room surface especially on the upper walls and ceiling. Therefore, clean environment means MF is high.

- **GLARE**

  Glare is a general term for the reduction of visual performance or the disturbance of perception, as caused by high luminance or contrasts in luminance within a visual environment. Glare can be calculated as

$$g = 0.9\frac{Ls^{1.6}\omega^{0.8}}{L_b P^{1.6}}$$

L_s and L_b are source luminaire and background luminance respectively (Cd/m^2)

W is the solid angle subtended by at the eye by the source (steradians)

P is the position index

Tips to reduce glare in lighting design

1) Prioritize proper light placement
2) opt for thoughtful fixture selection
3) Harness the power of natural light
4) Embrace/Smart lighting controls
5) Incorporate surface finishes and materials
6) Regular maintenance and cleaning (Not possible in Industrial Lighting)

3.3 LAWS OF LIGHT [6]

i. **Rectilinear Propagation of light**

This means that light travels in straight lines. It travels at 300,000 km/S and requires no medium for propagation

ii. **Inverse Square Law:** The area illuminated by the point light source increases in proportion to the square of the distance. It follows that the average illuminance would decrease by the same ratio.

$$E = \frac{I}{d^2}$$

$$d = \textbf{the distance between the source and the object}$$

$$I = Luminous\ Intensity\ .$$

iii. **Cosine Law**: When light does not fall normally on a surface, the area illuminated increases reducing the average illuminance by the same ratio.

$$E = \frac{I cos\theta}{d^2}$$

3.4 Quality of Illumination

The main aspect of lighting layout design is to provide an optimal performance for a given task. Any lighting design the basic determinations are adequate illumination and proper visualization of task, but in practical the ambience, physiological and quality of lights, intensity distribution are taken into consideration.

Regular maintenance of lighting installations cannot be neglected without prejudicing the level of illumination and hence the benefits that proceed from good lighting. Attention is drawn to the progressive depreciation of the lighting installation depending on the locations of usage and hence the maintenance problem is an extremely important one.

Special mention should be made of group replacement of the lamps and starters in case of fluorescent lamps lighting fittings. The desirability of group replacement is largely determined by lamp replacement costs and should be considered on its merit in each case

Ideally a lighting system should be designed in such way that it provides uniform distribution of light over entire work place. Adequacy of lighting is necessary to avoid occupational eye strain and accidents due to insufficient lighting. Adequate lighting creates proper illuminous work environment, increases the speed and accuracy of the task.

3.5 Lux level in Industry as per Indian Standards (IS 6665) [7]

Illumination recommendations for different industrial activities are given below3

Table 3.5.1 Recommended illumination for different areas in a Thermal Power Plant

Industrial buildings and process	Average Illumination (Lux)	Limiting Glare Index
1.General Factory areas		
Canteen	150	
Cloakrooms	150	
Entrances, corridors, stairs	100	

Factory Outdoor Areas		
Stockyards, entrances, exit roads, internal roads		
2.Boiler Houses (Industrial)		
a) Coal and Ash Handling Plants	100	
b) Boiler Rooms:		
Boiler front and operating areas	100	
Other areas	20-25	
4.Electricirty generating stations: Indoor Locations		
Turbine halls	200	25
Auxiliary Equipment; battery rooms; blowers; auxiliary generators, switchgear and transformer chambers	100	
Boiler houses (including operating floors) platforms, coal conveyors, pulverizes, feeders, precipitators, soot and sag blowers	70-100	
Boiler house and turbine house	100	
Basements	70	
Governor houses, conveyor gentries, junction towers	70-100	
4. Electricity Generating Stations: Outdoor Locations		
Coal unloading areas	20	
Coal storage areas	20	
Conveyors	50	
Fuel oil delivery headers	50	
Oil storage tanks	50	
Platforms, boiler and turbine decks	50	
Transformers and outdoor switchgear	100	
Catwalks	50	
Name of the room	**Range of Illumination (Lux)**	
Office Room	300-700	

Battery Room	50-150
Motor Control Center	100-200
Wagon Tippler Control Room	200-500
Transformer Room	100-200
Pump Room	200-500
Drive House	100-200
Remote Input Output Area	200-500
Switchgear Room	100-200
Cable Celler Room	100-200
Corridor	100-200
Transfer Points (TP)	50-150
Crusher House	50-150
Bunker Area	50-150
Junction Tower	50-150
Hopper	50-150
Conveyor	50-150

3.6 Luminance and Luminance ratios

The ability to see details depends on the contrast between the details and the background the greater the contrast i.e. the difference in luminance the more readily the task is visualized. To get the recommended luminance relationship, it is important to select the reflectance of all the room surfaces and the equipment as well as controls the luminance distribution.

The relationship between the luminances of an object and its immediate background. It is equal to $(L1 – L2)/L1$ or $(L2 – L1)/L1 = | \Delta L/L1 |$ where L1 and L2 are the luminances of the background and object, respectively. The form of the equation must be specified. The ratio $\Delta L/L1$ is known as Weber's fraction. [8]

The ratio between the luminances of any two areas in the visual field is known as luminance ratio.

3.7 Distribution, Shadows and Stroboscopic Effects

In uniform distribution of light with maximum and minimum illumination at any point should not be 1/6 th above or below the average level in the area.

Apparent change of motion or immobilization of an object, when the object is illuminated by a periodically varying light of appropriate frequency. Harsh shadows should be avoided though in some cases it is preferred in order to accentuate the depth and form the objects. Care should be taken that no stroboscopic effect takes place as this might cause serious accidents to occur.

For general visualization of tasks in industrial areas, the effect of glare should be eliminated. Proper color of light and color matching is part of visual comfort to perform the task correctly with less errors or errors.

4. Lighting design process and design parameters

For any designer proper knowledge of lighting designs and layouts are necessary. To achieve the best overall outcome in a lighting installation, it is important to avoid the tendency of rushing straight into luminaire selection before determining more broadly what is required from the system. The use of a structured design process helps to avoid this. Lighting technology is a technical-scientific discipline focused on the study and implementation of lighting solutions. This term refers to "the tools and techniques relating to the rational use of various light sources" both in the architecture and design of civil environments and for the development of lighting components for devices that can be integrated into various applications.

The design process for a lighting solution begins with an analysis of the customer's requirements. The preliminary meeting defines the fundamental technical aspects, which will be followed by feasibility studies to select the best solution.

The key steps in the design process are:

- Light Distribution and Brightness
- Conservation of Energy
- The Appearance of the Space and Luminaires
- Glare
- The Appearance of Color
- Lighting Control and Flexibility
- Lighting of Faces
- Cost of Implementation
- Installation
- Maintenance

4.1 Design principles and steps

The parameters to be established at the start of a project are those relating to the type of light required and the end product into which the light fitting is to be incorporated. At this stage, the function of the light as a component of a more complex application is defined. It can be a signaling, emergency or aesthetic lighting function. The next step is to consider the position of the light in order to determine its measurements and overall dimensions.

The next step is to choose the color, hue and color temperature of the light. These analyses help to define the most appropriate light source. Once chosen, other technical parameters, which are not secondary, will be established, such as the operating voltage, the type of power supply, the maximum temperature and the heat dissipation mode for the light source.

Lighting design requires interdisciplinary skills related primarily to light propagation, but also to electronics and plant engineering. There is no doubt that many technical skills are needed to work successfully in this field, but creative input is also required.

In this process, the Research and Development laboratory plays a fundamental role, where the uses of the latest generations of LEDs and fibre optics for lighting are studied and explored in order to offer original lighting solutions.

4.2 Tools Used

For any project the following projects are required for an optimal lighting design.

i. **Survey:** It includes the basic information required for design like the type of luminaire used, numbers of luminaires used and wattage of lamps. Site survey is important but not mandatory depends on the clients whether allow the design to survey or not,
ii. **Lux meter:** A lux meter is a device for measuring brightness, specifically, the intensity with which the brightness appears to the human eye. A lux meter works by using a photo cell to capture light.

Figure 2 Lux Meter

iii. **IS 3646:1992 Part 1 and 2:** Lighting solutions are done as per the IS 3646:1992 standards.
Part I Principles of good lighting and aspects of deign.

Part II Schedule for values of illumination and glare index.

iv. **IS 6665:1972:** This code covers the principles and practice governing good lighting for various industrial premises. It recommends the levels of illumination and quality requirements to be achieved by general principles of lighting.

v. **Dialux 4.12:** DIALux is a user friendly lighting simulation software which is used to calculate the luminaire quantity required to achieve the target illuminance on the area as per standards. It also provides the information about total power consumption by the lighting load and hence calculate the Lighting Power Density (LPD) of the proposed scheme gives help in identifying an energy efficient lighting scheme**.** DIALux is advantageous for office lighting design as it allows for simulation and analysis of lighting systems, ensuring adherence to standards and energy efficiency. It enables the comparison of different lighting solutions, aiding in cost-efficiency analysis and valuable learning experiences for students.

vi. **DIALux EVO:** DIALux evo is a comprehensive planning tool that provides you with all the necessary functions for professional lighting design free of charge. One can calculate and visualize lighting for indoor and outdoor areas. With DIALux evo 12.0 one can import luminaire data in GLDF format. GLDF (Global Lighting Data Format) is a new, modular lighting data format with a clear XML structure that describes simple to complex luminaires and sensors. It is an open and freely available data format.

4.3 Input Data

i. The drawing of the workspace
ii. Room dimensions
iii. Reflectance factors: This can be provided by the clients. Otherwise it should as per the IS standards. This includes floor, wall , ceiling , work plane reflectances
iv. Maintenance factor
v. Nature of visual tasks to be performed
vi. Recommended type of arrangements of luminaires
vii. Target vales of illuminance

4.4 Design Parameters [8]

`In any lighting layout design the basic parameters to be observed on which the design is based on. Viz.

i. **Average illuminance (E_{avg}):** It is the amount of light falling on the owrkplane per unit area of light of light receiving surface.

   Accurate illuminance calculation is a very complicated problem. Its essence is the transfer of luminous flux. It includes point illuminance calculation, area illuminance calculation, direct illuminance calculation, and indirect illuminance calculation, etc. The variable factors that need to be considered will also be different.

   The concept of coefficient of utilization is used in the average illuminance. This concept is easier to understand, that is, as the lamp is used, its luminous flux will gradually decrease.

   Average illuminance = luminous flux of lamps * number of lamps * maintenance factor * utilization factor/area

   This method of calculating the average illuminance is usually called the lumen method. Also because of the coefficient value used, it can also be called the coefficient method.

   The degree of light decay is a crucial factor in maintaining proper illumination over time. As a light source is used, it naturally undergoes decay, resulting in diminished brightness compared to its initial output. If illuminance is calculated based solely on the initial luminous flux, it will be insufficient as the lamp's brightness decreases.

   Additionally, airborne dust impacts the light emitted by a lamp, consequently affecting illuminance. Regular cleaning of the lamp can mitigate this effect, but the frequency of cleaning matters—cleaning once a year versus several times a year yields different outcomes. Environmental pollution also plays a role; a dusty environment will naturally reduce the lamp's light output. The aging of materials used in lamps, the IP rating (which indicates the level of protection against dust and water), and other factors also influence the maintenance factor of the lamps. In a clean indoor space with high-quality light sources, the maintenance factor can be set higher.

   For instance, road lighting conditions are generally less favourable, resulting in a lower maintenance factor, typically around 0.6. In contrast, factory lighting often has a higher maintenance factor, around 0.7. Home lighting environments, which are usually cleaner, have a maintenance factor generally set between 0.7 and 0.8. The maintenance factor is commonly denoted by the uppercase English letter K.

When calculating illuminance, the utilization factor is another important parameter. It is primarily influenced by the size of the illuminated space and the reflectivity of the walls. For example, higher reflectivity of the ceiling, walls, and floor leads to a higher utilization factor. To calculate illuminance accurately, manufacturers typically provide tables to reference the utilization factor values based on these variables.

ii. **Uniformity (U_0):** The definition of light uniformity refers to the consistent distribution of illumination across an area. It is typically measured by the ratio of **the minimum illumination level to the average illumination level**. Adequate uniformity in lighting is essential for ensuring consistent visibility across the task area, regardless of whether direct or indirect lighting is employed.

Generally, $U_0=E_{min}/E_{avg}$

Industrial and Commercial Lighting Uniformity Requirements are as per IS 3646:1992**[6]**

The Area	**The Light Uniformity Standard**
Sports Field	0.5-0.8
Office	0.4-0.6
Parking Lot	0.4-0.5
Warehouse	0.4-0.6
Running Track	0.3-0.5
Airport	0.2-0.3
Road lighting	U0 between 0.35 and 0.4; UI between 0.4 and 0.7

Table 4.4 Required Uniformity for Industrial lighting

iii. Glare: Glare in the installations is of mainly two types

a) **Disability glare:** the effect of stray light in the eye whereby visibility and visual performance are reduced. A direct glare source that produces discomfort can also produce disability glare by introducing a measurable amount of stray light in the eye.

b) **Discomfort glare:** glare that produces discomfort. It does not necessarily interfere with visual performance or visibility

Discomfort Glare Rating (DGR) a numerical assessment of the capacity of a number of sources of luminance, such as a luminaire, in a given visual environment for producing discomfort.

4.5 Design Consideration

i. **Ceiling, Wall, Floor Reflectance:** The reflectance properties of room surface significantly impact the effectiveness of a lighting system in an interior space. Surfaces with low reflectance require higher light levels to achieve equivalent lux levels.
The choice of room surface finishes can greatly enhance the efficiency of a lighting system. Lighter finishes can effectively increase light levels and enhance the perception of brightness. For example, in an existing space, simply repainting dark surfaces with lighter colors can significantly improve light levels and visual comfort. This improvement in reflectance can also enhance the coefficient of utilization, which is crucial for accurate design light level calculations in any application.

Office	K-12 School	Small Retail	Small Hospital and Healthcare	Warehouse and Self-Storage
Ceiling: >80% (90% if indirect lighting)	Ceiling: 70% (preferred 80-90%) Walls: 50% Floor: 20%	Ceiling: 80% (80+% if daylight zone) Wall: 50% (70+% if	Ceiling: 85% (direct lighting) and at least 90% (indirect and/or daylighting)	Ceiling: 80% Walls: 30% Product/Floor: 20%

		daylight zone) Floor: 20%	Walls: 50% (70% for walls adjacent to daylight apertures) Floor: 20%	

Table 4.6 Reflectance factors for different purpose rooms [8]

ii. **Maintenance Factor**
The maintenance factor of a lighting system indicates the percentage of its initial luminous flux that remains available by the end of its service life**.** Generally, in practical it is varied from 0.8 to 0.85 depending on the environmental conditions.

4.6 Design Selection

In design selection the following things are considered:

i. **Choice of lighting system:** The selection of a light source is normally the first step in equipment selection. In many cases more than one lamp type will be re- quired; however, it is good practice to keep the number of different lamps to a minimum to simplify relamping. Basically total 3 types of lighting systems are practiced in industrial lighting viz

a) **Uniform/General lighting:[9]** The term 'general lighting' or 'ambient lighting' refers to the background levels of light in a particular space. In the majority of workspaces, the minimum level of general lighting is determined in line with best practice guides to ensure safety and enable everyday visual tasks to be performed comfortably and efficiently.
Lighting system which provides an approximately uniform illuminance on the horizontal working plane over the entire area are called general lighting systems. Simple to plan & install.
Adv: It permits complete flexibility of task location
Disadv: Energy is wasted illuminating the whole area to the level needed only for the most critical tasks.

b) **Localized lighting:** Localized lighting systems provide targeted illuminance on specific work areas while maintaining reduced illuminance in adjacent spaces. These systems use luminaries positioned strategically around tasks and workstations, delivering the necessary service illuminance to work areas while keeping the general illumination level lower throughout the space. As a result, localized lighting typically consumes less energy than general lighting systems

c) **Task lighting:** Task lighting provides increased light for specific tasks in a room that may already have some ambient light. Task lighting is especially useful for seeing small objects or objects of low contrast. It is also known as **local lighting**.
It is a very efficient system, particularly when high standards of task illuminance are required.

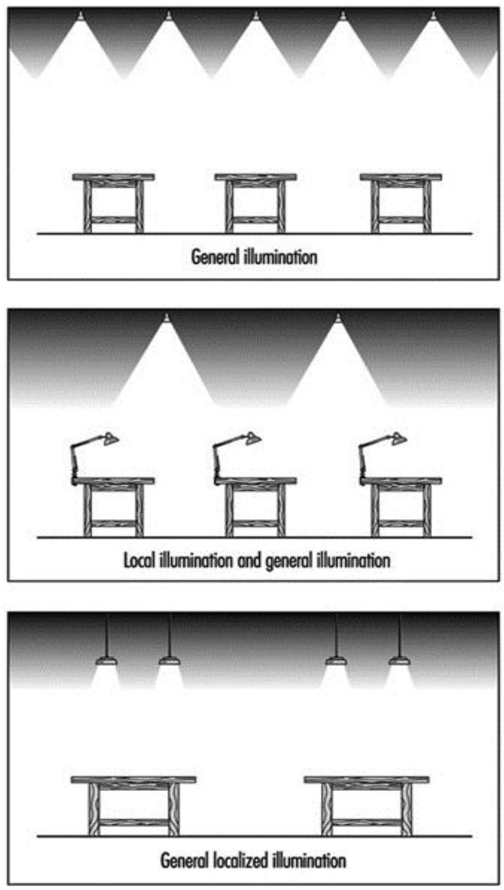

Figure 3 types of lighting according to their purpose[9]

ii. Choice of luminaire and lamps

For a designer the selection of lamps and luminaire are important. Designer should have proper knowledge of layout and the required amount of light, thus selection of lamps are crucial in the design purpose. The light distribution curves define the intensity distribution, symmetrical features of lamps. The proper CRI of lamp gives satisfactory vision adaption.

In industrial lighting the CRI is not so important instead of this the focused characteristics of lamps are durability, toughness, IK rating. In most industrial settings, luminaires are typically categorized as direct or semi-direct types. Luminaires that emit some upward light are generally preferred because they help illuminate ceilings or upper structures, thereby reducing the contrast between the brightness of the luminaires and the background. This approach minimizes the starkness associated with entirely direct lighting, creating a more pleasant and inviting atmosphere. Even with completely direct lighting, favorable environmental luminance can be achieved if the room's reflectance and illumination levels are sufficiently high.

For industrial lighting the installations include **[6]**

a) Light-colored finishes on the outside of luminaires to reduce luminance ratios between the outside of the luminaire and the inner reflecting surfaces.
b) Higher mounting heights to raise luminaires out of the normal field of view.
c) Better shielding of the light source by deeper reflectors, cross baffles, or louvres. This is particularly important with high wattage incandescent filament or mercury vapor discharge sources.
d) Selecting light control material, such as specular or non-specular aluminum or prismatic configured glass or plastic that can limit the luminaire luminance in the shielded zone.

