STUDIES ON ENERGY EFFICIENT LIGHTING DESIGN SOLUTIONS FOR FOOD PROCESSING INDUSTRY

A dissertation submitted in
Partial fulfillment of the requirements for the degree of

Master of Technology in Illumination Technology & Design

Submitted By,

SAPTASISH RAY

Exam Roll no. M6ILT24011
Registration no.160419 of 2021-2022

Under the guidance of

Dr. SUDDHASATWA CHAKRABORTY
Associate Professor
Electrical Engineering Department
Jadavpur University

SCHOOL OF ILLUMINATION SCIENCE, ENGINEERING AND DESIGN

JADAVPUR UNIVERSITY

Course affiliated to
Faculty of Engineering & Technology
Jadavpur University
KOLKATA-700032

2024

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

CERTIFICATE OF RECOMMENDATION

This is to certify that the thesis entitles "STUDIES ON ENERGY EFFICIENT LIGHTING DESIGN SOLUTIONS FOR FOOD PROCESSING INDUSTRY" is a bonafide work carried out by **Saptasish Ray** under my supervision and guidance for partial fulfillment of the requirement of M.Tech (Illumination Technology and Design) in School of Illumination Science, Engineering and Design, during the academic session 2023-2024.

THESIS SUPERVISOR
Dr.Suddhasatwa Chakraborty
Associate Professor
Electrical Engineering Department
Jadavpur University

Dr. Parthasarathi Satvaya
DIRECTOR
School of Illumination Science, Engineering and Design,
Jadavpur University,
Kolkata-700 032

Prof. Ratan Mondal
DEAN -Faculty Council of Interdisciplinary Studies Law and Management
Jadavpur University,
Kolkata-700032

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

CERTIFICATE OF APPROVAL

This foregoing thesis is hereby approved as a credible study of an engineering subject carried out and presented in a manner satisfactorily to warranty its acceptance as a prerequisite to the degree for which it has been submitted. It is understood that by this approval the undersigned do not endorse or approve any statement made or opinion expressed or conclusion drawn therein but approve the thesis only for purpose for which it has been submitted.

Board of Examiners

____

____

**** Only in case the thesis is approved.**

DECLARATION OF ORIGINALITY AND COMPLIANCE OF ACADEMIC ETHICS

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

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

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

NAME: SAPTASISH RAY

EXAM. ROLL NUMBER: M6ILT24011

THESIS TITLE: STUDIES ON ENERGY EFFICIENT LIGHTING DESIGN SOLUTIONS FOR FOOD PROCESSING INDUSTRY

SIGNATURE: **DATE:**

Acknowledgement

At the very Beginning, with immense gratitude, I show my gratitude and acknowledge the support, help extended by my supervisor **Dr. Suddhasatwa Chakraborty,** Associate Professor, Electrical Engineering Department, Jadavpur University whose encouragement and phenomenal supervision and visionary guidance from the preliminary to the concluding level enabled me to complete this project work.

I would like to acknowledge my sincere thanks to **Dr. Parthasarathi Satvaya,** Director of School of Illumination Science, Engineering and Design, Jadavpur University, for providing me the opportunity to carry out my project work in Illumination Engineering Laboratory of Jadavpur University.

I would like to thank **Mr. Subhadeep Majumdar,** Head-Lighting Design and Application, Magik Lighting for his guidance and constant support during and after the internship in Magik Lighting.

I would also like to thank all the staff members of Illumination Engineering Department for helping me in times of need.

Last but not least, I wish convey my gratitude to my parents, whose love, teachings and support have brought me this far.

ABSTRACT

Lighting is one of the major energy consuming sector in any type of buildings. Lighting design plays a role in Green Building concepts to provide optimized lighting levels and better energy efficiency. This thesis is based on the lighting design of a food processing industry adhering to Food and Drug administration norms so as to achieve Green Building certification. The study is conducted on a food processing industry located at Guwahati, Assam. Lighting simulations are done on DIALux software in order to analysis lux level, uniformity and Lighting Power Density (LPD) values and compared with the standards.

CONTENTS

CHAPTER 1

INTRODUCTION

1.1. Introduction of Project:

Industrial lighting system is installed for the purpose to provide "energy efficient illumination in quality and quantity sufficient for safety and to enhance visibility and productivity within a pleasant environment."
It is only within recent years however, that the term "energy efficient" has played a major role in the selection of lighting equipment and the design of industrial lighting systems. During the 1950's, 60's and early 70's electrical energy costs for industrial customers were very low and while they were occasionally considered when selecting a lighting system, they were of minor importance. It is now common practice to replace old inefficient lighting system with a new system that provides better lighting, and pay for the new system in one to two years with the savings in energy cost.

1.2. Aims and Objectives:

- Industrial lighting aims for the visualization of tasks, working conditions and economic conditions. Visual tasks may be classified small or very large; dark or light; opaque, transparent or translucent; specular of diffuse surfaces; flat or contoured shapes. With each of the various task situations, lighting should be appropriate for adequate visibility in emerging raw materials into finished products.

- Light should serve not only as a production tool and an aid to safety but should also contribute to the overall environment conditions of the work space.

- The design of a lighting system and selection of equipment is influenced by many economic factors. The choice should not only be based on the project and the running costs of the lighting but also on the relationship of total lighting cost to costs arising out of other plant producing facilities and labor.

- Lighting design for industry completely different from each other, as lighting requirements depends on types of application is done in that particular industry. Ex. lighting requirements for food industry and lighting requirements for tyre industry is completely different.

- In case food industry, CRI is very important as distinguishing the Colour food and in case of tyre industry the luminaries have to be flame proof luminaries. So, depending on the application selection of luminaries are different.

- For any lighting design there are some parameters that are to be achieved; i.e., average Illuminance, uniformity, glare etc. And there are some standards to achieve the above- mentioned parameters.

- For industrial lighting design the standards that are to be follows are as below.

IS-3646: This standard covers the indoor part of industry.
NLC: This is in general guide book for any kind of lighting design.
IS-6665: This is very specific for designing of any kind of industrial area. This covers both outdoor and indoor of an industry.

1.2.1 Objectives:

In this thesis work, effort have been made to study some lighting design of industrial application and its various aspects and parameters along with the practical challenges faced during its application. Every industrial application has different design requirements for the structure and the layout of different lighting requirement.

- **Primary Objective:**

Lighting designing should be clear description of requirements and what need to be created to provide right conditions for the occupant's .Primary objective to provide best lighting design by considering safety and healthy, appearance and comfort.

- **Secondary Objective:**

Designing is done depending up on the application, and reaching standard values for lighting levels. Simultaneously results are generated for each design by considering the power consumption of the fixture and other basic lighting factors required for designing.
Lighting accounts for 5 % to 15% of residential energy use and up to 30% of commercial building energy use, and continues to increase. In certain business types, for example the retail sector, lighting can account for up to 80% of energy use. This is due to long operating hours and the need to "keep things bright" and stand out from the competition. Therefore, in this context, greater sustainability can be achieved by making a conscious decision to reduce the amount of electricity used through appropriate lighting designed by selecting energy efficient luminaires and effective control systems. LED is the new green technology sweeping the lighting industry.

CHAPTER 2

LITERATURE REVIEW AND BASIC OF LIGHTING

2.01.01. Literature review:

Light source:

The selection of light sources is normally the first step in equipment selection. The choice of lamp for a given task must be chosen carefully. This is influenced by the ambiance a designer wishes to create and the tasks being undertaken within the environment. It is best practice to use the highest efficacy lamp available and suitable for the task being undertaken. Colour rendering of lamps are important when choosing a lamps for specific applications. Where lighting quality is of low priority, a low maintenance lamp may be used (e.g. street lighting). When designing for an environment where you want to retain people for long periods of time and create a warm social ambiance a lamp emitting a warm appearance should be used (red/orange). When designing for an environment where a fast turnaround of people may be required (commercial / super market) a lamp emitting a sharp cool / cold appearance (blue) should be used.

Lamp Efficacy = f / P

Where f = luminous flux (lm) P = lamp power.

In many case more than one lamp type will be required, it is good practice to keep the number of different lamps to a minimum to simplify the relamping. The selection of a light source is based on the task requirement, economics and aesthetic consideration. In many case one or more factor will be weighted more heavily than others.

Luminaire position:

Luminaire position is the most crucial parameter of lighting designing. First of all one type of luminaire is used for general lighting to achieve the average Illuminance level and second one is used for the task lighting whose use is confined to the task area. So it's very important reminder for a lighting designer that the wrong position of a luminaire creates a glare which is dangerous for the workers especially in case of industrial lighting.

Basic lighting method:

Artificial lighting has to be designed into buildings to compensate for the lack of daylight in either non glazed locals or during night-time hours of operation. The design methods adopted either utilize the direct beam of light from a lamp when illuminating the working plane in large high ceiling or outdoor spaces or direct, diffuse and reflected light when illuminating confined internal spaces. Using the inverse square law, the Illuminance at a point A on a horizontal plane directly below the light source (L) could be calculated from

$E = Io/H^2$

Where

E0 = Illuminance on measurement plane (lx)

Io = intensity towards point A (cd)

H = height of light source above the plane (m)

Average Illuminance:

When designing a lighting system for more confined areas with low ceiling heights a different method is required since the point of illumination is illuminated by direct and diffused / reflected light from surrounding surfaces. The method used for determining Lumens required is the "Lumen Formula" as shown below.

Lamp Lumens Required= (E x A)/ (UF x LLF)

Where

E = standard service Illuminance (lx)

A = area of working plane (m2)

UF = Utilization factor

LLF = Lamp loss factor

Utilization Factor (UF):

This measures the efficiency of the lighting scheme to deliver the light to the working plane relative to the room/environment it is operating within. This incorporates the proportion of flux reaching the working plane from both the direct and reflected off other surfaces encasing the room/environment.

For conventional room layouts (offices, meeting rooms etc.) a room index (Kr) can be established from the room dimensions.

Where room index= (length x width)/ (length + width) x mounting height

Light Loss Factor (LLF)

Light loss factors are induced by the output from a lamp reducing as its operational hour's increases; a buildup of dust on the luminaire reducing the transitivity of the light into the room; a buildup of dust on room surfaces reducing the reflectance over a period of time and the ballast factor.

The Light Loss Factor (LLF) is a product of all four maintenance factors (MF) mentioned above Light Loss Factor (LLF) =Ballast Factor MF x Lamp lumen MF x Luminaire MF x Room surface MF

The lumen output from a high efficiency discharge lamp (fluorescent tube) after 2000 hrs. of operation is typically about 0.9 of the initial lumen output when new.

Design of Installation

Lamp installation should be located to achieve a uniform throw of light onto the working plane. The spacing between lamps should be uniform to maintain an effective working Illuminance over the entire working plane. For this reason, manufacturers recommended space to height ratios should be adhered to at all times. A symmetrical installation of lamps on a grid pattern should be employed to achieve a uniform light distribution. To maintain the desired symmetrical pattern, the number of lamps being used should always be increased as opposed to reduce to ensure design Illuminance is always maintained or exceeded. Where daylight utilization is being incorporated within the lighting design, or there is a requirement for minimal security lighting during periods of un-occupancy, the circuit wiring of the lamps should take this into consideration. Properly planned circuit wiring will result in lower energy demands for the lighting scheme since lamps near/ in front of windows can be dimmed/ deactivated independently without disruption to continuously operational lamps. Wiring of safety lighting during unoccupied periods would allow a minimalist lighting strategy to operate, i.e. only 10% of the lighting system would be operational to maintain a uniform low level of Illuminance.

Glare:

The presence of a luminance much above the average for the visual field will produce discomfort and is called glare. There are five forms of glare associated with lighting installation.

- **Saturation glare:**

This occurs when a large part of the visual field is at a very high luminance for a long time, e.g. sunlight on snow. Saturation glare is painful and the behavioral response is to shield the eyes in some way, e.g. by wearing low transmittance glasses.

- **Adaptation glare:**

This occurs when the visual system is exposed to a sudden, large increase in luminance of the whole visual field, e.g. Exiting a long road tunnel into bright sunlight. The perception of glare is due to the visual system being oversensitive. Adaptation glare is temporary in that visual adaptation will soon adjust the visual sensitivity to the new conditions. It can be avoided by providing a transition zone of intermediate luminance, the transition zone being large enough to allow the visual system time to adapt to the new conditions.

- **Disability glare:**

This occurs when high luminance is present in a low luminance scene. Light from the source is scattered in the eye thereby forming a luminous veil over the retinal image of parts of the scene adjacent to the source. This luminous veil reduces the luminance contrast any colors in the retinal image of the adjacent parts of the scene. For glare sources within an angular range of 0.1 to 30 degrees, this is given by the equation

Where:

Lv = equivalent veiling luminance (cd/m2)

En = Illuminance at the eye from the nth glare source (lx)

Θn^2= angle of the nth glare source from the line of sight (degrees)

$$L_v = 10 \sum \frac{E_n}{\Theta_n^2}$$

Fig1. Formula for disability glare

Unified Glare Rating:

This occurs when people complain about visual discomfort in the presence of bright light sources, luminaires or windows. Discomfort glare is quantified by the Unified Glare Rating (UGR), derived from the equation

$$UGR = 8 \log_{10} \frac{0.25}{L_b} \sum \frac{L_s^2 \, \omega}{p^2}$$

Fig2. Formula for Unified Glare Rating

Where: UGR =Unified Glare Rating

L_b = background luminance (cd/m²), excluding the contribution of the glare sources.

L_s = luminance of the luminaire (cd/m²)

W = solid angle subtended at the observer's eye by the luminaire (steradians)

p = Guth position index

UGR values typically range from 13 to 30, the lower the value, the less the discomfort. Luminaire manufacturers publish UGR values for regular arrays of their luminaires in a number of standardized rooms. This enables comparisons to be made between different luminaire types. When making such a comparison the smallest meaningful difference is one whole unit in UGR. Where a luminous ceiling or uniform indirect lighting is used, discomfort glare is limited by setting a maximum average Illuminance. Specifically, if a UGR value of 13 is desired then the average Illuminance provided should not exceed 300 lx, for UGR = 16, the maximum average Illuminance should not exceed 600 lx and for UGR = 19, the maximum average Illuminance should not exceed 1,000.

Colorimetry:

Colorimetry is defined as the science of measuring Colour and distinguishing it systematically. One fundamental aspects of Colorimetry is Colour mixing and matching. Three Colour components called primaries and are additive when adding Colour lights and subtractive when adding paints pigment the most common primaries are red, blue and green.

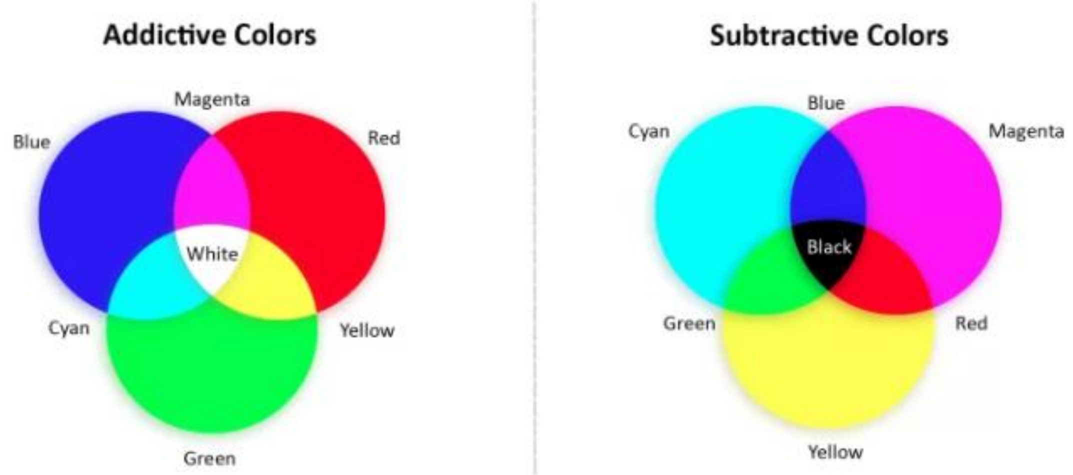


Fig3.Additive and subtractive mixing colors

Colour rendering index:

The CIE Colour rendering index measures how well a given light source renders a set of standard test colors relative to their rendering under a reference light source of the same correlated Colour temperature as the light source of interest. The reference light source used is an incandescent light source for light sources with a correlated Colour temperature below 5000K and some form of daylight for light sources with correlated Colour temperature above 5000K.

Correlated Colour Temperature:

While the CIE Colorimetry system is the most exact means of quantifying Colour, it is complex. The metric used to characterize the Colour appearance of the light emitted by a light source is the correlated Colour temperature. The basis of this measure is the fact that the spectral power distribution of a black body is defined by Planck's Radiation Law and hence is a function of its temperature shows a section of the CIE 1931 chromaticity diagram with the Planckian locus.. The locus is the curved line joining the chromaticity coordinates of black bodies at different temperatures. The lines running across the Planckian locus are iso-temperature lines. When the CIE 1931 chromaticity coordinates of a light source lie directly on the Planckian locus, the Colour appearance of that light source is expressed by the Colour temperature, i.e. the temperature of the black body that has the same chromaticity coordinates. For light sources that have chromaticity coordinates close to the Planckian locus but not on it, their Colour appearance is quantified as the correlated Colour temperature, i.e. the temperature of the iso temperature line that is closest to the actual chromaticity coordinates of the light source. The temperatures are usually given in kelvins (K).

Flicker:

A general lighting installation that produces visible flicker will be almost universally disliked, unless it is being used for entertainment. The magnitude of individual differences, and the fact that electrical signals associated with flicker can be detected in the retina even when there is no visible flicker imply that a clear safety margin is necessary if flicker is not to be perceived by anyone. The main variables that determine flicker perception are the frequency and percentage modulation of the oscillation in light output, the proportion of the visual field over which the flicker occurs, and the adaptation luminance. Temporal modulation transfer functions can be used to predict whether a given fluctuation of light output will be visible.

Effect of light on human being:

The effects of solar radiation on humans and animals include such wide-ranging phenomena as damage to ocular tissues, skin effects, tumor formation, and the synchronization of biological rhythms. A variety of diseases have been treated with or UV energy, alone or in combination with sensitizing drugs. Since the beginning of recorded history, psoralen, a UVactivated drug, combined with exposure to solar UV radiation, has been the therapy for vertigo, a skin condition marked by an absence of normal pigment. By the turn of the century, lupus vulgaris, a condition where skin nodules are present, was shown to be cured with UV either from sunlight or from carbon arcs. Psoriasis, a skin condition where lesions are covered with scales, is now being alleviated with the same therapy that has been applied to vertigo, using electric light sources of more constant UV output than from the sun. Visible radiation, particularly the short wavelengths (400 to 500 nm), is used in the phototherapy of jaundiced infants. Photodynamic therapy (PDT) is a rapidly developing field for the treatment of such disorders as cancers involving rapid cell division. A photoactive dye is absorbed by dividing cells. When the dye is photo activated in the presence of oxygen, free radicals develop that critically damage the reproducing cells. Other extra visual effects of light include the regulation of biological rhythm

2.01.02 Lighting Fundamental:

Basic Radiometric and Photometric Principles:

Radiometry is the study of optical radiation — light, ultraviolet radiation, and infrared radiation. Photometry, on the other hand, is concerned with humans' visual response to light. Radiometry is concerned with the total energy content of the radiation, while photometry examines only the radiation that humans can see.

Type	Radiometric Quantity		Photometric Quantity	
Quantity	Symbol	Units	Symbol	Units
Wavelength	ʌ	Nanometer	λ	Nanometer
Radiant and Luminous Energy Density	U	Watt-Second/m3	Uv	Lumen – Sec/m3
Radiant and Luminous Flux	φ	Watt	φv	Lumen
Irradiance And Illuminance	E	Watt/cm3	Ev	Lux
Radiance and Luminance	L	Watt/m^2/Steradians	Li	Lumens/ m^2 /Steradian
Radiant & Luminous Intensity	I	Watt/Steradian	Iv	Candela

Illuminance

Illuminance (Ev) is a measure of photometric flux per unit area, or visible flux density. Illuminance is measured in either lux (lm/m2) or foot-candles (lm/ft2). In the following figure, the lamp is producing a candela. A 1-cd light source emits 1 lm/sr in all directions (isotropically). “Solid Angle,” one Steradian has a projected area of 1 square foot at a distance of 1 foot, and an area of 1 square meter at a distance of 1 meter. Therefore, a 1-candela (1 lm/sr) light source produces 1 lumen per square foot at a distance of 1 foot, and 1 lumen per square meter at 1 meter. Note that as the luminous flux projects farther from the source, it becomes less dense. In Figure 3.4, for example, the Illuminance decreases from 1 lm/ft2 at a distance of 1 foot to 0.0929 lm/ft2 (1 lm/m2) at a distance of 3.28 feet (1 m).

Basic Radiometric and Photometric Measurement

As a surface that is illuminated by a light source moves away from the light source, the surface appears dimmer. In fact, it becomes dimmer much faster than it moves away from the source. The inverse square law, which quantifies this effect, relates Illuminance (Ev) and intensity (Iv) as follows: Ev = Iv/d2 Where d = the distance from the light source.

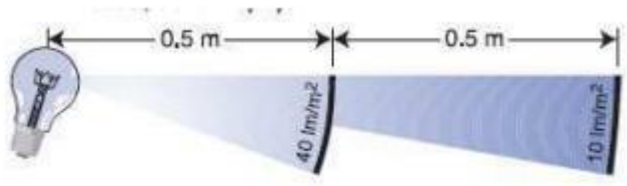


Fig4.Measurement procedure for intensity

Lambert’s Cosine Law:

Lambert’s cosine law states that the Illuminance falling on any surface depends on the cosine of the light’s angle of incidence, θ. “Reflection,” that the angle of incidence is measured from a line normal to the surface. E =Ecosθ.

Light sources:

The lighting industry makes millions of electric light sources, called lamps. Those used for providing illumination can be divided into three general classes: incandescent, discharge, and solid-state lamps. Incandescent lamps produce light by heating a filament until it glows. Discharge lamps produce light by ionizing a gas through electric discharge inside the lamp. Solid-state lamps use a phenomenon called electroluminescence to convert electrical energy directly to light. In addition to manufactured light sources, daylight — sunlight received on the Earth, either directly from the sun, scattered and reflected by the atmosphere, or reflected by the moon — provides illumination. The prime characteristic of daylight is its variability. Daylight varies in magnitude, spectral content, and distribution with different meteorological conditions, at different times of the day and year, and at different latitudes. The Illuminance on the Earth’s surface produced by daylight can cover a large range, from 150,000 lx on a sunny summer’s day to 1000 lx on a heavily overcast day in winter. The spectral composition of daylight also varies with the nature of the atmosphere and the path length through it.

- **Discharge Lamps**

Discharge lamps produce light by passing an electric current through a gas that emits light when ionized by the current. An auxiliary device known as a ballast supplies voltage to the lamp's electrodes, which have been coated with a mixture of alkaline earth oxides to enhance electron emission. Two general categories of discharge lamps are used to provide illumination: high-intensity discharge and fluorescent lamps.

- **Metal-Halide Lamps**

A metal-halide lamp is a mercury vapor lamp with other metal compounds (known as halides) added to the arc tube to improve both Colour and luminous efficacy. Figure shows the construction of a typical single-ended, screw base metal-halide lamp.

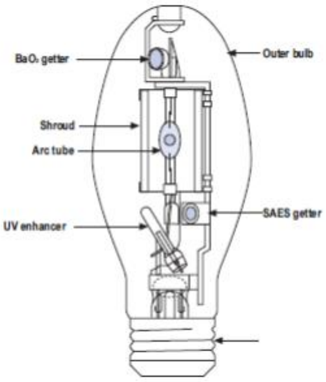


Fig5. Construction of Metal Halide Lamp

- **Fluorescent Lamps**

Fluorescent lighting accounts for two-thirds of all electric light in the India. The fluorescent lamp is a gas discharge source that contains mercury vapor at low pressure, with a small amount of inert gas for starting. Once an arc is established, the mercury vapor emits ultraviolet radiation. Fluorescent powders (phosphors) coating the inner walls of the glass bulb respond to this ultraviolet radiation by emitting wavelengths in the visible region of the spectrum. Ballasts, which are required by both fluorescent and HID lamps, provide the necessary circuit conditions (voltage, current, and wave form) to start and operate the lamps. Two general types of ballasts are available for fluorescent lamps: magnetic and electronic. Electronic ballasts are often more expensive, but are usually lighter, quieter, and eliminate the lamp flicker associated with magnetic ballasts. Fluorescent lamps are often described in terms of the diameter of the lamp tube. For this designation, the diameter is given in eighths of an inch. For example, a T8 lamp has a diameter of one inch (eight eighths), while a T5 lamp has a diameter of 5/8 inch.

Linear Fluorescent Lamps Linear fluorescent lamps range in length from six inches to eight feet, and in diameter from 2/8 inch (T2) to 2-1/8 inches (T17). Their power ranges from 14 to 215 watts.

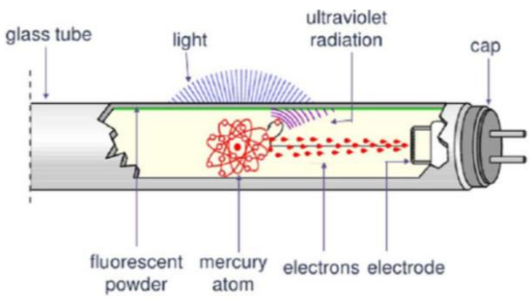


Fig6. Construction of Linear Fluorescent Lamp

- **LEDs (Light-Emitting Diodes)**

LEDs are solid-state semiconductor devices that convert electrical energy directly into light. LEDs can be extremely small and durable; some LEDs can provide much longer lamp life than other sources. Figure shows several typical LEDs. The plastic encapsulated and the lead frames occupy most of the volume. The light-generating chip is quite small (typically a cuboids with one side equal to 0.25 mm). Light is generated inside the chip, a solid crystal material, when current flows across the junctions of different materials. The composition of the materials determines the wavelength and therefore the Colour of light.

LEDs can generate red, yellow, green, blue or white light and have a life up to 1,00,000 hours, and are widely used in traffic signals and for decorative purposes. White light LEDs are a recent advance and may have a great potential market for some general lighting applications.

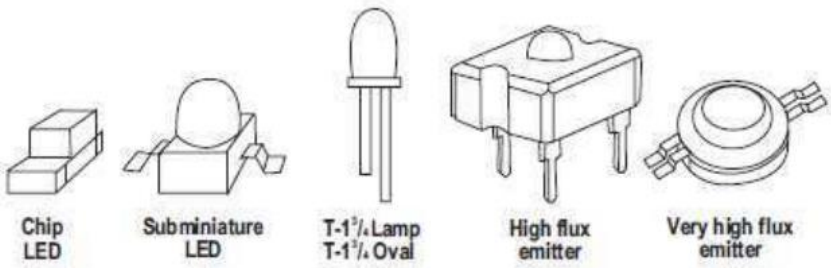


Fig7. Construction of Led Chip Structural Construction

2.01.03 Basic ballast technology:

Introduction:

In discharge lamps a gas vapor is contained in an arc tube, when a stream of electrons pass through the arc tube the gas vapor is ionized, it becomes excited and emits radiant energy the gas discharge lamp has a negative voltage-current characteristics. This means that with decreasing lamp voltage increasing current in the lamp which needs to be controlled. Because of this negative resistance characteristic it is required to stabilize the lamp current this is possible by putting impedance in series with the lamp. Thus an extra module needed to start and run continuously a lamp is called ballast. The ballast basically contains an inductor. It is required for a discharge lamp to generate arcing voltage and also limit the current.

We know there are basically two types of ballasts are there,

a. Electromagnetic Ballast.

b. Electronic Ballast.

In electromagnetic ballast there is an inductor whose size and value is too large compared to that of electronic ballast. So, the power consumption in electromagnetic ballast is more compared to that of electronic ballast. Basically, the point of consideration is power saving. For same light output electronic ballast needs less power compared to that of electromagnetic ballast. So, to save the power the choice of electronic ballast is optimum.

Different types of ballasts

The prime function of ballast is to prevent current runaway and to operate the lamp at its correct electrical characteristics. Ballasts should be efficient, simple, ensure proper lamp starting, have no adverse effect on lamp life and ensure stable lamp run-up and operation. The different types of ballasts are:
a. Resistor Ballasts

b. Choke or Reactor Ballasts

c. Capacitor Ballasts

d. Leakage Reactance Transformer Ballasts

e. Electronic Ballasts

Electronic ballast:

Electronic ballasts are actually power converter circuits i.e. they draw a mains supply current and change its characteristics in terms of frequency, waveform and magnitude in order to supply the lamp with an energy source tailored to its requirements. It uses solid state electronic circuitry to provide the proper starting and operating electrical condition to power one or more fluorescent lamps and more recently HID lamps. Electronic ballasts usually change the frequency of the power from the standard mains frequency of 50 Hz to 20,000 Hz or higher, substantially eliminating the stroboscopic effect of flicker (a product of the line frequency) associated with fluorescent lighting. In addition, because more gas remains ionized in the arc stream, the lamps operate at about 9% higher efficacy above approximately 10 kHz. Lamp efficacy increases sharply at about 10 kHz and continues to improve until approximately 20 kHz. Because of the higher efficiency of the ballast itself and the improvement of lamp efficacy by operating at a higher frequency, electronic ballasts offer higher system efficacy for low pressure lamps like the fluorescent lamp.

Led lamp driver

Led driver and its application:

An LED driver is a self-contained power supply that controls the amount of current and voltage supplied to an LED light. An LED constant current driver monitors the loop current of each LED and automatically adjusts the generated DC voltage output to the minimum value needed to produce the highest forward voltage. As mains power is Alternating Current (AC) and Light Emitting Diodes run on Direct Current (DC), this current needs to be converted by a rectifier. Some LED lamps have inbuilt rectifiers so can be used with ironcore transformers. If there is no inbuilt rectifier then the LED light needs to be used in conjunction with an LED specific driver as they all have rectifiers as standard. Some LED Drivers use Pulse Width Modulation (PWM) in conjunction to enable the LED light to become dimmable. Iron-core transformers are the old type of transformers that are made by winding two wires around an iron core. This produces an unregulated 12 volts of AC which will drive an LED sufficiently provided there is a rectifier in use. Another type of transformer is the electronic transformer which contains an inverter which allows the size of the actual transformer to be reduced. The electronic transformer uses a high-power switching semiconductor to interrupt the mains voltage at a high frequency and had been designed to work across a wide range of power loads. The average electronic transformer will be specified for a load range of 20 to 60 watts, which means that it will operate within its specification only when connected to a load which is somewhere within that range. Because LED lights draw so little power, they will not reach the minimum voltage of an electronic transformer. To get the best result of high brightness and long lamp life of 80,000 hours+ from an LED light, it is highly recommended that it be used in conjunction with an LED constant current driver. This driver delivers the exact current required by the LED and will make the lamp work over a range of voltages. Without a n LED constant current driver the lamp would be sensitive to voltage changes, by getting dim or going out if the voltage drops too low, and the lifetime of the lamp will be reduced if the voltage goes too high.

Types of led driver:

There are two types of LED driver one is Constant Current source type and another is Constant Voltage source type.

Constant current type: LEDs are current-driven devices that require current limiting when driven from a voltage source. In most applications, it is desirable to drive LEDs with a constant-current source. The current source is used to regulate the current through the LED regardless of power supply (voltage) variations or changes in forward voltage drops, VF, between LEDs. Designed to provide stable output current (constant current), output voltage will be determined by LED total VF. For example, using LED with VF = 3.5V @ 350mA and with 12pcs connected in series. The total VF will be 3.5Vx12=42V. With 2 strips connected in parallel, the total If = 350mAx2 = 700mA If MW constant current LED power supply LPC-35-700 (VIN = 90~264VAC, Vout = 48V/700mA) is used to drive LED load directly, LED power supply will work in CC mode. Output voltage will drop to 42VDC while output current remains constant at 700Ma.