Maintenance of the luminaires: Lamps are subjected to depreciation by the passage of time. By depreciation lumen output of the lamp reduces over time. Thus lamps need to be cleaned. Regular maintenance of lighting installations is essential to maintain the desired level of illumination and the associated benefits of good lighting. The performance of lighting systems gradually declines over time, varying with the location of use, making consistent maintenance crucial.

Ingress Protection (IP) Rating: Ingress protection are developed by the European committee for electro technical Standardization, specifying the environmental protection the enclosure provides. The IP rating normally has two numbers

Number 1 indicates Protection from solid objects or materials

Number 2 indicates protection from the liquids (water)

The below given tables describes the significance and the values of the IP rating **[10]**

First characteristic numerical	**Object size protected against**	**Effective against**
0	--	No protection against contact and ingress of objects
1	>50mm	Any large surface of the body, such as the back of a hand, but no protection against deliberate contact with a body part
2	>12.5mm	Fingers or similar objects
3	>2.5mm	Tools, thick wires e.t.c
4	>1mm	Most wires, slender screws, ants
5	Dust protected	Ingress of dust is not entirely prevented , but it must not enter in sufficient quantity to interfere with the satisfactory operation of the equipment
6	Dust tight	No ingress of dust; complete protection against contact. Vacuum must be applied. Test duration up to 8 hours based on air flow

Table 4.7.1 Values for First characteristics numerical and protection level

Second characteristic numerical	**Object size protected against**	**Effective against**
0	Not protected	-----

1	Dripping water	Dripping water (Vertically falling drops) shall have no harmful effect
2	Dripping water when tilted up to 15	Vertically dripping water shall have no harmful effect when the enclosure is tilted at an angle up to 15 degree
3	Spraying Water	Water falling as a spray at any angle up to 60deg from the vertical shall have no harmful effect
4	Splashing of Water	Water splashing against the enclosure from any direction no harmful effect
5	Water jets	Water projected by a nozzle (6.3mm) against enclosure from any direction shall have no harmful effects

Table 4.7.2 Values for Second characteristics numerical and protection level [10]

5. Light Sources for Industrial Lighting

In traditional incandescent bulbs, 90% of the energy they emit is given off as heat, making them a very wasteful option. Changing bulb types to more efficient LEDs can be one of the best ways to save energy, which is good for both the environment and your bottom line. LED stands for light-emitting diodes, and they work through a process called electroluminescence, which generates light as an electric current passes through a semiconductor material.

5.1 Conventional Light Sources for Industrial Lighting

In industrial lighting the conventional lights are

i. **HID Lamps:** HID sources can cause direct glare due to the high amount of light emitted from their small lamps. To reduce excessive direct glare, it is recommended to mount fixtures at sufficient heights. These guidelines apply to open-bottom, industrial-type fixtures. Luminaires with special lenses can be mounted at lower heights, and manufacturers' literature should be consulted for specific fixture recommendations. The potential for direct glare increases with a higher spacing-to-mounting-height ratio because fixtures with greater spacing criteria emit more light at higher angles. Fluorescent lamps, with their lower luminance, rarely cause serious glare and are generally preferred for mounting heights below 16 feet.

   HID lamps are used primarily in applications where the most critical factor is creating as much visible light per watt as possible. Major applications include streetlights, gymnasiums, warehouses, large retail facilities, and stadiums, and plant growing rooms.

   Generally, these lamps are of three types

   a. **High Pressure Sodium Vapor (HPSV) Lamp:** A high-pressure sodium vapor lamp operates at high pressure (above 1 atm) and high temperature (above 1000 °C) within a ceramic arc tube made of polycrystalline alumina (PCA). This tube contains xenon gas, sodium-mercury amalgam, and electrodes at both ends, all enclosed in a heat-resistant outer glass bulb.

      The lamp functions by applying a high voltage pulse from a ballast and igniter to the electrodes, ionizing the xenon gas to create an arc. This arc heats the tube, vaporizing the mercury and sodium. The mercury vapor emits bluish-white light, while the sodium vapor emits yellow light. Together, they produce a golden-white light with a color temperature of about 2000 K and a color rendering index of 25.

High-pressure sodium vapor lamps are also used for lighting various industrial applications, such as warehouses, factories, workshops, mines, power plants, and stadiums. They provide high luminous efficacy, high reliability, and high resistance to harsh environments.

b. **Metal Halide (MH) Lamp:** Metal halide lamps are a type of high-intensity discharge (HID) lamp that generate light through an electric arc in a gaseous mixture of vaporized mercury and metal halides. Known for their high luminous efficacy, excellent color rendition, and long lifespan, these lamps are commonly used for both indoor and outdoor general lighting. To operate safely and efficiently, metal halide lamps require special fixtures and ballasts. Additionally, proper maintenance is essential to ensure optimal performance and longevity.

c. **Mercury Vapor (MV) Lamp:**

ii. Fluorescent Lamp

iii. Incandescent Lamp

5.2 Replacement of Conventional Light Sources by LED

LED bulbs have several benefits that make them the ideal choice for an office environment. They are:

i. **More efficient:** LEDs can use anywhere from 25 to 80% less energy than their incandescent counterparts. These savings offer significant reductions in operational costs. Compare the annual energy cost for a lightbulb used for two hours a day at 11 cents per kilowatt-hour. For a 60-watt traditional incandescent, the yearly energy cost is $4.80, but a 12W LED would only cost $1.00.

ii. **Longer lasting:** LED lights also save money through replacements. They can last up to 25 times longer than traditional incandescents, which also reduces maintenance needs.

iii. **Cooler:** With a lower heat output, these lights are safer and help you maintain your desired temperature without added warmth.

iv. **Dimmable:** Colors are varied and flexible, allowing for lighting fixtures that can adapt to your needs. The color rendition of LED bulbs is excellent, so your office can look just how you intended.

Figure 4 Preference of LED s nowadays than other lamps

5.2.1 LED (Lighting Emitting Diodes)

LEDs have gained popularity as an alternative to CCFL for backlighting media size LCD displays. The advantages of WLEDs are power efficiency and low profile design. Due to the large number of WLEDs, they are often arranged in series and parallel, and powered by a boost regulator with multiple current sink regulators. Having more WLEDs in series reduces the number of parallel strings and therefore improves overall current matching.

Working Principle

The working of the LED depends on the quantum theory. The LED is a semiconductor diode that emits light current passing through it. The n-side is heavily doped. The LED is connected in the forward biased, the recombination shows that the conduction band to valence band and they emits electromagnetic energy in form of photons .i.e. electroluminescence. The light emitting diode works like a normal PN-junction diode. When the diode is forward biased, then the current flows through the diode. The flow of current in the semiconductors is caused by the both flow of holes in the opposite direction of current and flow of electrons in the direction of the current. Hence there will be recombination due to the flow of these charge carriers. The recombination indicates that the electrons in the conduction band jump down to the valence band. When the electrons jump from one band to another band the electrons will emit the electromagnetic energy in the form of photons and the photon energy is equal to the forbidden energy gap (Eg).

$$\mathbf{Eg} = \frac{\mathbf{hc}}{\boldsymbol{\lambda}}$$

Where h is known as a Planck constant, and f is the frequency of the emitted electromagnetic radiation. Fig 5 &6 defines the Recombination process and I-V Characteristic of LED

In WLEDs, a blue LED chip is coated with a phosphor material, which converts some of the blue light into white light.**[11]**

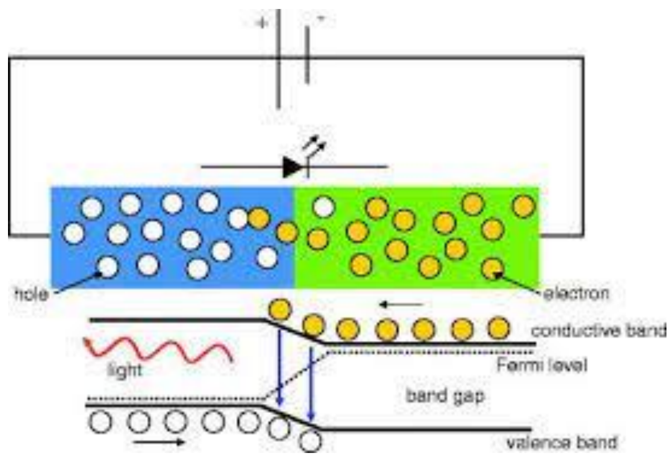

Figure 5 LED working Process

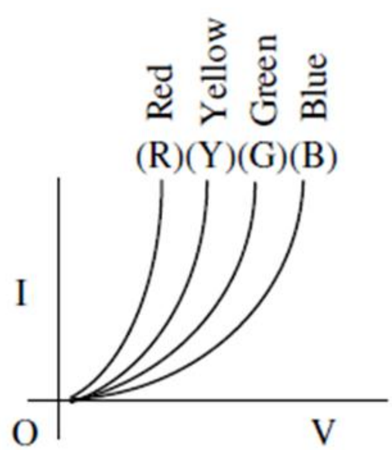

Figure 6 I-V Characteristic of LED

Semiconductor materials used for producing different colors,

Table 5.2.1 Semiconductor material features

Typical Features of LED			
Semiconductor Material	**Wavelength(nm)**	**Colour**	**V_F @20 mA (V)**
GaAs	850-940	Infra-Red	1.2
GaAsP	630-660	Red	1.8
GaAsP:N	605-620	Amber	2
AlGaP	550-570	Green	3.5
SiC	430-505	Blue	3.6
GaInN	450	White	4

Some commonly used LEDs are mentioned below

- Gallium Arsenide (GaAs) – infra-red
- Gallium Arsenide Phosphide (GaAsP) – red to infra-red, orange
- Aluminium Gallium Arsenide Phosphide (AlGaAsP) – high-brightness red, orange-red, orange, and yellow
- Gallium Phosphide (GaP) – red, yellow and green
- Aluminium Gallium Phosphide (AlGaP) – green
- Gallium Nitride (GaN) – green, emerald green
- Gallium Indium Nitride (GaInN) – near ultraviolet, bluish-green and blue
- Silicon Carbide (SiC) – blue as a substrate
- Zinc Selenide (ZnSe) – blue
- Aluminium Gallium Nitride (AlGaN) – ultraviolet

Construction of LED:

The methods used to construct LED are to deposit three semiconductor layers on the substrate. The three semiconductor layers deposited on the substrate are n-type semiconductor, p-type semiconductor and active region. Active region is present in between the n-type and p-type semiconductor layers. When LED is forward biased, free electrons from n-type semiconductor and holes from p-type semiconductor are pushed towards the active region. When free electrons from n-side and holes from p-side recombine with the opposite charge carriers (free electrons with holes or holes with free electrons) in active region, an invisible or visible light is emitted. In LED, most of the charge carriers recombine at active region. Therefore, most of the light is emitted by the active region. The active region is also called as depletion region.

Generation of White light LED

There are two primary ways of producing white light-emitting diodes, LEDs that generate high intensity white light.

i. RGB synthesis
ii. Using Blue LED with phosphor coating.

RGB Synthesis combining red, blue and green LED to produce white light.

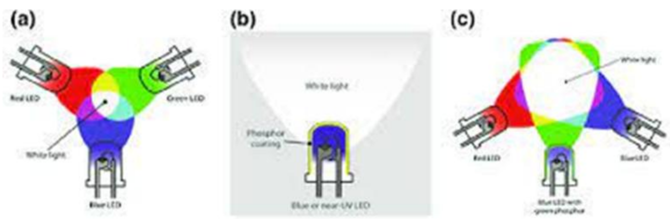

Figure 7 RGB LED

Using Blue LED with phosphor coating: a blue LED chip is coated with a yellow phosphor to produce an LED package that emits white light. The blue light produced by the LED chip passes through the yellow phosphor layer, resulting in white light with the combination of blue and yellow.

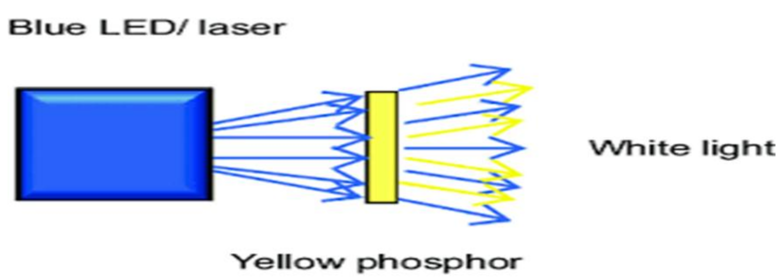

Figure 8 White Light using Blue LED

There are three main methods of mixing colors to produce white light from an LED

i. Red LED + Green LED + Blue LED
ii. Near-UV or UV LED + RGB phosphor
iii. Blue LED + Yellow Phosphor

LED Technologies

i. **DIP Chip:** DIP LEDs, or dual in-line package LEDs, are stalwarts in the realm of lighting technology. These LEDs house separate red, green, and blue diodes within a simple yet sturdy plastic package with two parallel connecting pins. Their design, though straightforward, ensures robustness and reliability. The distinct advantage of DIP LEDs lies in their capability to emit bold, brilliant lights, making them ideal for environments with abundant natural light. Their exceptional brightness is particularly effective against direct sunlight, catering to settings that demand high luminosity and resilience to outdoor conditions.

However, due to their specialized nature and lower production volume compared to other LED types, DIP LEDs tend to be more costly. They excel in applications requiring superior impact resistance, owing to their resin encapsulation that shields the LED components effectively. Each DIP LED features a cylindrical shape topped with a sphere, enhancing light projection. Inside, a single semiconductor crystal emits light continuously when powered. Notably, DIP LEDs are restricted to single-color outputs since each diode emits only one color—red, green, or blue. For LED screens, DIP LEDs are often combined into 3 DIP pixels, each capable of emitting one primary color. Their integration onto modules or LED boards involves direct welding to circuitry via two pins, ensuring a secure connection far more resistant than alternatives like SMD LEDs.

In summary, DIP LEDs remain a preferred choice for specialized projects necessitating high impact resistance and intense luminosity, despite their higher cost and single-color limitation. Their enduring design and robust construction make them a dependable ally in demanding lighting applications.

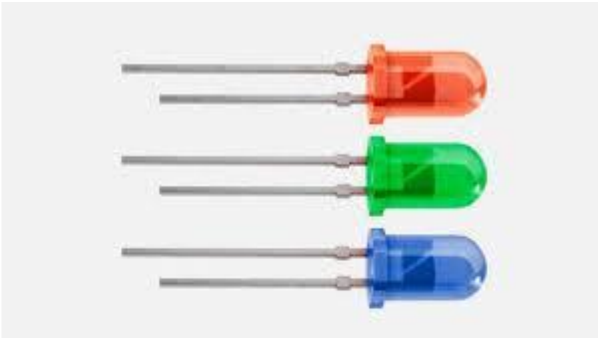

Figure 9 DIP LED

ii. **SMD:** Surface Mounted Diode are much smaller and more efficient than DIP Chips. LED modules are described by the dimensions of the LED package. A single multicolor module may have three individual LEDs within that package, one each of red, green and blue, to allow many colors or shades of white to be selected, by varying the brightness of the individual LEDs. LED brightness may be increased by using a higher driving current, at the cost of reducing the device's lifespan.

Figure 10 Bicolor SMD LED

iii. **COB:** A CoB LED (or chip-on-board LED) is a single device with many LED chips mounted on a thermally efficient substrate placed below a uniform phosphor coating. COB LED has multiple diodes typically around 9 or more. The close placement of the LED chips allows for high intensity or light density to be emitted from a smaller area than is possible with single packaged LEDs. The CoB LED manufacturer then applies a uniform phosphor coating to the entire array of chips to convert the blue light to the required white color temperature.

A single CoB LED can contain hundreds of chips forming a dense array. This dense array enables a CoB LED to produce more light output from a smaller area than is generally possible with an array of packaged LEDs.

COB Lighting is popularly used to achieve focused, high-quality illumination in spaces like living rooms, photography and videography

Figure 11 COB LED

Compared to SMD, COB LED are small in size. But when the temperature gets high up to 74 degree which requires a large heat sink. In case of SMD large LED spacing on the board helps heat to dissipate faster.

SMD chips have higher luminous efficiency than COBs. With better performance of heat dissipation, SMD chips could pass the LM80/TM 21 test.

LED Binning

LED binning is a method used to ensure the uniformity and grading of LED lighting products. It involves examining individual LED chips for their brightness, temperature, and other factors.

LED binning is essential to keep up

i. The quality of LED lighting.
ii. Improved Color Consistency
iii. Increased Efficiency
iv. Better Quality Control

Types of LED Binning

i. Color Binning: This CIE standard divides LED color temperatures into four categories. These are;

Type Of Color	**Color Temperature (CCT)**
Warm	2700K to 3500K
Neutral	3500K to 5000K

Cool	5000K to 7000K
Ultra-cool	7000K to 10000K

ii. Luminous Flux Binning

iii. Voltage Binning: Based on forward voltage, LED bins are generally divided into four categories: high-voltage, low-voltage, standard-voltage, and ultra-low-voltage.

Forward Voltage Standard	Range
High-Voltage	4.0 – 4.2 V
Standard-voltage	3.3 – 3.6 V
Low-voltage	2.7 – 3.2 V
Ultra-low-voltage	2.7 V

iv. Temperature Binning

Different Lighting Cases	Operating temperature
Outdoor Luminaires	60° to 65°C
Freezer Cases	20° to 25°C
Down lights in Insulated Ceilings/Retrofit bulb	often over 100°C

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5.3 Types of LED Used in Thermal Power Plant [12]

i. **Explosion Proof High Bays:** Use inside the power plant in high ceiling areas typically 15 feet or higher.

Figure 12 Explosion Proof High Bays

ii. **Explosion Proof Flood Lights:** Use around the exterior of the power plant. These can mount to walls, ceilings, or on poles.

Figure 13 Explosion Proof Flood Lights

iii. **Explosion Proof Linear Lights:** Suspended ceiling lights for use inside the plant, typically on ceilings under 15 feet high**.**

Figure 14 Explosion Proof Linear Light

iv. **Jelly Jar Lights:** Specialized light bulbs encased in a metal cage to ensure shatterproof resistance.

Figure 15 Jelly Jar Lights

v. **Vapor Tight Lights:** Linear fixtures with an extra layer of protection against water vapor.

Figure 16 Vapor Tight Lights

Environments with explosive materials, flammable gases, vapors, or dust require shielding of any potential ignition sources to ensure workplace safety. Power plants, like other industrial environments, often handle combustible materials such as coal, natural gas, or oil. Consequently, the light fixtures used in power plant lighting must adhere to a variety of stringent requirements.