Constant voltage type: Conventional power supply will provide stable regulated voltage (constant voltage) for load usage. Regardless of AC input variation (90~264VAC) or load variation, output voltage will be regulated to within voltage tolerance specification (single output unit typically 1~2%). For example, LPV-60-48 used in powering LED driver + LED light strip, output voltage will remain constant at 48V.

CHAPTER 3

REVIEW ON INDUSTRIAL LIGHTING FOR FOOD PROCESSING INDUSTRY

3.1 Factors of good Industrial lighting:

Industry encompasses a wide range of visual tasks, operating conditions, and economic considerations. Visual tasks may be small or large; dark or light; opaque, transparent, or translucent; on specular or diffuse surfaces; positioned in horizontal, vertical, or inclined planes; and involve flat or contoured shapes. In addition, the task may involve movement of the object, the viewer, or both. With each of the various task conditions, the lighting must provide adequate visibility so that materials can be transformed into finished products. Physical hazards exist in manufacturing processes, so lighting is of the utmost importance 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 must be a compensating factor to increase the speed of seeing.

Quality of Illumination:

There are certain quality factors that should be considered when designing a lighting system for an industrial facility. The term "quality" as used here implies that all luminances are designed to contribute favorably to visual performance, visual comfort, ease of seeing, safety, and aesthetics for the specific visual task involved. Glare (direct, reflected, and veiling reflections), diffusion, direction, shadows, uniformity, color, luminance, and luminance ratios all have a significant effect on visibility and the ability to see accurately and quickly. Modeling of the task, material characteristics, and the relationship of the eye to the light source are also important considerations for a high-quality lighting design for an industrial task. Certain visual tasks, such as discernment of fine details, require much more careful analysis and higher-quality illumination than other industrial tasks. Areas where the visual tasks are critical, or where they are performed over long periods of time, require much higher quality lighting than visual tasks that are casual or of relatively short duration. Quality of the Visual Environment contains a matrix of issues for industrial lighting. Vision and Perception, provides guidance for the control of glare. Poor-quality industrial lighting can be uncomfortable and possibly hazardous. Unfortunately, moderate deficiencies in the lighting are not easy to detect. Even minimal glare, for instance, can result in measurable loss of seeing efficiency and undue fatigue.

Direct Glare:

Direct glare is caused by having a light source within the field of view, whether daylight or electric lighting. To reduce direct glare in industrial areas, the following steps can be taken: (1) decrease the luminance of light sources or lighting equipment, or both; (2) reduce the area of high luminance producing the glare condition; (3) By increasing the angle between the glare source and the line of vision; (4) By increasing the luminance of the area surrounding the glare source and against which it is seen; and (5) place louvers or refractors between the glare source and the line of sight.

Reflected Glare:

Reflected glare is caused by the reflection of high-luminance light sources from shiny surfaces. In manufacturing processes this may be a particularly serious problem where critical seeing is involved with very shiny surfaces such as polished or machined metal, vernier scales, and digital displays. Reflected glare can be minimized or eliminated by using light sources of low luminance or by orienting the work so reflections are not directed in the normal line of vision. It should be noted, however, that it is often desirable to use reflections. Large-area, low-luminance sources can be used for certain specular tasks to accentuate flaws and defects in the finished product. In special cases it is practical to reduce the specular reflection (and the resultant reflected glare) by changing the specularity of the offending surface.

Veiling Reflections:

Where the task materials are specular or semi-specular, veiling reflections can reduce, or in some cases increase, task visibility. Source/task/eye geometries should be carefully considered in the design process.

Glare Control:

There is such a wide range of industrial tasks and environmental conditions that it is impossible to provide guidelines on a degree of glare control that suits all needs. The designer should work closely with the users, management, production personnel, and plant safety departments to determine where additional glare control may be required.

Uniformity:

Uniform lighting is used more often in industrial lighting than in other applications. While no uniform lighting can add interest to lighting applications that are of a more aesthetic nature, uniform lighting in industrial applications can provide higher-quality lighting where the task is three-dimensional (e.g., milled material) rather than two-dimensional (e.g., office paper tasks). Uniform lighting allows for repositioning the task locations or production machinery without the need to relocate the lighting. It is particularly useful for high-bay industrial facilities where the cost and inconvenience of moving luminaires located 10 m (30 ft.) or more above the factory floor can be substantial. At the same time, there are instances where no uniform lighting is appropriate. Maintaining uniformity between contiguous areas that have significantly different visibility (and illumination) requirements (for example, a storage area adjacent to a machine shop) wastes energy. In such instances, it is prudent to design and apply no uniform lighting between those areas. This can be accomplished by using luminaires of different wattages or by adjusting the density of luminaires.

Luminance and Luminance Ratios:

The ability to see detail depends on the contrast between the item being examined and its background. The greater the contrast, or difference in luminance, the easier it is to see detail. However, the eyes function more comfortably and efficiently when the luminance within the rest of the space is kept uniform; thus, all luminances in the field of view need to be carefully controlled. In manufacturing, it is not practical to achieve the same luminance ratios as can be achieved in offices. Most industrial areas have luminance ratios that lie between the extremes of heavy manufacturing and office spaces.

3.2 General Considerations for Industrial Lighting:

The designer of an industrial lighting system should consider the following important factors:

- Quality and quantity of illumination suitable for the manufacturing processes involved, as well as the necessary safety requirements.
- Lighting equipment that satisfies the design requirements by considering photometric characteristics as well as the mechanical performance required to meet installation and operating conditions.
- Equipment that is safe, easy, and practical to maintain. Certain lamps may be prone to possible violent end-of-life failures, and they should be used only in properly shielded luminaires.
- Energy, economic, and operating characteristics of the selected lighting system. All of these factors must be properly weighted prior to finalizing the design.
- Quality, quantity, and safety. All three design issues should be properly weighted and addressed in the design implementation.

HID sources are potential sources of direct glare because they produce large amount of light from physically small lamps. Excessive direct glare may be minimized by mounting fixture at sufficient heights.

3.2.1 Factors of Special Consideration:

Lighting and Spacing Conditions, Sometimes lighting, heating, cooling, and atmospheric control are combined in an integrated system. The lighting system may provide a significant amount of the heat energy during winter months. When cooling is required, much of the lighting heat can be removed by the ventilation system. Luminaires should be considered on thermal considerations. Special Considerations must be considered on High Humidity or Corrosive Atmosphere and Hazardous Location Lighting. Enclosures protect the interior of the luminaire from conditions prevailing in the area. Steam processing, plating areas, wash and shower rooms, and other areas of unusually high humidity require enclosed and gasketed luminaires. Severe corrosive conditions necessitate knowledge of the atmospheric content to permit selection of proper material for the luminaires. Enclosed and gasketed luminaires are also required in food preparation areas of manufacturing plants, in dairy and ice cream plants, and food processing plants to permit the hosing-down of the areas for cleaning and sanitary reasons. Hazardous locations are areas where atmospheres contain flammable dusts, vapors, or gases in explosive concentrations.

3.2.2 Abnormal Temperature Conditions:

Low ambient temperatures exist in unheated heavy industrial plants, frozen food plants, and cold storage warehouses. Equipment has to be selected to operate under these cold conditions, and particular attention should be given to lamp starting and light output characteristics if fluorescent equipment is considered. With HID equipment, temperature variations have practically no effect on light output, but the proper starting conditions must be provided. With incandescent lamp equipment, neither starting nor operation is a problem at low temperatures. Abnormally high temperatures are common at truss height in foundries, steel mills, and forge shops. Caution should be exercised in selecting lighting equipment for mounting in these locations. It is particularly important to consider the temperature limitations of fluorescent and HID ballasts. Ballasts should be remotely located at a lower and cooler level or located within a cooled enclosure, or special high-temperature equipment should be used. Reduced fluorescent lamp output at high operating temperatures should be recognized. Incandescent lamps operated under high-temperature conditions, as in an oven, may experience a reduction in life.

3.2.3 Maintenance:

Regular cleaning and prompt replacement of failed lamps having the same operating and performance characteristics are essential to maintain the lighting system. The lighting designer should analyze the luminaire construction and reflector finish and also make provisions for maintenance access so that the system can be properly serviced. Sometimes the servicing has to be performed during plant operating hours.

3.2.4 Supplementary task lighting in industry:

Difficult visual tasks, such as inspection, often require a specific quality and quantity of lighting that cannot readily be obtained by general lighting methods. Supplementary luminaires are often used to provide better visibility in small or restricted areas. They can also be used to furnish a certain luminance or color or to permit special aiming or positioning of light sources to produce or avoid highlights or shadows so as to best portray the details of the visual task.

3.2.5 Emergency, Safety, and Security Lighting:

Quality of the Visual Environment provides a matrix of design issues for emergency, safety, and security lighting. Reference to this chapter is recommended for further details on the design and selection of hardware for these very important systems. Emergency lighting is a very important part of an industrial lighting system. The buildings are usually large, complicated, and subject to materials being moved in and out continuously. In the event of an emergency where normal illumination is lost, a worker could become confused.

Emergency lighting requirements are often covered in codes or local ordinances that detail the levels of Illuminance required, the duration of the lighting in the event of a loss of power, and the types of power supplies that are acceptable to "the authority having jurisdiction." Reference to these codes and ordinances is essential to ensure compliance with them. Lighting designers must put themselves in the place of building occupants and mentally walk themselves through the facility to ensure that they have provided lighting for exit and emergency egress that covers all foreseeable conditions. Touring the facility after construction is complete is usually necessary to demonstrate to all parties that the emergency lighting is satisfactory. Additions to the system are often needed to fill in where unexpected pieces of machinery or owner-furnished obstructions have been installed during the project that changes the emergency lighting requirement.

3.2.6 Lighting for Specific Tasks:

Inspection:

Inspections are generally conducted at intermediate stages during the manufacture of the product. The inspections at some stages are either combined with the functional operation or performed in the same area. The type of inspection dictates the proper quality and quantity of illumination. A typical inspection is that of cores by the core maker prior to baking. Later, the castings may be inspected and scrapped as necessary by the shake-out handlers or by the grinder operators, avoiding subsequent waste of labor on defective parts. Small castings are frequently inspected and sorted simultaneously. In sorting areas, a simple lighting system of ventilated fluorescent-lamp industrial luminaires can be mounted 1.2 m (4 ft.) or more above the sorting table or conveyor. Atmospheric and maintenance conditions determine the type of luminaires (open, enclosed, or filtered) to be used. For medium inspections, fluorescent-lamp luminaires may reduce reflected glare and improve diffusion of light. Medium-fine and fine inspections sometimes require special lighting equipment, such as task lighting.

Manufacturing and Assembly:

Common tasks in manufacturing facilities include the manufacture of parts and the joining of those parts into larger subassemblies.

Incoming Raw Material:

Raw materials are delivered to manufacturing facilities by truck or rail shipment. Both opentop and closed-top vehicles may be used. The visual task is to identify the materials and compare the material and shipping documents. General lighting with supplementary lighting for trailer or rail car interiors is required.

Active Storage Areas:

Raw materials are often unloaded in the receiving areas by lift trucks or overhead cranes. They are transported to the active storage areas or directly to the production process by the same means. The visual task is to identify the materials (labels or markings) from the cab of an overhead crane or lift truck and to move the materials and deposit them at a designated location. General illumination is required on horizontal and vertical surfaces.

Testing:

Highly diversified and complicated procedures and test equipment determine compliance with design specifications for many subassemblies. Testing activities can be manual, semiautomatic, or automatic. The visual tasks are to secure the assembly to the test fixture, to perform tests on electrical or mechanical connections, to run tests and read gauges and meters, to perform mechanical or electrical adjustments as required, to complete test reports, and to disconnect and remove the assembly from the test fixture. General lighting and properly positioned supplementary lighting are required.

Final Inspection:

Inspection determines whether the manufactured part or subassembly is in total compliance with the design specifications. The visual tasks are to inspect the part or subassembly for specification compliance and to ensure that all intermediate inspections and tests are satisfactory. General lighting with supplementary lighting to inspect the part or subassembly is required. Good Colour rendering of light sources is important.

Packing:

Parts are manually or semi-automatically placed in boxes, containers, or racks for shipment. The visual tasks are to identify the part and place it in a destination-designated shipping container or rack. General area lighting is required.

Lighting for Large Component Sub- and Final Assembly:

This phase of manufacturing has special requirements not usually found in other types of manufacturing. Modern industrial requirements have necessitated the construction of buildings with clear bay areas that can exceed 26,000 m2 (300,000 ft2) and truss heights of more than 24 m (80 ft.) from floor level. The lighting issues in buildings of this size are not limited to engineering systems and design concepts but include maintenance and lamp replacement. Catwalks or traveling-bridge cranes may be appropriate to allow access to the lighting units. In some cases, mobile telescoping cranes can be used to reach luminaires from the floor, but the heights involved and obstructions on the floor can make this method of maintenance impractical. Where access is available from the floor, disconnecting hangers and lowering chains or cables can be an effective method for maintaining luminaires in high-bay areas.

Control Room:

The control room is the nerve centre of facilities such as electric generating plants, electricdispatch facilities, steam- or hot-water generating plants, and chemical plants, and it must be continuously monitored. Its lighting must be designed with special attention to the comfort of the operator: direct and reflected glare and veiling reflections must be minimized, and luminance ratios must be low. Giving operators full control of Illuminance levels through the use of multiple switching or dimming systems increases lighting flexibility. Along with ordinary office-type visual tasks, the operator has to read meters, often 3 to 4.5 m (10 to 15 ft.) away. Reflected glare and veiling reflections must be eliminated from meters, including those with curved glass faces. While the practice is not standardized, most control-room lighting involves one of two general categories: diffuse lighting or directional lighting. Diffuse lighting may be from low-luminance, indirect lighting equipment, solid luminous plastic ceilings, or louvered ceilings. Directional lighting may be from recessed troffers that follow the general contour of the control board. (These luminaires must be accurately located to keep reflected light out of the glare zone.) Illumination for the rest of the room may utilize any type of low-luminance general lighting equipment.

Fig8. Lighting for Control Room

Warehouse and Storage Area Lighting:
Placing items in storage, accounting for them, and later retrieving them are some of the most common activities requiring electric lighting in industrial facilities. Storage activities are found in business operations of every type, from small local operations to multinational corporations. Since rapid changes are taking place in the business world, the traditional concept of the warehouse

must be expanded to encompass new techniques, including automation, high-rise storage, barcoding, cold storage, and shrink-wrap packaging.

A variety of specific tasks can occur in a warehouse :
-Open storage: Areas of material stored without the use of rack systems. This includes storage on the floor and on pallets that may be stacked on each other.
- High rise. Areas generally automated, where storage bins may be rotated so that unused bins are kept high up, and with storage levels rising to over 30 m (100 ft.).
- Offices. Paperwork areas located within warehouses.
- Cold storage: Areas that warehouse normally perishable food items and require low (sometimes below freezing) temperatures.
- Hazardous materials storage. Areas where there are containers of materials with special requirements.
- Exit and emergency. Areas within warehouses that must provide safe exit from the building or that must conform to the Life Safety Code in case of emergency.
- Shipping and receiving: Areas where materials are received into the warehouse for sorting and placement in storage areas. Such areas also serve as staging areas for coordination of products to be sorted and placed on trucks or trains for shipping.
- Loading docks and staging areas: Areas, generally just outside the shipping area, that may be outdoors but are often covered. These areas are used to place items on and off trucks and railroad cars and to assemble goods.

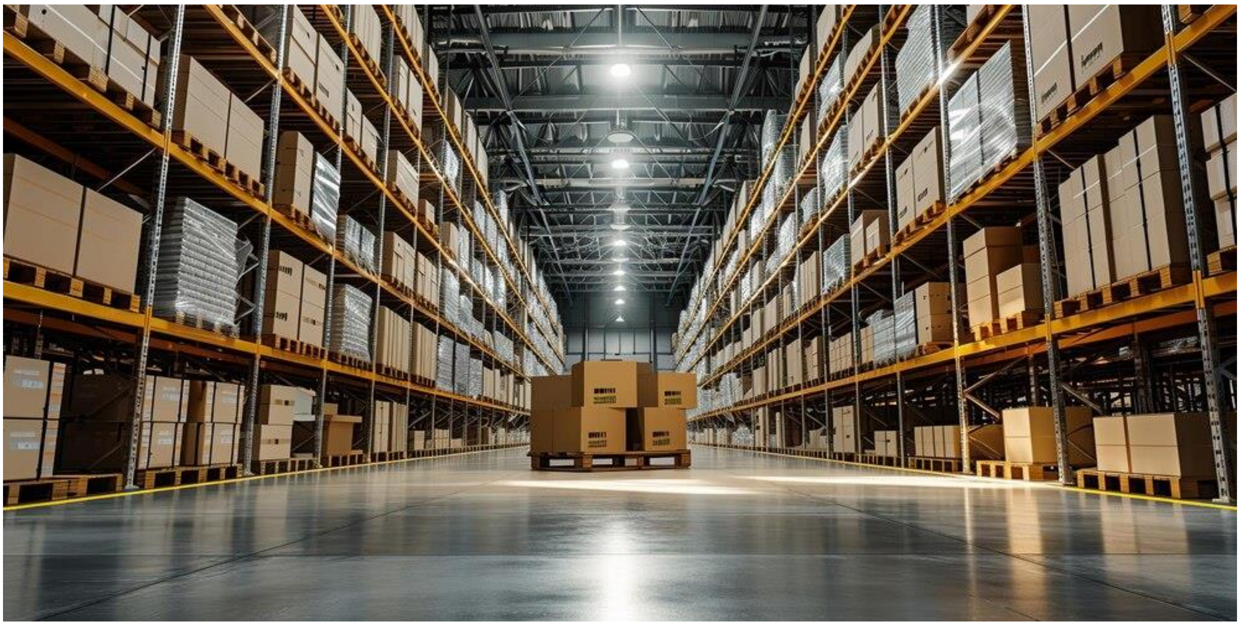


Fig9.Lighting for Warehouse

CHAPTER 4

NATIONAL AND INTERNATIONAL STANDARD RELATED TO FOOD PROCESSING INDUSTRY

4.1 Lighting standard and industrial standard:

A **standard** consists of technical definitions and guidelines that function as instructions for designers/manufacturers and operators/users of equipment/system designer. These provides guidelines but not enforceable by law.
A **code** is a standard that has been adopted by one or more governmental bodies and is enforceable by law.

The designs illustrated in this thesis work are in conformation with the various codes and standards followed in India. The various codes and standards have been discussed below.

4.1.1 National Lighting Code:

The NATIONAL LIGHTING CODE (NLC) published by the Bureau of Indian Standards has been formulated for the purpose of setting out in a convenient form the requirements for responsible social, commercial and engineering conduct for the designers, manufacturers and suppliers of lighting. Lighting technology plays a significant role in achieving basic social safety and environmental objectives.

The intent of this code is to encourage good lighting practices and systems which would minimize light pollution, glare, light trespass and conserve energy while maintaining safety, security, utility and productivity.

The lighting industry is highly fragmented and has relatively low technical barriers to entry. Despite its fundamental importance to many basic safety operations it is subjected to comparatively low levels of regulation. Consequently end users and consumers do not always have access to accurate and reliable information on what represents a safe, reliable and efficient lighting system.

This code aims to build up a trust between the industry and its customers through integration of commerce and technology National lighting code. The NATIONAL LIGHTING CODE (NLC) published by the Bureau of Indian Standards has been formulated for the purpose of setting out in a convenient form the requirements for responsible social, commercial and engineering conduct for the designers, manufacturers and suppliers of lighting. Lighting technology plays a significant role in achieving basic social safety and environmental objectives. The intent of this code is to encourage good lighting practices and systems which would minimize light pollution, glare, light trespass and conserve energy while maintaining safety, security, utility and productivity. The lighting industry is highly fragmented and has relatively low technical barriers to entry. Despite its fundamental importance to many basic safety operations it is subjected to comparatively low levels of regulation. Consequently end users and consumers do not always have access to accurate and reliable information on what represents a safe, reliable and efficient lighting system. This code aims to build

up a trust between the industry and its customers through integration of commerce and technology.

Actual Coverage:

The NATIONAL LIGHTING CODE (NLC) covers the following:
a) Guidance on illuminating engineering practices to be followed by various types of occupancies;
b) Guidance on good engineering practices to be followed during the design, selection, installation and maintenance of lighting system for indoor and outdoor areas;
c) Coordination aspects to be considered while designing the lighting system such as day lighting; and
d) Aspects relating to energy management and energy conservation in lighting installation including guidelines for design and good practices to be adopted for effective and efficient use of light sources.

Table: Lux level required for food Processing industry as per NLC code

Sl no	**Area**	**Lux level**
1	General area	300
2	Inspection	500
3	Grading and shorting of raw material	750
4	Preparation	500
5	Canned and bottle goods	300
6	Retorts	300
7	Automatic process	200
8	Labeling and process	300
9	Frozen Foods	300
10	Process area	300
11	Packaging and store	300
12	Bottle washing	200
13	Key inspection	300
14	Bottle filling	500
15	Refining and blending	300
16	Production	500

4.1.2 IS 3646: 1992 (Part 1 & Part 2)

IS 3646-Part 1 (1992) manages the degree of enlightenment needed for indoor lighting. IS 3646- Part 2 (1966) manages the degree of enlightenment needed for indoor lighting just as the limit of glare. Since conditions might be essentially unique for various insides utilized for a similar application or for various conditions for a similar sort of movement, a scope of Illuminance is suggested for each kind of inside or action proposed, of a solitary estimation of Illuminance. Each reach comprises of three progressive strides of the suggested size of Illuminance. For working insides, the center estimation of each reach addresses the suggested administration Illuminance that would be utilized except if at least one of the elements referenced underneath apply.[8] To some extent 2 Table gives estimations of brightening and restricting estimations of glare file comparable with the overall norms of the lighting portrayed in the code and identified with numerous occupations and structures.

The higher value of the range should be used when:
a) Remarkably low reflectance or contrasts are present in the task;
b) Errors are costly for remedy;
c) Speed of work is high
d) Accuracy or higher productivity is of great importance; and
e) Age of occupants is higher.

The lower value of the range may be used when:
a) Reflectance or contrasts are unusually high;
b) Speed and accuracy are not important; and
c) Occupant’s age is comparatively younger.

4.1.3 IS 6665: 1972:
Taking into consideration the increasing industrial activities in India whereby a large number of people have to work on tasks and processes of increasing intricacy and detail with working hours extending into the night has been felt for well-planned and efficient industrial lighting which loud create easier seeing conditions and agreeable atmosphere.
For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS: 2-1960s. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard. If industrial lighting and shall be read in conjunction with IS: 3646 (Part I) - 1966, IS: 3646 (Part II)-1966 and IS: 3646 (Part III)-1968.
Scope:
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.

4.1.4 ISO 8995-1:2002(E)/CIE S 008/E: 2001
This is the international standard approved by CIE as well as ISO which specifies lighting requirements for humans in indoor workplaces, which meet the needs for visual comfort, safety and performance of people.

CHAPTER 5

ENERGY EFFICIENT LIGHTING

5.01.01 Introduction:

Energy is one of the major inputs for economic development of any country. In the case of developing countries, the energy sector assumes critical importance in view of the ever increasing energy needs, widening of supply–demand gaps, and also huge investments required to meet them. In the Indian context, the current peak demand shortage is 14% and the energy deficit is 8.4%. In certain areas, this could be as high as 25%. In such scenarios, efficient use of electricity necessitates persistent energy conservation efforts. Energy efficiency is achieved when energy usage in a specific product is reduced without affecting output or user comfort levels. Very simply, energy efficiency means using less energy to perform the same function. For example, by replacing traditional light bulbs with compact fluorescent lamps, one uses only 25% of the energy originally needed to illuminate the room. Pollution levels are also reduced by the same amount. Lighting is an essential requirement for any facility and it touches the day-to-day lives of people in more ways than one. It accounts for 15% of the total energy consumed in a developing country as against about 7%–10% in developed countries. Energy efficiency has often been viewed as a 'resource option', just like coal, oil, or natural gas. For a developing country such as India, it provides additional economic value by preserving the resource base and reducing pollution. Today, energy efficiency assumes even greater importance because it is the most cost effective and reliable means of mitigating global climate change. Recognition of such potential has led to high expectations regarding control of future carbon dioxide emissions through more frequent energy-efficiency improvements as compared to those in the past. Thus, with new product development taking place at a much faster pace, the lighting sector as a whole has immense potential to pursue energy efficiency options. Efforts are on worldwide to achieve the following interacting lighting variables.

- Lighting upgrades yield quick savings on energy bills but more efficient lights release less heat—an indirect benefit for the air-conditioning systems.
- The light quality, the lighting quantity, and the type of light fittings are dependent on the task at hand. Thus, efforts to promote efficient lighting that ignore the users' needs are likely to fail.
- For optimal lighting solutions, the total system involving day lighting, lamps, fixtures, controls, configuration, materials, and furnishing needs to be considered holistically.
- Broader impacts of lighting choices, including the persistence of energy efficiency measures, with implications for the type of technologies, are to be considered.

5.01.02 Measures for Energy Efficient & Economic Use of Lighting:

Measures which can contribute for energy efficient and economic use of lighting are as under:

- Segregation of general and task lighting.
- Automatic switching on and off of lighting by using sensors.
- Maximum use of daylight.
- Use of energy efficient lamps (LED, CFL, TL5 tubes etc.).
- Use of dimmers to reduce the intensity of artificial light when daylight is available.
- Using high efficiency luminaires.
- Using high frequency ballasts.

5.01.03 Energy Conservation Building Code Guidelines:

The Energy Conservation Building Code (ECBC) has been developed by the International Institute for Energy Conservation (IIEC) under contract with the United States Agency for International Development (USAID) as a part of the Energy Conservation and Commercialization (ECO) Project providing support to the Bureau of Energy Efficiency (BEE Action Plan). The purpose of this code is to provide minimum requirements for energy efficient design & construction of buildings. In case of Lighting, ECBC has provided some limiting values to assess optimum energy requirements for energy efficient lighting designs. It is estimated in terms of lighting energy required per unit area, termed as, Lighting Power Density or LPD. There are two methods for this purpose: one is Building Area Method & the other is Space Function Method.

5.01.04 Building Area Method:

Determination of interior lighting power allowance by the building area method shall be in accordance with the following:

- Determination of the allowed lighting power density from Table for each appropriate building area type.
- Calculation of the gross lighted floor area for each building area type.
- The interior lighting power allowance is the sum of the products of the gross lighted floor area of each building area times the allowed lighting power density for that building area types.

Building Area Type	LPD (W/m2)	Building Area Type	LPD (W/m2)
Automotive Facility	9.7	Multifamily	7.5
Convention Center	12.9	Museum	11.8
Court House	12.9	Office	10.8
Dining : Bar Lounge/Leisure	14.0	Parking Garage	3.2
Dining : Cafeteria/Fast Food	15.1	Penitentiary	10.8
Dining : Family	17.2	Performing Arts Theater	17.2
Dormitory	10.8	Police/Fire Station	10.8
Exercise Center	10.8	Post Office	11.8
Gymnasium	11.8	Religious Building	14.0
Healthcare-Clinic	10.8	Retail	16.1
Hospital/Health Care	12.9	School/University	12.9
Hotel	10.8	Sports Arena	11.8
Library	14.0	Town Hall	11.8
Manufacturing Facility	14.0	Transportation	10.8
Motel	10.8	Warehouse	8.6
Motion Picture Theater	12.9	Workshop	15.1

5.01.05 Space Function Method:

Determination of interior lighting power allowance (watts) by the space function method shall be in accordance with the following:

- Determination of the appropriate building type from Table and the allowed lighting power density.
- For each space enclosed by partitions 80% or greater than ceiling height, determination of gross interior floor area by measuring to the centre of the partition wall including the floor area of balconies or other projections. Retail spaces do not have to comply with the 80% partition height requirements.
- The interior lighting power allowance is the sum of the lighting power allowances for all spaces. The lighting power allowance for a space is the product of the gross lighted floor area of the space times the allowed lighting power density for that space.

Space Function	**LPD (W/m2)**	**Space Function**	**LPD (W/m2)**
Office - Enclosed	11.8	Library	6.1
Office – Open Plan	11.8	Card File & Cataloging	11.8
Conference/Meeting/Multipurpose	14.0	Stacks	18.3
Classroom/Lecture/Training	15.1	Reading Area	12.9
Lobby	14.0	Hospital	8.6
For Hotel	11.8	Emergency	29.1
For Performing Arts Theater	35.5	Recovery	8.6
For Motion Picture Theater	11.8	Nurse Station	10.8
Audience/Seating Area	9.7	Exam Treatment	16.1
For Gymnasium	4.3	Pharmacy	12.9
For Exercise Center	3.2	Patient Room	7.5
For Convention Center	7.5	Operating Room	23.7

For Religious Building	18.3	Nursery	6.5
For Sports Arena	4.3	Medical Supply	15.1
For Transportation	5.4	Laundry – Washing	6.5
Atrium - First Three Floors	6.5	Automotive – Service Repair	7.5
Atrium – Each Additional Floor	2.2	Manufacturing	
Lounge/Recreation	12.9	Low Bay (<6m ceiling)	12.9
Dining Area	9.7	High Bay (>6m ceiling)	18.3
For Hotel	14.0	Detailed Manufacturing	22.6
For Motel	12.9	Equipment Room	12.9
For Bar Lounge/Leisure Dining	15.1	Control Room	5.4
For Family Dining	22.6	Hotel/Motel Guest Rooms	11.8
Food Preparation	12.9	Dormitory – Living Quarters	11.8
Laboratory	15.1	General Exhibition	10.8
Restrooms	9.7	Restoration	18.3
Dressing/Locker/Fitting Room	6.5	Bank Office – Banking Activity Area	16.1
Corridor/Transition	5.4	Worship-pulpit, choir	25.8
For Manufacturing Facility	5.4	Fellowship Hall	9.7

Stairs – Active	6.5	Sales Area	18.3
Active Storage	8.6	Mall Concourse	18.3
Inactive Storage	3.2	Ring Sports Area	29.1
For Museum	8.6	Court Sports Area	24.8
Electrical/Mechanical	16.1	Indoor Field Area	15.1
Workshop	20.5	Physical Therapy	9.7
Sleeping Quarters	3.2	Radiology	4.3

Note: Based on these LPD values, the designer can have an idea of the energy efficiency of his/her lighting design.

CHAPTER 6

INTRODUCTION TO THE COMPUTER AIDED LIGHTING DESIGN

6.1 Role of the Software:

6.1.1Introduction:

From the earliest times, humans have found ways to create light. Pre-historic peoples used natural materials (moss, grass, etc.) soaked in animal fat and then ignited. Around 3000 to 4500 BC, oil lamps and then candles were invented. Starting in the middle of the 19th century, electrical lighting became available with the invention of the fluorescent and incandescent lamps. Technology has continued to improve and today we see the massive use of electrical lighting in the form of fluorescent, mercury and sodium vapor, metal halide and light emitting diodes (LED). Technology is continuing to develop with the latest developments being the introduction of magnetic induction and sulfur lamps. Lighting design is the field of creating light, its application and use by people. When looking objectives, the lighting designer will consider:

1. Day lighting and how it is used
2. Types of artificial lighting to be considered
3. Required light levels and uniformity
4. Types and methods of lighting control
5. Maintenance of the slighting system
6. The efficiency goals of the lighting system.