5.4 New trends in industrial lighting

The way light distribution is managed by luminaires significantly influences glare, shadows, distribution, and diffusion effects. Many industrial applications necessitate direct or semi-direct lighting systems. Traditional fittings are often preferred due to the lower initial costs compared to LEDs. However, these conventional systems consume substantial energy and contribute to industrial pollution. Consequently, industries are transitioning towards cleaner, safer, and more environmentally friendly lighting solutions, such as LEDs. Despite their higher upfront cost, LEDs offer significant long-term savings. Calculating their payback period and return on investment demonstrates their economic viability.

5.4.1 Use of T5 LED instead of 36W/40W FTL

These T5 LEDs are having excellent CRI and less power consumption with high efficacy.

Used in Commercial interiors, ware house, corridor, passage, and basement.

Figure 17 T5 LED

5.4.2 Weather Proof Luminaire

Surface mounting weatherproof Luminaire with Corrosion Resistant Polycarbonate body and cover. Suitable for 1, 2X18/20W LED Tube. Luminaire fulfills IP65 rating.

Used in chemical industries, food processing industries, paint factories, textile mills.

Figure 18 Weatherproof Luminaire

5.4.3 2×2 Square Luminaire

Opal acrylic diffuser with sheet steel frame white powder coated finish with IP 20

Used in control room, laboratories, airport lounge, Office rooms

Figure 19 2×2 Square Luminaire

5.4.4 Industrial Well Glass

Basically these are flameproof/ explosion proof lamps used in hazardous flammable industries. The Industrial Flameproof Well Glass is made from high-quality stainless steel, making it durable and resistant to corrosion. PDC (Pressure Die Castings) Aluminium Housing Suspended Mounting with IP 65

It is a perfect LED solution for industrial applications of harsh working environment like Cement Plant, Power Generation Plant, Metal Plant, and non-hazardous area in Gas, Chemical and Petrochemical Industry.

Figure 20 Industrial Well Glass

5.4.5 Bulkhead

PDC Aluminium Housing surface mounting with IP 65 rating.

These types of luminaires are widely used for emergency purposes in industry. These are suitable for pole ceiling and wall mounting.

Used in Basement, staircase, Balconies, Store areas

Figure 21 bulkhead light fitting

5.4.6 Mid Bay and High Bay

PDC Aluminium Housing suspended with IP 66 rating. Ventilation technology for better thermal management

Mid-Bay and High-Bay lighting are designed for taller ceilings and larger areas. These luminaires are ideal for warehouses, manufacturing facilities, ports and any industrial application. Installing High-Bay Lighting is the starting point for improving your factory conditions, an investment that will enhance the yield by improving the productivity of your workers.

Figure 22 High bay LED

5.4.7 Floodlight

A floodlight is a broad-beamed, high-intensity artificial light. It can provide functional area lighting for travel-ways, parking, entrances, work areas, and sporting venues to enable visibility adequate for safe task performance, ornamental lighting for advertising, façades, monuments, or support perimeter security.

6. Study on Thermal Power Plant Lighting Scheme

In this chapter the lighting simulation result on “Thermal Power Plant” using DIALux 4.13 lighting software is discussed and then energy efficiency is analyzed. A thermal plant consists of different areas and each area is constructed for specific tasks. The following designs are based on the specific purpose.

6.1 Purpose of the Project

The primary goal of this project is to analyze the design methodology applied across various areas of a Thermal Power Plant. The project involves a thorough examination of the design approach, including the types of luminaires used, and the consideration of parameters such as maintenance factors and reflectance (of walls, ceilings, and floors). Additionally, DIALUX simulation will be utilized to achieve the desired lighting outcomes. After the simulation results are produced, they will be reviewed by clients to ensure that the designs adhere to relevant criteria and standards.

Given the diverse activities in a Thermal Power Plant—such as monitoring, controlling, processing, and the loading/unloading of raw materials—adequate visibility is crucial. To address this, the project aims to ensure that proper illuminance and uniformity levels are achieved, in accordance with industry standards and guidelines.

6.2 Design Methodology

Step 1: Consult with clients to gather their requirements and discuss with team members the functionality of different rooms within the Thermal Power Plant.

Step 2: Design each room according to the specifications provided in the client's datasheet.

Step 3: Group rooms based on their purpose. For example, if there are multiple rooms with similar dimensions and functions, such as drive houses or bunker areas, use one representative room for the design, which will apply to all rooms of the same type and size.

Step 4: Input values such as maintenance factors (MF) and reflectance (for ceilings, walls, and floors) into the design model.

Step 5: Select the most suitable luminaire based on the functionality and requirements of each room.

Step 6: Determine the appropriate luminaire arrangement, whether it be single fixtures, linear arrays, or floodlighting.

Step 7: Simulate the lighting design to achieve the desired levels of illuminance and uniformity.

Step 8: If the simulation results do not meet the target values, revise the design by adjusting the luminaire arrangement or choosing different luminaires to achieve the required outcomes.

6.3 Luminaires Used

Image	Details
	DAY-BRITE**[13]** G10L(P)4FT08LUV840 G10 4-2LINEP 2.62 4000K BOARDS 75W DRIVER 1730mA Article No.: G10L(P)4FT08LUV840 Luminous flux (Luminaire): 8840 lm Luminous flux (Lamps): 8840 lm Luminaire Wattage: 57.6 W Luminaire classification according to CIE: 100 CIE flux code: 45 77 95 100 100 Fitting: 1 x User defined (Correction Factor 1.000)
	DIALIGHT LSA3C4M2F SafeSite LED Linear 4700 Lumens, 1181mm, Medium Distribution, Diffused Glass Lens Article No.: LSA3C4M2F Luminous flux (Luminaire): 4706 lm Luminous flux (Lamps): 4706 lm Luminaire Wattage: 67.0 W

	Luminaire classification according to CIE: 100 CIE flux code: 55 88 99 100 100 Fitting: 1 x SafeSite LED Linear - LSA3C4M2F 67W 4706.29lm (Correction Factor 1.000).
	SIGNIFY DAY-BRITE - CFI LBX40L840-UNV**[13]** 4'LBX 2-2LP 1.0 4000K BOARDS 40W DRIVER 2.7K RESISTOR OPEN Article No.: LBX40L840-UNV Luminous flux (Luminaire): 4654 lm Luminous flux (Lamps): 4654 lm Luminaire Wattage: 31.0 W Luminaire classification according to CIE: 100 CIE flux code: 47 79 96 100 100 Fitting: 1 x LED. LUMINAIRE OUTPUT = 4655 LUMENS (Correction Factor 1.000).
	BY200P LED44 L-BCW PSU **[14]** Article No.: Luminous flux (Luminaire): 4400 lm Luminous flux (Lamps): 4400 lm Luminaire Wattage: 40.0 W Luminaire classification according to CIE: 89 CIE flux code: 36 66 87 89 100 Fitting: 1 x LED (Correction Factor 1.000).

	PHILIPS 45W Core SL China_30-09-2022 **[14]** Article No.: Luminous flux (Luminaire): 5425 lm Luminous flux (Lamps): 5430 lm Luminaire Wattage: 42.2 W Luminaire classification according to CIE: 100 CIE flux code: 37 71 96 100 100 Fitting: 1 x LED (Correction Factor 1.000).

6.4 6.6 KV SWGR Room

The 6.6kV Indoor VCB Switchgear Panels of voltage range 3.3kV to 11kV and current ratings from 630A to 3150A. For compactness in panels rated up to 2000A special bus raiser panel is provided with bus coupler panel extended in the rear side. IP4X/IP 55 degree of protection is provided externally and IP2X between compartments. Panels shall have adequate space for terminating large cable sizes.

Figure 23 6.6 KV Unit 1 SWGR

<u>Design Requirement</u>

Target Illuminance (E_{avg}): 200 lux

Target Uniformity (U_0): ≥ 0.4

Design aim: To achieve uniform illumination of the mentioned area which is used to monitor and measure the data perfectly with proper lighting. Also the room temperature is slightly up from normal temperature so using a flameproof lamp is good decision in this lighting design

DIALux Simulation Report:

DIALux simulation report is based on the arrangement of luminaire chosen and the number of luminous used for the designed to get the target illuminance. The illuminance level should be as per the requirements and IS Standard based.

Height of Room: 19.685 ft, Mounting Height: 18.044 ft, Light loss factor: 0.8
Values in Lux, Scale 1:103

Surface	ρ [%]	E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0
Workplane	/	215	145	260	0.674
Floor	20	193	134	234	0.693
Ceiling	80	59	40	71	0.673
Walls (4)	50	138	45	374	/

Workplane:

Height: 2.493 ft

Grid: 10 x 8 Points

Boundary Zone: 0.000 ft

Illuminance Quotient (according to LG7): Walls / Working Plane: 0.670, Ceiling / Working Plane: 0.277

6.6 KV Unit 1 SWGR / Luminaire parts list

4 Pieces DAY-BRITE G10L(P)4FT08LUV840 G10 4-2LINEP 2.62 4000K BOARDS 75W DRIVER 1730mA

Article No.: G10L(P)4FT08LUV840

Luminous flux (Luminaire): 8840 lm

Luminous flux (Lamps): 8840 lm

Luminaire Wattage: 57.6 W

Luminaire classification according to CIE: 100

CIE flux code: 45 77 95 100 100

Fitting: 1 x User defined (Correction Factor 1.000).

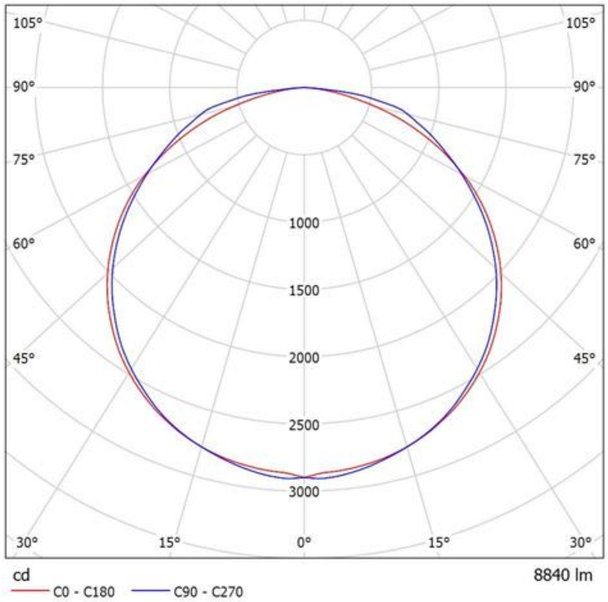


Figure 24 Luminous emittance

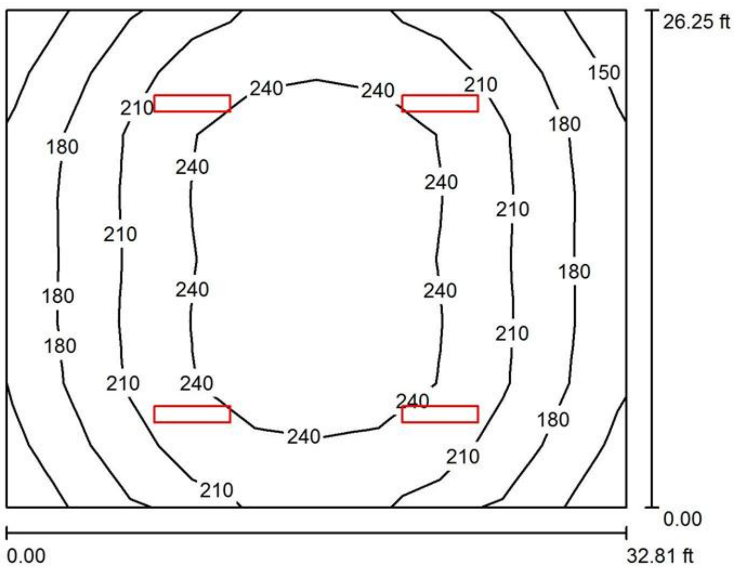


Figure 25 Isolux Diagram

Fig 26 shows the dimension of SWGR of the luminaires and the isolux values over the workplane of the room 4×57.6W luminaires are used.

Surface	ρ [%]	E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0
Workplane	/	215	145	260	0.674
Floor	20	193	134	234	0.693
Ceiling	80	59	40	71	0.673
Walls (4)	50	138	45	374	/

Figure 26 values of the average illuminance & overall uniformity on different surface and LPD value of the room

Luminaire Parts List

No.	Pieces	Designation (Correction Factor)	φ(Luminaire) [lm]	φ (Lamps) [lm]	P [W]
1	4	DAY-BRITE G10L(P)4FT08LUV840 G10 4-2LINEP 2.62 4000K BOARDS 75W DRIVER 1730mA (1.000)	8840	8840	57.6
		Total	35362	35362	230.4

Specific connected load: 0.27 W/sq ft = 0.12 W/sq ft/100 lx (Ground area: 861.11 sq ft)

Surface	Average illuminances [lx] direct	indirect	total	Reflection factor [%]	Average luminance [cd/m²]
Workplane	152	63	215	/	/
Floor	131	62	193	20	12
Ceiling	0.07	59	59	80	15
Wall 1	96	55	152	50	24
Wall 2	65	56	121	50	19
Wall 3	96	55	152	50	24
Wall 4	65	57	122	50	19

6.6 KV Unit 1 SWGR / Luminaires (layout plan)

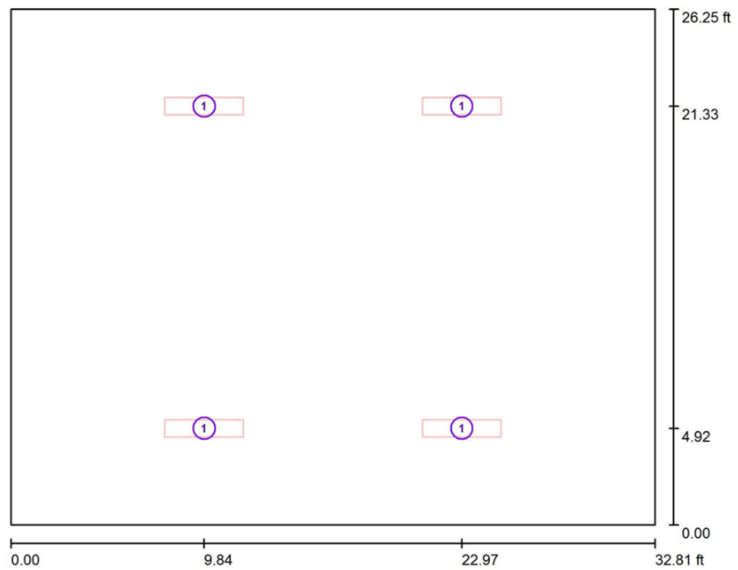


Figure 27 Luminaire Layout Plan

Uniformity on the working plane u0: 0.674 (1:1)

Emin / Emax: 0.558 (1:2)

Illuminance Quotient (according to LG7): Walls / Working Plane: 0.670, Ceiling / Working Plane: 0.277.

Specific connected load: 0.27 W/sq ft = 0.12 W/sq ft/100 lx (Ground area: 861.11 sq ft)

6.6 KV Unit 1 SWGR / 3 D Rendering

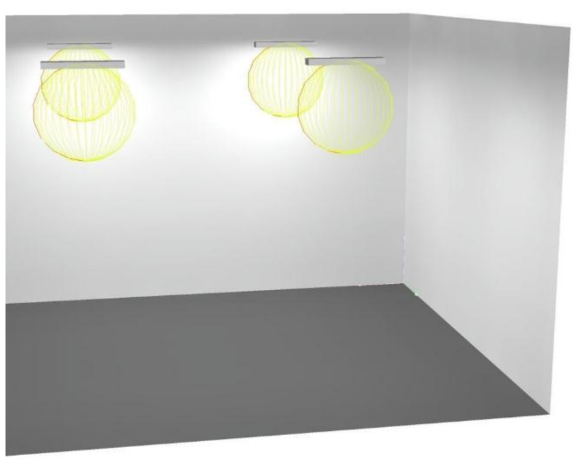


Figure 28 3D Rendering Index of SWGR Room

6.6 KV Unit 1 SWGR / Workplane / Value Chart (E)

Values in Lux, Scale 1:75

Position of surface in room:

Marked point:

(0.000 ft, 0.000 ft, 2.493 ft)

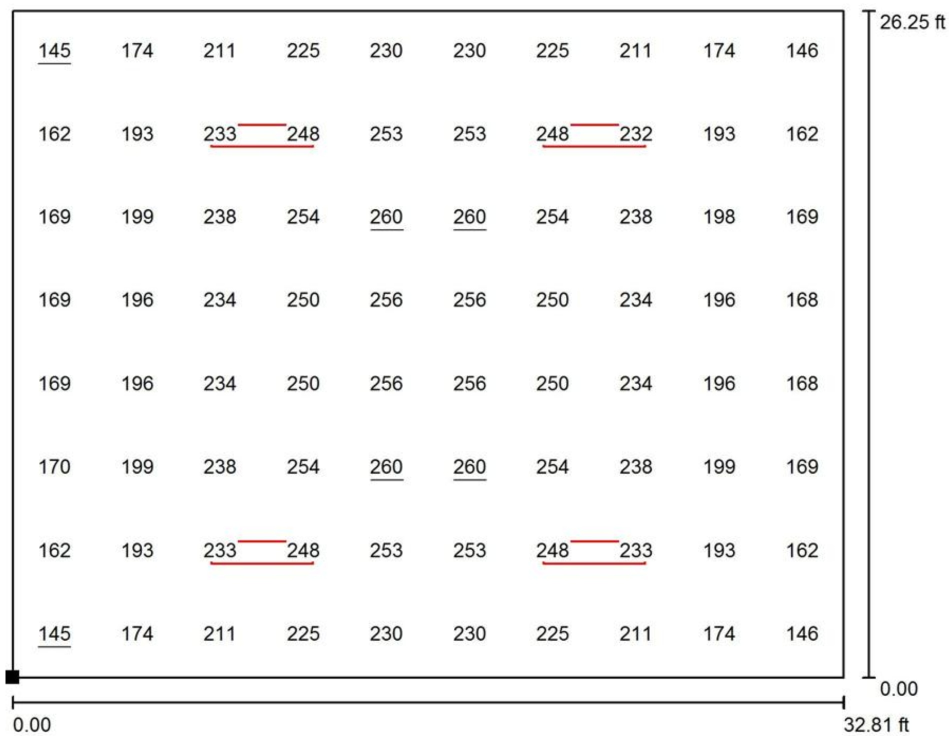


Figure 29 Value Chart

Grid: 10 x 8 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	Emin / Emax
215	145	260	0.674	0.558

6.5 6.6 KV Unit 2 SWGR Room

The 6.6kV Indoor VCB Switchgear Panels of voltage range 3.3kV to 11kV and current ratings from 630A to 3150A. For compactness in panels rated up to 2000A special bus raiser panel is provided with bus coupler panel extended in the rear side.

IP4X/IP 55 degree of protection is provided externally and IP2X between compartments. Panels shall have adequate space for terminating large cable sizes.