6.2 Need of Lighting Design Software:

The software is typically used by importing the CAD files. Then lighting elements are inserted. And finally, the lighting objects are associated with a photometry via IES files. The photometry of a light fixture describes the way it distributes its light into space areas. Once this process is completed, the Illuminance and luminance produced by each fixture in the space can be calculated. The main goal of lighting designing is to achieve the specified lighting level and achieve the specified uniformity. Side by side the Colour temperature and Colour rendering index is very important for lighting designing for specialized area. If we do this work physically then it is becomes rigorous and time consuming and also it economically not viable. For that reason lighting software gives us the space where we design the prototype lighting design in a pseudo environment which is resembles to the actual environment. The advantage of this system is in this process we modified and simulate the system various time as we want and biggest axe of this system that its simulated result almost matches with the physical model. In commercial lighting design when a client gives a tender to a lighting designing company the primarily check the estimates by using this software. In marketing and higher-level design, 3D photometric analysis is useful to give a graphical (no numeric) output of a proposed design. For specialized lighting designing there are different lighting software which helps us to do the design more efficiently for example road lighting design agi32 is more prominent than any other software and for tunnel lighting design the RELUX which has been developed for experts and is based on the CIE88, CIE140 and SLG201 standard. Lightning simulation software are being used to simulate and visualize any design virtually. Different lighting software is now developed to design any lighting installation such as DIALux, AGi 32, Lighting Reality pro, Relux, CGLux, Calculux, Photolux, Sunlux, Lumen Micro, Lumen Designer etc.All the lighting software is different, but the aim is same. Different lighting company uses different lighting software. Descriptions of some commonly used software's are given below:

6.2.1 DIALux: DIALux is complete free lighting software which has been developed by DIAL Company for professional light planning and is open to luminaires of all manufacturers.

Virtual worlds can be created simply and intuitively with DIALux. Results can be documented in photorealistic visualizations. Daylight and artificial light scenarios can also be simulated. CAD data of other architectural software can be imported in this software to provide for accurate simulation and to provide a design background and the same can be exported easily.

While designing, DIALux calculates the energy of your light solution requires and supports you in complying with the respective national such as NLC 2010, IS standards and international regulations. DIALux supports the luminaires of the world's leading manufacturers and therefore have the greatest possible freedom in the design process.

Benefits of DIALux:

- Simple, effective and professional light planning
- Support any photometric data file in required format(.ies)
- Latest photometric data files of the world's leading manufacturers
- Results can be compared with international standard result
- Dynamic light scenes with LED or other color changing luminaires
- Planning 3D model and simulate photometric data to any buildings, landscape, façade or roadway model
- CAD file can be imported or exported

6.2.2 AGI32: A commercial flux transfer program with limited ray-tracing functions based on North American IES photometric file Format. The program models interior and external lighting and models daylight contribution in spaces.

6.2.3 Calculux: Calculux, developed at the Philips Lighting Design and Application Center, is PC-based lighting design software that can help professionals to select and evaluate lighting systems.

CHAPTER 5:

COMPARATIVE CASE STUDIES FOR DIFFERENT SECTIONS OF FOOD PROCESSING INDUSTRY OF CONVENTIONAL LUMINAIRES WITH LED LUMINAIRES

FOOD AND BEVERAGE INDUSTRY GUWAHATI, ASSAM:

Block A and Block B Area:

Description: Block A consists of a large warehouse area of a clear height 12m whereas Block B consists of many other areas like Packing Area at a clear height of 6m, Packing and Label storage Area, Engineering Store, Blowing and Filling Area, Ozone+MIS CIP room.

7.1 AutoCAD Layout:

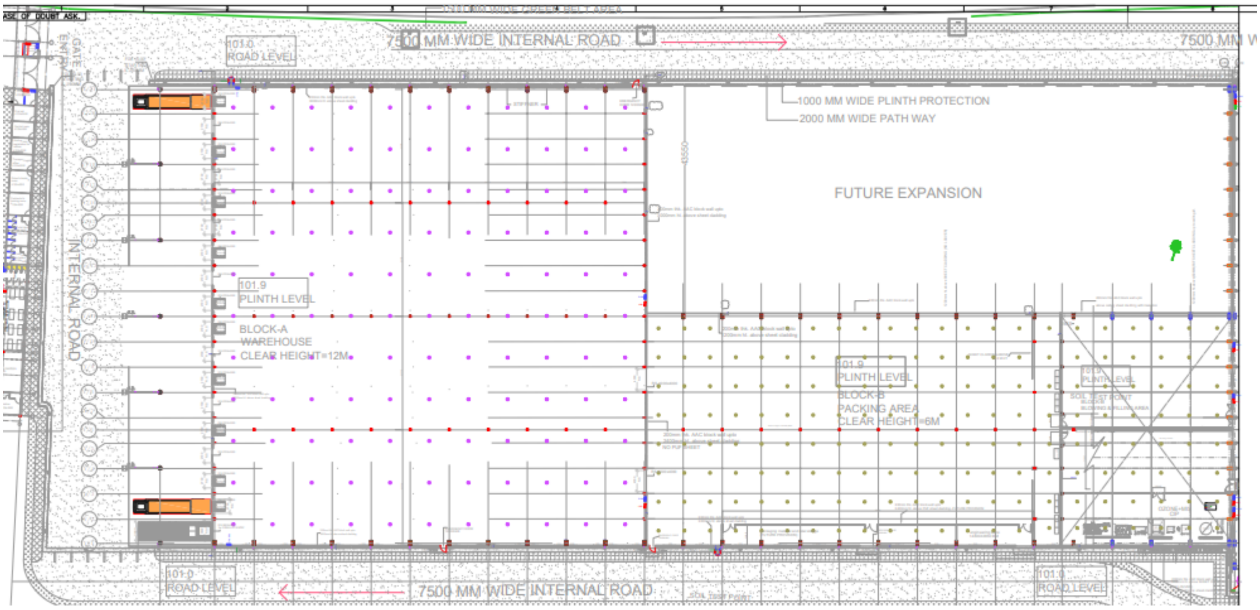


Fig AutoCAD Layout of Block-A and Block-B

7.2 Block A Warehouse:

Technical details of the Luminaire (Conventional):

Luminaire Used: Linear Fluorescent Highbay T5HO 6 lamp type 54W each

Fig.Image of the luminaire

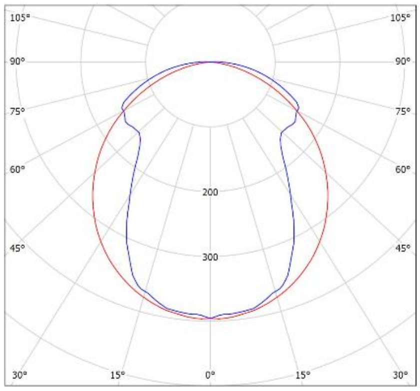


Fig. Intensity distribution curve

Specification:

1. The heavy-duty 20 gauge housing exceeds code gauge steel, and all components are post painted with a glossy, high reflectance white paint. Sockets include secure, positioning rotating collars.
2. The superior beam spread optic covers from narrow aisle lighting to open area general lighting.
3. It is available using a specular aluminum (SA) or a white aluminum (WA) reflector, which have a 25 year warranty.
4. The reflector options include up light or non-up light, depending on the application.
5. Ballasts are also thermally protected; sound rated and tightly secured by mounting bolts, as well as NEMA Premium and CEE qualified.
6. The baked white enamel finish is electrostatically applied and post painted with a glossy, highly reflective and durable white paint.

Technical Details:

1. System Wattage: 339.9W
2. Total Luminaire Lumen Output: 25954lumen
3. Input Voltage Range: 120-277V
4. Weight: 4.5Kg
5. Lamp Life: 25,000 Burning Hours@L70
6. System Luminous Efficacy: 76.35lm/W

Design Consideration:
For lighting of Warehouse-Block A with the conventional luminaries, following details has been considered:

1. Reflection Factors: Ceiling: 50%, Wall: 30% and Floor: 10%.
2. Height of the Room: 12m
3. Maintainace Factor: 0.70
4. Mounting Type: Suspension by chain of 1m
5. Mounting Height of the Luminaire: 11m
6. Standard Racks with boxes are considered as an obstruction.

The design has been done by using 171 numbers of 6x54W Linear Fluorescent Highbay T5HO Luminaire. The following 3D view has been provided below.

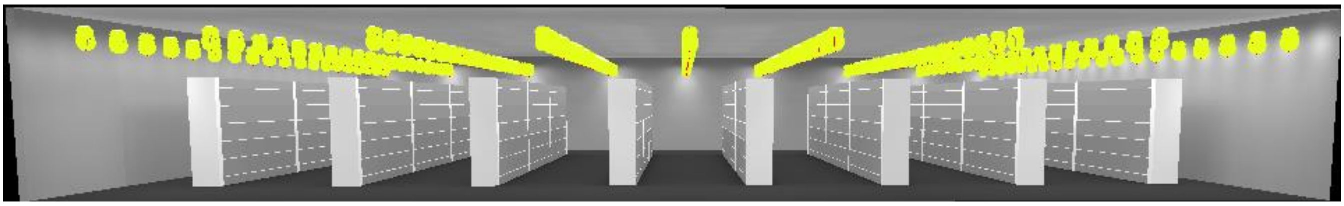
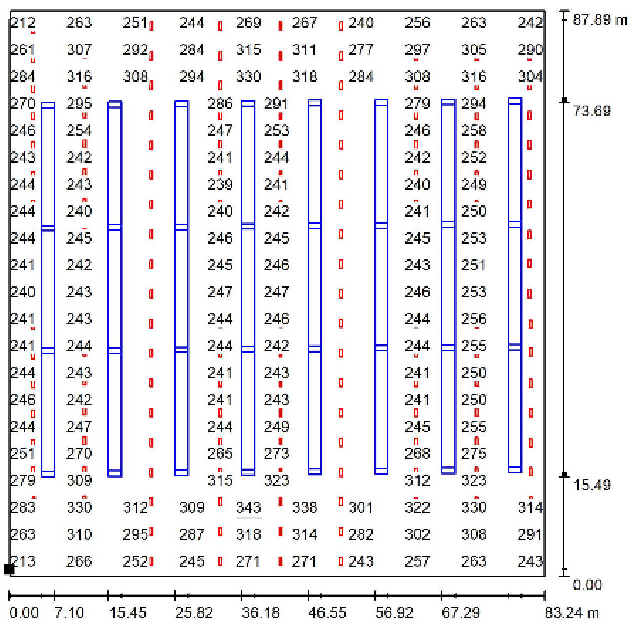


Fig.3D View of Warehouse-Block A under Conventional Luminaires

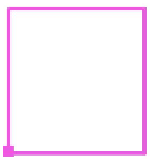
BLOCK A WAREHOUSE _Conventional / Workplane / Value Chart (E)



Values in Lux, Scale 1 : 750

Not all calculated values could be displayed.

Position of surface in room:
Marked point: (45.974 m, 74.448 m, 0.000 m)

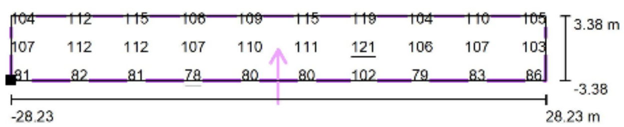


Grid: 19 x 21 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
253	177	343	0.700	0.515

Fig Value Chart for the Work plane area in Warehouse-Block A

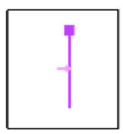
BLOCK A WAREHOUSE _Conventional / Rack Area / Value Chart (E, Vertical)



Values in Lux, Scale 1 : 500

Not all calculated values could be displayed.

Position of surface in room:
Marked point: (92.399 m, 146.178 m, 0.613 m)



Grid: 19 x 3 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
100	78	121	0.78	0.65

Fig Value chart for the vertical area of Rack in Warehouse-Block A

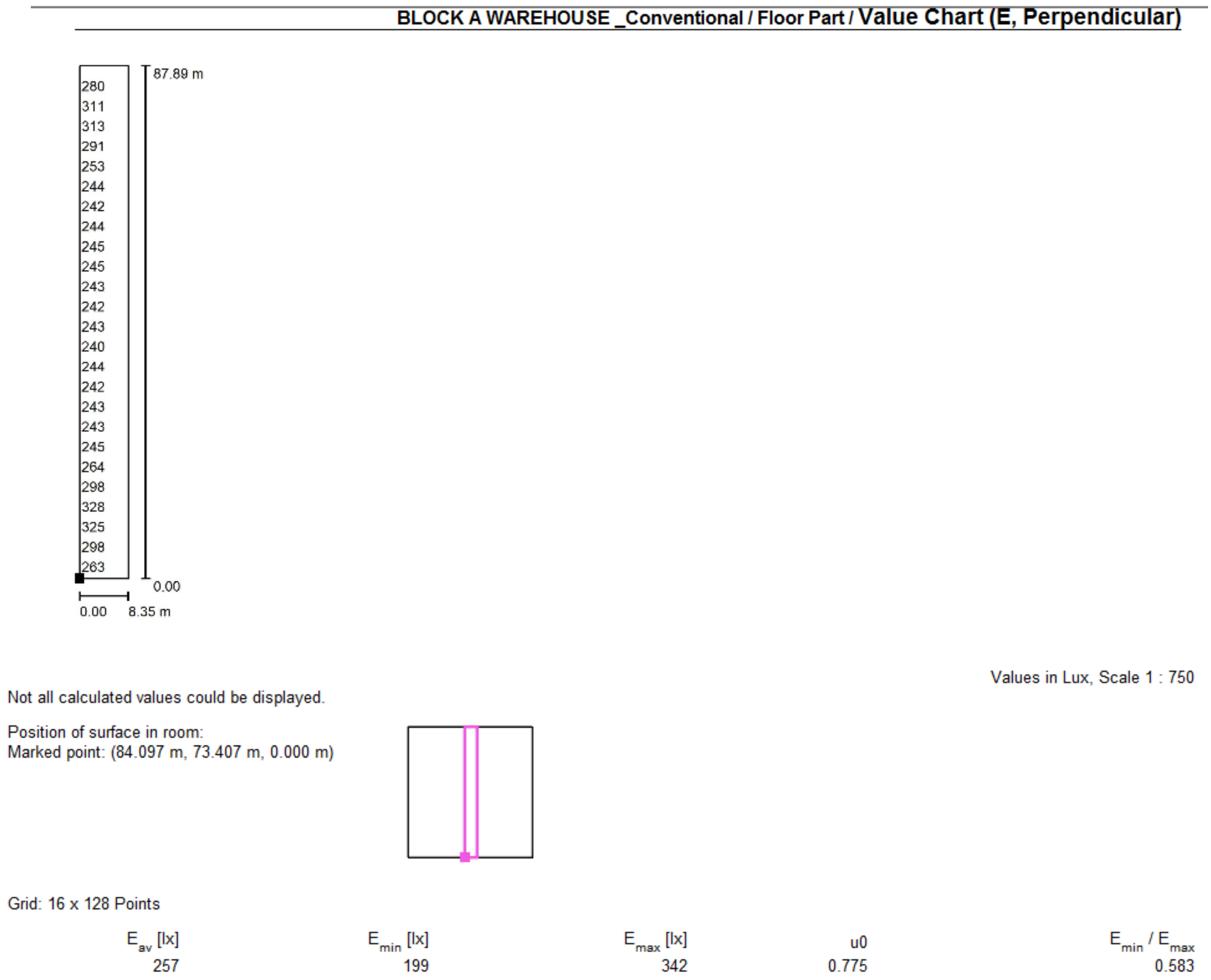


Fig Value chart for Floor part of Warehouse-Block A using Conventional luminaire

Photometric Result:

1. In this photometric result the minimum and maximum Illuminance value is 177 & 343 lux of Work plane area in Warehouse-Block A. The achieved average Illuminance is 253lx (recommended ≥200 lux) and Overall Uniformity is 0.700(recommended ≥0.4).
2. For Horizontal Floor Area, the minimum and maximum Illuminance is 199 & 342 lux. The achieved average Illuminance is 257 lux (recommended ≥200 lux) and overall uniformity is 0.775(recommended ≥0.4).
3. For Vertical Illuminance at Rack Portion, the minimum and maximum Illuminance value is 78 & 121 lux. The achieved Illuminance is 100lux (recommended ≥ 75 lux) and overall uniformity is 0.78.

False Colour Rendering:

It is used to describe different lux level distribution in different Colour inside Warehouse-Block A. The Colour distribution of different Lux level ranges is given.

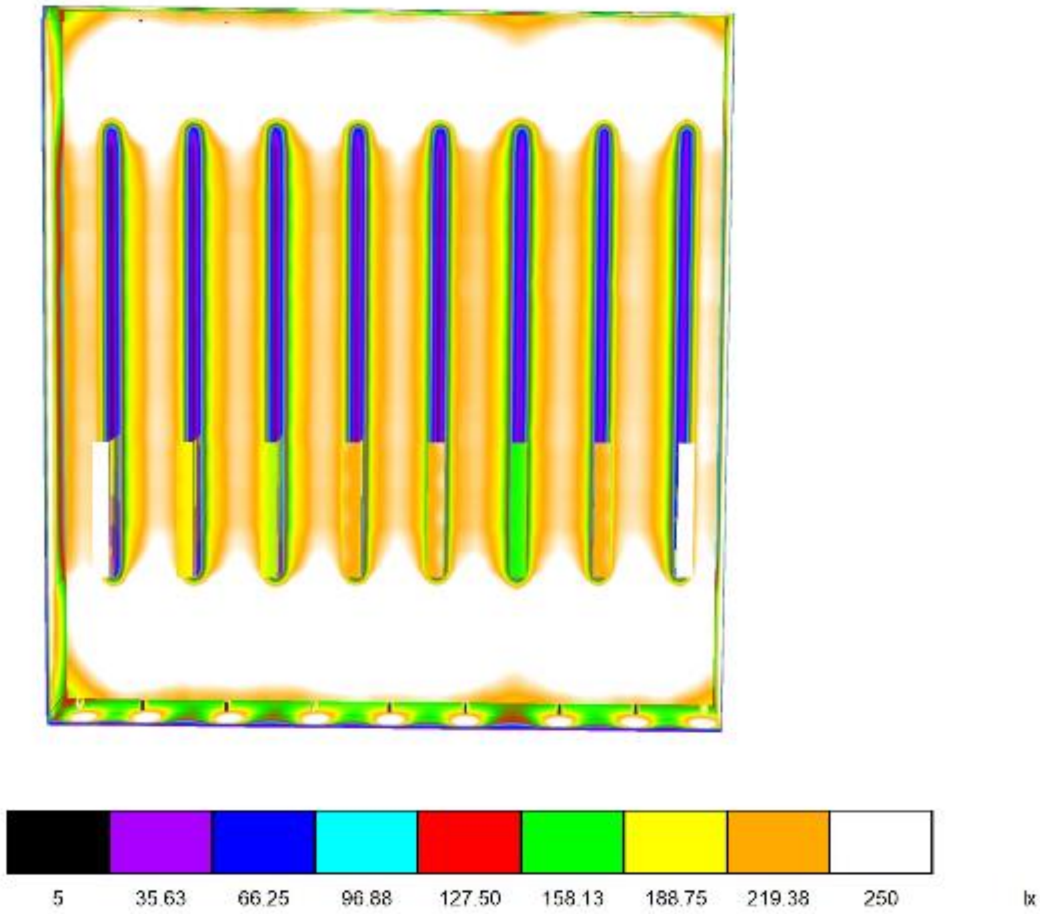


Fig Lux level distribution in different Colour under conventional luminaires

Technical details of the Luminaire (LED) Option 1:

Luminaire Used: 2’x2’ LED Linear Highbay 180W 5000K

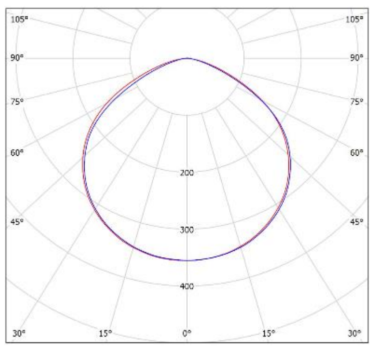


Fig.Image of the luminaire

Fig. Intensity distribution curve

Specification:

1. Offering quality lighting and excellent energy savings compared to linear fluorescent and HID Highbay fixtures.
2. Voltage is 120-277V & 347V/480V.
3. Lumen output from 8800-43800lm with efficacy up to 144lm/W.

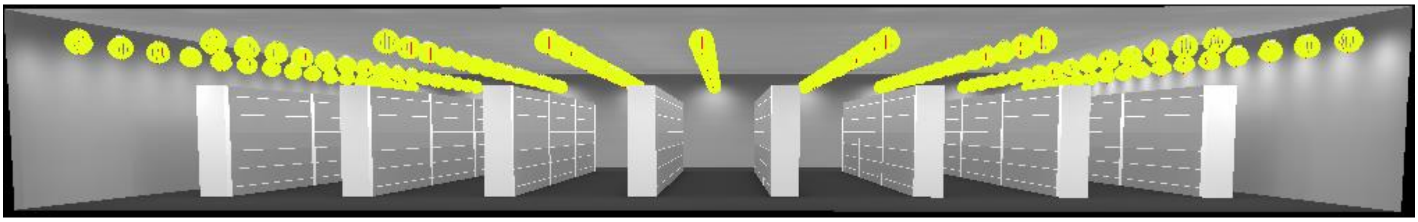
4. Multiple optics Prismatic Diffuser, Medium lens and Aisle lens available.
5. PIR Sensor optional and supports Emergency Battery.
6. Standard 0-10V dimming Chain or pendant mounting available projected life span of 50,000 hrs.
7. Operating temperature is -40℃ to 55℃ (-40℉ to 131℉).

Technical Details:
1. System Wattage: 179.3W
2. Total System Lumen Output: 25727 lumen
3. Voltage is 120-277V & 347V/480V
4. System Luminous Efficacy: 143.48lm/W
5. Lamp Life:50,000 Burning Hours@L70

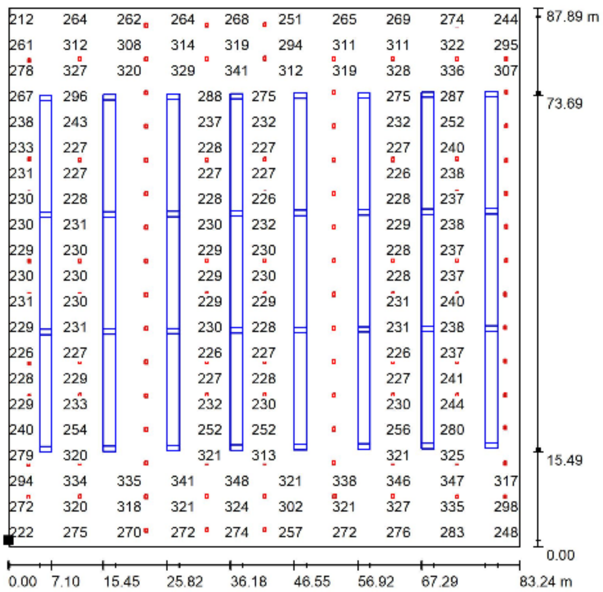
Design Consideration:
For lighting of Warehouse-Block A with the LED Linear Highbay luminaries, following details has been considered:
1. Reflection Factors: Ceiling: 50%, Wall: 30% and Floor: 10%.
2. Height of the Room: 12m
3. Maintainace Factor: 0.85
4. Mounting Type: Suspension by chain of 1m
5. Mounting Height of the Luminaire: 11m
6. Standard Racks with boxes are considered as an obstruction.

The design has been done by using 144 numbers of 2x2 LED Linear Highbay 180W 5000K. The following 3D view has been provided below.

Fig.3D View of Warehouse-Block A under LED Linear Luminaires



BLOCK A WAREHOUSE _Linear LED Highbay / Workplane / Value Chart (E)



Values in Lux, Scale 1 : 750

Not all calculated values could be displayed.

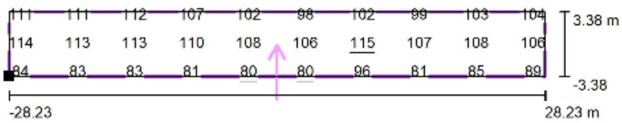
Position of surface in room:
Marked point: (45.974 m, 74.448 m, 0.000 m)

Grid: 19 x 21 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
254	190	354	0.747	0.536

Fig Value chart of Work plane area in Warehouse using 2x2 linear led Highbay

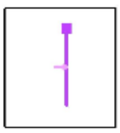
BLOCK A WAREHOUSE _Linear LED Highbay / Rack Area / Value Chart (E, Vertical)



Values in Lux, Scale 1 : 500

Not all calculated values could be displayed.

Position of surface in room:
Marked point: (92.272 m, 146.212 m, 0.613 m)

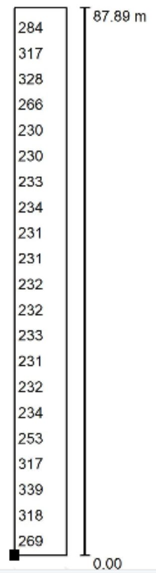


Grid: 19 x 3 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
100	80	115	0.80	0.69

Fig Value Chart of Vertical Illuminance values at Rack Part using 2x2 linear led Highbay

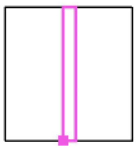
BLOCK A WAREHOUSE _Linear LED Highbay / Floor Part / **Value Chart (E, Perpendicular)**



Values in Lux, Scale 1 : 750

Not all calculated values could be displayed.

Position of surface in room:
Marked point: (84.097 m, 73.407 m, 0.000 m)



Grid: 8 x 64 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
251	195	343	0.779	0.569

Fig Value chart for Floor part of Warehouse-Block A using 2x2 linear led Highbay

Photometric Result:

1. In this photometric result the minimum and maximum Illuminance is 190 & 354 lux of Work plane area in Warehouse-Block A. The achieved average Illuminance is 254lx (recommended ≥200 lux) and Overall Uniformity is 0.747(recommended ≥0.4).
2. For Horizontal Floor Area, the minimum and maximum Illuminance is 195 & 343lux. The achieved average Illuminance is 251 lux (recommended ≥200 lux) and overall uniformity is 0.779(recommended ≥0.4).
3. For Vertical Illuminance at Rack Portion, the minimum value is 80 & 115 lux. The achieved Illuminance is 100lux (recommended ≥ 75 lux) and overall uniformity is 0.80.

False Colour Rendering:

It is used to describe different lux level distribution in different Colour inside Warehouse-Block A. The Colour distribution of different Lux level ranges is given.

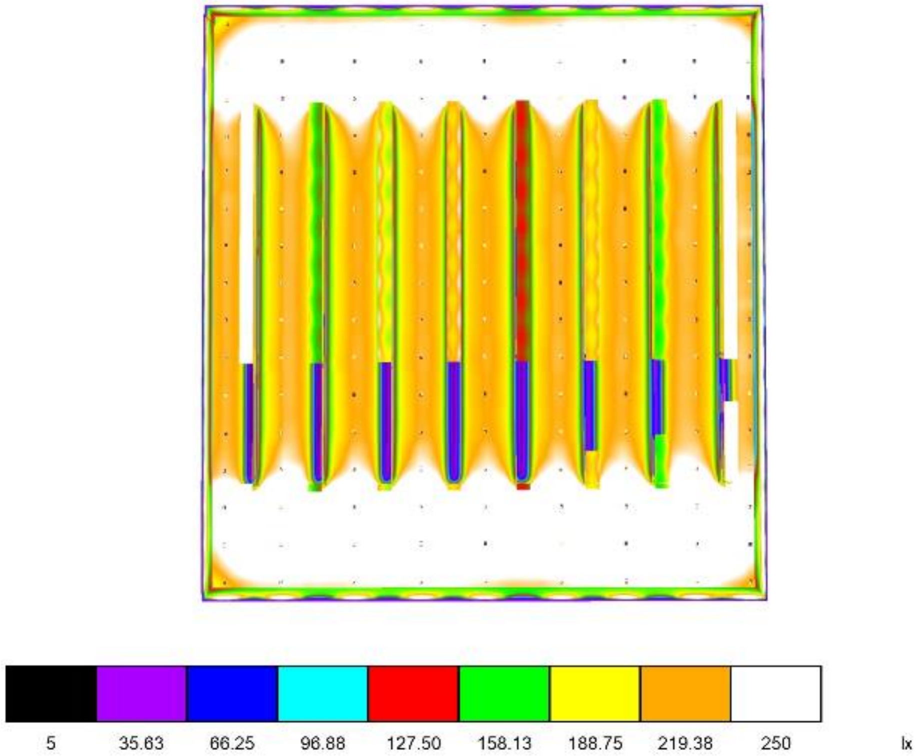


Fig Lux level distribution in different Colour under 2x2 linear led Highbay

Technical details of the Luminaire (LED) Option 2:

Luminaire Used: ROUND LED Highbay 180W 5000K

Fig.Image of the luminaire

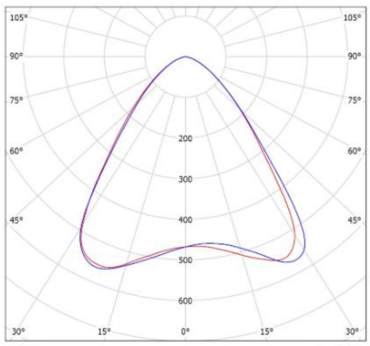


Fig. Intensity distribution curve

Specification:
1. The Highbay comes with specially designed high transitivity lens to deliver an exceptional optical performance.
2. The innovative Aeroflot design facilitates free flow of air through the die casted aluminium housing keeping heat away from the electrical components.
3. Low Operational Cost.
4. Features of IP66

Technical Details:

1. System Wattage: 180W
2. Total System Lumen Output: 25198lumen
3. Voltage is 120-277V & 347V/480V
4. System Luminous Efficacy: 139.98lm/W
5. Lamp Life: 50,000 Burning Hours@L70

Design Consideration:
For lighting of Warehouse-Block A with the LED Round Highbay 180W luminaries, following details has been considered:

1. Reflection Factors: Ceiling: 50%, Wall: 30% and Floor: 10%.
2. Height of the Room: 12m
3. Maintainace Factor: 0.85
4. Mounting Height of the Luminaire: 12m
5. Standard Racks with boxes are considered as an obstruction.

The design has been done by using 144 numbers of ROUND LED Highbay 180W 5000K. The following 3D view has been provided below.

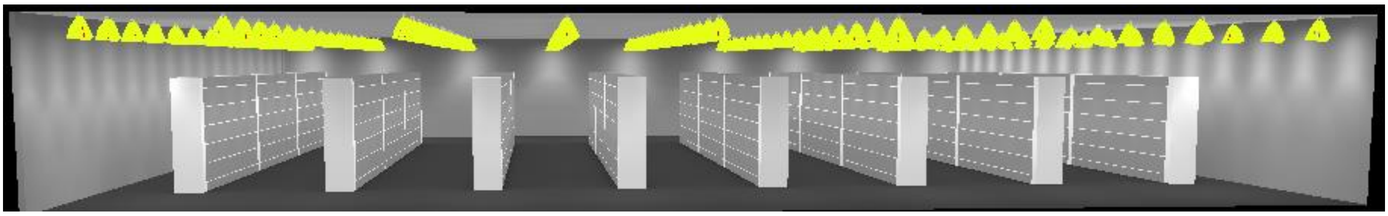
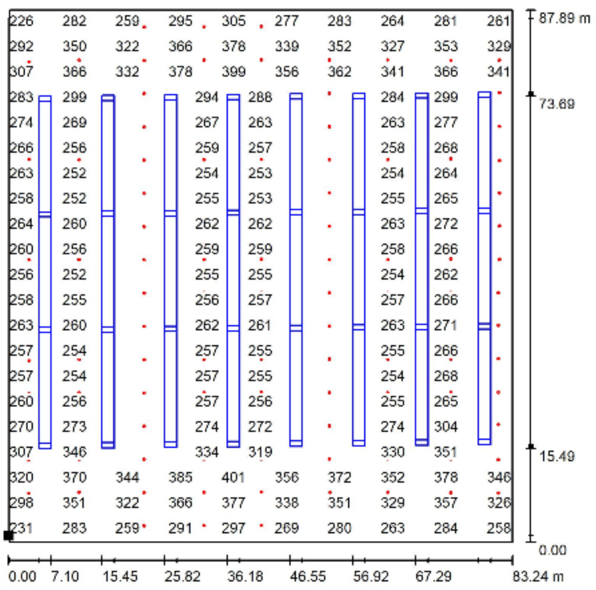


Fig.3D View of Warehouse-Block A under LED Round Highbay 180W

BLOCK A WAREHOUSE _LED ROUND 180W / Workplane / **Value Chart (E)**



Values in Lux, Scale 1 : 750

Not all calculated values could be displayed.