Figure 30 6.6 KV Unit 2 SWGR

Design Requirement

Target Illuminance (E_{avg}): 200 lux

Target Uniformity (U_0): ≥ 0.4

Design aim: To achieve uniform illumination of the mentioned area which is used to monitor and measure the data perfectly with proper lighting. Also the room temperature is slightly up from normal temperature so using a flameproof lamp is good decision in this lighting design

DIALux Simulation Report:

DIALux simulation report is based on the arrangement of luminaire chosen and the number of luminous used for the designed to get the target illuminance. The illuminance level should be as per the requirements and IS Standard based.

Height of Room: 19.685 ft, Mounting Height: 18.044 ft, Light loss factor: 0.8
Values in Lux, Scale 1:103

6.6KV Unit 2 Breaker Room / Luminaire parts list

DIALIGHT LSA3C4M2F SafeSite LED Linear 4700

Lumens, 1181mm, Medium Distribution, Diffused Glass Lenss

Article No.: LSA3C4M2F

Luminous flux (Luminaire): 4706 lm

Luminous flux (Lamps): 4706 lm

Luminaire Wattage: 67.0 W

Luminaire classification according to CIE: 100

CIE flux code: 55 88 99 100 100

Fitting: 1 x SafeSite LED Linear - LSA3C4M2F 67W 4706.29lm (Correction Factor 1.000).

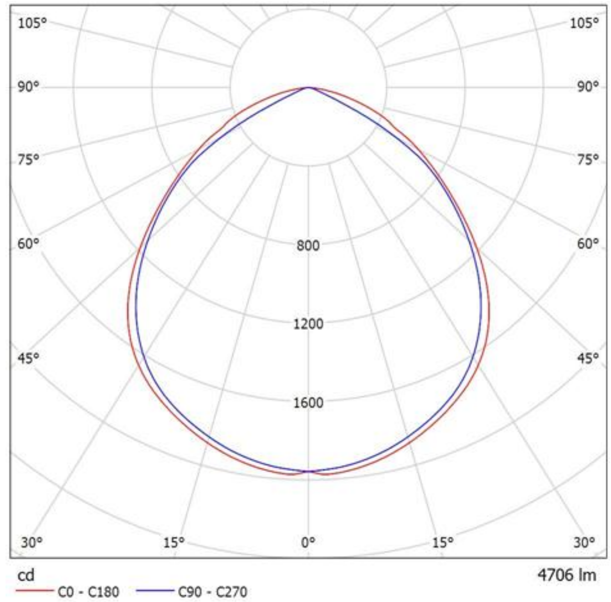


Figure 31 Luminous emittance

Glare Evaluation According to UGR

ρ Ceiling		70	70	50	50	30	70	70	50	50	30
ρ Walls		50	30	50	30	30	50	30	50	30	30
ρ Floor		20	20	20	20	20	20	20	20	20	20
Room Size X	Y	Viewing direction at right angles to lamp axis					Viewing direction parallel to lamp axis				
2H	2H	22.3	23.4	22.5	23.7	23.9	21.6	22.8	21.9	23.1	23.3
	3H	23.4	24.4	23.7	24.7	25.0	21.7	22.7	22.0	23.0	23.3
	4H	23.8	24.8	24.1	25.0	25.3	21.6	22.6	21.9	22.9	23.2
	6H	24.0	24.9	24.3	25.2	25.5	21.6	22.5	21.9	22.8	23.1
	8H	24.0	24.9	24.4	25.2	25.5	21.5	22.4	21.9	22.7	23.0
	12H	24.0	24.8	24.4	25.2	25.5	21.5	22.3	21.9	22.6	23.0
4H	2H	22.7	23.7	23.0	24.0	24.2	22.1	23.1	22.5	23.4	23.7
	3H	23.9	24.8	24.3	25.1	25.4	22.3	23.1	22.6	23.4	23.7
	4H	24.4	25.2	24.8	25.5	25.9	22.2	22.9	22.6	23.3	23.7
	6H	24.7	25.4	25.1	25.7	26.1	22.2	22.8	22.6	23.2	23.6
	8H	24.8	25.4	25.2	25.7	26.2	22.1	22.7	22.6	23.1	23.5
	12H	24.8	25.3	25.2	25.7	26.1	22.1	22.6	22.5	23.0	23.5
8H	4H	24.4	25.0	24.8	25.4	25.8	22.3	22.9	22.7	23.2	23.7
	6H	24.7	25.2	25.2	25.6	26.1	22.2	22.7	22.7	23.1	23.6
	8H	24.8	25.2	25.3	25.6	26.1	22.2	22.6	22.7	23.1	23.5
	12H	24.8	25.1	25.3	25.6	26.1	22.2	22.5	22.7	23.0	23.5
12H	4H	24.4	24.9	24.8	25.3	25.7	22.3	22.8	22.7	23.2	23.6
	6H	24.7	25.1	25.2	25.6	26.0	22.2	22.6	22.7	23.1	23.5
	8H	24.7	25.1	25.2	25.6	26.1	22.2	22.5	22.7	23.0	23.5
Variation of the observer position for the luminaire distances S											
S = 1.0H		+0.2 / -0.3					+0.4 / -0.5				
S = 1.5H		+0.4 / -0.7					+0.8 / -1.6				
S = 2.0H		+0.8 / -1.3					+1.9 / -6.5				
Standard table		BK04					BK01				
Correction Summand		7.4					4.2				
Corrected Glare Indices referring to 4706lm Total Luminous Flux											

Figure 32 Glare Evaluation According to UGR

6.6KV Unit 2 Breaker Room / Summary

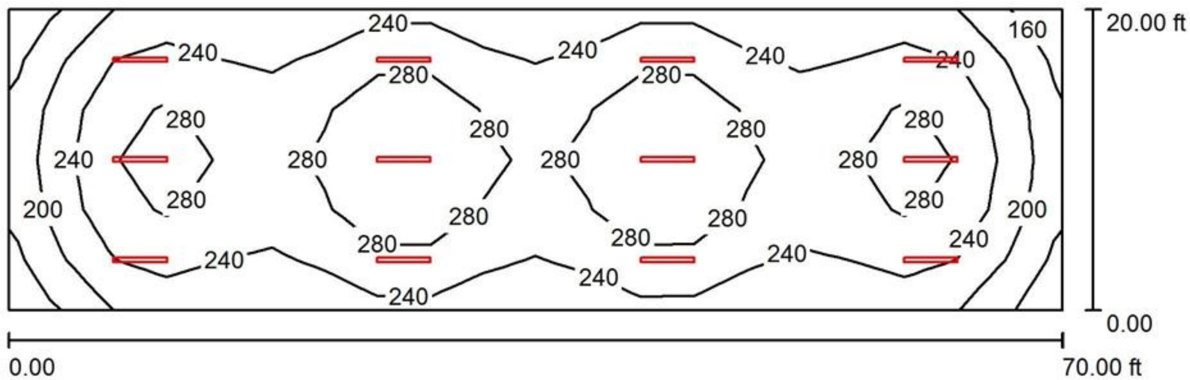


Figure 33 Isolux Diagram

Height of Room: 25.000 ft, Mounting Height: 15.000 ft, Light loss factor: 0.80

Surface	ρ [%]	E_{av}[lx]	E_{min} [lx]	E_{max} [lx]	U0
Workplane	/	252	154	324	0.609
Floor	20	232	140	284	0.603
Ceiling	80	40	30	45	0.756
Walls (4)	50	95	28	290	/

Workplane:

Height: 2.493 ft

Grid: 20 x 6 Points

Boundary Zone: 0.000 ft

Illuminance Quotient (according to LG7): Walls / Working Plane: 0.363, Ceiling / Working Plane: 0.157.

No.	Pieces	Designation (Correction Factor)	φ(Luminaire) [lm]	φ (Lamps) [lm]	P [W]
1	12	DIALIGHT LSA3C4M2F SafeSite LED Linear 4700	4706	4706	67

	Lumens, 1181mm, Medium Distribution, Diffused Glass Lenss (1.000)			
	Total	56476	56476	804

Specific connected load: 0.57 W/sq ft = 0.23 W/sq ft/100 lx (Ground area: 1400.03 sq ft)

6.6KV Unit 2 Breaker Room / Luminaires (layout plan)

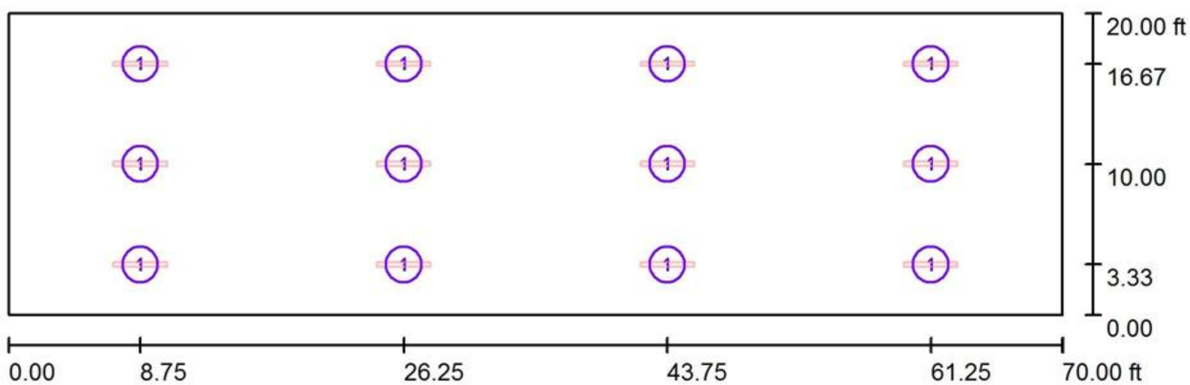


Figure 34 6.6KV Unit 2 Breaker Room / Luminaires (layout plan)

6.6KV Unit 2 Breaker Room / Photometric Results

Total Luminous Flux: 56476 lm

Total Load: 804.0 W

Light loss factor: 0.80

Boundary Zone: 0.000 ft

Surface	Average illuminances [lx]			Reflection factor [%]	Average luminance [cd/m²]
	Direct	Indirect	Total		
Workplane	204	48	252	/	/
Floor	182	50	232	20	15
Ceiling	0	40	40	80	10

Wall 1	56	44	100	50	16
Wall 2	35	43	78	50	12
Wall 3	56	43	99	50	16
Wall 4	35	43	78	50	12

Uniformity on the working plane

u0: 0.609 (1:2)

Emin / Emax: 0.474 (1:2)

Illuminance Quotient (according to LG7): Walls / Working Plane: 0.363, Ceiling / Working Plane: 0.157.

Specific connected load: 0.57 W/sq ft = 0.23 W/sq ft/100 lx (Ground area: 1400.03 sq ft)

6.6KV Unit 2 Breaker Room / 3D Rendering

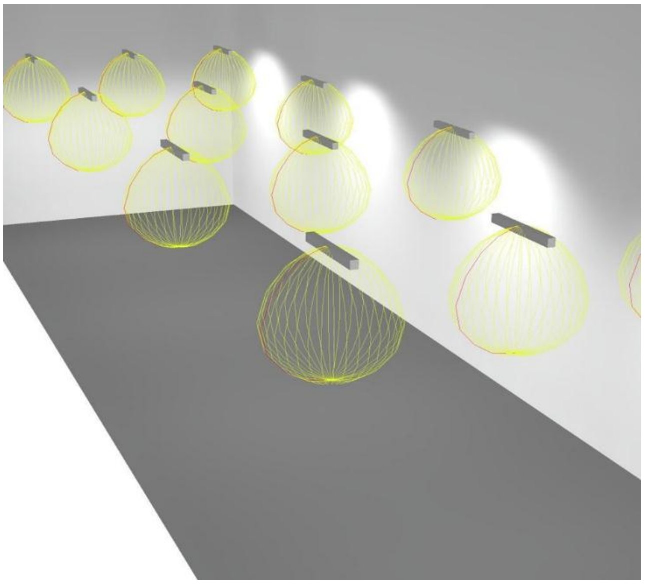


Figure 35 3D Rendering of Unit 2 6.6 KV SWGR

6.6KV Unit 2 Breaker Room / Workplane / Value Chart (E)

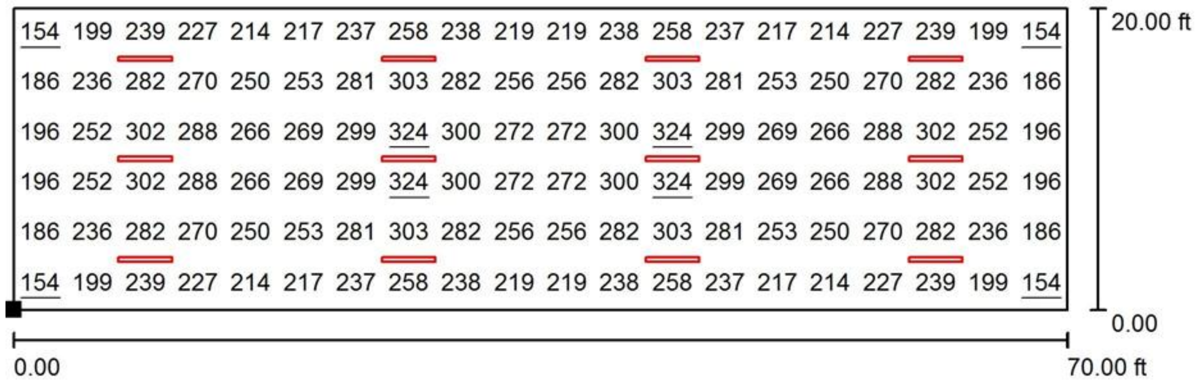


Figure 36 6.6KV Unit 2 Breaker Room / Workplane / Value Chart (E)

Values in Lux, Scale 1 : 153

Position of surface in room:

Marked point: (0.000 ft, 0.000 ft, 2.493 ft)

Grid: 20 x 6 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	Emin / Emax
252	154	324	0.609	0.474

6.6 415 V MLDB Room

Main Lighting Distribution Board MLDB is a panel or enclosure that houses the fuses, circuit breakers and ground leakage protection units where the electrical energy, which is used to distribute electrical power to numerous individual circuits or consumer points, is taken in from the transformer or an upstream panel. Panels are assembled in a systematic manner such as incomer section and outgoing section.

A MDB is comprised of a free-standing enclosure, a bus bar system, MCCB's, metering and support equipment’s and required current transformers.

Figure 37 415 V MLDB Room

Design Requirement

Target Illuminance (E_{avg}): 200 lux

Target Uniformity (U_0): ≥ 0.4

Design aim: To achieve uniform illumination of the mentioned area which is used to monitor and measure the data perfectly with proper lighting. Also the room temperature is at normal temperature so using a linear lamp is good decision in this lighting design

DIALux Simulation Report:

DIALux simulation report is based on the arrangement of luminaire chosen and the number of luminous used for the designed to get the target illuminance. The illuminance level should be as per the requirements and IS Standard based.

Height of Room: 20.000 ft, Mounting Height: 12.000 ft, Light loss factor:0.80

Values in Lux, Scale 1:88

415 V MLDB Room / Luminaire parts list

SIGNIFY DAY-BRITE - CFI LBX40L840-UNV

4'LBX 2-2LP 1.0 4000K BOARDS 40W DRIVER

2.7K RESISTOR OPEN

Article No.: LBX40L840-UNV

Luminous flux (Luminaire): 4654 lm

Luminous flux (Lamps): 4654 lm

Luminaire Wattage: 31.0 W

Luminaire classification according to CIE: 100

CIE flux code: 47 79 96 100 100

Fitting: 1 x LED. LUMINAIRE OUTPUT = 4655

LUMENS (Correction Factor 1.000).

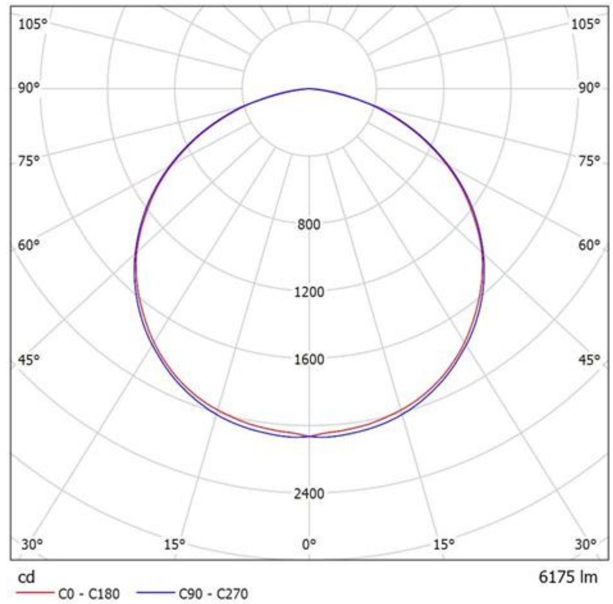


Figure 38 Luminous emittance

415 V MLDB Room / Summary

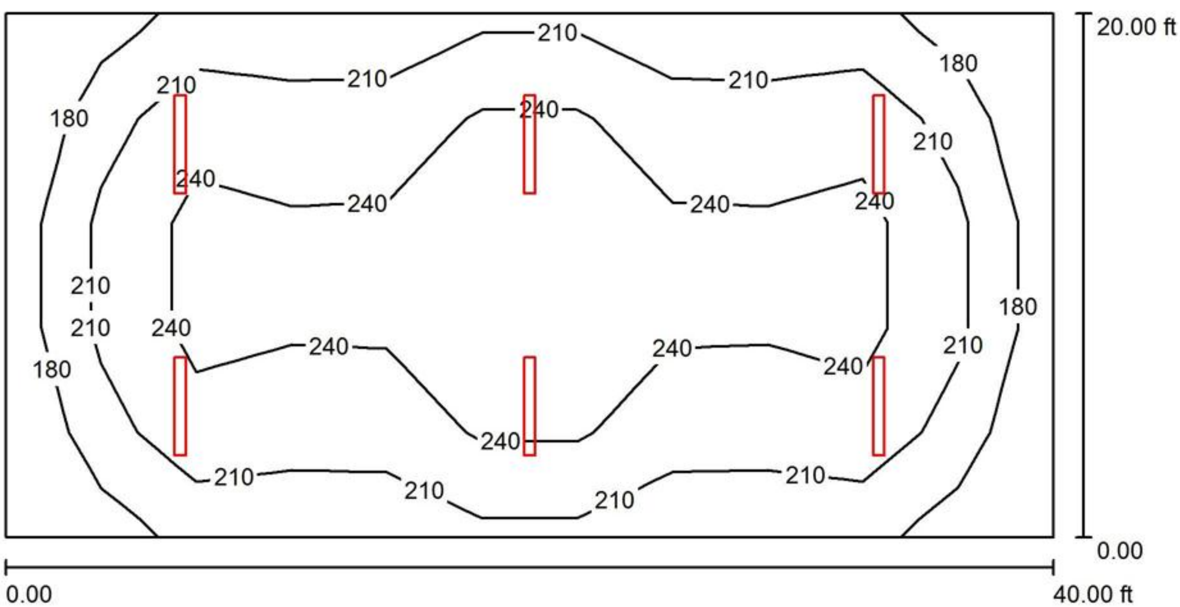


Figure 39 Isolux Diagram

Surface	ρ [%]	E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0
Workplane	/	224	155	276	0.693
Floor	20	197	126	240	0.641
Ceiling	80	37	27	43	0.731
Walls (4)	50	89	26	240	/

Figure 40 values of the average illuminance & overall uniformity on different surface and LPD value of the room

Workplane:

Height: 2.493 ft

Grid: 11 x 5 Points

Boundary Zone: 0.000 ft

Illuminance Quotient (according to LG7): Walls / Working Plane: 0.389, Ceiling / Working Plane: 0.164.