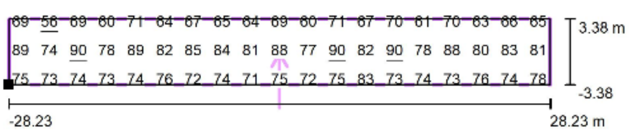
Position of surface in room:
Marked point: (45.974 m, 74.448 m, 0.000 m)

Grid: 19 x 21 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
283	215	408	0.760	0.527

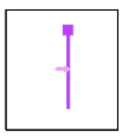
Fig Value chart of Work plane area in Warehouse using Round 180W LED Highbay

BLOCK A WAREHOUSE _LED ROUND 180W / Rack Area / **Value Chart (E, Vertical)**



Values in Lux, Scale 1 : 500

Position of surface in room:
Marked point: (92.214 m, 146.197 m, 0.617 m)

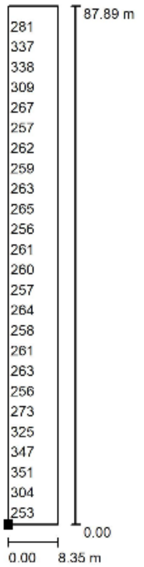


Grid: 19 x 3 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
75	56	90	0.76	0.63

Fig Value Chart of Vertical Illuminance values at Rack Part using Round 180W LED Highbay

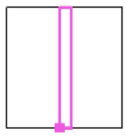
BLOCK A WAREHOUSE _LED ROUND 180W / Floor Part / **Value Chart (E, Perpendicular)**



Values in Lux, Scale 1 : 750

Not all calculated values could be displayed.

Position of surface in room:
Marked point: (84.097 m, 73.407 m, 0.000 m)



Grid: 16 x 128 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
275	212	390	0.771	0.544

Fig Value chart for Floor part of Warehouse-Block A using Round 180W LED Highbay

Photometric Result:

1. In this photometric result the minimum and maximum Illuminance is 215 & 408 lux of Work plane area in Warehouse-Block A. The achieved average Illuminance is 283lx (recommended ≥200 lux) and Overall Uniformity is 0.760(recommended ≥0.4).
2. For Horizontal Floor Area, the minimum and maximum Illuminance is 212 & 390lux. The achieved average Illuminance is 275 lux (recommended ≥200 lux) and overall uniformity is 0.771(recommended ≥0.4).
3. For Vertical Illuminance at Rack Portion, the minimum and maximum value is 56 & 90 lux. The achieved Illuminance is 75lux (recommended ≥ 75 lux) and overall uniformity is 0.76.

False Colour Rendering:

It is used to describe different lux level distribution in different Colour inside Warehouse-Block A. The Colour distribution of different Lux level ranges is given

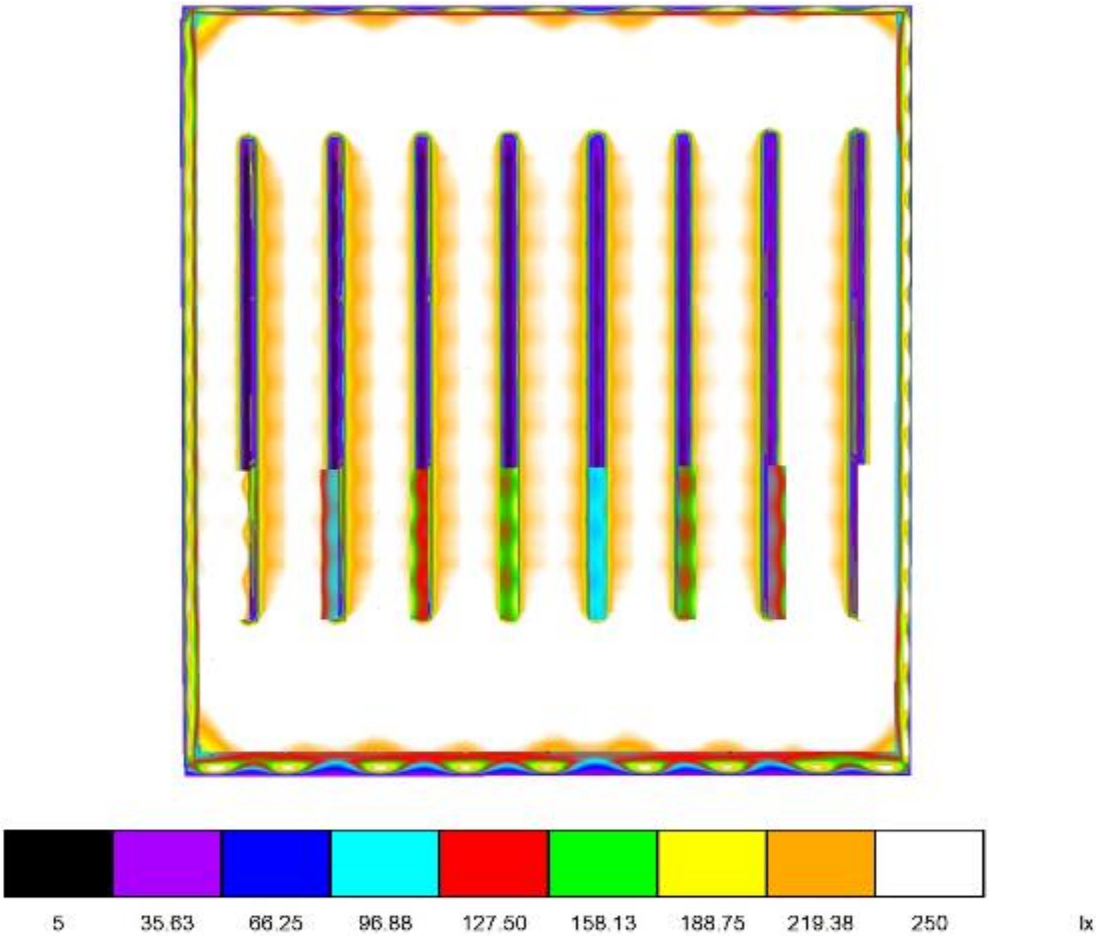


Fig Lux level distribution in different Colour under Round 180W LED Highbay

Technical details of the Luminaire (LED) Option 3:

Luminaire Used: ROUND LED Highbay 150W 5700K

Fig.Image of the luminaire

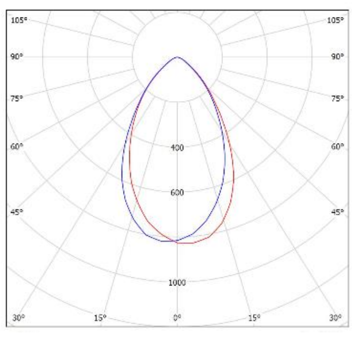


Fig. Intensity distribution curve

Specification:

1. Pressure Die cast Aluminium Housing for heat dissipation and less dust accumulation.
2. Protected against corrosion and vibrations. Also luminaire is impact resistant.
3. Lens technology ensures high performance photometry, soft light, no glare, will not cause eye fatigue of workers.
4. Breathing port (pressure equalizer valve) for better IP Protection.

Technical Details:

1. System Wattage: 142.2W
2. Total System Lumen Output: 24023lumen
3. Operating Voltage is 100-300V
4. System Luminous Efficacy: 168.93lm/W
5. Lamp Life: 50,000 Burning Hours@L70

Design Consideration:

For lighting of Warehouse-Block A with the LED Round Highbay 150W luminaries, following details has been considered:

1. Reflection Factors: Ceiling: 50%, Wall: 30% and Floor: 10%.
2. Height of the Room: 12m
3. Maintainace Factor: 0.85
4. Mounting Height of the Luminaire: 12m
5. Standard Racks with boxes are considered as an obstruction.

The design has been done by using 144 numbers of ROUND LED Highbay 150W 5700K. The following 3D view has been provided below.

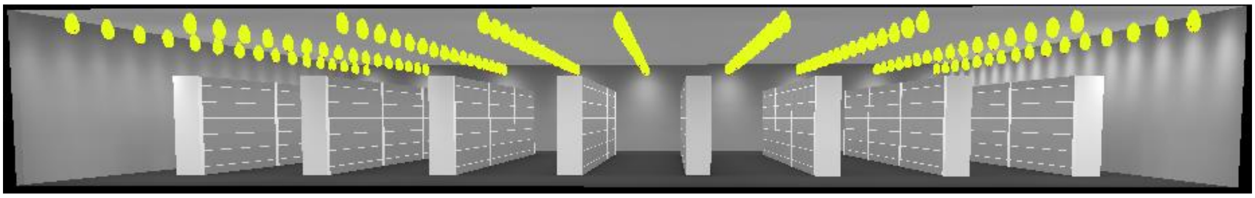
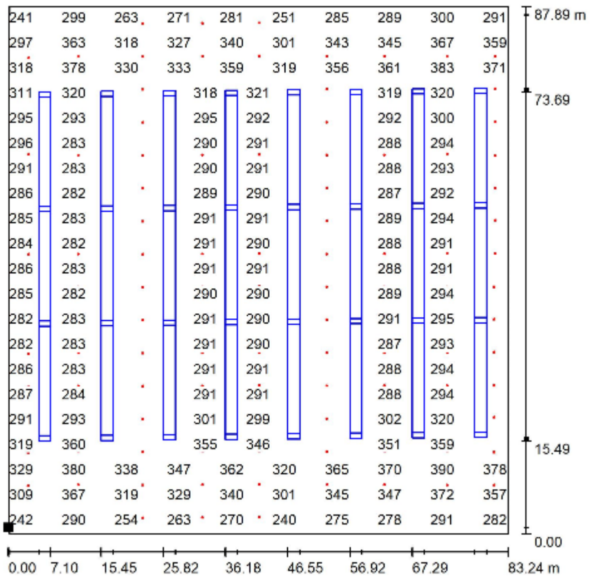


Fig.3D View of Warehouse-Block A under LED Round Highbay 150W

BLOCK A WAREHOUSE _LED 150W / Workplane / Value Chart (E)



Values in Lux, Scale 1 : 750

Not all calculated values could be displayed.

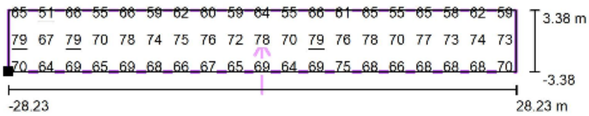
Position of surface in room:
Marked point: (45.974 m, 74.448 m, 0.000 m)

Grid: 19 x 21 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
289	203	394	0.703	0.515

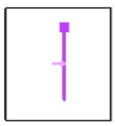
Fig Value chart of Work plane area in Warehouse using Round 150W LED Highbay

BLOCK A WAREHOUSE _LED 150W / Rack Area / Value Chart (E, Vertical)



Values in Lux, Scale 1 : 500

Position of surface in room:
Marked point: (92.272 m, 146.212 m, 0.613 m)

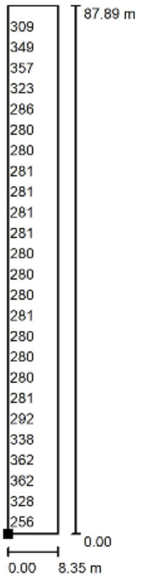


Grid: 19 x 3 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
68	51	79	0.75	0.65

Fig Value Chart of Vertical Illuminance values at Rack Part using Round 150W LED Highbay

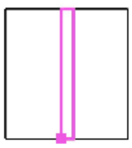
BLOCK A WAREHOUSE _LED 150W / Floor Part / **Value Chart (E, Perpendicular)**



Values in Lux, Scale 1 : 750

Not all calculated values could be displayed.

Position of surface in room:
Marked point: (84.097 m, 73.407 m, 0.000 m)



Grid: 16 x 128 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
284	196	369	0.690	0.530

Fig Value chart for Floor part of Warehouse-Block A using Round 150W LED Highbay

Photometric Result:

1. In this photometric result the minimum and maximum Illuminance is 203 & 394 lux of Work plane area in Warehouse-Block A. The achieved average Illuminance is 289lx (recommended ≥200 lux) and Overall Uniformity is 0.703(recommended ≥0.4).
2. For Horizontal Floor Area, the minimum and maximum Illuminance is 196 & 369lux. The achieved average Illuminance is 284 lux (recommended ≥200 lux) and overall uniformity is 0.690(recommended ≥0.4).
3. For Vertical Illuminance at Rack Portion, the minimum value is 51 & 79 lux. The achieved Illuminance is 68lux (recommended ≥ 75 lux) and overall uniformity is 0.75.

False Colour Rendering:

It is used to describe different lux level distribution in different Colour inside Warehouse-Block A. The Colour distribution of different Lux level ranges is given:

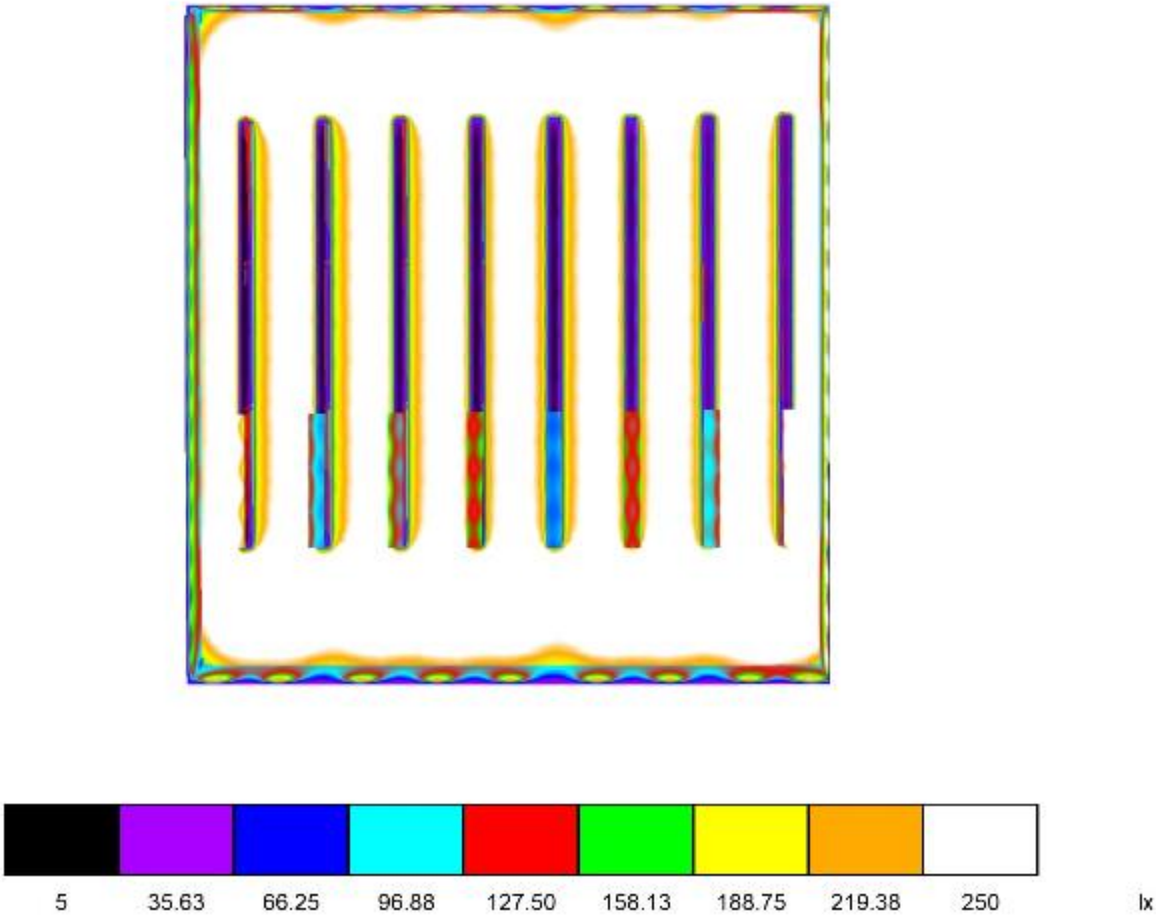


Fig Lux level distribution in different Colour under Round 150W LED Highbay

Conclusion:
Below table provides the details of LPD value comparison of Conventional Luminaire with LED:

Name of the Product	Total Number of Quantities	Obtained LPD Values (Recommended LPD value as per ECBC:7.08W/m²)
1. Linear Fluorescent Highbay T5HO 6 lamp type 54W	171	7.95W/m²
2.LED Linear Highbay 180W	144	3.53W/m²
3.Round LED Highbay 180W	144	3.54W/m²
4.Round LED Highbay 150W	144	2.80W/m²

So, LED Luminaire Products are more energy efficient than conventional luminaire.

7.3 Block B PACKING AREA:

Technical details of the Luminaire (Conventional):
Luminaire Used: Linear Fluorescent Highbay T8 6 lamp type 32W each

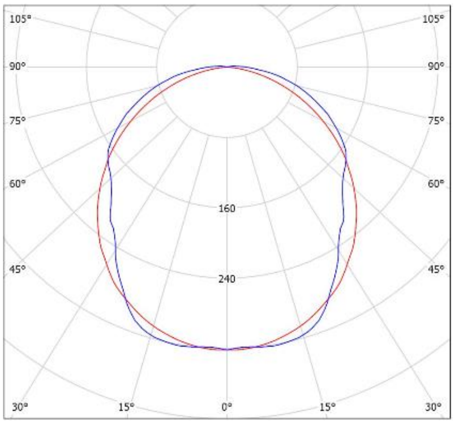


Fig.Image of the luminaire

Fig. Intensity distribution curve

Specification:

1. The heavy-duty 20 gauge housing exceeds code gauge steel, and all components are post painted with a glossy, high reflectance white paint. Sockets include secure, positioning rotating collars.
2. The superior beam spread optic covers from narrow aisle lighting to open area general lighting.
3. It is available using a specular aluminum (SA) or a white aluminum (WA) reflector, which have a 25 year warranty.
4. The reflector options include up light or non-up light, depending on the application.
5. Ballasts are also thermally protected; sound rated and tightly secured by mounting bolts, as well as NEMA Premium and CEE qualified.
6. The baked white enamel finish is electrostatically applied and post painted with a glossy, highly reflective and durable white paint.

Technical Details:

1. System Wattage: 218.1W
2. Total Luminaire Lumen Output: 16106lumen
3. Input Voltage Range: 120-277V
4. Weight: 4.5Kg
5. Lamp Life: 25,000 Burning Hours@L70
6. System Luminous Efficacy: 73.84lm/W

Design Consideration:
For lighting of Packing Area-Block B with the conventional luminaries, following details has been considered:

1. Reflection Factors: Ceiling: 50%, Wall: 30% and Floor: 10%.
2. Height of the Room: 6m
3. Maintainace Factor: 0.70
4. Mounting Type: Suspension by chain of 0.5m
5. Mounting Height of the Luminaire: 5.5m
6. No obstruction is considered.

The design has been done by using 113 numbers of 6x32W Linear Fluorescent Highbay .The following 3D view has been provided below.

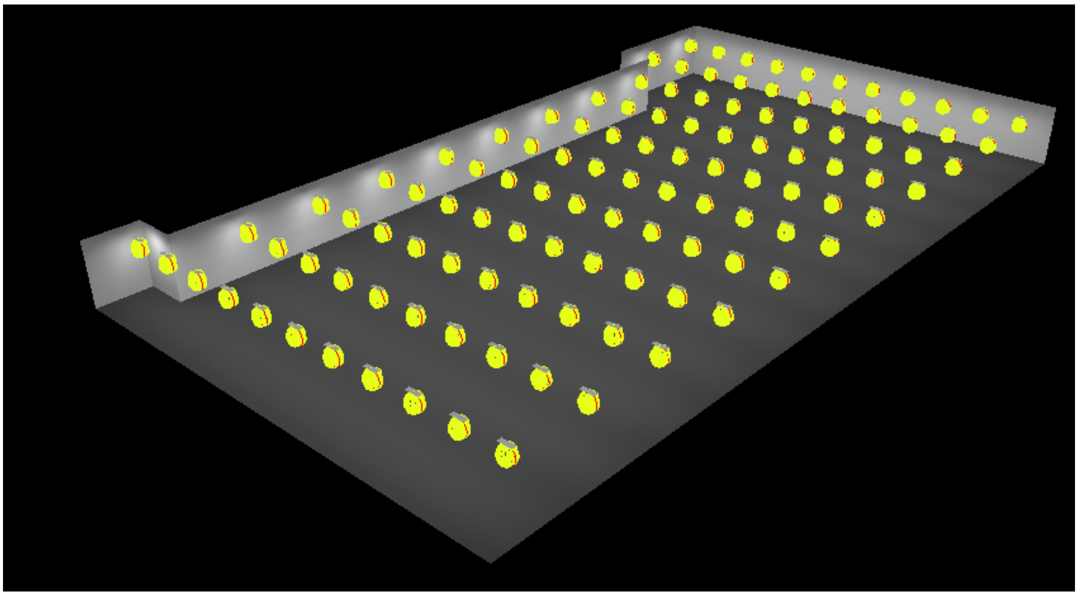
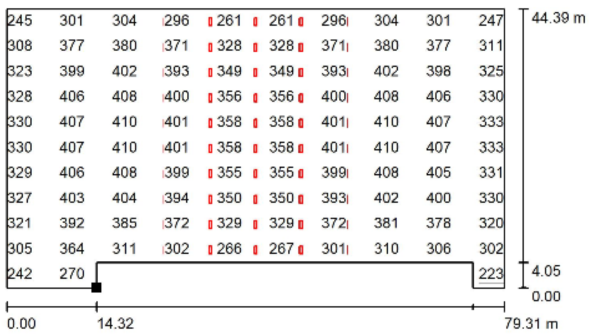


Fig.3D View of Packing Area-Block B under Fluorescent Linear Highbay 218W

BLOCK B PACKING AREA_218W Linear Fluoroscent Highbay / Workplane / **Value Chart (E)**



Values in Lux, Scale 1 : 750

Not all calculated values could be displayed.

Position of surface in room:
Marked point: (143.654 m, 73.427 m, 0.000 m)

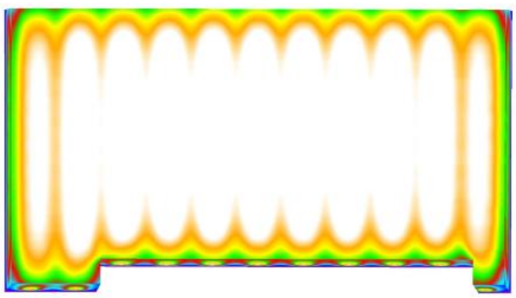
Grid: 11 x 19 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
351	223	422	0.636	0.530

Fig Value chart of Work plane area in Packaging Area using Linear Fluorescent Highbay 218W

Photometric Result:
In this photometric result the minimum and maximum Illuminance is 223 & 422 lux of Work plane area in Packaging Area-Block B. The achieved average Illuminance is 351lx (recommended ≥300 lux) and Overall Uniformity is 0.636(recommended ≥0.4).

False Colour Rendering:
It is used to describe different lux level distribution in different Colour inside PACKING AREA-Block B. The Colour distribution of different Lux level ranges is given:



Technical details of the Luminaire (LED) Option 1:

Luminaire Used: ROUND LED Highbay 100W 90° beam angle

Fig.Image of the luminaire

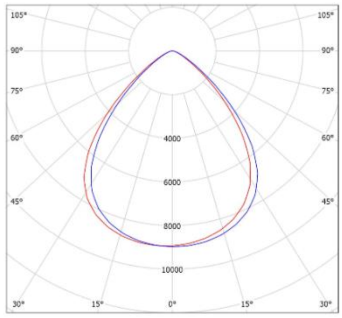


Fig. Intensity distribution curve

Specification:

- Pressure Die cast Aluminium Housing for heat dissipation and less dust accumulation.
- Protected against corrosion and vibrations. Also luminaire is impact resistant.
- Lens technology ensures high performance photometry, soft light, no glare, will not cause eye fatigue of workers.
- Breathing port (pressure equalizer valve) for better IP Protection.

Technical Details:

1. System Wattage: 102.2W
2. Total System Lumen Output: 16320lumen
3. Operating Voltage is 100-300V
4. System Luminous Efficacy: 160lm/W
5. Lamp Life: 50,000 Burning Hours@L70

Design Consideration:
For lighting of Packing Area-Block B with the ROUND LED Highbay 100W 90° beam angle luminaries, following details has been considered:
1. Reflection Factors: Ceiling: 50%, Wall: 30% and Floor: 10%.
2. Height of the Room: 6m
3. Maintainace Factor: 0.85
5. Mounting Type: i-bolt
6. No obstruction is considered.

The design has been done by using 91 numbers of ROUND LED Highbay 100W 90° beam angle .The following 3D view has been provided below.

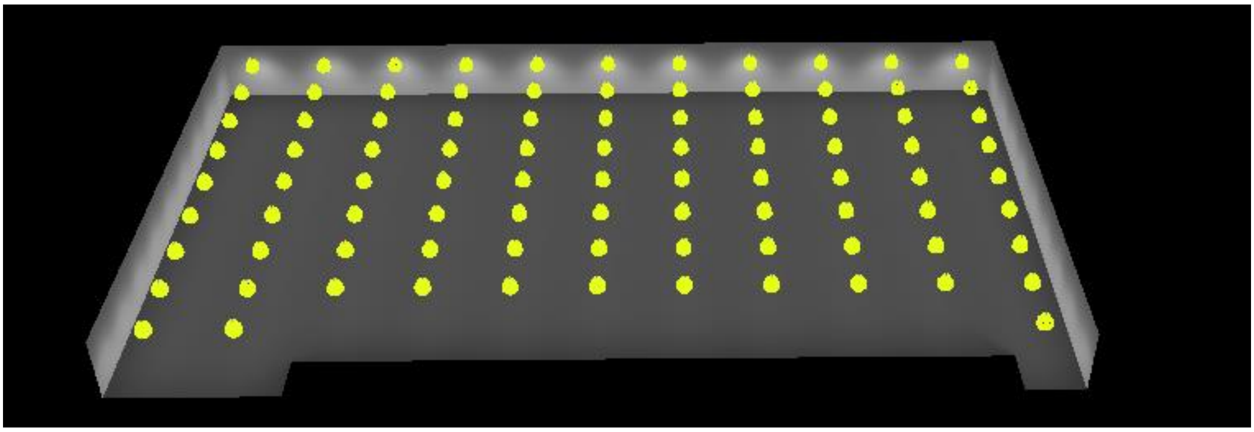
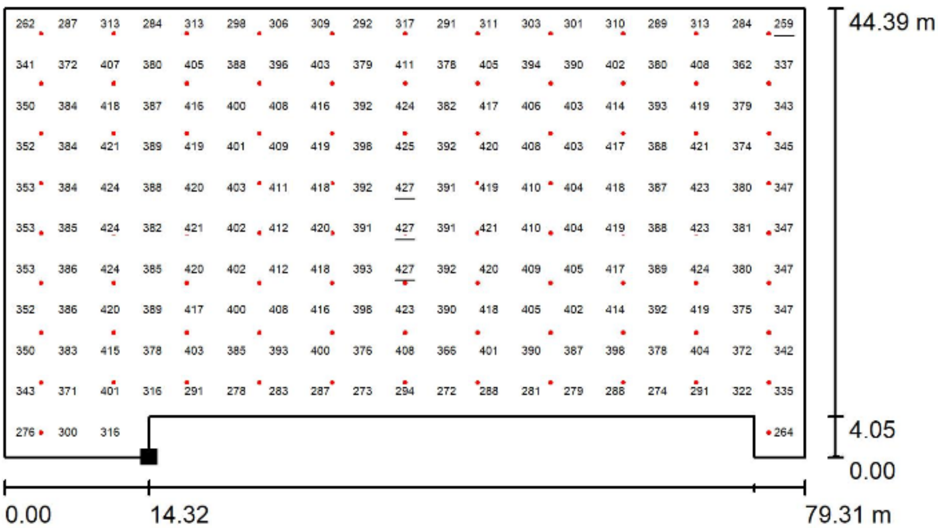


Fig.3D View of Packing Area-Block B under Round LED Highbay 100W 90° beam angle

BLOCK B PACKING AREA_100W Highabay 90 deg / Workplane / Value Chart (E)



Values in Lux, Scale 1 : 750

Not all calculated values could be displayed.

Position of surface in room:
Marked point: (143.654 m, 73.427 m, 0.000 m)

Grid: 11 x 19 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
375	259	427	0.692	0.608

Fig Value chart of Work plane area in Packing Area using Round LED Highbay 100W 90° beam angle

Photometric Result:
In this photometric result the minimum and maximum Illuminance is 259 & 427 lux of Work plane area in Packaging Area-Block B. The achieved average Illuminance is 375lx (recommended ≥300 lux) and Overall Uniformity is 0.692(recommended ≥0.4).

False Colour Rendering:
It is used to describe different lux level distribution in different Colour inside PACKING AREA-Block B. The Colour distribution of different Lux level ranges is given:

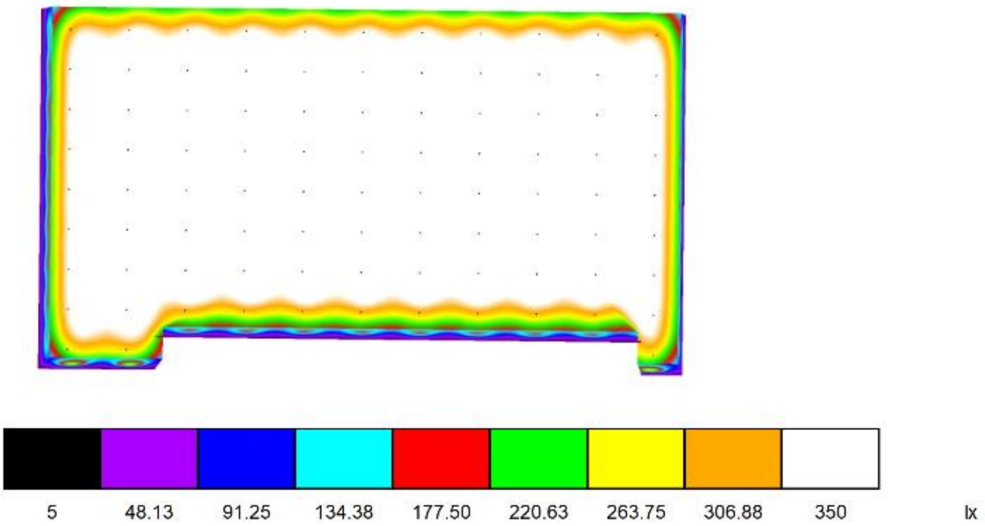


Fig Lux level distribution in different Colour under Round LED Highbay 100W 90° beam angle

Technical details of the Luminaire (LED) Option 2:

Luminaire Used: ROUND LED Highbay 100W 60° beam angle

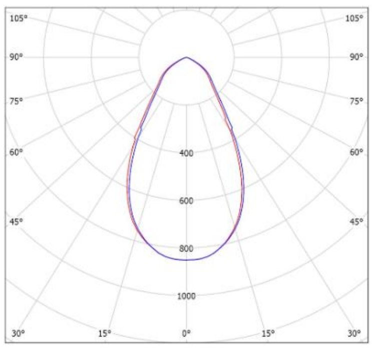


Fig.Image of the luminaire

Fig. Intensity distribution curve

Specification:

- Pressure Die cast Aluminium Housing for heat dissipation and less dust accumulation.
- Protected against corrosion and vibrations. Also luminaire is impact resistant.
- Lens technology ensures high performance photometry, soft light, no glare, will not cause eye fatigue of workers.
- Breathing port (pressure equalizer valve) for better IP Protection.

Technical Details:

1. System Wattage: 100W
2. Total System Lumen Output: 15997lumen
3. Operating Voltage is 100-300V
4. System Luminous Efficacy: 160lm/W
5. Lamp Life: 50,000 Burning Hours@L70

Design Consideration:
For lighting of Packing Area-Block B with the ROUND LED Highbay 100W 60° beam angle luminaries, following details has been considered:
1. Reflection Factors: Ceiling: 50%, Wall: 30% and Floor: 10%.
2. Height of the Room: 6m
3. Maintainace Factor: 0.85
4. Mounting Type: i-bolt
5. No obstruction is considered.

The design has been done by using 91 numbers of ROUND LED Highbay 100W 60° beam angle .The following 3D view has been provided below.

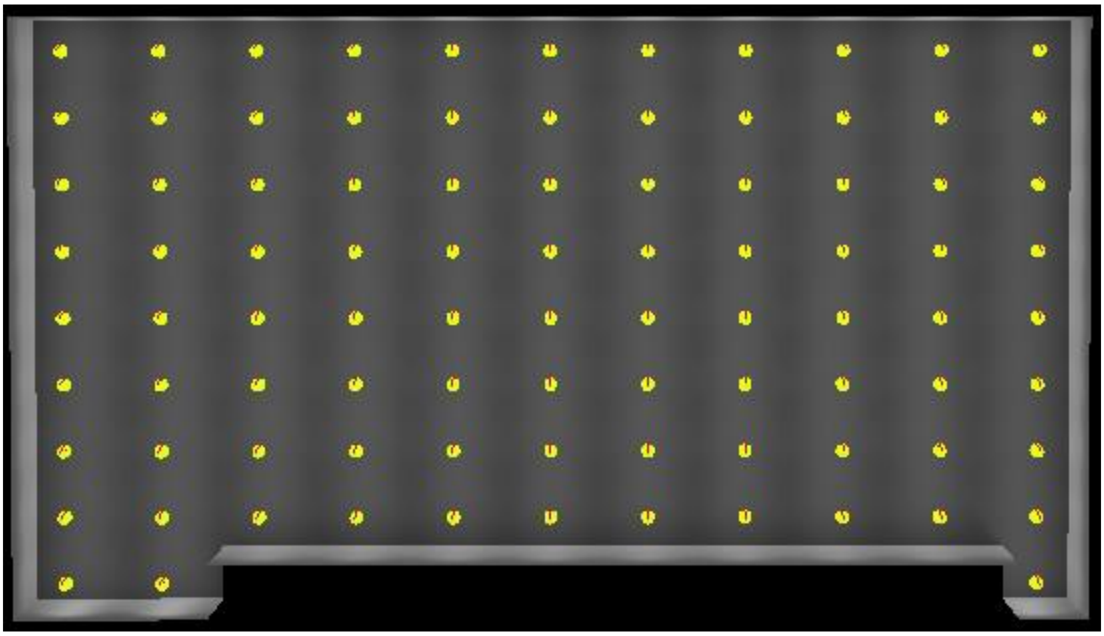
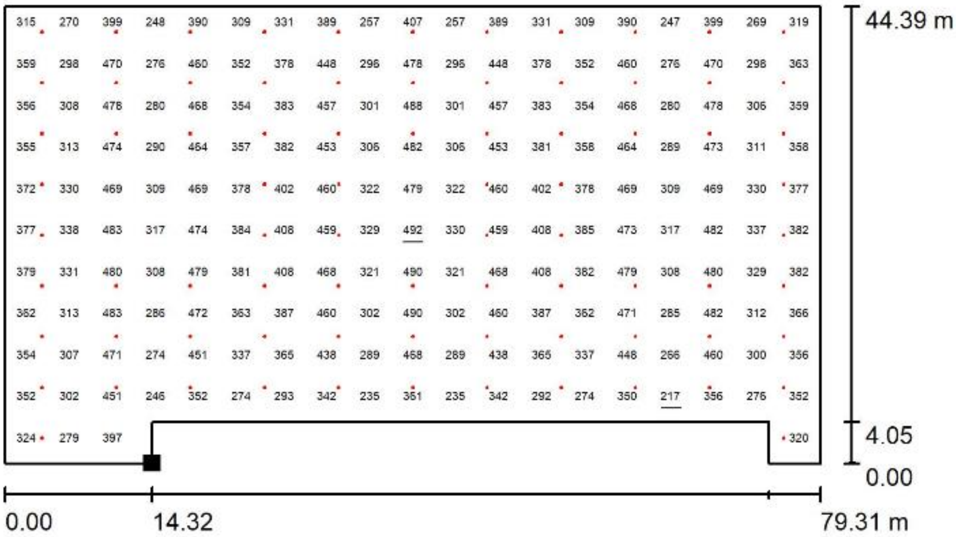


Fig.3D View of Packing Area-Block B under Round LED Highbay 100W 60°beam angle

BLOCK B PACKING AREA_100W Highabay 60 deg / Workplane / Value Chart (E)



Values in Lux, Scale 1 : 750

Not all calculated values could be displayed.

Position of surface in room:
Marked point: (143.654 m, 73.427 m, 0.000 m)

Grid: 11 x 19 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
372	217	492	0.584	0.441

Fig Value chart of Work plane area in Packing Area using Round LED Highbay 100W 60° beam angle

Photometric Result:
In this photometric result the minimum and maximum Illuminance is 217 & 492 lux of Work plane area in Packaging Area-Block B. The achieved average Illuminance is 372lx (recommended ≥300 lux) and Overall Uniformity is 0.584(recommended ≥0.4).

False Colour Rendering:
It is used to describe different lux level distribution in different Colour inside PACKING AREA-Block B. The Colour distribution of different Lux level ranges is given:

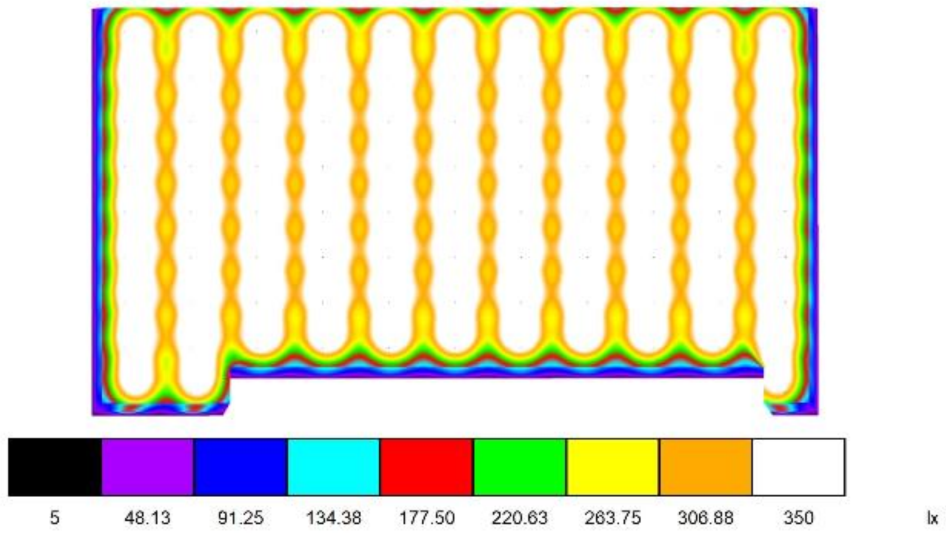


Fig Lux level distribution in different Colour under Round LED Highbay 100W 60° beam angle

Conclusion:
Below table provides the details of LPD value comparison of Conventional Luminaire with LED:

Name of the Product	Total Number of Quantities	Obtained LPD Values
1. Linear Fluorescent Highbay T8 6 lamp type 32W	113	7.52W/m^2
2.Round LED Highbay 100W 90°	91	2.84W/m^2
3.Round LED Highbay 100W 60°	91	2.78W/m^2

So, LED Luminaire Products are more energy efficient than conventional luminaire.

7.4 Block B- PACKING AND LABEL STORAGE AREA:

Technical details of the Luminaire (Conventional):
Luminaire Used: Linear Fluorescent Highbay T8 6 lamp type 32W each

Fig.Image of the luminaire

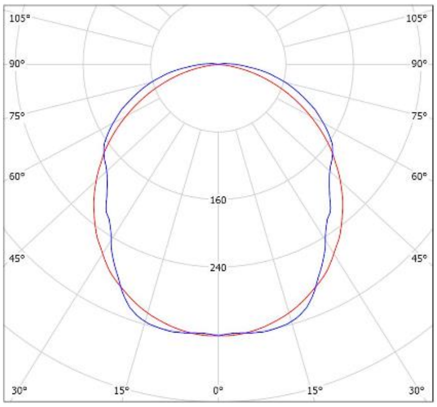


Fig. Intensity distribution curve

Specification:
1. The heavy-duty 20 gauge housing exceeds code gauge steel, and all components are post painted with a glossy, high reflectance white paint. Sockets include secure, positioning rotating collars.
2. The superior beam spread optic covers from narrow aisle lighting to open area general lighting.
3. It is available using a specular aluminum (SA) or a white aluminum (WA) reflector, which have a 25 year warranty.
4. The reflector options include up light or non-up light, depending on the application.
5. Ballasts are also thermally protected; sound rated and tightly secured by mounting bolts, as well as NEMA Premium and CEE qualified.
6. The baked white enamel finish is electrostatically applied and post painted with a glossy, highly reflective and durable white paint.

Technical Details:
1. System Wattage: 218.1W
2. Total Luminaire Lumen Output: 16106lumen
3. Input Voltage Range: 120-277V
4. Weight: 4.5Kg
5. Lamp Life: 25,000 Burning Hours@L70
6. System Luminous Efficacy: 73.84lm/W

Design Consideration:
For lighting of Packing and Label Storage Area-Block B with the conventional luminaries, following details has been considered:
1. Reflection Factors: Ceiling: 50%, Wall: 30% and Floor: 10%.
2. Height of the Room: 6m
3. Maintainace Factor: 0.70
4. Mounting Type: Suspension by chain of 0.5m

5. Mounting Height of the Luminaire: 5.5m
6. No obstruction is considered.

The design has been done by using 14 numbers of Linear Fluorescent Highbay 6x32W.The following 3D view has been provided below.

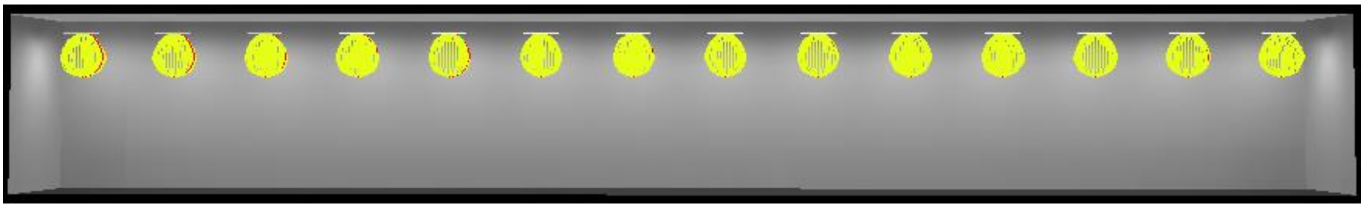
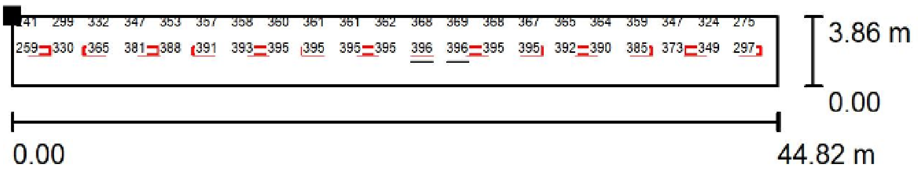


Fig.3D View of Packing Area-Block B under Linear Fluorescent Highbay 6x32W

Packing & Label storage _218W Linear Highbay / Workplane / Value Chart (E)



Values in Lux, Scale 1 : 500

Not all calculated values could be displayed.

Position of surface in room:
Marked point:
(143.856 m, 77.268 m, 0.000 m)

Grid: 16 x 128 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
353	200	396	0.567	0.504

Fig Value chart of Work plane area in Packing and Label Storage Area using Linear Fluorescent Highbay 6x32W

Photometric Result:
In this photometric result the minimum and maximum Illuminance is 200 & 396 lux of Work plane area in Packing and Label Storage Area-Block B. The achieved

average Illuminance is 353lx (recommended ≥300 lux) and Overall Uniformity is 0.567(recommended ≥0.4).

False Colour Rendering:
It is used to describe different lux level distribution in different Colour inside Packing and Label Storage Area-Block B. The Colour distribution of different Lux level ranges is given:

Fig Lux level distribution in different Colour under Linear Fluorescent Highbay 6x32W

Technical details of the Luminaire (LED) Option 1:

Luminaire Used: ROUND LED Highbay 100W 90° beam angle

Fig.Image of the luminaire

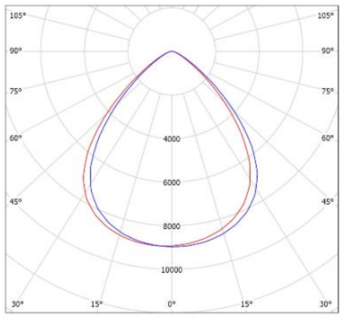


Fig. Intensity distribution curve

Specification:

- Pressure Die cast Aluminium Housing for heat dissipation and less dust accumulation.
- Protected against corrosion and vibrations. Also luminaire is impact resistant.
- Lens technology ensures high performance photometry, soft light, no glare, will not cause eye fatigue of workers.
- Breathing port (pressure equalizer valve) for better IP Protection.

Technical Details:

1. System Wattage: 102.2W
2. Total System Lumen Output: 16320lumen
3. Operating Voltage is 100-300V
4. System Luminous Efficacy: 160lm/W
5. Lamp Life: 50,000 Burning Hours@L70

Design Consideration:
For lighting of Packing and Label Storage Area-Block B with the ROUND LED Highbay 100W 90° beam angle luminaries, following details has been considered:

1. Reflection Factors: Ceiling: 50%, Wall: 30% and Floor: 10%.
2. Height of the Room: 6m
3. Maintainace Factor: 0.85
4. Mounting Type: i-bolt
5. No obstruction is considered.

The design has been done by using 10 numbers of ROUND LED Highbay 100W 90° beam angle .The following 3D view has been provided below.

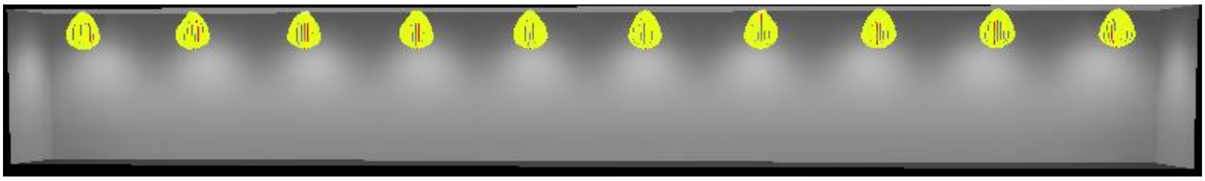
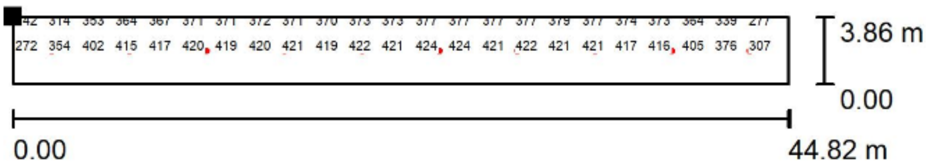


Fig.3D View of Packing Area-Block B under Linear Fluorescent Highbay 6x32W

Packing & Label storage_100W Highbay 90deg / Workplane / Value Chart (E)



Values in Lux, Scale 1 : 500

Not all calculated values could be displayed.

Position of surface in room:
Marked point:
(143.856 m, 77.268 m, 0.000 m)

Grid: 32 x 256 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
378	205	425	0.543	0.483

Fig Value chart of Work plane area in Packing and Label Storage Area using Round LED Highbay 100W 90° beam angle

Photometric Result:
In this photometric result the minimum and maximum Illuminance is 205 & 425 lux of Work plane area in Packing and Label Storage Area-Block B. The achieved average Illuminance is 378lx (recommended ≥300 lux) and Overall Uniformity is 0.543(recommended ≥0.4).

False Colour Rendering:
It is used to describe different lux level distribution in different Colour inside Packing and Label Storage area-Block B. The Colour distribution of different Lux level ranges is given:

Technical details of the Luminaire (LED) Option 2:

Luminaire Used: ROUND LED Highbay 100W 60° beam angle

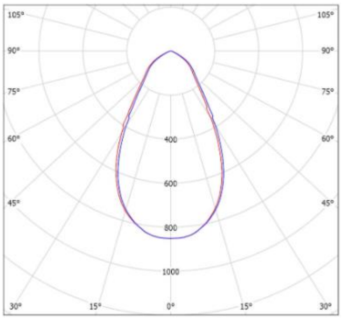


Fig.Image of the luminaire

Fig. Intensity distribution curve

Specification:

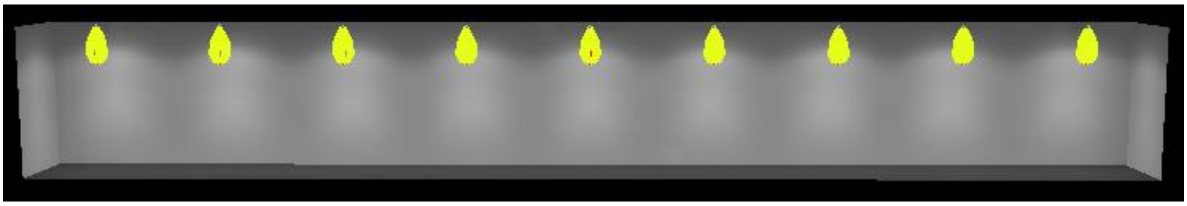
- Pressure Die cast Aluminium Housing for heat dissipation and less dust accumulation.
- Protected against corrosion and vibrations. Also luminaire is impact resistant.
- Lens technology ensures high performance photometry, soft light, no glare, will not cause eye fatigue of workers.
- Breathing port (pressure equalizer valve) for better IP Protection.

Technical Details:

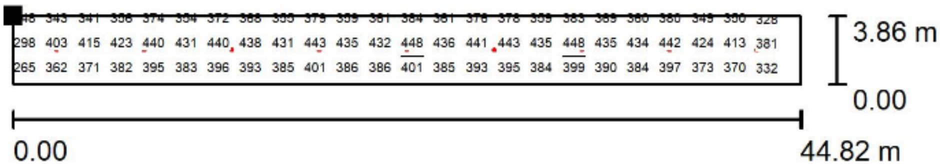
1. System Wattage: 100W
2. Total System Lumen Output: 15997lumen
3. Operating Voltage is 100-300V
4. System Luminous Efficacy: 160lm/W
5. Lamp Life: 50,000 Burning Hours@L70

Design Consideration:
For lighting of Packing and Label Storage Area-Block B with the ROUND LED Highbay 100W 60° beam angle luminaries, following details has been considered:
1. Reflection Factors: Ceiling: 50%, Wall: 30% and Floor: 10%.
2. Height of the Room: 6m
3. Maintainace Factor: 0.85
4. Mounting Type: i-bolt
5. No obstruction is considered.

The design has been done by using 9 numbers of ROUND LED Highbay 100W 60° beam angle .The following 3D view has been provided below.



Packing & Label storage_100W Highbay 60deg / Workplane / Value Chart (E)



Values in Lux, Scale 1 : 500

Not all calculated values could be displayed.

Position of surface in room:
Marked point: (143.856 m, 77.268 m, 0.000 m)

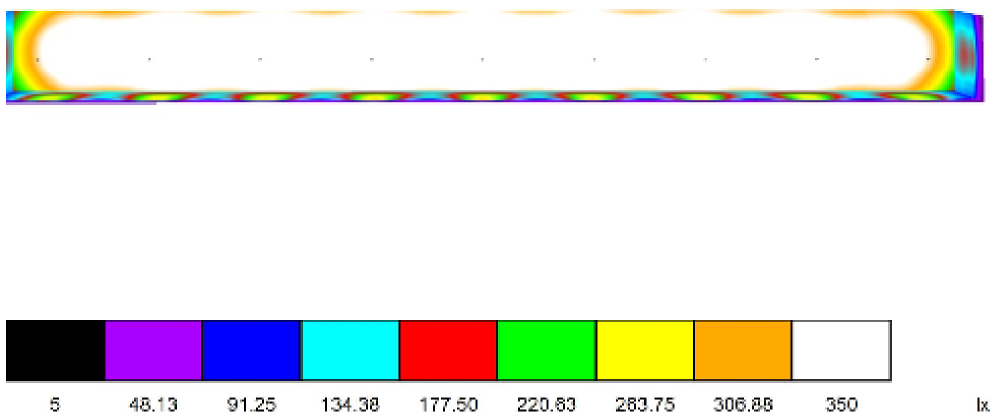
Grid: 64 x 512 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
387	187	448	0.483	0.416

Fig Value chart of Work plane area in Packing and Label Storage Area using Round LED Highbay 100W 60° beam angle

Photometric Result:
In this photometric result the minimum and maximum Illuminance is 187 & 448 lux of Work plane area in Packing and Label Storage Area-Block B. The achieved average Illuminance is 387lx (recommended ≥300 lux) and Overall Uniformity is 0.483(recommended ≥0.4).

False Colour Rendering:
It is used to describe different lux level distribution in different Colour inside Packing and Label Storage Area-Block B. The Colour distribution of different Lux level ranges is given:



Conclusion:
Below table provides the details of LPD value comparison of Conventional Luminaire with LED:

Name of the Product	Total Number of Quantities	Obtained LPD Values(recommended as per ECBC code:6.8W/m²)
1. Linear Fluorescent Highbay T8 6 lamp type 32W	14	17.72W/m²
2.Round LED Highbay 100W 90°	10	5.93W/m²
3.Round LED Highbay 100W 60°	9	5.22W/m²

So, LED Luminaire Products are more energy efficient than conventional luminaire.

7.5 ENGINEERING STORE AREA:

Technical details of the Luminaire (Conventional):

Luminaire Used: Linear Fluorescent Highbay T8 6 lamp type 32W each

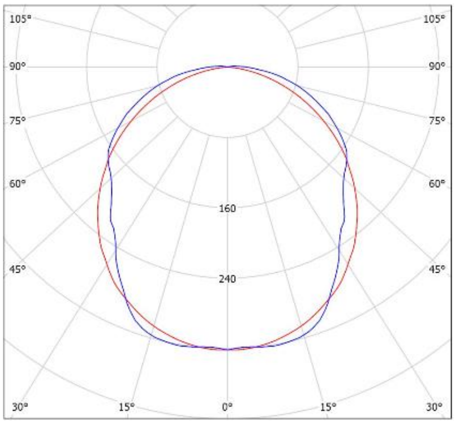


Fig.Image of the luminaire

Fig. Intensity distribution curve

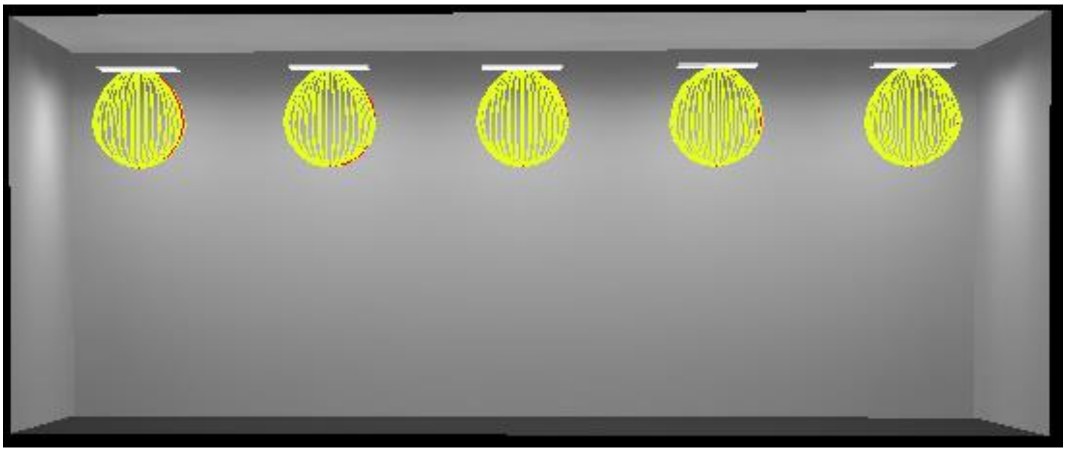
Specification:
1. The heavy-duty 20 gauge housing exceeds code gauge steel, and all components are post painted with a glossy, high reflectance white paint. Sockets include secure, positioning rotating collars.
2. The superior beam spread optic covers from narrow aisle lighting to open area general lighting.
3. It is available using a specular aluminum (SA) or a white aluminum (WA) reflector, which have a 25 year warranty.
4. The reflector options include up light or non-up light, depending on the application.
5. Ballasts are also thermally protected; sound rated and tightly secured by mounting bolts, as well as NEMA Premium and CEE qualified.
6. The baked white enamel finish is electrostatically applied and post painted with a glossy, highly reflective and durable white paint.

Technical Details:
1. System Wattage: 218.1W
2. Total Luminaire Lumen Output: 16106lumen
3. Input Voltage Range: 120-277V
4. Weight: 4.5Kg
5. Lamp Life: 25,000 Burning Hours@L70
6. System Luminous Efficacy: 73.84lm/W

Design Consideration:
For lighting of Engineering Store Area-Block B with the conventional luminaries, following details has been considered:

1. Reflection Factors: Ceiling: 50%, Wall: 30% and Floor: 10%.
2. Height of the Room: 6m
3. Maintainace Factor: 0.70
4. Mounting Type: Suspension by chain of 0.5m
5. Mounting Height of the Luminaire: 5.5m
6. No obstruction is considered.

The design has been done by using 5 numbers of Linear Fluorescent Highbay T8 6x32W .The following 3D view has been provided below.



Engineering Store / Workplane / Value Chart (E)

240	297	334	356	367	369	365	353	328	285
260	320	359	384	395	397	392	380	352	307
257	317	355	379	390	392	388	375	348	304
240	297	333	356	367	368	365	351	327	284

3.84 m
0.00
0.00
14.80 m

Values in Lux, Scale 1 : 200

Not all calculated values could be displayed.

Position of surface in room:
Marked point: (188.871 m, 73.407 m, 0.000 m)

Grid: 64 x 16 Points

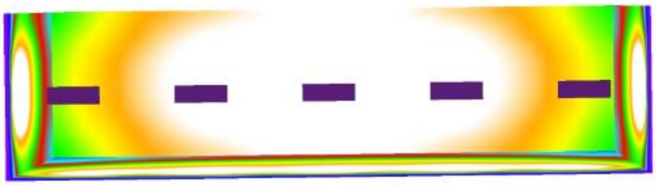
E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
334	223	398	0.668	0.561

Fig Value chart of Work plane area in Engineering Store using Linear Fluorescent Highbay T8 6x32W

Photometric Result:
In this photometric result the minimum and maximum Illuminance is 223 & 398 lux of Work plane area in Engineering Store Area-Block B. The achieved

average Illuminance is 334lx (recommended ≥300 lux) and Overall Uniformity is 0.668(recommended ≥0.4).

False Colour Rendering:
It is used to describe different lux level distribution in different Colour inside Engineering Store Area-Block B. The Colour distribution of different Lux level ranges is given:



Technical details of the Luminaire (LED) Option 1:

Luminaire Used: ROUND LED Highbay 100W 90° beam angle

Fig.Image of the luminaire

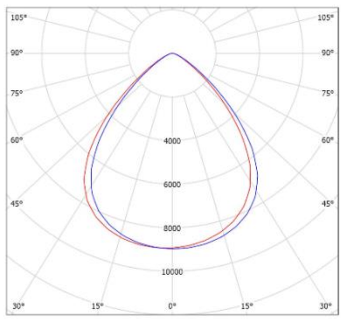


Fig. Intensity distribution curve

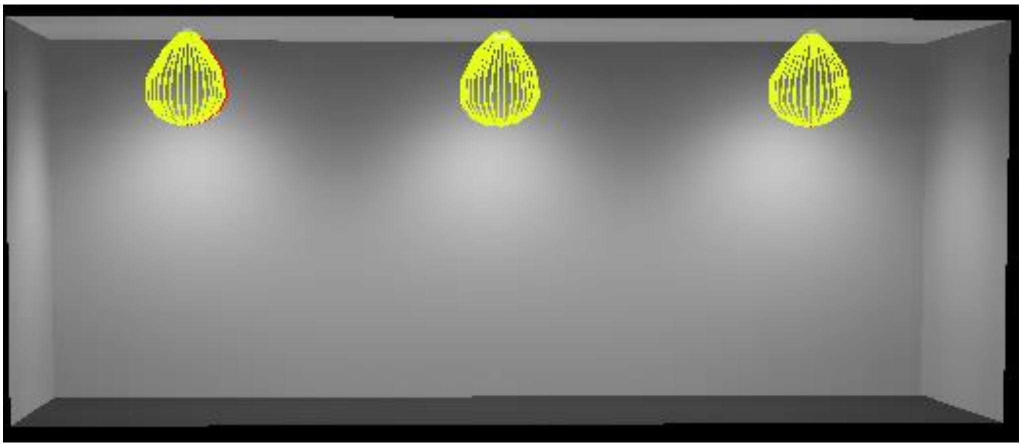
Specification:

- Pressure Die cast Aluminium Housing for heat dissipation and less dust accumulation.
- Protected against corrosion and vibrations. Also luminaire is impact resistant.
- Lens technology ensures high performance photometry, soft light, no glare, will not cause eye fatigue of workers.
- Breathing port (pressure equalizer valve) for better IP Protection.

Technical Details:
1. System Wattage: 102.2W
2. Total System Lumen Output: 16320lumen
3. Operating Voltage is 100-300V
4. System Luminous Efficacy: 160lm/W
5. Lamp Life: 50,000 Burning Hours@L70

Design Consideration:
For lighting of Engineering Store Area-Block B with the ROUND LED Highbay 100W 90° beam angle luminaries, following details has been considered:
1. Reflection Factors: Ceiling: 50%, Wall: 30% and Floor: 10%.
2. Height of the Room: 6m
3. Maintainace Factor: 0.85
4. Mounting Type: i-bolt
5. No obstruction is considered.

The design has been done by using 3 numbers of ROUND LED Highbay 100W 90° beam angle .The following 3D view has been provided below.



Engineering Store__Highbay 100W 90deg / Workplane / Value Chart (E)

223	278	312	331	340	343	341	333	319	291	244
243	302	339	359	368	373	370	362	347	317	266
240	297	336	355	364	367	366	358	343	312	264
223	278	313	332	340	342	342	334	319	292	246

3.84 m
0.00
0.00 — 14.80 m

Values in Lux, Scale 1 : 200

Not all calculated values could be displayed.