No.	Pieces	Designation (Correction Factor)	φ(Luminaire) [lm]	φ (Lamps) [lm]	P [W]
1	6	SIGNIFY DAY-BRITE - CFI LBX40L840-UNV 4'LBX 2-2LP 1.0 4000K BOARDS 40W DRIVER 2.7K RESISTOR OPEN (1.000)	4654	4654	31
		Total	27923	27923	186

Specific connected load: 0.23 W/sq ft = 0.10 W/sq ft/100 lx (Ground area: 800.02 sq ft)

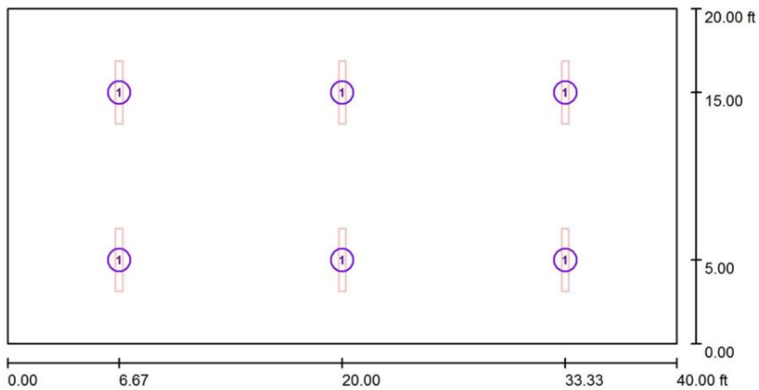


Figure 41 Lumianaire layout of 415 V MLDB Room

415 V MLDB Room / Luminaires (layout plan)

Total Luminous Flux:27923 lm

Total Load: 186.0 W

Light loss factor: 0.80

Boundary Zone: 0.000 ft

Surface	Average illuminances [lx] direct	indirect	total	Reflection factor [%]	Average luminance [cd/m²]
Workplane	179	44	224	/	/
Floor	151	47	197	20	13
Ceiling	0.00	37	37	80	9.30
Wall 1	53	40	92	50	15
Wall 2	45	39	84	50	13
Wall 3	53	39	92	50	15
Wall 4	45	39	84	50	13

Uniformity on the working plane u0: 0.693 (1:1)

Emin / Emax: 0.562 (1:2)

Illuminance Quotient (according to LG7): Walls / Working Plane: 0.389, Ceiling / Working Plane: 0.164.

Specific connected load: 0.23 W/sq ft = 0.10 W/sq ft/100 lx (Ground area: 800.02 sq ft)

415 V MLDB Room / 3D Rendering

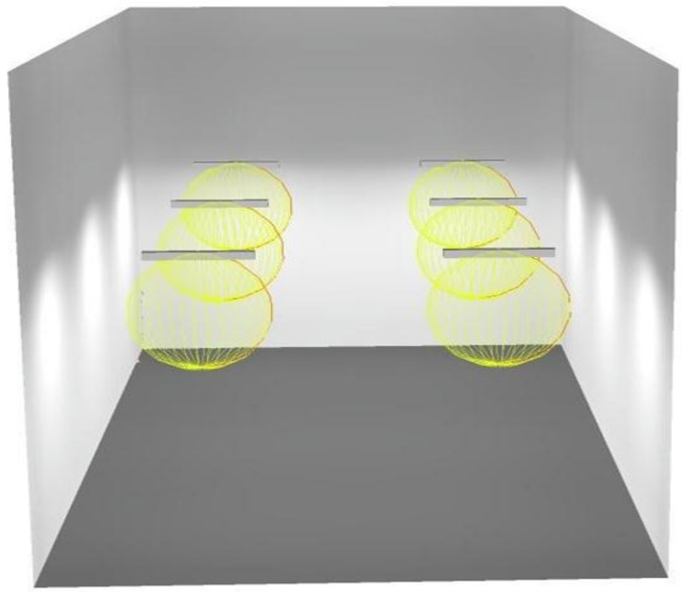


Figure 42 415 V MLDB Room / 3D Rendering

415 V MLDB Room / Workplane / Value Chart (E)

Figure 43 415 V MLDB Room / Workplane / Value Chart (E)

Position of surface in room:

Marked point: (0.000 ft, 0.000 ft, 2.493 ft)

Grid: 11 x 5 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	Emin / Emax
224	155	276	0.693	0.562

6.7 415 V Unit 1 Turbine MCC & Boiler MCC

A motor control center (MCC) is an assembly to control some or all electric motors in a central location. It consists of multiple enclosed sections having a common power bus and with each section containing a combination starter, which in turn consists of motor starter, fuses or circuit breaker, and power disconnect.A motor control center can also include push buttons, indicator lights, variable-frequency drives, programmable logic controllers, and metering equipment. It may be combined with the electrical service entrance for the building.

Figure 44 415 V Unit 1 Turbine MCC & Boiler MCC

<u>Design Requirement</u>

Target Illuminance (E_{avg}): 200 lux

Target Uniformity (U_0): ≥ 0.4

Design aim: To achieve uniform illumination of the mentioned area which is used to monitor and measure the data perfectly with proper lighting. Also the room temperature is at normal temperature so using a linear lamp is good decision in this lighting design

DIALux Simulation Report:

DIALux simulation report is based on the arrangement of luminaire chosen and the number of luminous used for the designed to get the target illuminance. The illuminance level should be as per the requirements and IS Standard based.

415 DIALIGHT LSA3C4M2F SafeSite LED Linear 4700

Lumens, 1181mm, Medium Distribution, Diffused Glass Lenss

Article No.: LSA3C4M2F

Luminous flux (Luminaire): 4706 lm

Luminous flux (Lamps): 4706 lm

Luminaire Wattage: 67.0 W

Luminaire classification according to CIE: 100

CIE flux code: 55 88 99 100 100

Fitting: 1 x SafeSite LED Linear - LSA3C4M2F 67W 4706.29lm (Correction Factor 1.000).

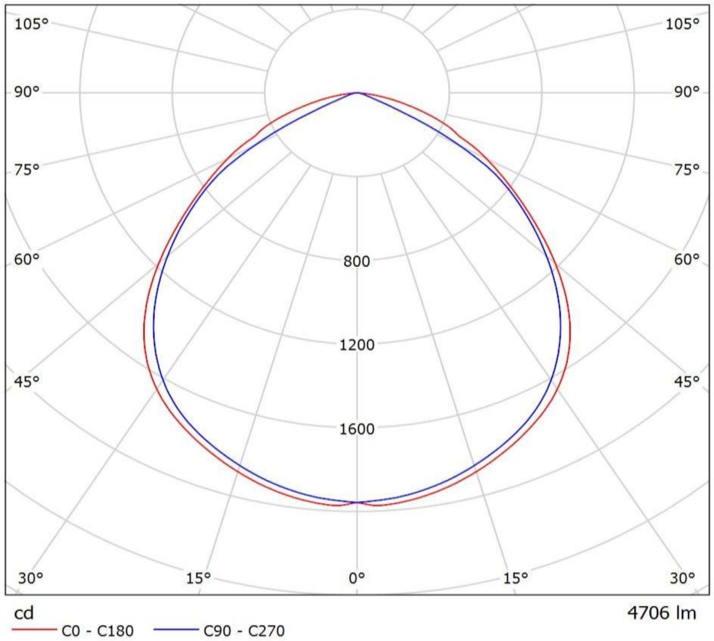


Figure 45 Luminous intensity distribution curve

Glare Evaluation According to UGR

ρ Ceiling		70	70	50	50	30	70	70	50	50	30
ρ Walls		50	30	50	30	30	50	30	50	30	30
ρ Floor		20	20	20	20	20	20	20	20	20	20
Room Size X	Y	Viewing direction at right angles to lamp axis					Viewing direction parallel to lamp axis				
2H	2H	22.3	23.4	22.5	23.7	23.9	21.6	22.8	21.9	23.1	23.3
	3H	23.4	24.4	23.7	24.7	25.0	21.7	22.7	22.0	23.0	23.3
	4H	23.8	24.8	24.1	25.0	25.3	21.6	22.6	21.9	22.9	23.2
	6H	24.0	24.9	24.3	25.2	25.5	21.6	22.5	21.9	22.8	23.1
	8H	24.0	24.9	24.4	25.2	25.5	21.5	22.4	21.9	22.7	23.0
	12H	24.0	24.8	24.4	25.2	25.5	21.5	22.3	21.9	22.6	23.0
4H	2H	22.7	23.7	23.0	24.0	24.2	22.1	23.1	22.5	23.4	23.7
	3H	23.9	24.8	24.3	25.1	25.4	22.3	23.1	22.6	23.4	23.7
	4H	24.4	25.2	24.8	25.5	25.9	22.2	22.9	22.6	23.3	23.7
	6H	24.7	25.4	25.1	25.7	26.1	22.2	22.8	22.6	23.2	23.6
	8H	24.8	25.4	25.2	25.7	26.2	22.1	22.7	22.6	23.1	23.5
	12H	24.8	25.3	25.2	25.7	26.1	22.1	22.6	22.5	23.0	23.5
8H	4H	24.4	25.0	24.8	25.4	25.8	22.3	22.9	22.7	23.2	23.7
	6H	24.7	25.2	25.2	25.6	26.1	22.2	22.7	22.7	23.1	23.6
	8H	24.8	25.2	25.3	25.6	26.1	22.2	22.6	22.7	23.1	23.5
	12H	24.8	25.1	25.3	25.6	26.1	22.2	22.5	22.7	23.0	23.5
12H	4H	24.4	24.9	24.8	25.3	25.7	22.3	22.8	22.7	23.2	23.6
	6H	24.7	25.1	25.2	25.6	26.0	22.2	22.6	22.7	23.1	23.5
	8H	24.7	25.1	25.2	25.6	26.1	22.2	22.5	22.7	23.0	23.5
Variation of the observer position for the luminaire distances S											
S = 1.0H		+0.2 / -0.3					+0.4 / -0.5				
S = 1.5H		+0.4 / -0.7					+0.8 / -1.6				
S = 2.0H		+0.8 / -1.3					+1.9 / -6.5				
Standard table		BK04					BK01				
Correction Summand		7.4					4.2				
Corrected Glare Indices referring to 4706lm Total Luminous Flux											

Figure 46 Glare Evaluation

415 V Unit 1 Turbine MCC & Boiler MCC / Summary

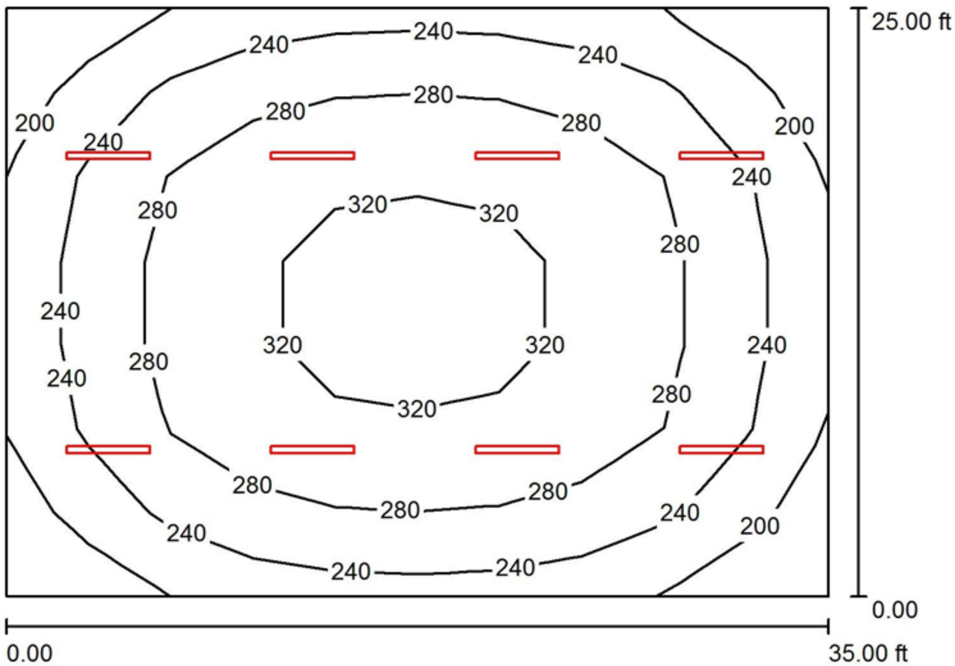


Figure 47 Isolux Diagram

Surface	ρ [%]	E_{av}[lx]	E_{min} [lx]	E_{max} [lx]	U0
Workplane	/	268	175	330	0.654
Floor	20	244	150	302	0.616
Ceiling	80	40	31	47	0.781
Walls (4)	50	97	30	76	/

Workplane:

Height: 2.493 ft
Grid: 10 x 7 Points
Boundary Zone: 0.000 ft

UGR

	Across to luminaire	Axis Lengthways
Left Wall	23	22
Lower Wall	23	22

(CIE, SHR = 0.25.)

Illuminance Quotient (according to LG7): Walls / Working Plane: 0.349, Ceiling / Working Plane: 0.149.

No.	Pieces	Designation (Correction Factor)	φ(Luminaire) [lm]	φ (Lamps) [lm]	P [W]
1	8	DIALIGHT LSA3C4M2F SafeSite LED Linear 4700 Lumens, 1181mm, Medium Distribution, Diffused Glass Lenss (1.000)	4706	4706	67
		Total	37650	37650	536

Specific connected load: 0.61 W/sq ft = 0.23 W/sq ft/100 lx (Ground area: 875.02 sq ft)

415 V Unit 1 Turbine MCC & Boiler MCC / Photometric Results

Total Luminous Flux: 37650 lm

Total Load: 536.0 W

Light loss factor: 0.80

Boundary Zone: 0.000 ft

Surface	**Average illuminances [lx]**			**Reflection factor [%]**	**Average luminance [cd/m²]**
	Direct	Indirect	Total		
Workplane	218	50	268	/	/
Floor	191	53	244	20	16
Ceiling	0.01	40	40	80	10
Wall 1	54	45	99	50	16
Wall 2	49	44	93	50	15
Wall 3	54	45	99	50	16
Wall 4	50	45	95	50	15

415 V Unit 1 Turbine MCC & Boiler MCC / 3D Rendering

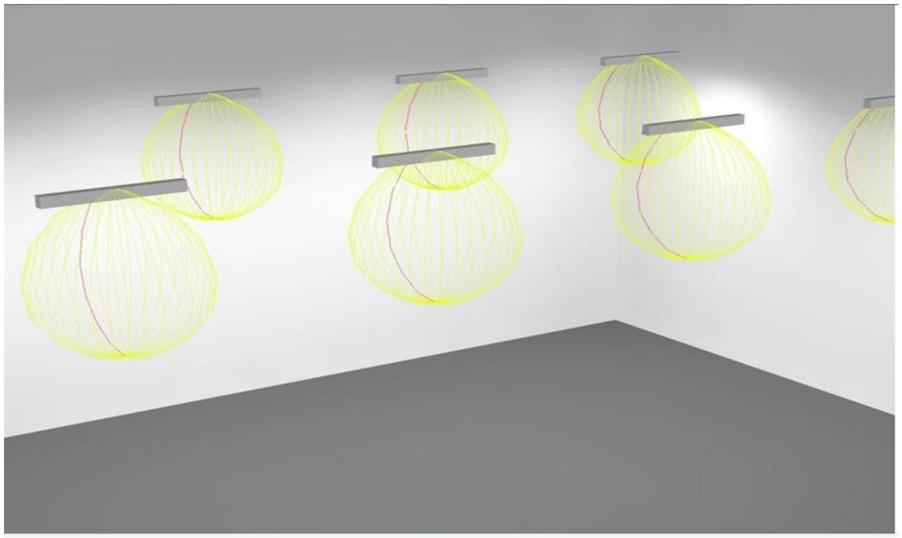


Figure 48 415 V Unit 1 Turbine MCC & Boiler MCC / 3D Rendering

415 V Unit 1 Turbine MCC & Boiler MCC / Workplane / Value Chart (E)

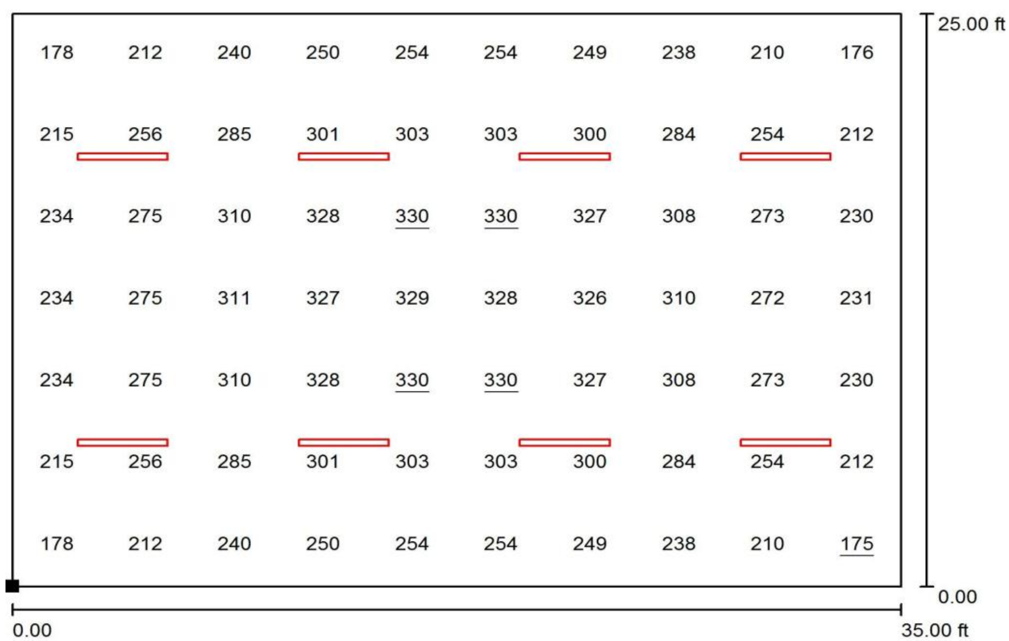


Figure 49 415 V Unit 1 Turbine MCC & Boiler MCC / Workplane / Value Chart (E)

Position of surface in room:

Marked point: (0.000 ft, 0.000 ft, 2.493 ft)

Grid: 10 x 7 Points

E_{av} [lx]	E_{min} [lx]	Emax [lx]	u0	Emin / Emax
268	175	330	0.654	0.532

6.8 CW Water Pump MCC

Cooling water pumps (CWP) play a crucial role in thermal power plants and other industrial facilities where steam turbines are used. Their primary function is to circulate cooling water to remove heat from the condenser, which is crucial for the efficient operation of steam turbines. In CW water pump room MCC controls, measures the features and running conditions motor.