Position of surface in room:
Marked point: (188.871 m, 73.407 m, 0.000 m)

Grid: 128 x 32 Points

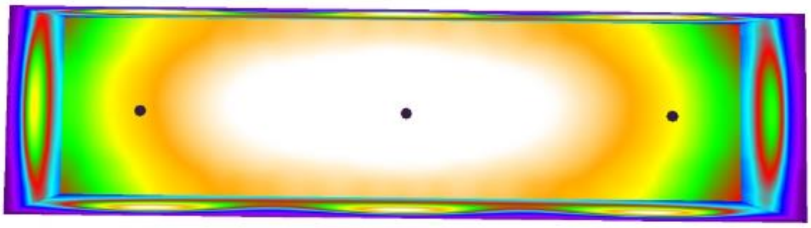
E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
310	182	375	0.585	0.484

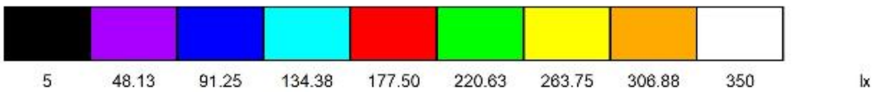
Fig Value chart of Work plane area in Engineering Store using Round LED Highbay 100W 90°

Photometric Result:

In this photometric result the minimum and maximum Illuminance is 182 & 375 lux of Work plane area in Engineering Store Area-Block B. The achieved average Illuminance is 310lx (recommended ≥300 lux) and Overall Uniformity is 0.585(recommended ≥0.4).

False Colour Rendering:
It is used to describe different lux level distribution in different Colour inside Engineering Store Area-Block B. The Colour distribution of different Lux level ranges is given:





Technical details of the Luminaire (LED) Option 2:

Luminaire Used: ROUND LED Highbay 100W 60° beam angle

Fig.Image of the luminaire

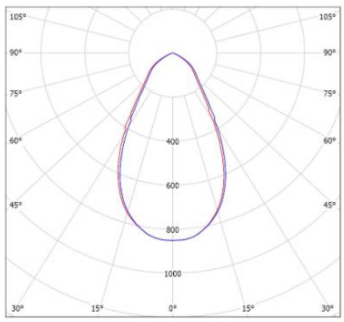


Fig. Intensity distribution curve

Specification:

- Pressure Die cast Aluminium Housing for heat dissipation and less dust accumulation.
- Protected against corrosion and vibrations. Also luminaire is impact resistant.
- Lens technology ensures high performance photometry, soft light, no glare, will not cause eye fatigue of workers.

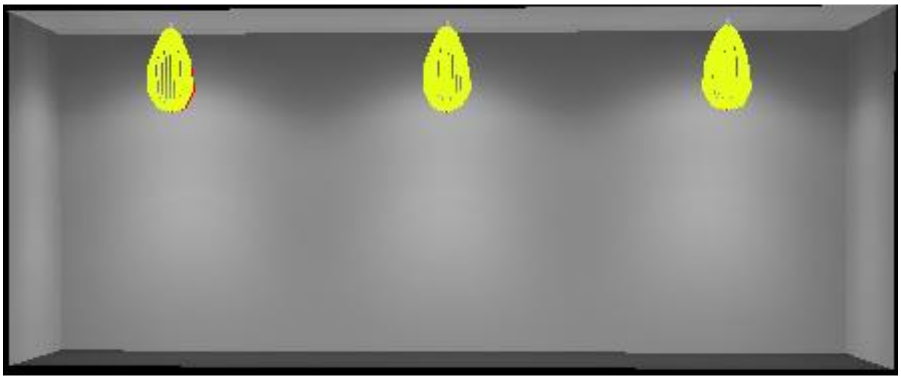
- Breathing port (pressure equalizer valve) for better IP Protection.

Technical Details:

1. System Wattage: 100W
2. Total System Lumen Output: 15997lumen
3. Operating Voltage is 100-300V
4. System Luminous Efficacy: 160lm/W
5. Lamp Life: 50,000 Burning Hours@L70

Design Consideration:
For lighting of Engineering Store Area-Block B with the ROUND LED Highbay 100W 60° beam angle luminaries, following details has been considered:
1. Reflection Factors: Ceiling: 50%, Wall: 30% and Floor: 10%.
2. Height of the Room: 6m
3. Maintainace Factor: 0.85
4. Mounting Type: i-bolt
5. No obstruction is considered.

The design has been done by using 3 numbers of ROUND LED Highbay 100W 60° beam angle .The following 3D view has been provided below.



Engineering Store _Highbay 100W 60deg / Workplane / Value Chart (E)

256	340	374	370	368	387	389	371	357	360	320
294	384	423	426	421	434	441	427	408	405	361
288	378	415	417	413	427	432	418	400	399	356
249	331	363	356	356	376	375	357	342	352	308

3.84 m
0.00
0.00
14.80 m

Values in Lux, Scale 1 : 200

Not all calculated values could be displayed.

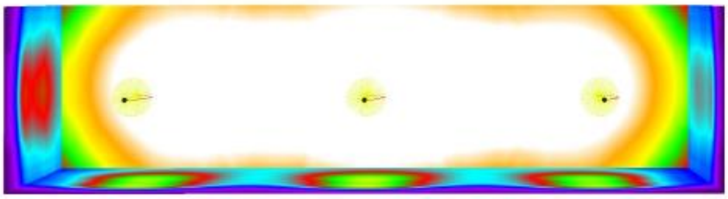
Position of surface in room:
Marked point: (188.871 m, 73.407 m, 0.000 m)

Grid: 256 x 64 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
363	180	445	0.495	0.404

Photometric Result:
In this photometric result the minimum and maximum Illuminance is 180 & 445 lux of Work plane area in Engineering Store Area-Block B. The achieved average Illuminance is 363lx (recommended ≥300 lux) and Overall Uniformity is 0.495(recommended ≥0.4).

False Colour Rendering:
It is used to describe different lux level distribution in different Colour inside Engineering Store Area-Block B. The Colour distribution of different Lux level ranges is given:



Conclusion:
Below table provides the details of LPD value comparison of Conventional Luminaire with LED:

Name of the Product	Total Number of Quantities	Obtained LPD Values(recommended as per ECBC code:6.8W/m²)
1. Linear Fluorescent Highbay T8 6 lamp type 32W	5	19.17W/m²
2.Round LED Highbay 100W 90°	3	5.39W/m²
3.Round LED Highbay 100W 60°	3	5.27W/m²

So, LED Luminaire Products are more energy efficient than conventional luminaire.

7.6 BLOWING AND FILLING AREA:

Technical details of the Luminaire (Conventional):

Luminaire Used: 2' Wide Recessed Cleanroom Fluorescent Luminaire for Standard T-Bar 140W

Fig.Image of the luminaire

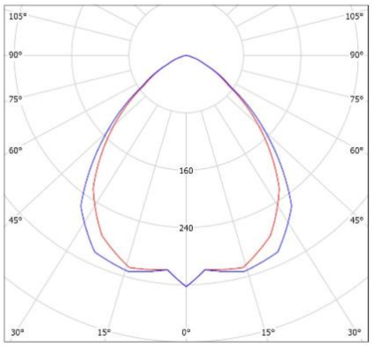


Fig. Intensity distribution curve

Specification:

1. 22 gallon cold rolled steel welded housing
2. All parts fitted and sealed
3. 20 gallon cold rolled steel door frame secured by T-hinges and positive spring loaded latches
4. Door frame sealed with neoprene gasket
5. Painted after fabrication
6. Baked white powder-coated finish
7. Minimum reflectance 90%
8. Inverted clear prismatic acrylic lens.

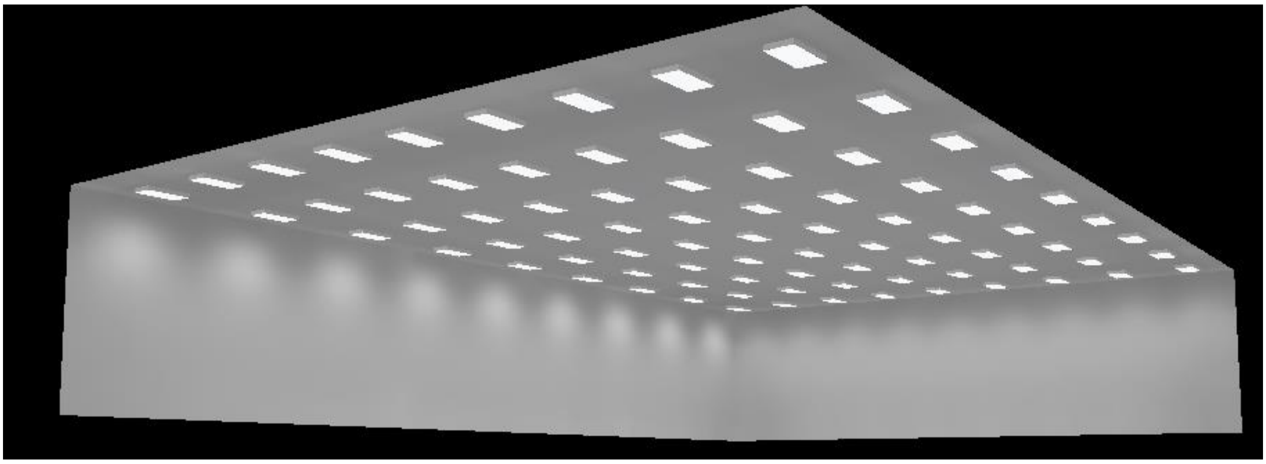
Technical Details:

1. System Wattage: 140W
2. Total System Lumen Output: 7262lumen
3. Operating Voltage is 120-277V
4. System Luminous Efficacy: 51.87lm/W
5. Lamp Life: 25,000 Burning Hours@L70

Design Consideration:
For lighting of Blowing and Filling Area-Block B with the 2' Wide Recessed Cleanroom Fluorescent Luminaire 140W, following details has been considered:

1. Reflection Factors: Ceiling: 70%, Wall: 50% and Floor: 20%.
2. Height of the Room: 6m
3. Maintainace Factor: 0.70
4. Mounting Type: Recessed
5. No obstruction is considered.

The design has been done by using 81 numbers of 2' Wide Recessed Cleanroom Fluorescent Luminaire 140W .The following 3D view has been provided below.



Blowing and Filling Area_Conventional Cleanroom / Workplane / Value Chart (E

315	360	403	413	423	430	434	433	435	435	435	436	436	434	433	433	422	414	386	355	308
359	406	454	466	477	485	488	487	489	490	491	491	491	488	486	486	476	467	436	398	344
403	454	508	522	533	541	544	545	546	547	546	545	546	543	541	541	529	521	486	442	389
427	481	538	554	566	575	578	577	578	580	579	578	579	575	574	574	562	553	515	469	408
449	511	568	584	600	607	612	611	613	615	612	612	610	609	607	605	594	584	545	495	432
459	519	579	595	611	617	622	621	625	626	624	625	624	620	619	618	607	596	556	505	441
471	533	592	609	626	634	639	638	643	642	641	641	638	635	632	632	622	611	571	517	452
472	534	595	611	627	635	639	640	644	644	644	644	641	639	635	635	624	612	572	519	453
474	537	599	614	632	639	644	645	648	648	648	649	645	644	639	639	629	616	576	523	456
478	540	600	617	634	643	649	648	652	652	650	651	648	645	642	641	632	620	579	525	457
475	538	600	616	633	641	647	645	649	650	649	650	648	644	643	642	631	620	576	524	457
474	538	600	616	633	642	647	646	650	650	650	649	647	645	642	640	631	619	576	525	457
476	536	597	615	629	640	643	641	645	647	646	646	647	641	640	640	628	618	573	522	454
473	534	598	615	627	637	639	640	644	644	644	643	643	639	636	637	624	614	571	519	453
467	528	589	606	618	627	630	631	634	634	634	633	633	629	627	627	615	605	563	512	446
463	522	582	599	611	620	624	623	626	627	627	626	627	622	621	620	609	599	557	506	442
443	501	560	575	589	598	602	602	606	606	605	605	603	600	598	597	588	578	538	488	427
425	479	534	550	563	573	576	575	578	579	579	578	578	574	572	573	562	554	513	466	408
386	440	493	506	519	525	529	529	533	531	531	530	529	527	525	524	516	506	472	430	372
352	398	447	457	471	475	480	478	481	482	480	483	480	478	475	474	468	457	428	389	341
322	364	405	413	425	429	433	434	436	436	434	436	433	432	430	428	422	412	385	354	312

21.75 m

0.00

0.00

32.84 m

Values in Lux, Scale 1 : 250

Not all calculated values could be displayed.

Position of surface in room:
Marked point: (241.677 m, 117.795 m, 0.000 m)

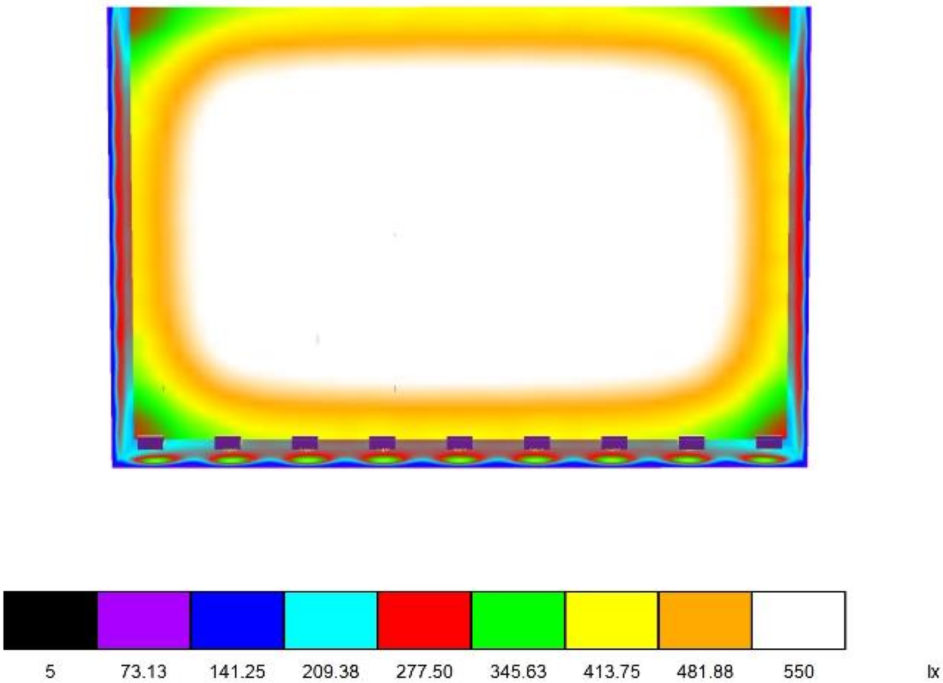
Grid: 64 x 64 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
546	285	652	0.521	0.436

Fig Value chart of Work plane area in Blowing and Filling Area using 2' Wide Recessed Cleanroom Fluorescent Luminaire 140W

Photometric Result:
In this photometric result the minimum and maximum Illuminance is 285 & 652 lux of Work plane area in Blowing and Filling Area-Block B. The achieved average Illuminance is 546lx (recommended ≥500 lux) and Overall Uniformity is 0.521(recommended ≥0.4).

False Colour Rendering:
It is used to describe different lux level distribution in different Colour inside Blowing and Filing Area-Block B. The Colour distribution of different Lux level ranges is given:



Technical details of the Luminaire (LED):

Luminaire Used: Recessed Mounting Bottom Opening Cleanroom LED Luminaire 80W

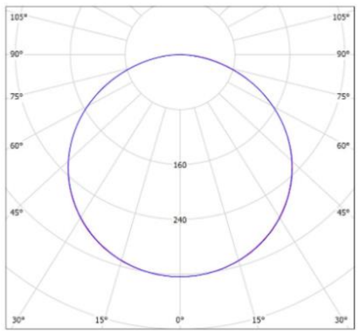


Fig.Image of the luminaire

Fig. Intensity distribution curve

Specification:

1. Recess mount bottom opening luminaire
2. Body fabricated from CRCA Sheet.
3. Epoxy powder coated finish, which helps against corrosion resistance for long life in challenging environments,
4. VHB gasket for proper and long life bonding (nonhydroscopic and antifungal gasket).

Technical Details:

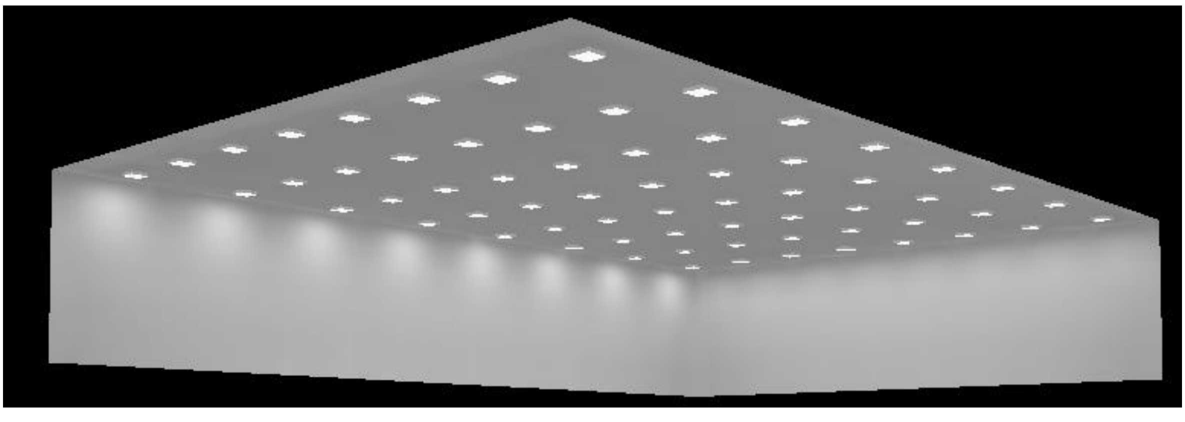
1. System Wattage: 81.5W
2. Total System Lumen Output: 8801lumen
3. Operating Voltage is 120-300V
4. System Luminous Efficacy: 107.98lm/W
5. Lamp Life: 50,000 Burning Hours@L70

Design Consideration:

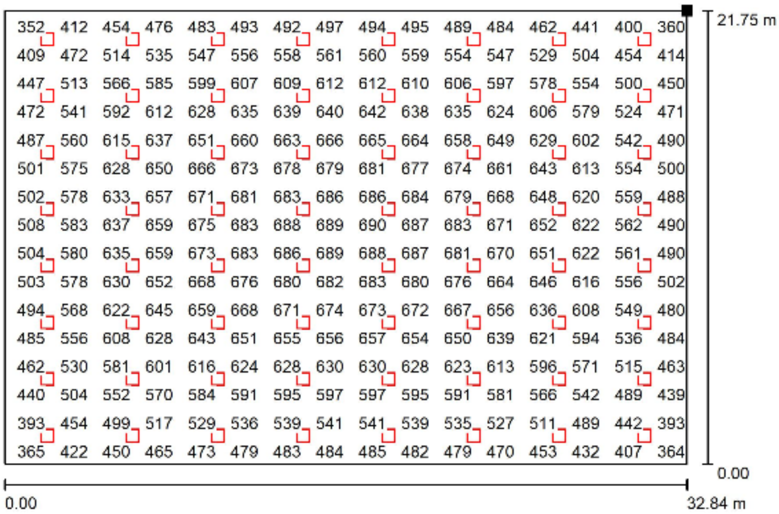
For lighting of Blowing and Filling Area-Block B with the Recessed Mounting Bottom Opening Cleanroom LED Luminaire 80W, following details has been considered:

1. Reflection Factors: Ceiling: 70%, Wall: 50% and Floor: 20%.
2. Height of the Room: 6m
3. Maintainace Factor: 0.85
4. Mounting Type: Recessed
5. No obstruction is considered.

The design has been done by using 64 numbers of Recessed Mounting Bottom Opening Cleanroom LED Luminaire 80W .The following 3D view has been provided below.



Blowing and Filling Area_Cleanroom LED / Workplane / Value Chart (E)



Values in Lux, Scale 1 : 250

Not all calculated values could be displayed.

Position of surface in room:
Marked point: (241.677 m, 117.795 m, 0.000 m)

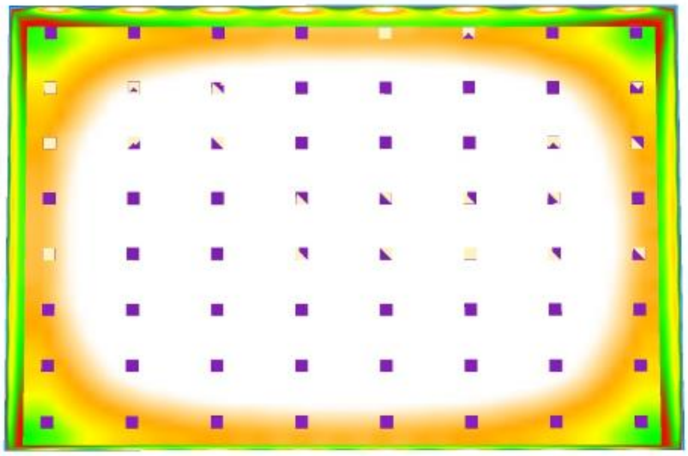
Grid: 64 x 64 Points

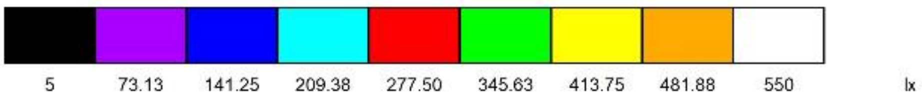
E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
577	343	692	0.595	0.496

Fig Value chart of Work plane area in Blowing and Filling Area using 80W LED Recessed Cleanroom

Photometric Result:
In this photometric result the minimum and maximum Illuminance is 343 & 692 lux of Work plane area in Blowing and Filling Area-Block B. The achieved average Illuminance is 577lx (recommended ≥500 lux) and Overall Uniformity is 0.595(recommended ≥0.4).

False Colour Rendering:
It is used to describe different lux level distribution in different Colour inside Blowing and Filing Area-Block B. The Colour distribution of different Lux level ranges is given:





Conclusion:

Below table provides the details of LPD value comparison of Conventional Luminaire with LED:

Name of the Product	Total Number of Quantities	Obtained LPD Values
1.Clean Room Fluorescent luminaire 140W	81	15.88W/m²
2. Clean Room LED luminaire 80W	64	7.31W/m²

So, LED Luminaire Products are more energy efficient than conventional luminaire.

7.7 Blowing Area 2:

Technical details of the Luminaire (Conventional):

Luminaire Used: 2' Wide Recessed Cleanroom Fluorescent Luminaire for Standard T-Bar 140W

Fig.Image of the luminaire

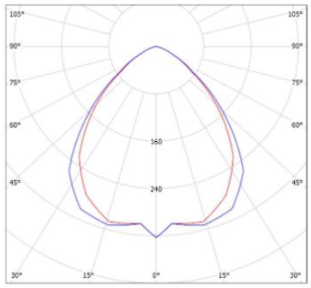


Fig. Intensity distribution curve

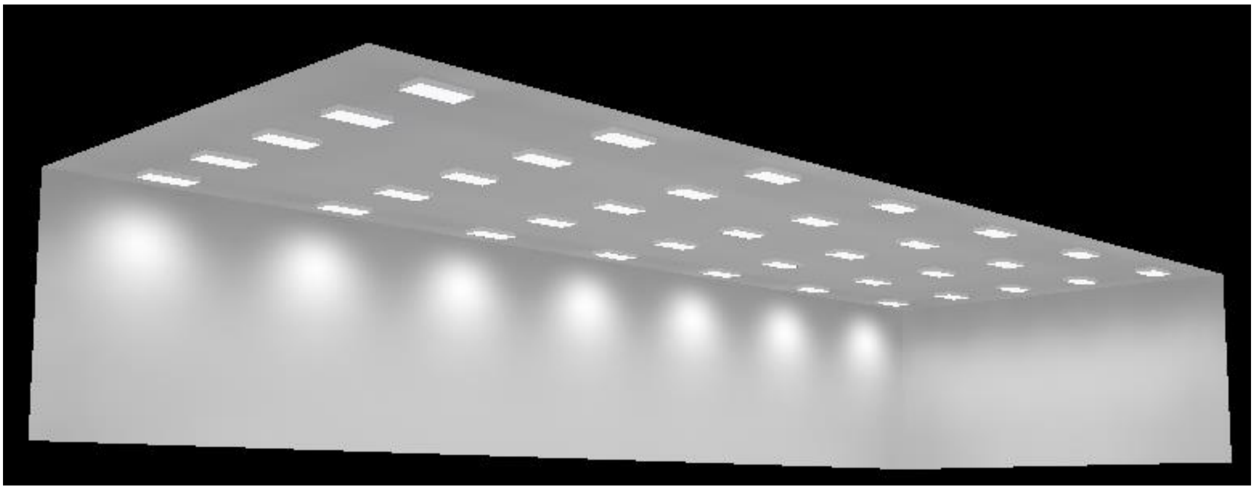
Specification:

1.22 gallon cold rolled steel welded housing
2. All parts fitted and sealed
3. 20 gallon cold rolled steel door frame secured by T-hinges and positive spring loaded latches
4. Door frame sealed with neoprene gasket
5. Painted after fabrication
6. Baked white powder-coated finish
7. Minimum reflectance 90%
8. Inverted clear prismatic acrylic lens.

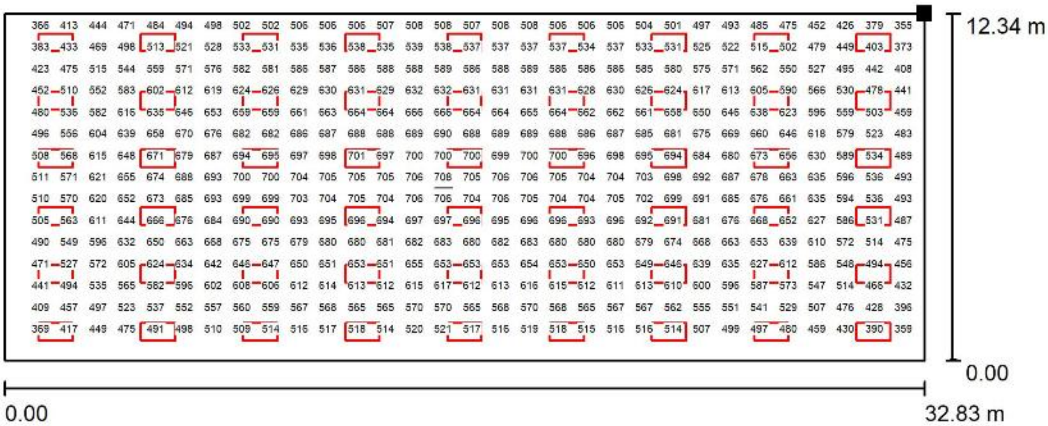
Technical Details:
1. System Wattage: 140W
2. Total System Lumen Output: 7262lumen
3. Operating Voltage is 120-277V
4. System Luminous Efficacy: 51.87lm/W
5. Lamp Life: 25,000 Burning Hours@L70

Design Consideration:
For lighting of Blowing Area 2-Block B with the 2' Wide Recessed Cleanroom Fluorescent Luminaire 140W, following details has been considered:
1. Reflection Factors: Ceiling: 70%, Wall: 50% and Floor: 20%.
2. Height of the Room: 6m
3. Maintainace Factor: 0.70
4. Mounting Type: Recessed
5. No obstruction is considered.

The design has been done by using 54 numbers of 2' Wide Recessed Cleanroom Fluorescent Luminaire 140W .The following 3D view has been provided below.



Blowing Area 2 / Workplane / Value Chart (E)



Values in Lux, Scale 1 : 250

Not all calculated values could be displayed.

Position of surface in room:
Marked point: (241.673 m, 95.846 m, 0.000 m)

Grid: 64 x 32 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
580	320	708	0.552	0.452

Fig Value chart of Work plane area in Blowing Area 2 using 2’ Wide Recessed Cleanroom Fluorescent Luminaire 140W

Photometric Result:
In this photometric result the minimum and maximum Illuminance is 320 & 708 lux of Work plane area in Blowing Area 2-Block B. The achieved average Illuminance is 580lx (recommended ≥500 lux) and Overall Uniformity is 0.552(recommended ≥0.4).

False Colour Rendering:
It is used to describe different lux level distribution in different Colour inside Blowing Area 2-Block B. The Colour distribution of different Lux level ranges is given:

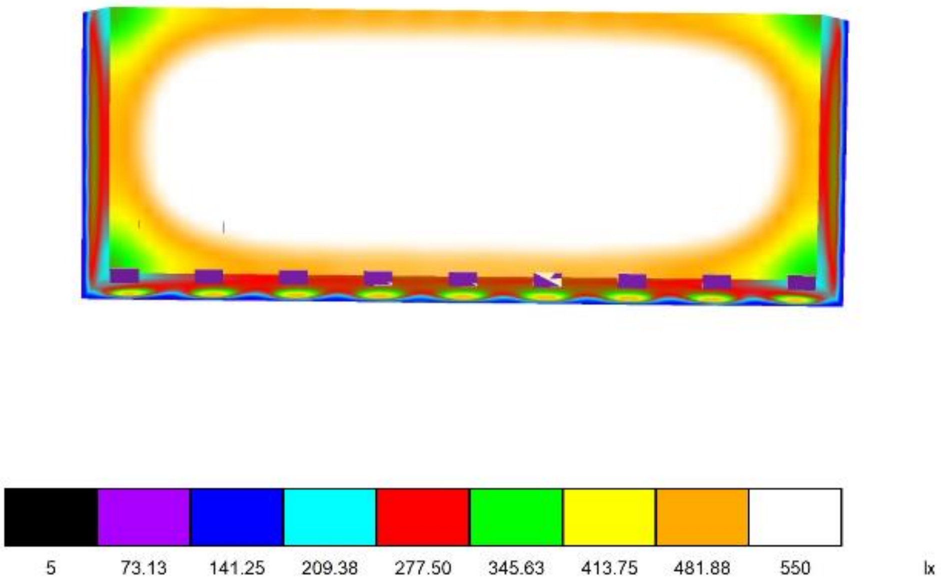


Fig Lux level distribution in different Colour under conventional luminaires

Technical details of the Luminaire (LED):

Luminaire Used: Recessed Mounting Bottom Opening Cleanroom LED Luminaire 80W

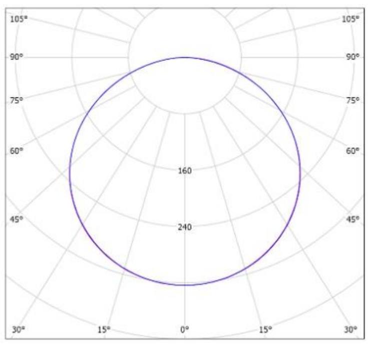


Fig.Image of the luminaire

Fig. Intensity distribution curve

Specification:

1. Recess mount bottom opening luminaire
2. Body fabricated from CRCA Sheet.
3. Epoxy powder coated finish, which helps against corrosion resistance for long life in challenging environments,
4. VHB gasket for proper and long life bonding (nonhydroscopic and antifungal gasket).