<u>Design Requirement</u>

Target Illuminance (E_{avg}): 200 lux

Target Uniformity (U_0): ≥ 0.4

Design aim: To achieve uniform illumination of the mentioned area which is used to monitor and measure the data perfectly with proper lighting. Also the room temperature is slightly up from normal temperature so using a flameproof lamp is good decision in this lighting design

DIALux Simulation Report:

DIALux simulation report is based on the arrangement of luminaire chosen and the number of luminous used for the designed to get the target illuminance. The illuminance level should be as per the requirements and IS Standard based.

CW Water Pump MCC / Luminaire parts list

DIALIGHT LSA3C4M2F SafeSite LED Linear 4700 Lumens, 1181mm, Medium Distribution, Diffused Glass Lenss

Article No.: LSA3C4M2F

Luminous flux (Luminaire): 4706 lm

Luminous flux (Lamps): 4706 lm

Luminaire Wattage: 67.0 W

Luminaire classification according to CIE: 100

CIE flux code: 55 88 99 100 100

Fitting: 1 x SafeSite LED Linear - LSA3C4M2F 67W 4706.29lm (Correction Factor 1.000).

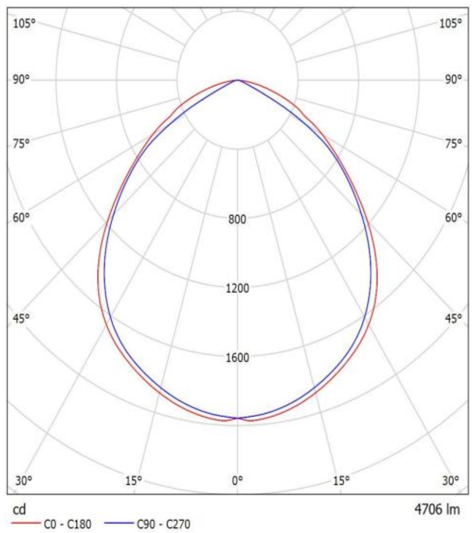


Figure 50 Luminous intensity distribution curve

Glare Evaluation According to UGR											
ρ Ceiling		70	70	50	50	30	70	70	50	50	30
ρ Walls		50	30	50	30	30	50	30	50	30	30
ρ Floor		20	20	20	20	20	20	20	20	20	20
Room Size X	Y	Viewing direction at right angles to lamp axis					Viewing direction parallel to lamp axis				
2H	2H	22.3	23.4	22.5	23.7	23.9	21.6	22.8	21.9	23.1	23.3
	3H	23.4	24.4	23.7	24.7	25.0	21.7	22.7	22.0	23.0	23.3
	4H	23.8	24.8	24.1	25.0	25.3	21.6	22.6	21.9	22.9	23.2
	6H	24.0	24.9	24.3	25.2	25.5	21.6	22.5	21.9	22.8	23.1
	8H	24.0	24.9	24.4	25.2	25.5	21.5	22.4	21.9	22.7	23.0
	12H	24.0	24.8	24.4	25.2	25.5	21.5	22.3	21.9	22.6	23.0
4H	2H	22.7	23.7	23.0	24.0	24.2	22.1	23.1	22.5	23.4	23.7
	3H	23.9	24.8	24.3	25.1	25.4	22.3	23.1	22.6	23.4	23.7
	4H	24.4	25.2	24.8	25.5	25.9	22.2	22.9	22.6	23.3	23.7
	6H	24.7	25.4	25.1	25.7	26.1	22.2	22.8	22.6	23.2	23.6
	8H	24.8	25.4	25.2	25.7	26.2	22.1	22.7	22.6	23.1	23.5
	12H	24.8	25.3	25.2	25.7	26.1	22.1	22.6	22.5	23.0	23.5
8H	4H	24.4	25.0	24.8	25.4	25.8	22.3	22.9	22.7	23.2	23.7
	6H	24.7	25.2	25.2	25.6	26.1	22.2	22.7	22.7	23.1	23.6
	8H	24.8	25.2	25.3	25.6	26.1	22.2	22.6	22.7	23.1	23.5
	12H	24.8	25.1	25.3	25.6	26.1	22.2	22.5	22.7	23.0	23.5
12H	4H	24.4	24.9	24.8	25.3	25.7	22.3	22.8	22.7	23.2	23.6
	6H	24.7	25.1	25.2	25.6	26.0	22.2	22.6	22.7	23.1	23.5
	8H	24.7	25.1	25.2	25.6	26.1	22.2	22.5	22.7	23.0	23.5
Variation of the observer position for the luminaire distances S											
S = 1.0H		+0.2 / -0.3					+0.4 / -0.5				
S = 1.5H		+0.4 / -0.7					+0.8 / -1.6				
S = 2.0H		+0.8 / -1.3					+1.9 / -6.5				
Standard table		BK04					BK01				
Correction Summand		7.4					4.2				
Corrected Glare Indices referring to 4706lm Total Luminous Flux											

Figure 51 Glare Evaluation

CW Water Pump MCC / Summary

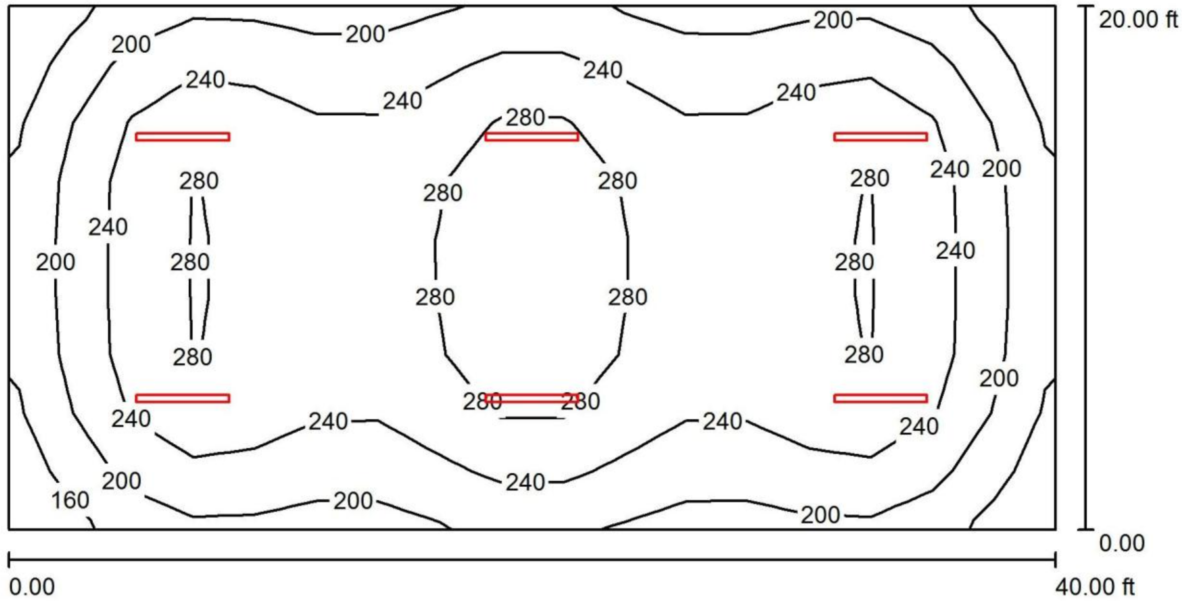


Figure 52 Isolux Diagram

Height of Room: 20.000 ft, Mounting Height: 12.000 ft, Light loss factor: 0.80
Values in Lux, Scale 1:88

Surface	ρ [%]	E_{av}[lx]	E_{min} [lx]	E_{max} [lx]	U0
Workplane	/	239	131	308	0.550
Floor	20	217	129	269	0.595
Ceiling	80	35	26	42	0.724
Walls (4)	50	82	25	205	/

Workplane:

Height:	2.493 ft
Grid:	17 x 9 Points
Boundary Zone:	0.000 ft

UGR	Lengthways	Across to luminaire axis
Left Wall	24	22
Lower Wall	23	22

Illuminance Quotient (according to LG7): Walls / Working Plane: 0.319, Ceiling / Working Plane: 0.146.

Luminaire Parts List

No.	Pieces	Designation (Correction Factor)	φ(Luminaire) [lm]	φ (Lamps) [lm]	P [W]
1	6	DIALIGHT LSA3C4M2F SafeSite LED Linear 4700 Lumens, 1181mm, Medium Distribution, Diffused Glass Lenss (1.000)	4706	4706	67
		Total	28238	28328	402

Specific connected load: 0.50 W/sq ft = 0.21 W/sq ft/100 lx (Ground area: 800.02 sq ft)

CW Water Pump MCC / Luminaires (layout plan)

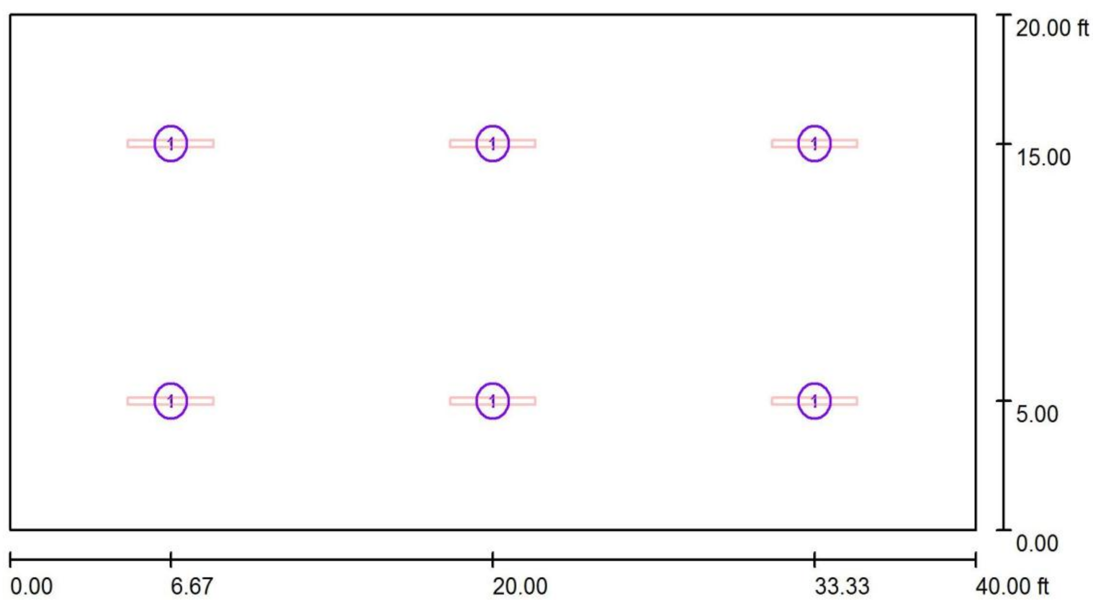


Figure 53 CW Water Pump MCC / Luminaires (layout plan)

Total Luminous Flux: 28238 lm

Total Load: 402.0 W

Light loss factor:0.80

Boundary Zone:0.000 ft

Surface	Average illuminances [lx]			Reflection factor [%]	Average luminance [cd/m²]
	Direct	Indirect	Total		
Workplane	200	40	240	/	/
Floor	173	44	217	20	14
Ceiling	0	35	35	80	8.99
Wall 1	48	38	86	50	14
Wall 2	35	38	73	50	12
Wall 3	48	39	87	50	14
Wall 4	35	38	73	50	12

CW Water Pump MCC / 3 D Rendering

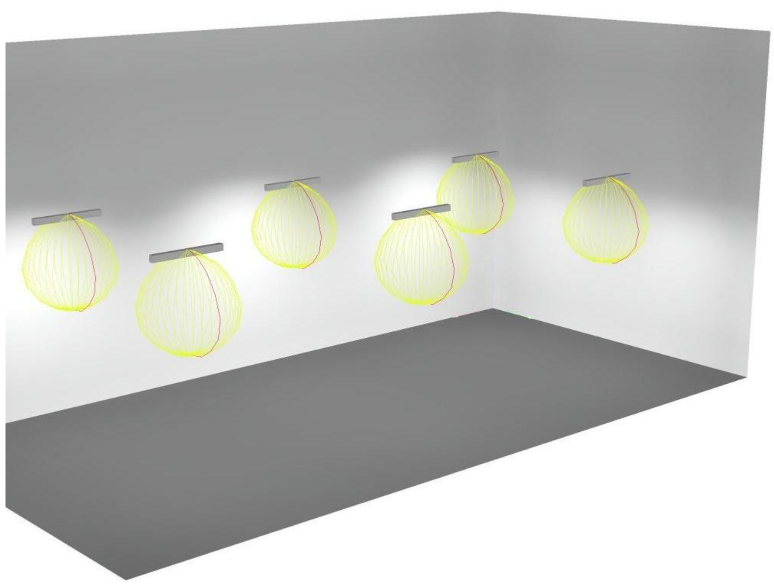


Figure 54 CW Water Pump MCC / 3 D Rendering

CW Water Pump MCC / Workplane / Value Chart (E)

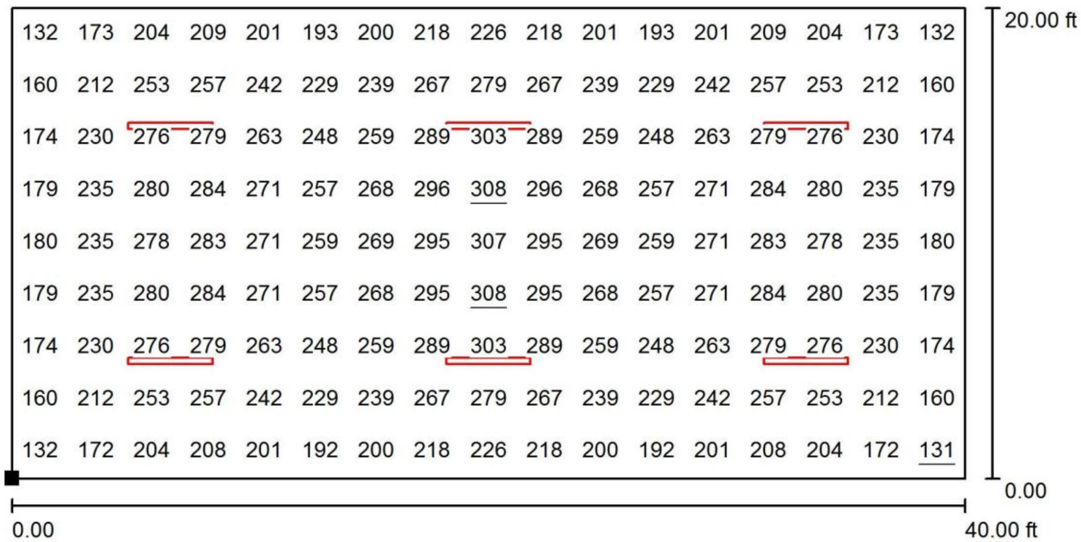


Figure 55 CW Water Pump MCC / Workplane / Value Chart (E)

Position of surface in room:

Marked point:

(0.000 ft, 0.000 ft, 2.493 ft)

Grid: 17 x 9 Points

E_{av} [lx]	E_{min} [lx]	Emax [lx]	u0	Emin / Emax
239	131	308	0.550	0.427

6.9 PMCC Unit 1 SWGR Room

Power cum Motor Control Centre panel is a combination of Motor Control Centre (MCC) and Power Control Centre (PCC). These panels provide the power distribution & monitoring solution for your plant. Necessary safety features along with required accessories are provided for safe operation and operator safety.

- Ingress protection – standard IP42, up to IP55 when required

- Design Isc level – up to 65KA for 1 Sec
- Rated Current – Up to 6300A
- Busbar material – EC Grade Copper / E91E Grade Aluminium

Figure 56 PMCC Unit 1 SWGR

<u>Design Requirement</u>

Target Illuminance (E_{avg}): 250 lux

Target Uniformity (U_0): ≥ 0.4

Design aim: To achieve uniform illumination of the mentioned area which is used to monitor and measure the data perfectly with proper lighting. Also the room temperature is slightly up from normal temperature so using a flameproof lamp is good decision in this lighting design

DIALux Simulation Report:

DIALux simulation report is based on the arrangement of luminaire chosen and the number of luminous used for the designed to get the target illuminance. The illuminance level should be as per the requirements and IS Standard based.

PMCC 415V SWGR / Luminaire parts list

SIGNIFY DAY-BRITE - CFI LBX40L840-UNV-A 4' LBX 2-2LP 1.0 4000K BOARDS 40W DRIVER 2.7K RESISTOR AISLE OPTICS

Article No.: LBX40L840-UNV-A

Luminous flux (Luminaire): 4656 lm

Luminous flux (Lamps): 4656 lm

Luminaire Wattage: 30.9 W

Luminaire classification according to CIE: 100

CIE flux code: 43 86 99 100 100

Fitting: 1 x LED. LUMINAIRE OUTPUT = 4656 LUMENS (Correction Factor 1.000)

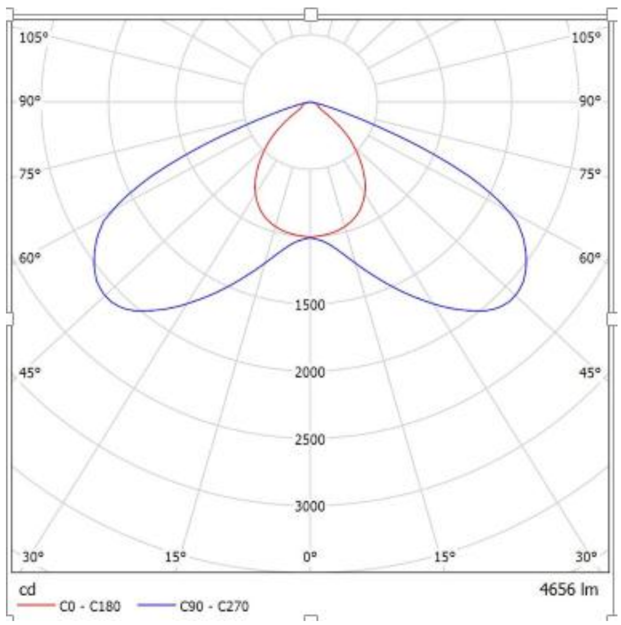


Figure 57 Luminous intensity distribution curve

PMCC 415V SWGR / Summary

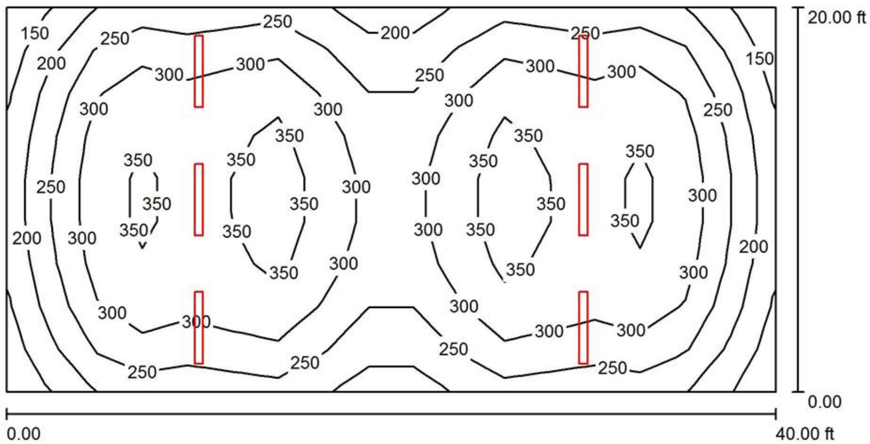


Figure 58 Isolux Diagram

Height of Room: 10.000 ft, Mounting Height: 9.000 ft, Light loss factor: Values in Lux, Scale 1:88

Surface	ρ [%]	E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0
Workplane	/	283	134	383	0.473
Floor	20	252	162	340	0.644
Ceiling	80	52	34	59	0.649
Walls (4)	50	116	35	293	/

Workplane:

Height: 2.493 ft

Grid: 17 x 9 Points

Boundary Zone: 0.000 ft
Illuminance Quotient (according to LG7): Walls / Working Plane: 0.365, Ceiling / Working Plane: 0.184

Luminaire Parts List

No.	Pieces	Designation (Correction Factor)	φ(Luminaire) [lm]	φ (Lamps) [lm]	P [W]

1	6	SIGNIFY DAY-BRITE - CFI LBX40L840-UNVA 4' LBX 2-2LP 1.0 4000K BOARDS 40W DRIVER 2.7K RESISTOR AISLE OPTICS (1.000)	4656	4656	30.9
		Total	27934	27934	185.4

PMCC 415V SWGR / Luminaires (layout plan)

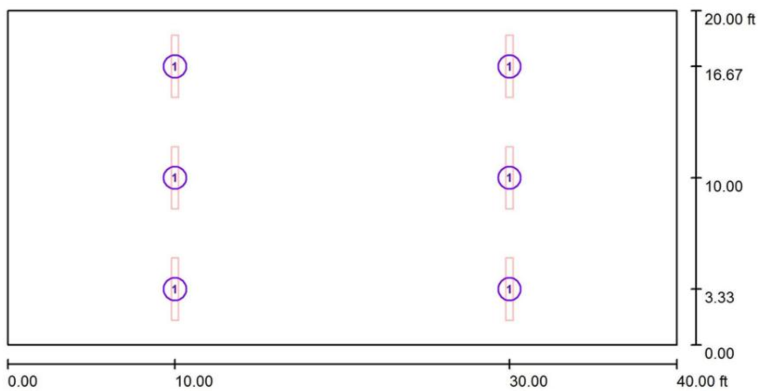


Figure 59 PMCC 415V SWGR / Luminaires (layout plan)

PMCC 415V SWGR / Photometric Results

Total Luminous Flux: 27934 lm

Total Load: 185.4 W

Light loss factor: 0.80

Boundary Zone: 0.000 ft

Surface	Average illuminances [lx] direct	indirect	total	Reflection factor [%]	Average luminance [cd/m²]
Workplane	236	47	283	/	/
Floor	200	52	252	20	16
Ceiling	0.00	52	52	80	13
Wall 1	66	49	115	50	18
Wall 2	71	47	118	50	19
Wall 3	66	49	115	50	18
Wall 4	71	47	118	50	19

Uniformity on the working plane

u0: 0.473 (1:2)

Emin / Emax: 0.350 (1:3)

Illuminance Quotient (according to LG7): Walls / Working Plane: 0.365, Ceiling / Working Plane: 0.184.

Specific connected load: 0.23 W/sq ft = 0.08 W/sq ft/100 lx (Ground area: 800.02 sq ft)

PMCC 415V SWGR / 3D Rendering

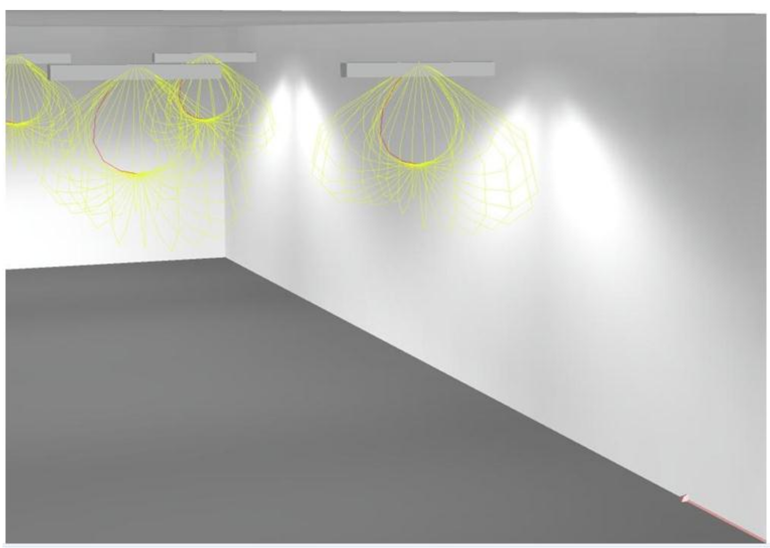


Figure 60 PMCC 415V SWGR / 3D Rendering

PMCC 415V SWGR / Workplane / Value Chart (E)

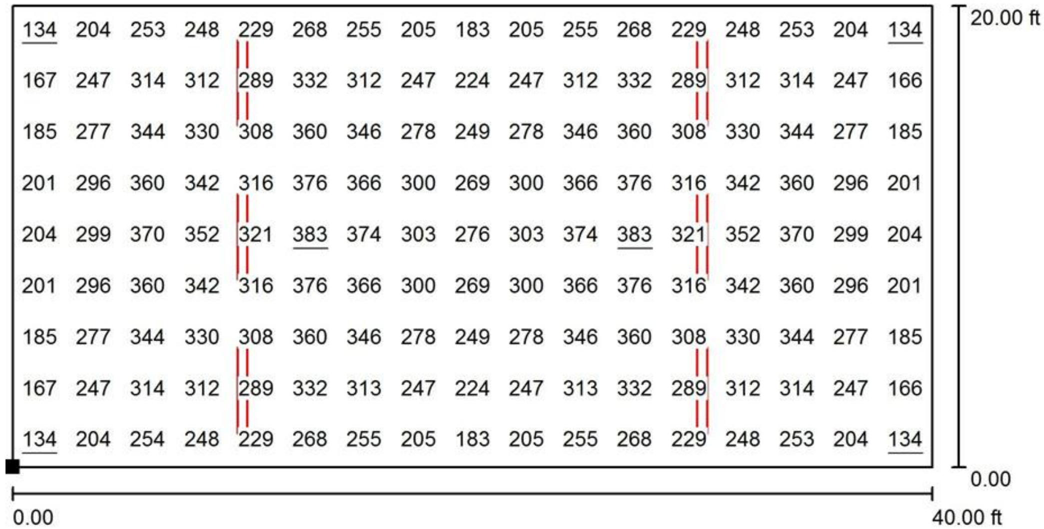


Figure 61 PMCC 415V SWGR / Workplane / Value Chart (E)

Position of surface in room:

Marked point: (0.000 ft, 0.000 ft, 2.493 ft)

Grid: 17 x 9 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	Emin / Emax
283	134	383	0.473	0.350

6.10 Chemical Feeding Room

Chemical feeds are used for wastewater treatment plants, chemical facilities, and other industrial sites requiring chemical injections to clean or purify water. Chemical feeds are most often used in these industries because of the pollutants that continually flow through them.

Figure 62 Chemical Feeding Room

<u>Design Requirement</u>

Target Illuminance (E_{avg}): 250 lux

Target Uniformity (U_0): ≥ 0.4

Design aim: To achieve uniform illumination of the mentioned area which is used to monitor and measure the data perfectly with proper lighting. Also the room temperature is slightly up from normal temperature so using a flameproof lamp is good decision in this lighting design

DIALux Simulation Report:

DIALux simulation report is based on the arrangement of luminaire chosen and the number of luminous used for the designed to get the target illuminance. The illuminance level should be as per the requirements and IS Standard based.

Chemical Feeding Room / Luminaire parts list

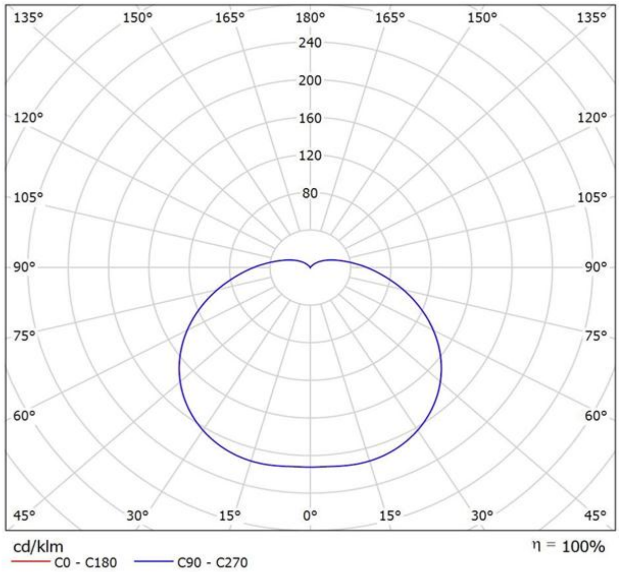


Figure 63 Luminous Intensity Distribution Curve

Glare Evaluation According to UGR

ρ Ceiling	70	70	50	50	30	70	70	50	50	30
ρ Walls	50	30	50	30	30	50	30	50	30	30
ρ Floor	20	20	20	20	20	20	20	20	20	20
Room Size X Y	Viewing direction at right angles to lamp axis					Viewing direction parallel to lamp axis				
2H 2H	23.6	25.0	24.1	25.4	25.9	23.6	25.0	24.1	25.4	25.9
3H	25.4	26.6	25.9	27.1	27.6	25.4	26.6	25.9	27.1	27.6
4H	26.2	27.3	26.7	27.8	28.4	26.2	27.3	26.7	27.8	28.4
6H	26.9	28.0	27.4	28.5	29.1	26.9	28.0	27.4	28.5	29.1
8H	27.2	28.3	27.8	28.8	29.4	27.2	28.3	27.8	28.8	29.4
12H	27.5	28.5	28.1	29.1	29.6	27.5	28.5	28.1	29.1	29.6
4H 2H	24.3	25.5	24.8	25.9	26.5	24.3	25.5	24.8	25.9	26.5
3H	26.3	27.3	26.8	27.8	28.4	26.3	27.3	26.8	27.8	28.4
4H	27.2	28.1	27.8	28.7	29.3	27.2	28.1	27.8	28.7	29.3
6H	28.1	28.9	28.7	29.5	30.1	28.1	28.9	28.7	29.5	30.1
8H	28.5	29.3	29.1	29.8	30.5	28.5	29.3	29.1	29.8	30.5
12H	28.9	29.6	29.5	30.2	30.9	28.9	29.6	29.5	30.2	30.9
8H 4H	27.6	28.3	28.2	28.9	29.6	27.6	28.3	28.2	28.9	29.6
6H	28.7	29.3	29.3	29.9	30.6	28.7	29.3	29.3	29.9	30.6
8H	29.2	29.8	29.9	30.4	31.1	29.2	29.8	29.9	30.4	31.1
12H	29.8	30.2	30.4	30.9	31.6	29.8	30.2	30.4	30.9	31.6
12H 4H	27.6	28.3	28.3	28.9	29.6	27.6	28.3	28.3	28.9	29.6
6H	28.8	29.4	29.5	30.0	30.7	28.8	29.4	29.5	30.0	30.7
8H	29.4	29.9	30.1	30.6	31.3	29.4	29.9	30.1	30.6	31.3
Variation of the observer position for the luminaire distances S										
S = 1.0H	+0.1 / -0.1					+0.1 / -0.1				
S = 1.5H	+0.2 / -0.3					+0.2 / -0.3				
S = 2.0H	+0.3 / -0.5					+0.3 / -0.5				
Standard table	BK08					BK08				
Correction Summand	13.0					13.0				
Corrected Glare Indices referring to 4400lm Total Luminous Flux										

Figure 64 Glare Evaluation according to UGR

Chemical Feeding Room / Summary

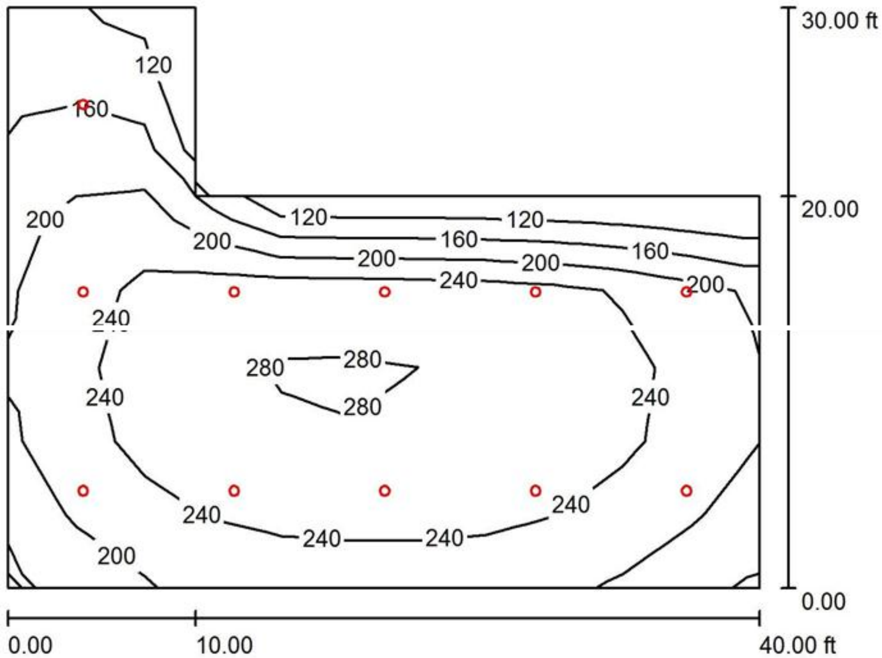


Figure 65 Isolux digram

Surface	ρ [%]	E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0
Workplane	/	232	111	287	0.477
Floor	20	205	96	255	0.469
Ceiling	80	48	29	58	0.604
Walls (6)	50	124	26	363	/

Luminaire Parts List

No.	Pieces	Designation (Correction Factor)	□ (Luminaire) [lm]	□ (Lamps) [lm]	P [W]
1	11	BY200P LED44 L-BCW PSU (1.000)	4400	4400	40.0

			Total: 48400	48400	440.0

Chemical Feeding Room / Luminaires (layout plan)

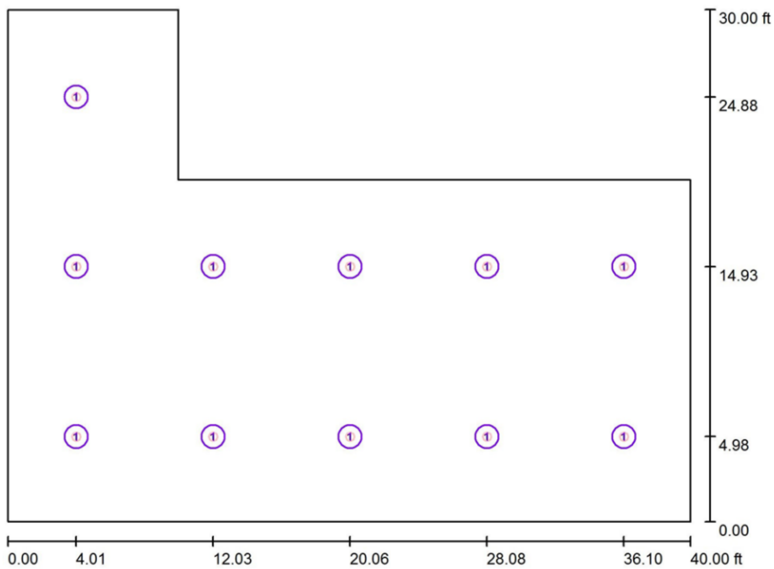


Figure 66 Chemical Feeding Room / Luminaires (layout plan)

Surface	Average illuminances [lx] direct	indirect	total	Reflection factor [%]	Average luminance [cd/m²]
Workplane	164	68	232	/	/
Floor	137	67	205	20	13
Ceiling	1.97	46	48	80	12
Wall 1	76	56	132	50	21
Wall 2	75	56	131	50	21
Wall 3	76	59	135	50	21
Wall 4	34	49	82	50	13
Wall 5	45	47	92	50	15
Wall 6	71	50	121	50	19

Chemical Feeding Room / 3D Rendering

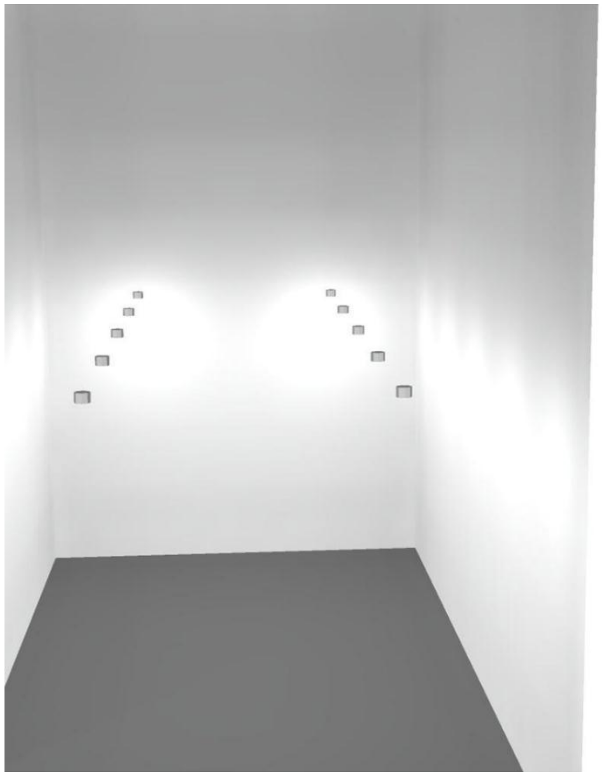


Figure 67 Chemical Feeding Room / 3D Rendering

Chemical Feeding Room / Workplane / Value Chart (E)

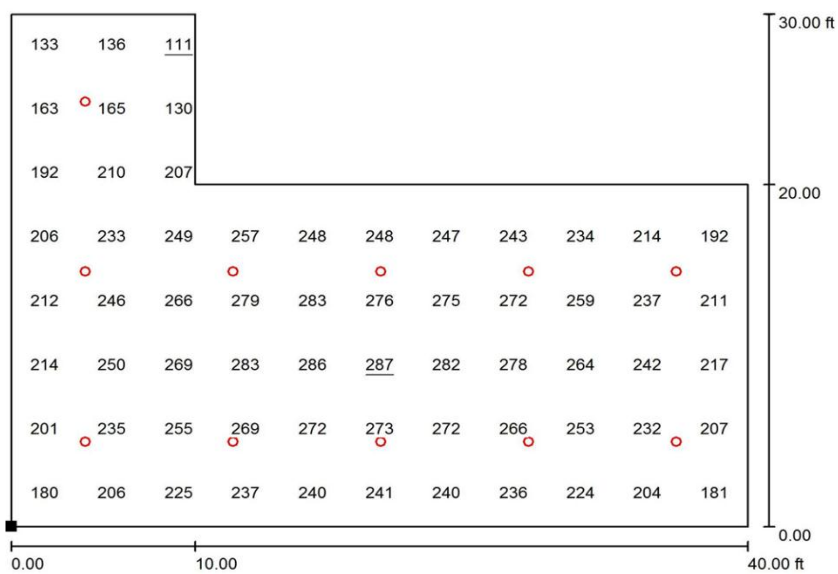


Figure 68 Chemical Feeding Room / Workplane / Value Chart (E)

Grid: 11 x 8 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
232	111	287	0.477	0.386

6.11 10M Width Road inside plant

<u>Design Requirement</u>

Target Illuminance (E_{avg}): 30 lux

Target Uniformity (U_0): ≥ 0.4

Design aim: To achieve uniform illumination of the mentioned area which is used to monitor and measure the data perfectly with proper lighting. For roads street lights luminaires are used.