Technical Details:

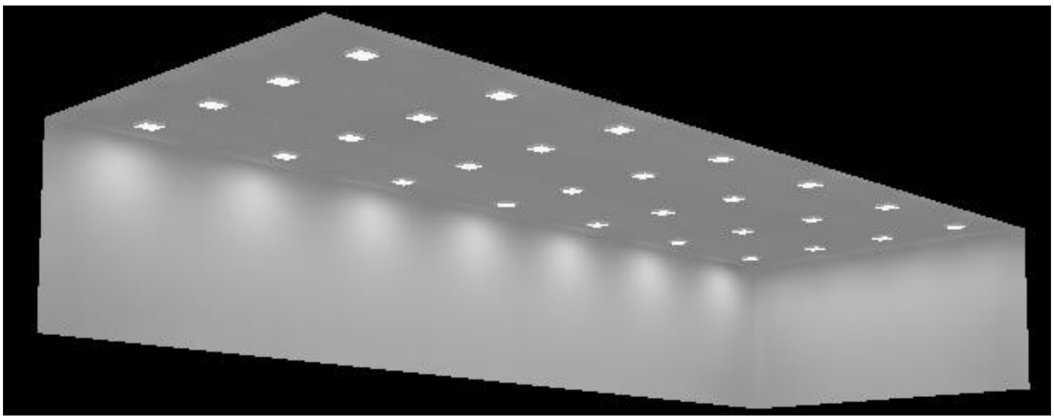
1. System Wattage: 81.5W
2. Total System Lumen Output: 8801lumen
3. Operating Voltage is 120-300V
4. System Luminous Efficacy: 107.98lm/W
5. Lamp Life: 50,000 Burning Hours@L70

Design Consideration:

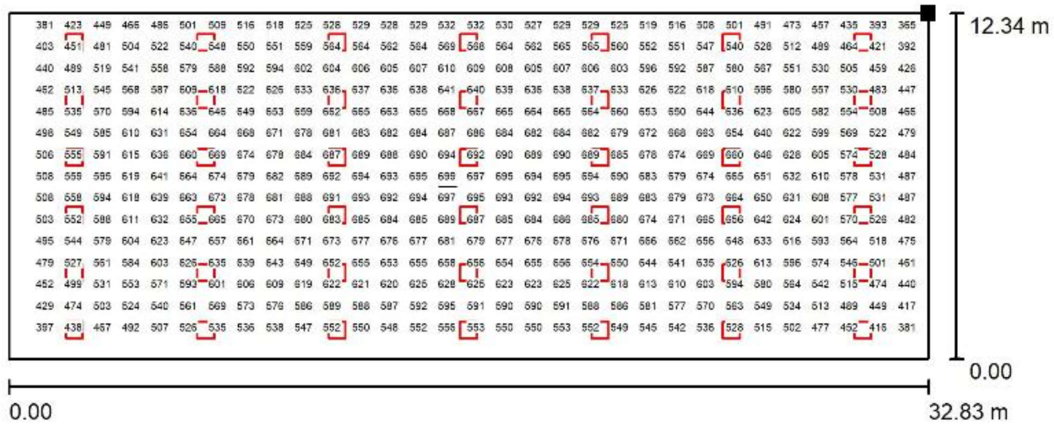
For lighting of Blowing Area 2-Block B with the Recessed Mounting Bottom Opening Cleanroom LED Luminaire 80W, following details has been considered:

1. Reflection Factors: Ceiling: 70%, Wall: 50% and Floor: 20%.
2. Height of the Room: 6m
3. Maintainace Factor: 0.85
4. Mounting Type: Recessed
5. No obstruction is considered.

The design has been done by using 42 numbers of Recessed Mounting Bottom Opening Cleanroom LED Luminaire 80W .The following 3D view has been provided below.



Blowing Area 2_Cleanroom LED / Workplane / Value Chart (E)



Values in Lux, Scale 1 : 250

Not all calculated values could be displayed.

Position of surface in room:
Marked point: (241.673 m, 95.846 m, 0.000 m)

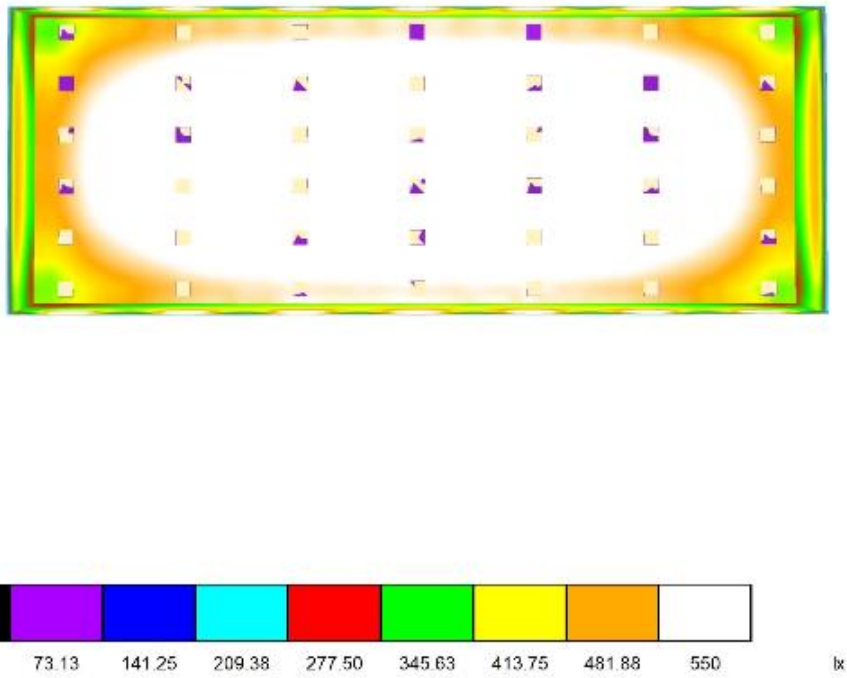
Grid: 64 x 32 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
585	362	699	0.618	0.517

Fig Value chart of Work plane area in Blowing Area-2 using 80W LED Recessed Cleanroom

Photometric Result:
In this photometric result the minimum and maximum Illuminance is 362 & 699 lux of Work plane area in Blowing Area 2-Block B. The achieved average Illuminance is 585lx (recommended ≥500 lux) and Overall Uniformity is 0.618(recommended ≥0.4).

False Colour Rendering:
It is used to describe different lux level distribution in different Colour inside Blowing Area 2-Block B. The Colour distribution of different Lux level ranges is given:



Conclusion:

Below table provides the details of LPD value comparison of Conventional Luminaire with LED:

Name of the Product	Total Number of Quantities	Obtained LPD Values
1.Clean Room Fluorescent luminaire 140W	54	18.67W/m²
2. Clean Room LED luminaire 80W	42	8.46W/m²

So, LED Luminaire Products are more energy efficient than conventional luminaire.

7.8 Ozone MIS Room-Block B:

Technical details of the Luminaire (Conventional):

Luminaire Used: 2' Wide Recessed Cleanroom Fluorescent Luminaire for Standard T-Bar 140W

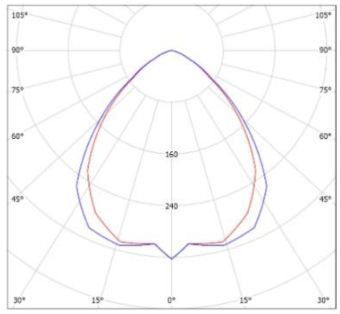


Fig.Image of the luminaire

Fig. Intensity distribution curve

Specification:

1.22 gallon cold rolled steel welded housing
2. All parts fitted and sealed
3. 20 gallon cold rolled steel door frame secured by T-hinges and positive spring loaded latches
4. Door frame sealed with neoprene gasket
5. Painted after fabrication
6. Baked white powder-coated finish
7. Minimum reflectance 90%
8. Inverted clear prismatic acrylic lens.

Technical Details:

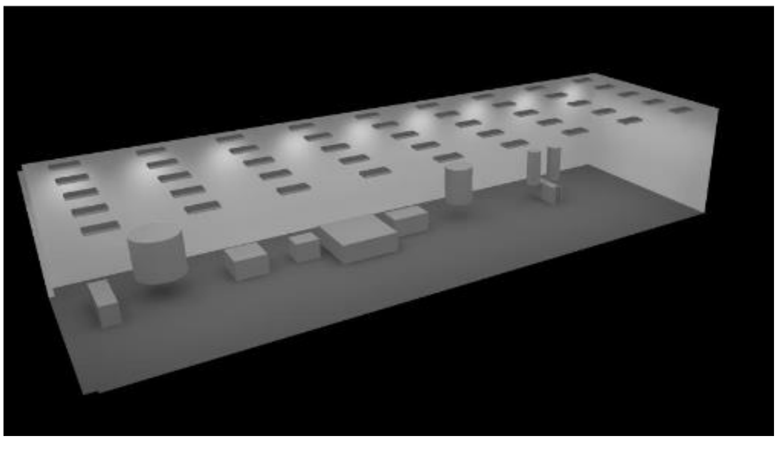
1. System Wattage: 140W
2. Total System Lumen Output: 7262lumen
3. Operating Voltage is 120-277V
4. System Luminous Efficacy: 51.87lm/W
5. Lamp Life: 25,000 Burning Hours@L70

Design Consideration:

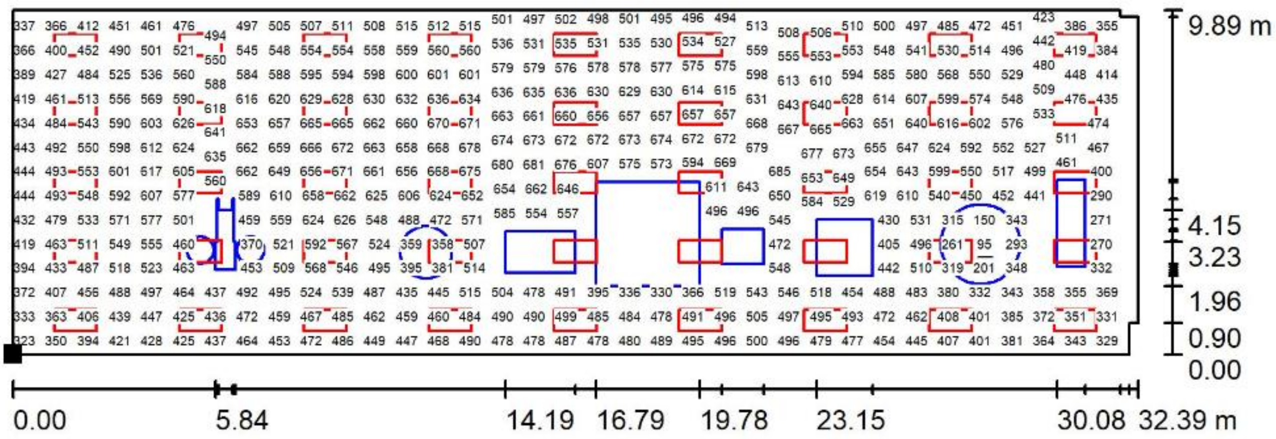
For lighting of Ozone MIS Room-Block B with the 2' Wide Recessed Cleanroom Fluorescent Luminaire 140W, following details has been considered:

1. Reflection Factors: Ceiling: 70%, Wall: 50% and Floor: 20%.
2. Height of the Room: 6m
3. Maintainace Factor: 0.70
4. Mounting Type: Recessed
5. Obstructions are considered.

The design has been done by using 45 numbers of 2' Wide Recessed Cleanroom Fluorescent Luminaire 140W .The following 3D view has been provided below.



Ozone +Mis CIP Room / Workplane / Value Chart (E)



Values in Lux, Scale 1 : 250

Not all calculated values could be displayed.

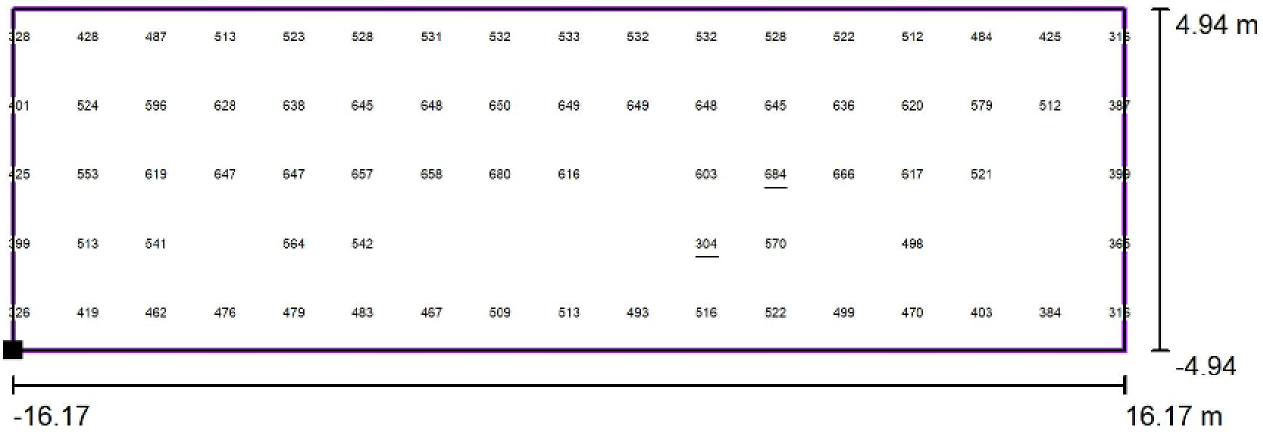
Position of surface in room:
Marked point: (208.840 m, 73.416 m, 0.000 m)

Grid: 1024 x 512 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
516	95	686	0.183	0.138

Fig Value chart of Work plane area in Ozone MIS CIP Room using 2' Wide Recessed Cleanroom Fluorescent Luminaire 140W

Photometric Result:
In this photometric result the minimum and maximum Illuminance is 95 & 686 lux of Work plane area in Ozone MIS Room-Block B. The achieved average Illuminance is 516lx (recommended ≥500 lux) and Overall Uniformity is 0.183.



Values in Lux, Scale 1 : 250

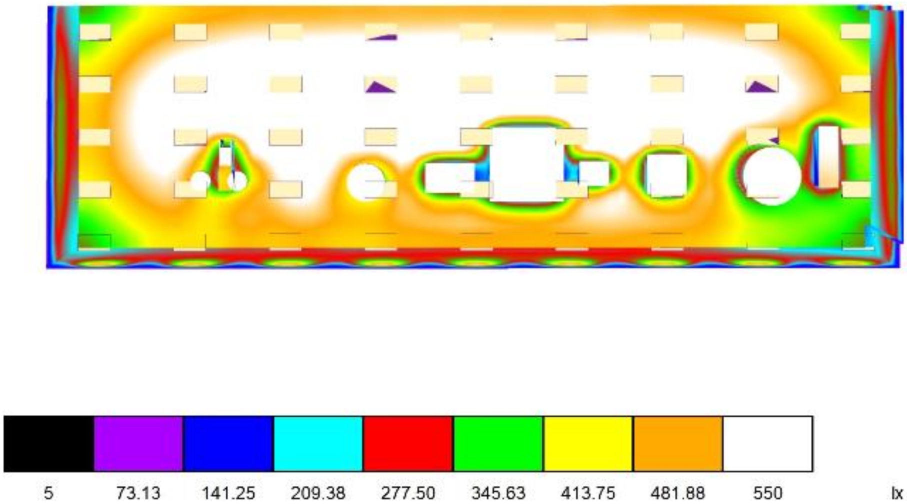
Position of surface in room:
Marked point: (208.900 m, 73.415 m, 0.000 m)

Grid: 75 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
525	304	684	0.58	0.44

Photometric Result:
In this photometric result the minimum and maximum Illuminance is 304 & 684 lux of Work plane area in Ozone MIS Room-Block B (Excluding Objects Grid Point). The achieved average Illuminance is 525lx (recommended ≥500 lux) and Overall Uniformity is 0.58(recommended≥0.4).

False Colour Rendering:
It is used to describe different lux level distribution in different Colour inside Ozone MIS Room-Block B. The Colour distribution of different Lux level ranges is given:



Technical details of the Luminaire (LED):

Luminaire Used: Recessed Mounting Bottom Opening Cleanroom LED Luminaire 80W

Fig.Image of the luminaire

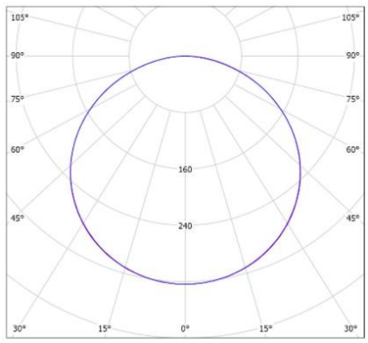


Fig. Intensity distribution curve

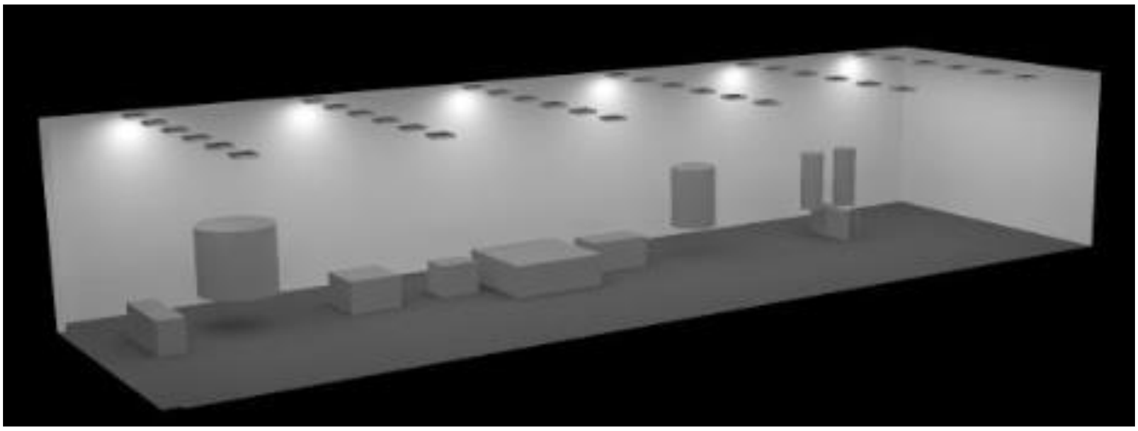
Specification:

1. Recess mount bottom opening luminaire
2. Body fabricated from CRCA Sheet.
3. Epoxy powder coated finish, which helps against corrosion resistance for long life in challenging environments,
4. VHB gasket for proper and long life bonding (nonhydroscopic and antifungal gasket).

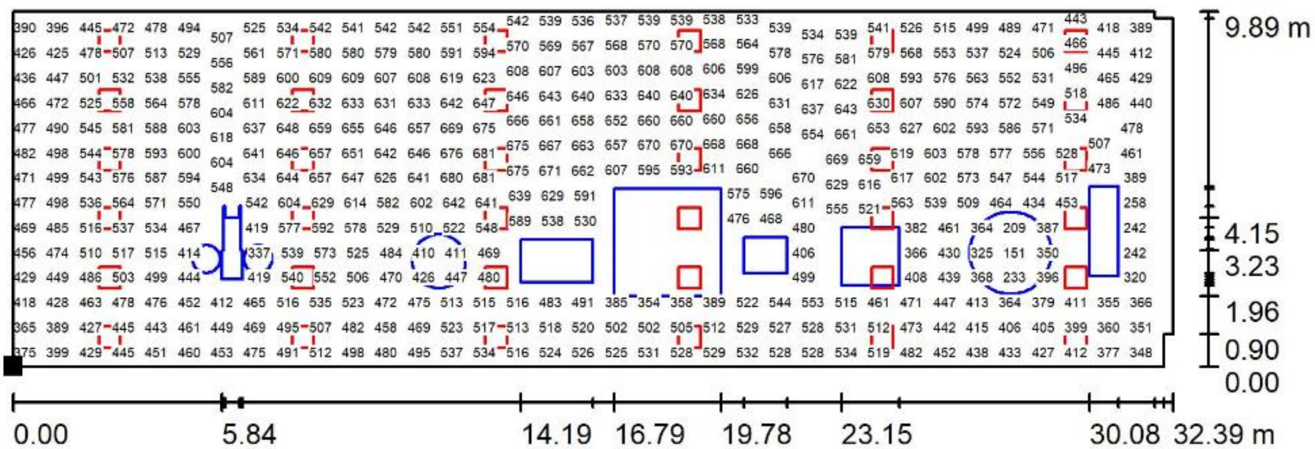
Technical Details:

1. System Wattage: 81.5W
2. Total System Lumen Output: 8801lumen
3. Operating Voltage is 120-300V
4. System Luminous Efficacy: 107.98lm/W
5. Lamp Life: 50,000 Burning Hours@L70

The design has been done by using 36 numbers of Recessed Mounting Bottom Opening Cleanroom LED Luminaire 80W .The following 3D view has been provided below.



Ozone +Mis CIP Room_Cleanroom LED / Workplane / Value Chart (E)



Values in Lux, Scale 1 : 250

Not all calculated values could be displayed.

Position of surface in room:
Marked point: (208.840 m, 73.416 m, 0.000 m)

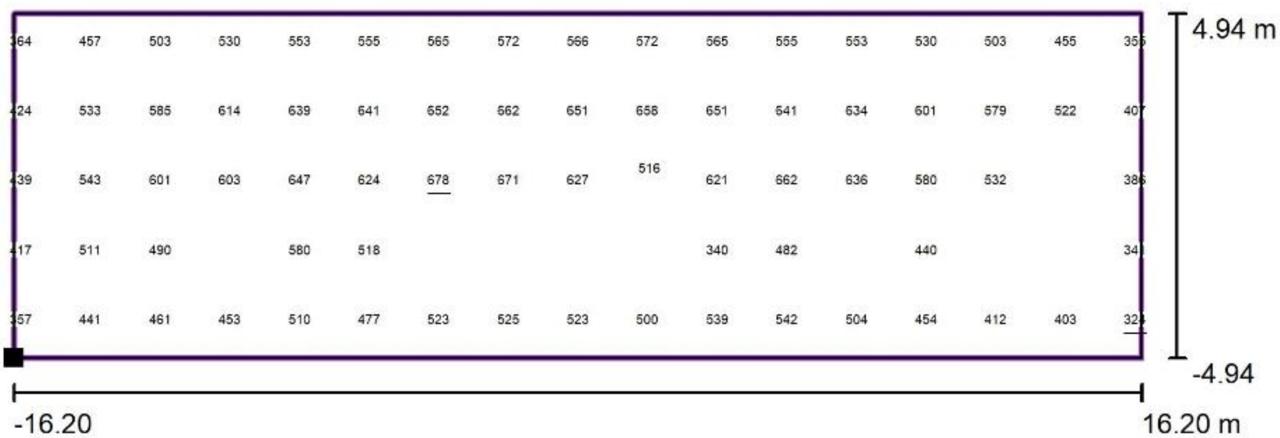
Grid: 1024 x 512 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
522	143	684	0.274	0.209

Fig Value chart of Work plane area in Ozone MIS CIP Room using 80W LED Recessed Cleanroom

Photometric Result:
In this photometric result the minimum and maximum Illuminance is 143 & 684 lux of Work plane area in Ozone MIS Room-Block B. The achieved average Illuminance is 522lx (recommended ≥500 lux) and Overall Uniformity is 0.274.

Ozone +Mis CIP Room_Cleanroom LED / Calculation Grid 1 / Value Chart (E, Perpendicular)



Values in Lux, Scale 1 : 250

Position of surface in room:
Marked point: (208.840 m, 73.415 m, 0.000 m)

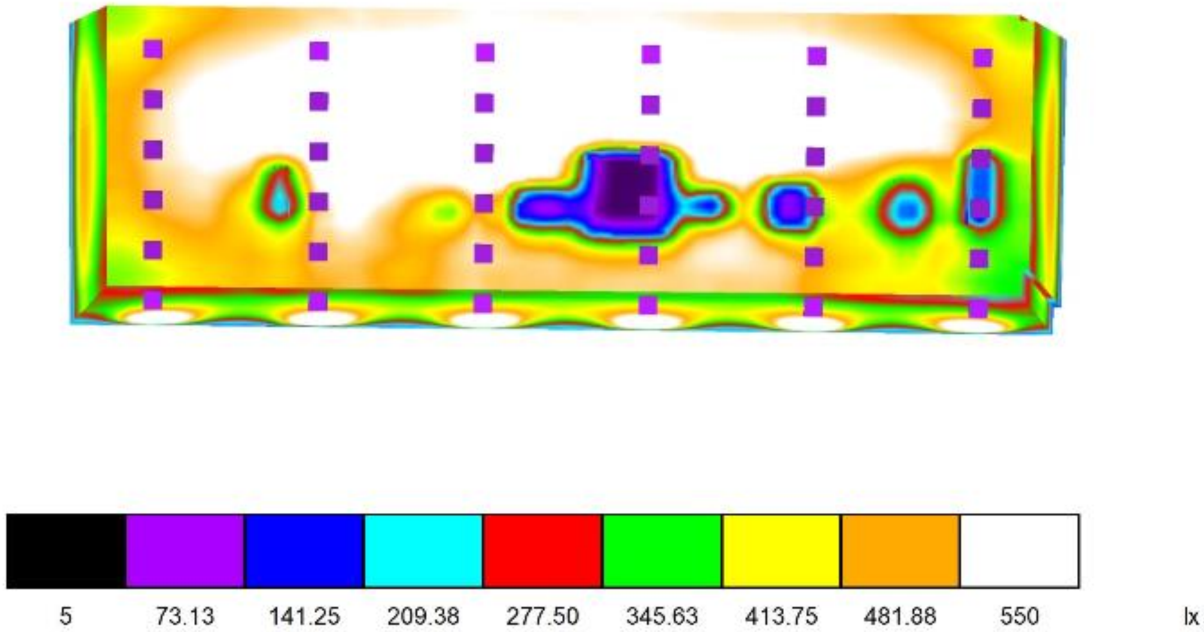
Grid: 76 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
530	324	678	0.61	0.48

Photometric Result:

In this photometric result the minimum and maximum Illuminance is 324 & 678 lux of Work plane area in Ozone MIS Room-Block B (Excluding Objects Grid Point). The achieved average Illuminance is 530lx (recommended ≥500 lux) and Overall Uniformity is 0.61(recommended≥0.4).

False Colour Rendering:
It is used to describe different lux level distribution in different Colour inside Ozone MIS Room-Block B. The Colour distribution of different Lux level ranges is given:



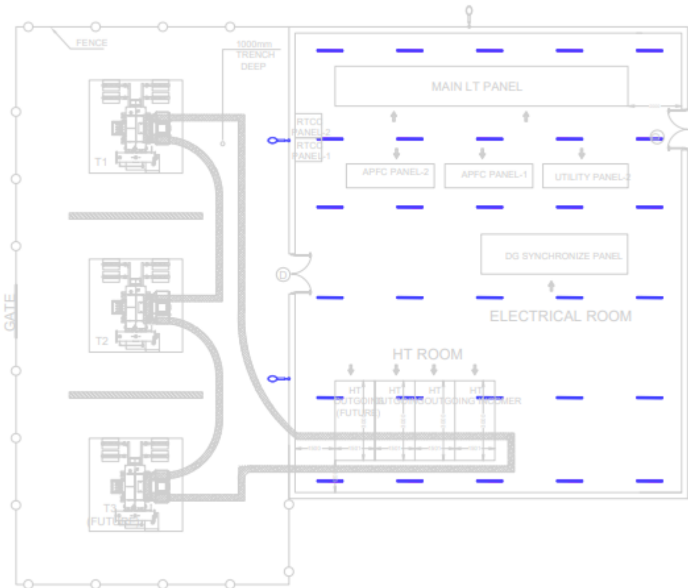
Conclusion:
Below table provides the details of LPD value comparison of Conventional Luminaire with LED:

Name of the Product	Total Number of Quantities	Obtained LPD Values
1.Clean Room Fluorescent luminaire 140W	45	19.69W/m2
2. Clean Room LED luminaire 80W	36	9.17W/m2

So, LED Luminaire Products are more energy efficient than conventional luminaire.

7.9 Electrical Room:

AutoCAD Layout:



Technical details of luminaire (Conventional):

Luminaire Used: 4 Foot Weather-proof Fluorescent White Reflector 32W T8 3-lamps HBF single packed

Fig. 1.Image of the luminaire

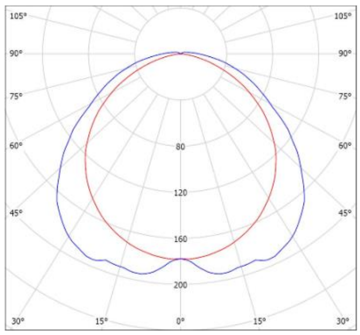


Fig.2. Intensity distribution curve

Specifications:

1. The gasketed enclosure is constructed of a fiberglass upper body and acrylic diffuser, with a continuous poured gasket.
2. The diffuser and upper components are locked by retaining latches, which ensures a tight seal.
3. Sockets include secure, positioning rotating collars.
4. The superior beam spread optics is ideal for an open area, general lighting.

5. The Wet Location fixture comes standard with a white channel cover, and is available using specular aluminum.
6. The Wet Location fixture is IP65 and IP67 rated, dust and moisture-resistant, making it ideal for harsh environments where humidity or moisture is present.

Technical Details:
1. System Wattage:86.7W
2. System Lumen Output: 5403 lumen
3. Input Voltage Range: 120V-277V
4. Weight:4.5Kg
5. Luminaire Life: 25,000 Burning Hours@ L70
6. System Luminous Efficacy: 62 lm/W

Design Consideration:
For Lighting of Electrical Room with the conventional luminaires, following details has been considered:
1. Reflection Factors: Ceiling: 50%, Wall: 30%, Floor: 10%
2. Height of the Room: 3.5m
3. Maintainace Factor: 0.70
4. Mounting Type: Ceiling at a height of 3.5m
5. Obstructions are considered

The design has been done by using 36 numbers of 3x32W Fluorescent Weather-proof Luminaire. The following 3D view has been provided below.

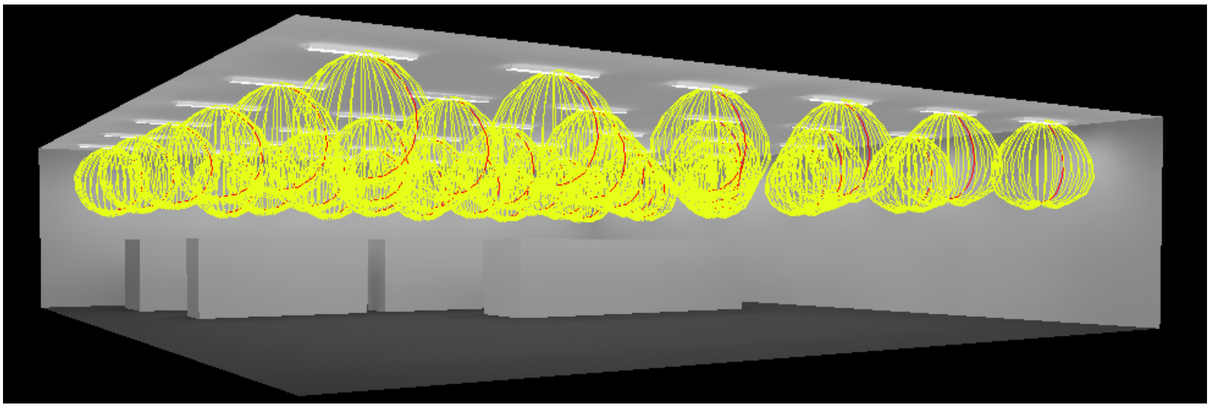
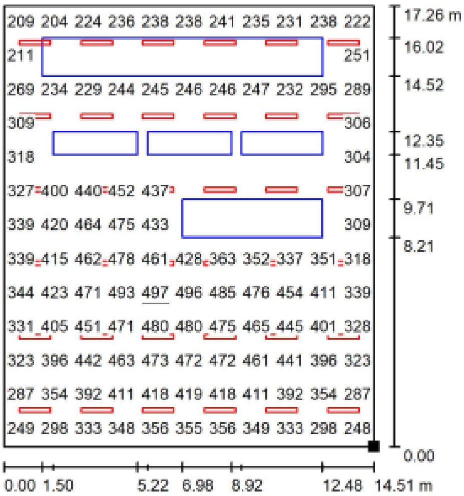


Fig.3D View of Electrical Room under Conventional Luminaires

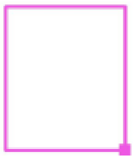
Electrical Room-Conventional / Workplane / Value Chart (E)



Values in Lux, Scale 1 : 200

Not all calculated values could be displayed.