DIALux Simulation Report:

DIALux simulation report is based on the arrangement of luminaire chosen and the number of luminous used for the designed to get the target illuminance. The illuminance level should be as per the requirements and IS Standard based.

Luminaire Data Sheet

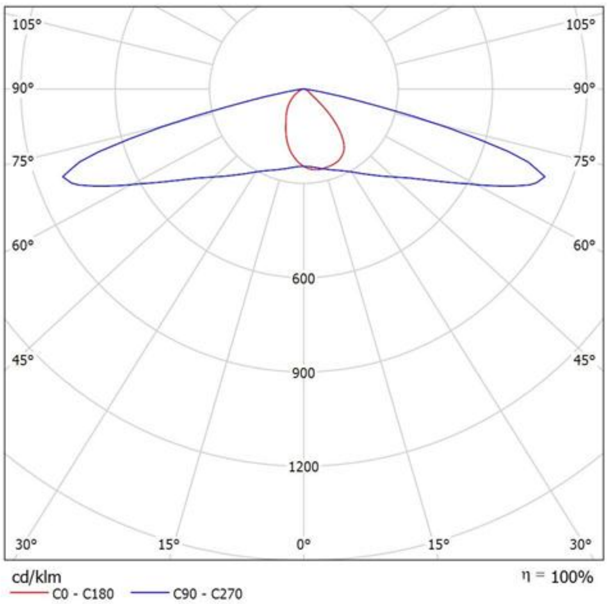


Figure 69 Luminous Intensity distribution curve

Luminaire classification according to CIE: 100

CIE flux code: 37 71 96 100 100

Planning data: Street 1

Street Profile

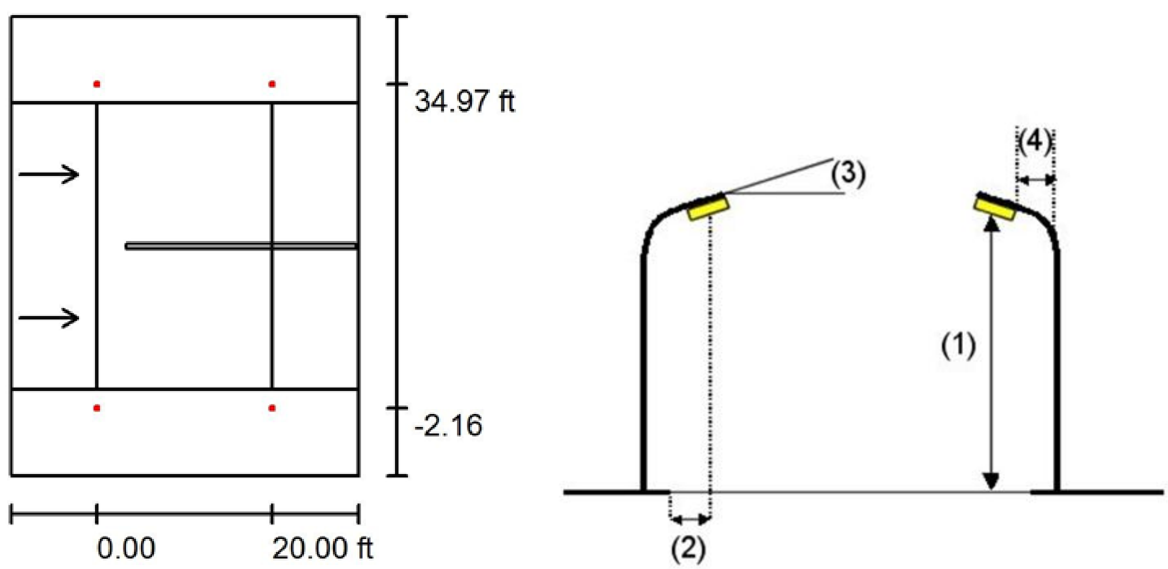
Grass Strip 1 (Width: 9.842 ft)

Roadway 1 (Width: 32.808 ft, Number of lanes: 2, tarmac: R3, q0: 0.070)

Grass Strip 2 (Width: 9.842 ft)

Light loss factor: 0.67

Luminaire Arrangements



Luminaire:	PHILIPS 45W Core SL China_30-09-2022	
Luminous flux (Luminaire):	5425 lm	Maximum luminous intensities
Luminous flux (Lamps):	5430 lm	at 70°: 797 cd/klm at
	42.2 W	80°: 489 cd/klm at
Luminaire Wattage:	Double row, opposing	90°: 12 cd/klm
Arrangement:	20.000 ft	Any direction forming the specified
Pole Distance:	20.000 ft	angle from the downward vertical, with
Mounting Height (1):	19.673 ft	the luminaire installed for use.
Height:	-2.133 ft	

Overhang (2):	No luminous intensities above 95°. Arrangement complies with glare index class D.3.

Boom Angle (3): 5.0 °
Boom Length (4): 0.000 ft

Street 1 / 3 D Rendering

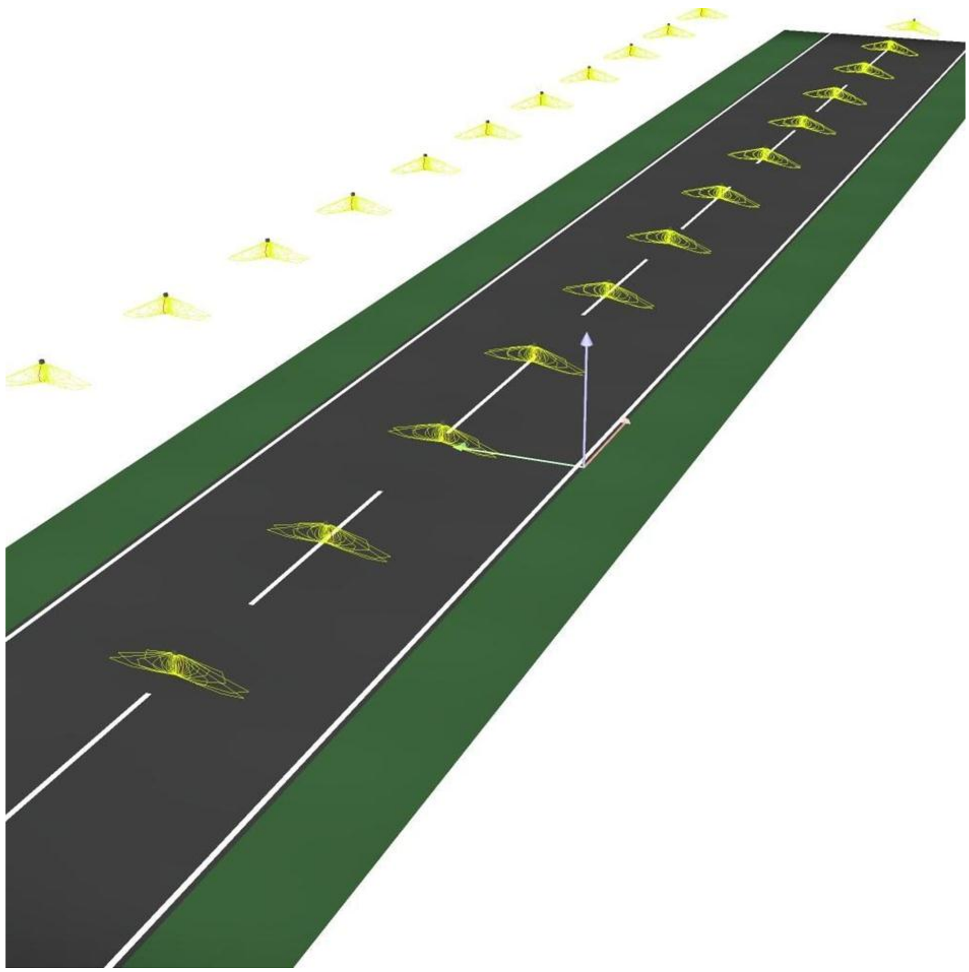


Figure 70 Street 1 / 3 D Rendering

Street 1 / Valuation Field Roadway 1 / Results overview

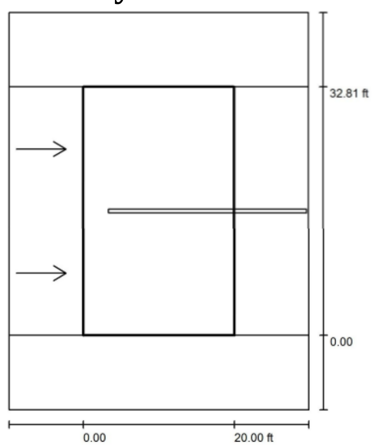


Figure 71 Valuation Field Roadway

Light loss factor: 0.67 Scale 1:149

Grid: 10 x 6 Points

Accompanying Street Elements: Roadway 1. tarmac: R3, q0: 0.070

Selected Lighting Class: ME4a (All lighting performance requirements are met.)

	L_{av} [cd/m²]	U0		Ul	TI [%]	SR
Calculated values:	1.46	0.84		0.95	3	0.93
Required values according to class:	≥ 0.75	≥0.4		≥0.50	≤ 15	≥60
Assigned observer (2 Pieces):						
NO	Observer	Position	L_{av} [cd/m²]	U0	Ul	TI
1	Observer 1	(-196.848, 8.202, 4.921)	1.47	0.84	0.97	3
2	Observer 2	(-196.848,	1.46	0.86	0.95	2

		24.606, 4.921)				

Street 1 / Valuation Field Roadway 1 / Isolines (E)

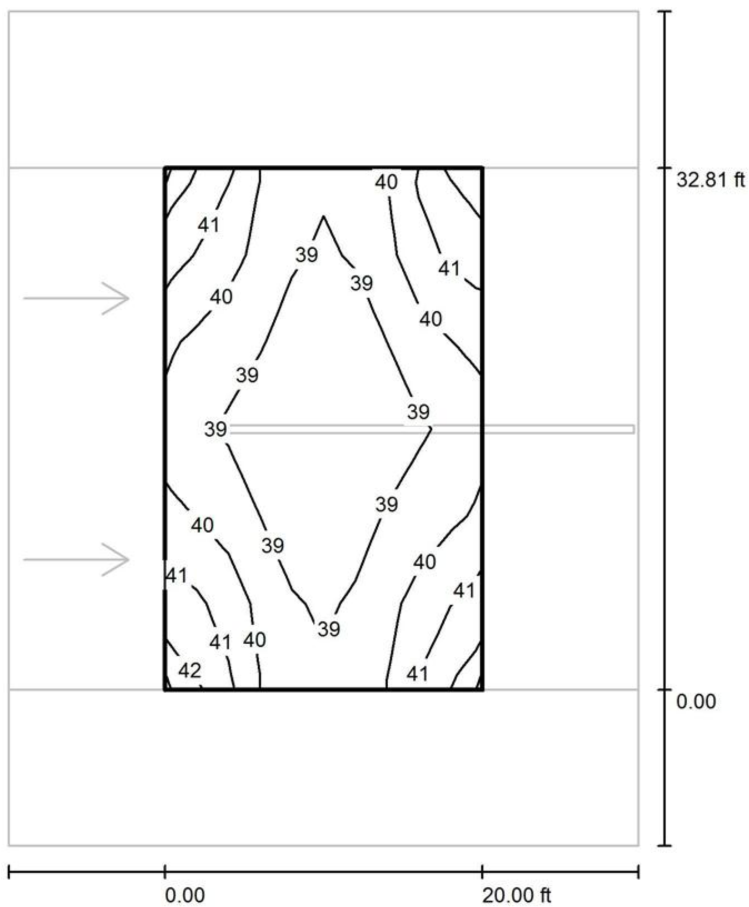


Figure 72 Valuation Field Roadway 1 / Isolines (E)

Street 1 / Valuation Field Roadway 1 / Value Chart (E)

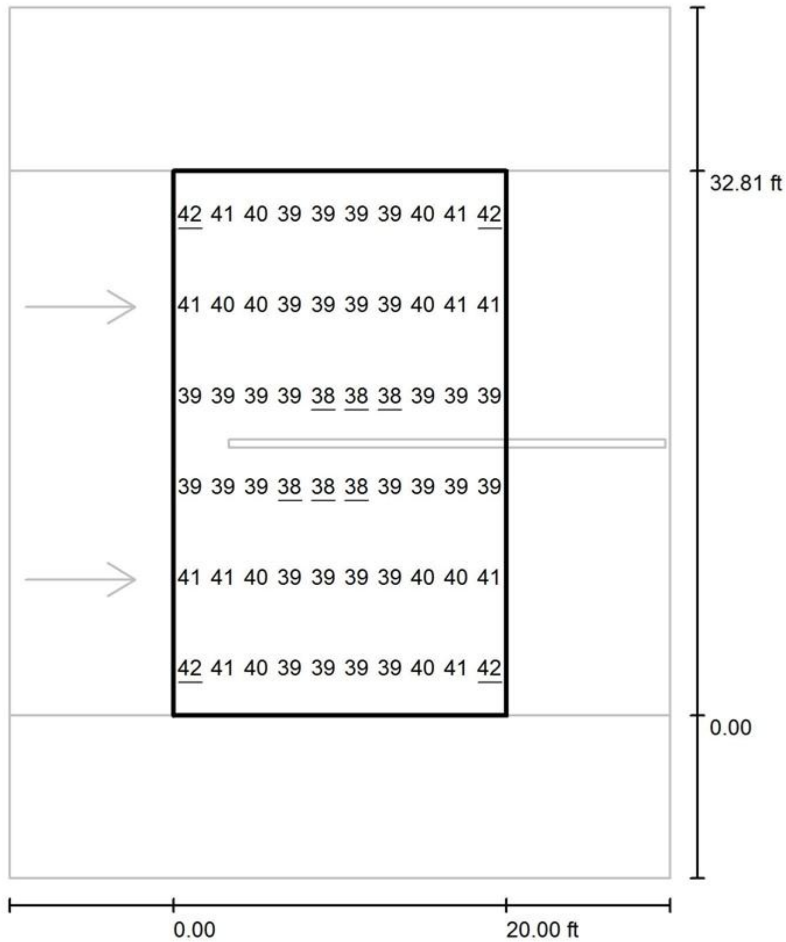
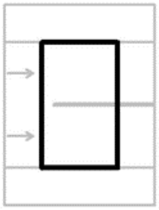


Figure 73 Street 1 / Valuation Field Roadway 1 / Value Chart (E)

Grid: 10 x 6 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
40	38	42	0.956	0.904



Street 1 / Valuation Field Roadway 1 / Table (E)

30.074	42	41	40	39	39	39	39	40	41	42
24.606	41	40	40	39	39	39	39	40	41	41
19.138	39	39	39	39	38	38	38	39	39	39
13.670	39	39	39	38	38	38	39	39	39	39
8.202	41	41	40	39	39	39	39	40	40	41
2.734	42	41	40	39	39	39	39	40	41	42

6.12 Chapter Summary

The organization asked to review the lighting in some areas where it is needed to be improved. For Chemical Feeding Room the flameproof lamps are used to avoid the fire explosion in case of fire. For the Pump house Well Glasses are used to focus on task and required area of lighting. As there was only the installation of Tube lights LED, the organization is interested review all designs or rooms with proper types of luminaires. The design is fully based on the requirement of the organization to review the designs.

7. Conclusion

Industrial lighting is crucial for ensuring safety, security, and proper illumination for various activities. It is essential to determine the appropriate level of lighting to balance the need for visibility with minimizing light pollution and enhancing energy efficiency. Proper lighting not only improves visibility but also ensures safety and security, particularly in industrial settings where poor visibility can lead to accidents.

This project focuses on analyzing processes and activities across different industrial areas to develop an energy-efficient lighting solution. It includes detailed design considerations, luminaire placement, power consumption, and Lighting Power Density (LPD) values. The goal is to educate clients about the benefits of an energy-efficient lighting system, emphasizing how it can reduce energy consumption while maintaining adequate illumination for safety and operational needs.

7.1 Challenges faced

In lighting simulations, the primary inputs typically come from the client's datasheets or documents, which often only provide room dimensions without details such as wall colors or environmental cleanliness. To account for these missing details, standard values are used in calculations. However, discrepancies can arise between calculated and actual conditions due to various factors, including tolerances in calculation methods, testing procedures, and field conditions such as voltage, power supply variations, and temperature fluctuations. Consequently, if the actual site conditions differ from the provided input data, the results may be inconsistent and deviate from expectations.

7.2 Future Scope

More energy efficient LEDs with better lumen efficacy and less maintenance can be developed, which can further reduce energy consumption. Application of daylight in industries sector still acts as a common phenomenon, thus further research and application can be carried out how to implement daylight in industrial sectors.

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