Position of surface in room:
Marked point:
(32.634 m, 29.213 m, 0.000 m)

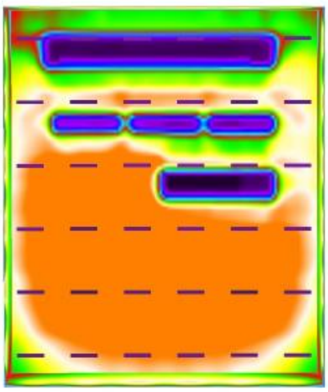


Grid: 13 x 11 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
348	192	497	0.552	0.386

Photometric Result:
In this photometric result the minimum and maximum Illuminance is 192 & 497lux. The achieved average Illuminance is 348lx (recommended ≥300 lux) and Overall Uniformity is 0.552(recommended ≥0.4).

False Colour Rendering:
It is used to describe different lux level distribution in different Colour inside electrical room. The Colour distribution of different Lux level ranges is given.



Technical details of luminaire (LED):

Luminaire Used: 4 Foot Weather-proof LED 2X20W T8 packed

Fig. 1.Image of the luminaire

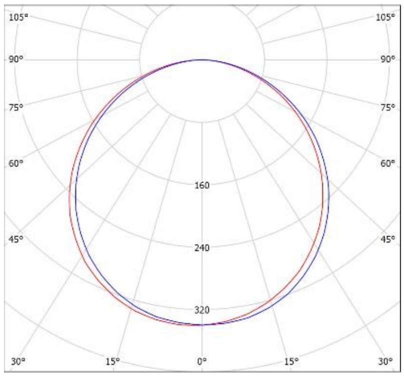


Fig.2. Intensity distribution curve

Specification:

1. Housing made up of corrosion resistant unbreakable polycarbonate body.
2. Made from impact-resistant and UV-stabilized polycarbonate is highly durable, completely leak-proof.
3. "Clear" version with transparent casing, guarantees high-quality appearance.

Technical Details:

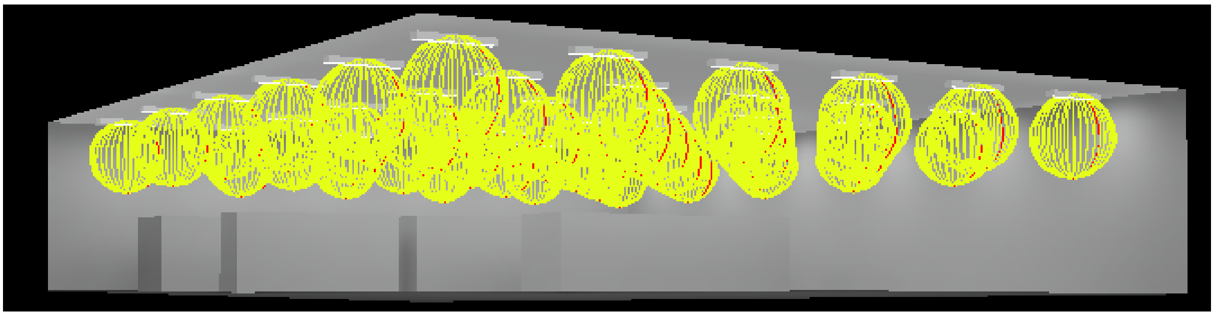
1. System Wattage: 38.9W
2. System Lumen Output: 4278 lumen
3. Input Voltage Range: 100V-300V
4. System Luminous Efficacy: 110lm/W
5. LED Life: 50,000 Burning Hours @L70

Design Consideration:

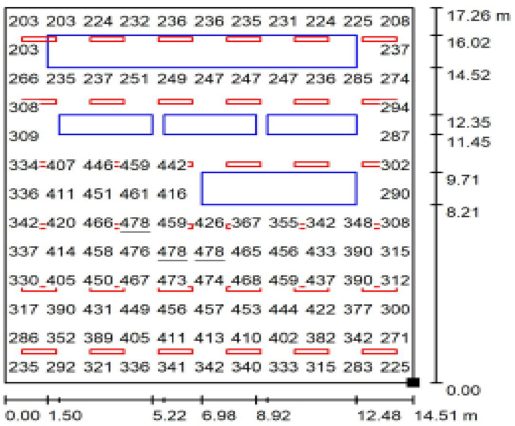
For Lighting of Electrical Room with the LED luminaires, following details has been considered:

1. Reflection Factors: Ceiling: 50%, Wall: 30%, Floor: 10%
2. Height of the Room: 3.5m
3. Maintainace Factor: 0.85
4. Mounting Type: Ceiling at a height of 3.5m
5. Obstructions are considered

The design has been done by using 36 numbers of 2x20W LED Weather-proof Luminaire. The following 3D view has been provided below.



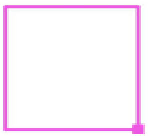
Electrical Room / Workplane / Value Chart (E)



Values in Lux, Scale 1 : 200

Not all calculated values could be displayed.

Position of surface in room:
Marked point:
(32.634 m, 29.213 m, 0.000 m)

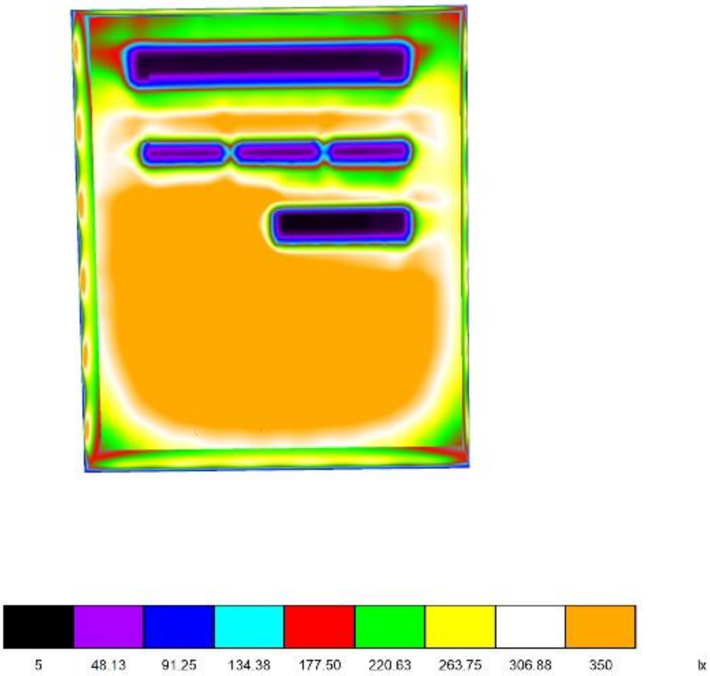


Grid: 13 x 11 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
341	182	478	0.533	0.380

Photometric Result:
In this photometric result the minimum and maximum Illuminance is 182 & 478lux. The achieved average Illuminance is 341lx (recommended ≥300 lux) and Overall Uniformity is 0.533(recommended ≥0.4).

False Colour Rendering:
It is used to describe different lux level distribution in different Colour inside electrical room. The Colour distribution of different Lux level ranges is given.



Conclusion:

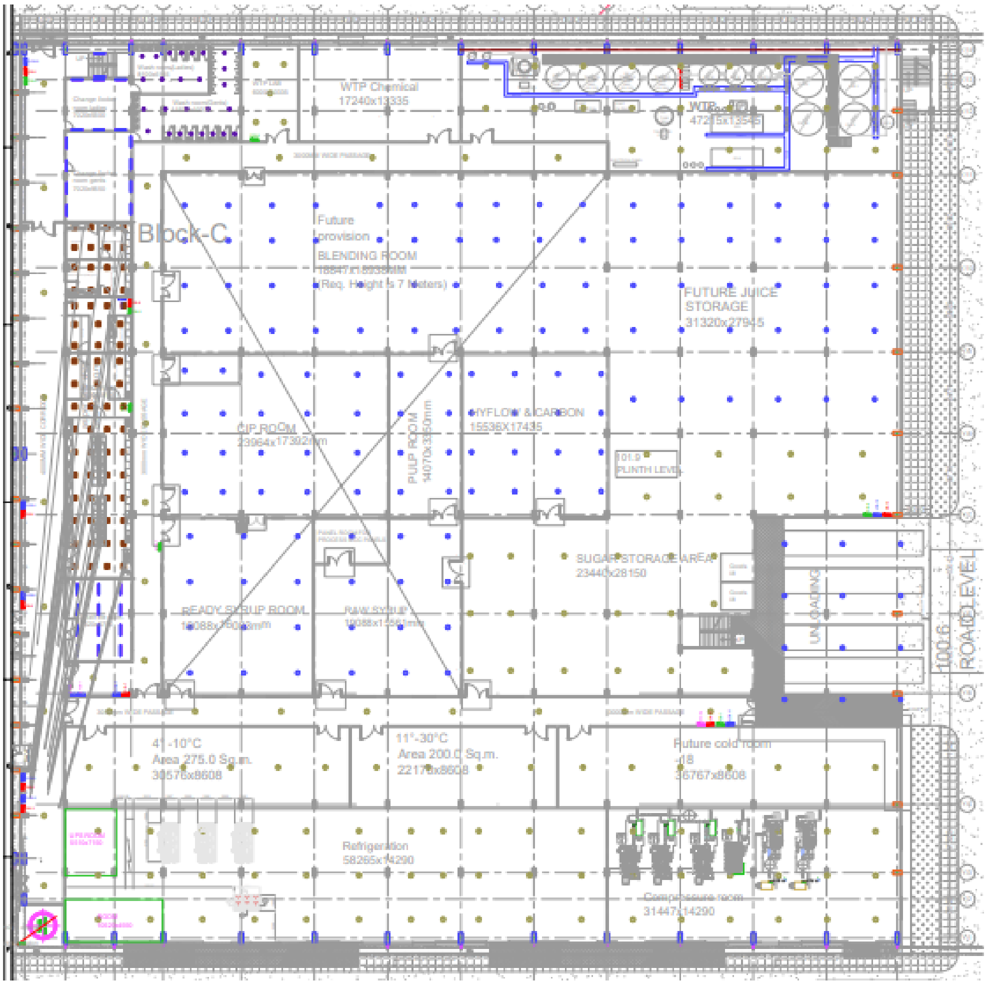
Below table provides the details of LPD value comparison of Conventional Luminaire with LED:

Name of the Product	Total Number of Quantities	Obtained LPD Values(recommended LPD Value as per ECBC:7.1W/m²)
1. 4 Foot Weather-proof Fluorescent White Reflector 32W T8 3-lamps	36	12.46W/m²
2. 4 Foot Weather-proof LED 2X20W T8 packed	36	5.60W/m²

So, LED Luminaire Products are more energy efficient than conventional luminaire.

GROUND & MEIZZANE FLOOR AREA-BLOCK C

7.10 AutoCAD Layout:



7.11 CORRIDOR AREA:

Technical details of luminaire (Conventional):

Luminaire Used: Surface mounted 45W luminaire with matt optic double parabolic louver closed.

Fig. 1.Image of the luminaire

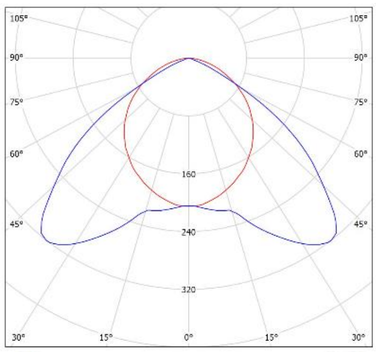


Fig.2. Intensity distribution curve

Specification:

1. Compact luminaire height of 79 mm.
2. Suitable for surface mounting on ceilings.
3. The concave shapes of the lamellae provide excellent light technical performance i.e. high efficiency and good uniformity.
4. Housing made of epoxy polyester powder coated CRCA sheet, with perforated in-fill panel.

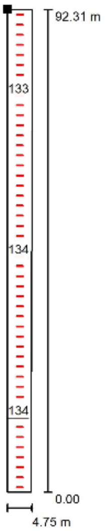
Technical Details:

1. System Wattage: 45.2W
2. Total System Lumen: 2261 lumen
3. System Luminous Efficacy: 50lm/w
4. Lamp Life: 25,000 Burning Hours@L70

Design Consideration:
For Lighting of Corridor Room with the conventional luminaires, following details has been considered:
1. Reflection Factors: Ceiling: 50%, Wall: 30%, Floor: 10%
2. Height of the Room: 4m
3. Maintainace Factor: 0.70
4. Mounting Type: Ceiling at a height of 4m
5. Obstructions are considered

The design has been done by using 48 numbers of Surface mounted 45W Conventional T8 Luminaire. The following 3D view has been provided below.

Corridor / Workplane / **Value Chart (E)**



Values in Lux, Scale 1 : 750

Not all calculated values could be displayed.

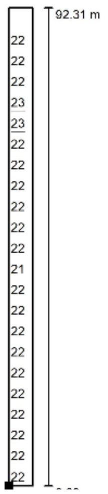
Position of surface in room:
Marked point: (3.412 m, 107.221 m, 0.000 m)

Grid: 3 x 8 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
118	99	134	0.838	0.739

Photometric Result:
In this photometric result the minimum and maximum Illuminance is 99 & 134lux. The achieved average Illuminance is 118lx (recommended ≥100 lux) and Overall Uniformity is 0.838(recommended ≥0.4). Maximum Value of UGR obtained is 23 (recommendedUGRmax≤28).

Corridor / UGR Calculation Area 1 / **Value Chart (UGR)**



Scale 1 : 750

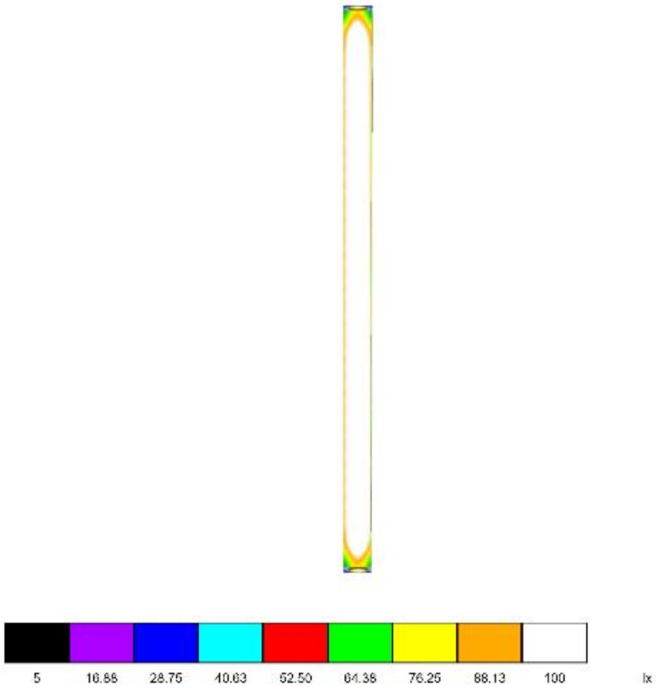
Not all calculated values could be displayed.

Position of surface in room:
Marked point: (3.412 m, 14.915 m, 1.200 m)

Grid: 4 x 92 Points

Min	Max
/	23

False Colour Rendering:
It is used to describe different lux level distribution in different Colour inside Corridor room. The Colour distribution of different Lux level ranges is given.



Technical details of luminaire (LED):

Luminaire Used: LED Round Slim Downlighter 10W

Fig. 1.Image of the luminaire

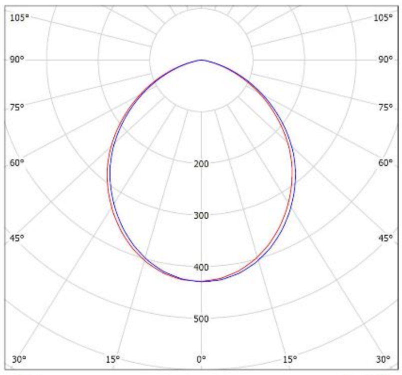


Fig.2. Intensity distribution curve

Specification:

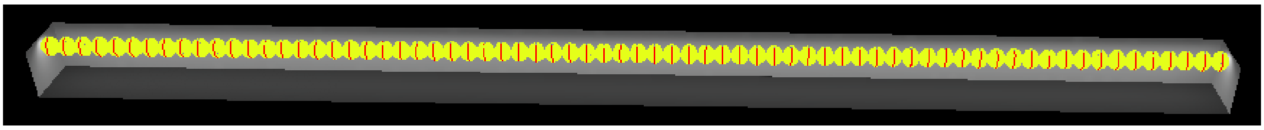
1. High performance and High Transmittance PMMA diffuser allows optimum light output with high uniformity.
2. With unique surface ring, any existing down light can be easily inserted inside the ring for surface application.
3. Suitable for both surface and Recess Mounting.

Technical Details:

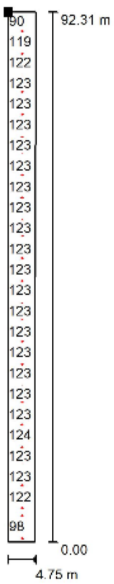
1. System Wattage: 11.8W
2. Total System Lumen: 1201 lumen
3. System Luminous Efficacy: 100lm/w
4. Lamp Life: 50,000 Burning Hours@L70

Design Consideration:
For Lighting of Corridor Room with the LED luminaires, following details has been considered:
1. Reflection Factors: Ceiling: 50%, Wall: 30%, Floor: 10%
2. Height of the Room: 4m
3. Maintainace Factor: 0.85
4. Mounting Type: Ceiling at a height of 4m
5. Obstructions are not considered

The design has been done by using 70 numbers of LED Round Slim Downlighter 10W. The following 3D view has been provided below.



Corridor / Workplane / Value Chart (E



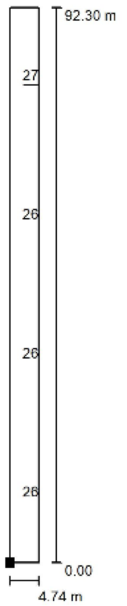
Values in Lux, Scale 1 : 750

Not all calculated values could be displayed.

Position of surface in room:
Marked point: (3.412 m, 107.221 m, 0.000 m)

Grid: 128 x 32 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
107	52	127	0.484	0.408



Scale 1 : 750

Not all calculated values could be displayed.

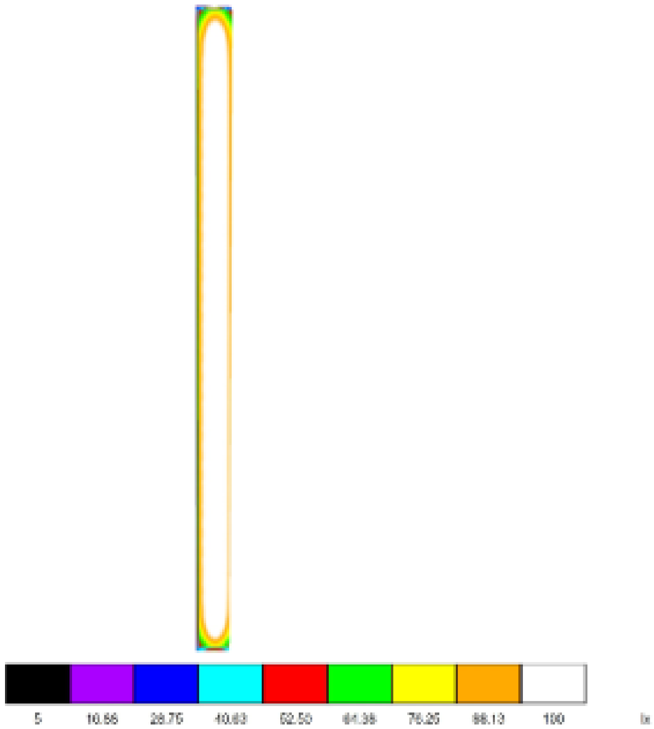
Position of surface in room:
Marked point: (3.412 m, 14.915 m, 1.200 m)

Grid: 4 x 92 Points

Min	Max
/	27

Photometric Result:
In this photometric result the minimum and maximum Illuminance is 52 & 127lux. The achieved average Illuminance is 107lx (recommended ≥100 lux) and Overall Uniformity is 0.484(recommended ≥0.4). Maximum Value of UGR obtained is 27 (recommendedUGRmax≤28).

Colour Rendering:
It is used to describe different lux level distribution in different Colour inside Corridor room. The Colour distribution of different Lux level ranges is given.



Conclusion:
Below table provides the details of LPD value comparison of Conventional Luminaire with LED:

Name of the Product	Total Number of Quantities	Obtained LPD Values(Recommended as per ECBC Code: 7.1W/m2)
1. Surface mounted 45W Conventional T8 Luminaire	48	5.08W/m²
2. LED Round Slim Downlighter 10W	70	1.94W/m²

So, LED Luminaire Products are more energy efficient than conventional luminaire.

7.12 Cold Storage Room:

Technical details of luminaire (Conventional):

Luminaire Used: 4 Foot Weather-proof Fluorescent White Reflector 32W T8 3-lamps HBF single packed

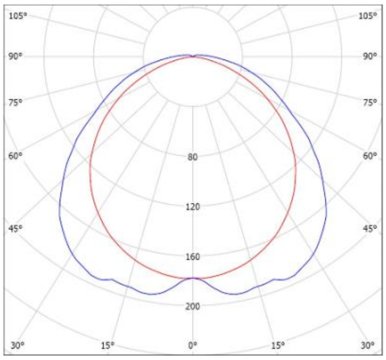


Fig. 1.Image of the luminaire

Fig.2. Intensity distribution curve

Specifications:

1. The gasketed enclosure is constructed of a fiberglass upper body and acrylic diffuser, with a continuous poured gasket.
2. The diffuser and upper components are locked by retaining latches, which ensures a tight seal.
3. Sockets include secure, positioning rotating collars.
4. The superior beam spread optics is ideal for an open area, general lighting.
5. The Wet Location fixture comes standard with a white channel cover, and is available using specular aluminum.
6. The Wet Location fixture is IP65 and IP67 rated, dust and moisture-resistant, making it ideal for harsh environments where humidity or moisture is present.

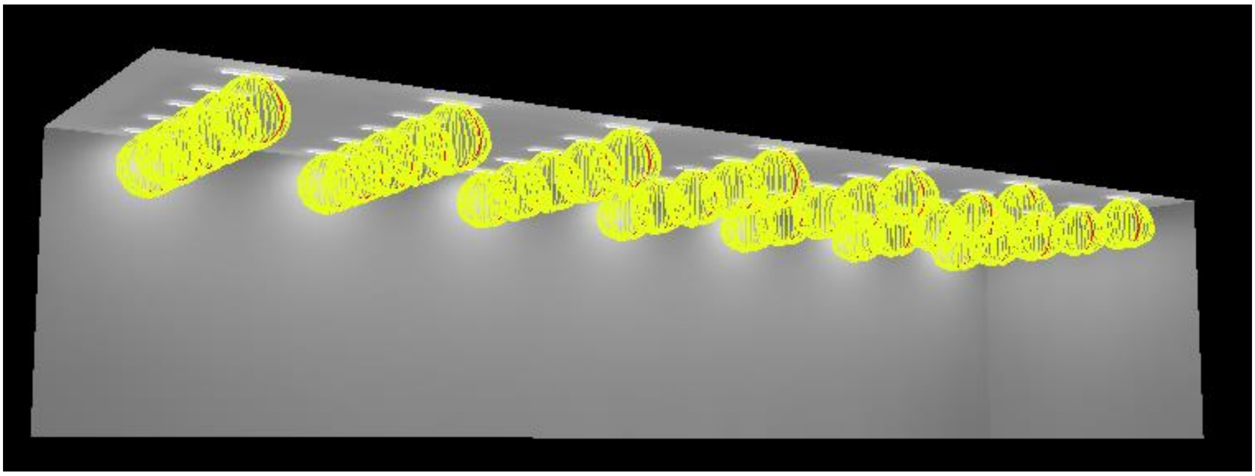
Technical Details:

1. System Wattage:86.7W
2. System Lumen Output: 5403 lumen
3. Input Voltage Range: 120V-277V
4. Weight:4.5Kg
5. Luminaire Life: 25,000 Burning Hours@ L70
6. System Luminous Efficacy: 62 lm/W

Design Consideration:
For Lighting of Cold Storage Room with the conventional luminaires, following details has been considered:

1. Reflection Factors: Ceiling: 50%, Wall: 30%, Floor: 10%
2. Height of the Room: 7m
3. Maintainace Factor: 0.70
4. Mounting Type: Ceiling at a height of 7m
5. Obstructions are not considered

The design has been done by using 35 numbers of 3x32W Fluorescent Weather-proof Luminaire. The following 3D view has been provided below.



Cold Storage / Workplane / Value Chart (E)

176	211	235	248	257	260	262	263	263	261	259	255	246	230	204	172
192	230	255	270	278	282	283	285	285	282	280	276	267	249	222	188
196	236	261	276	285	288	290	291	292	289	287	283	273	255	227	191
187	224	248	263	271	274	276	277	278	275	273	269	260	242	215	183
173	207	231	244	252	256	257	259	258	256	254	250	241	225	200	169

8.29 m
0.00
0.00
30.56 m

Values in Lux, Scale 1 : 250

Not all calculated values could be displayed.

Position of surface in room:
Marked point: (8.135 m, 25.554 m, 0.000 m)

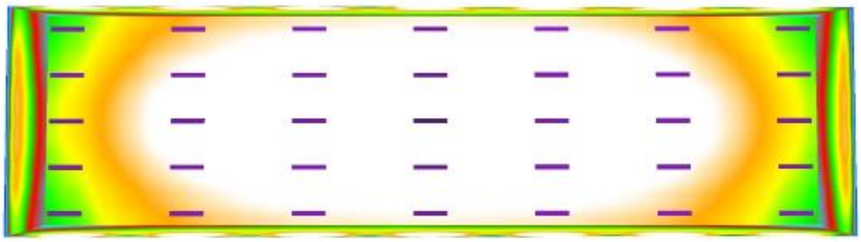
Grid: 16 x 64 Points

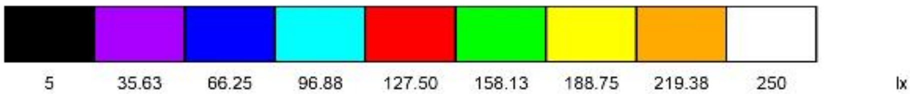
E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
247	156	292	0.631	0.533

Photometric Result:

In this photometric result the minimum and maximum Illuminance is 156 & 292lux. The achieved average Illuminance is 247lx (recommended ≥200 lux) and Overall Uniformity is 0.631(recommended ≥0.4).

False Colour Rendering:
It is used to describe different lux level distribution in different Colour inside cold storage room. The Colour distribution of different Lux level ranges is given.





Technical details of luminaire (LED):

Luminaire Used: 4 Foot Weather-proof LED Capsule 40W

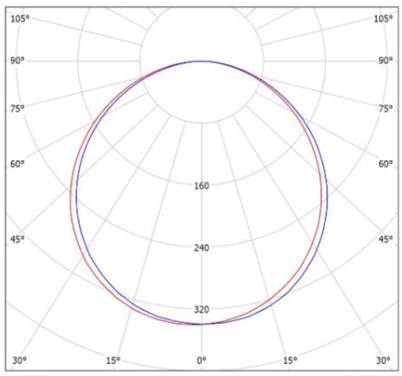


Fig. 1.Image of the luminaire

Fig.2. Intensity distribution curve

Specification:

1. Housing made up of corrosion resistant unbreakable polycarbonate body.
2. Made from impact-resistant and UV-stabilized polycarbonate is highly durable, completely leak-proof.
3. OPAL diffuser for glare free and uniform distribution.
4. MCPCB based LED for better heat dissipation and lumen maintainance.

Technical Details:

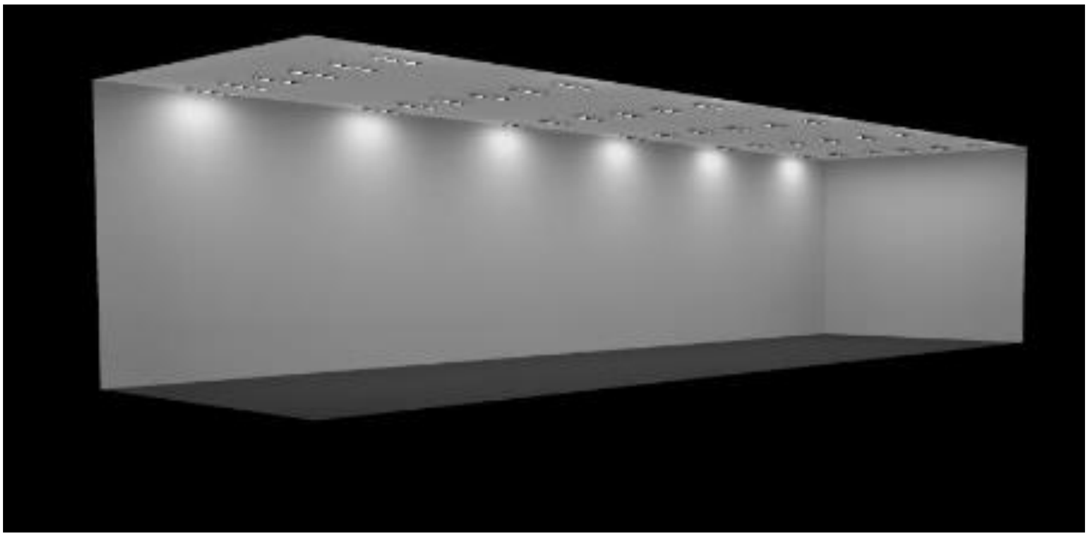
1. System Wattage: 38.9W
2. System Lumen Output: 4278 lumen
3. Input Voltage Range: 120V-277V
4. Luminaire Life: 50,000 Burning Hours@ L70
5. System Luminous Efficacy: 110 lm/W

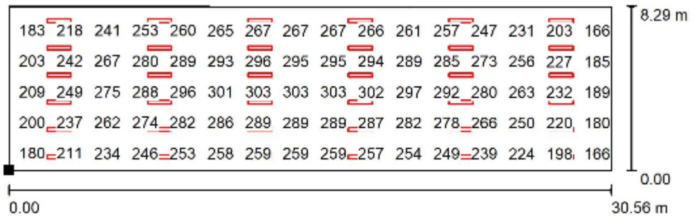
Design Consideration:

For Lighting of Cold Storage Room with the LED luminaires, following details has been considered:

1. Reflection Factors: Ceiling: 50%, Wall: 30%, Floor: 10%
2. Height of the Room: 7m
3. Maintainace Factor: 0.85
4. Mounting Type: Ceiling at a height of 7m
5. Obstructions are not considered

The design has been done by using 36 numbers of 4 Foot Weather-proof LED Capsule 40W. The following 3D view has been provided below.





Values in Lux, Scale 1 : 250

Not all calculated values could be displayed.

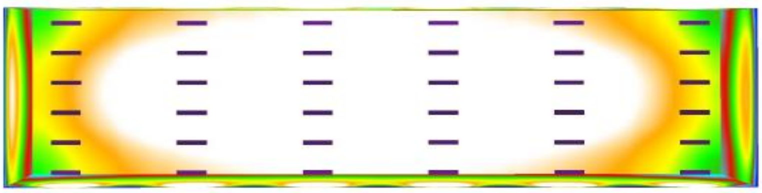
Position of surface in room:
Marked point: (8.135 m, 25.554 m, 0.000 m)

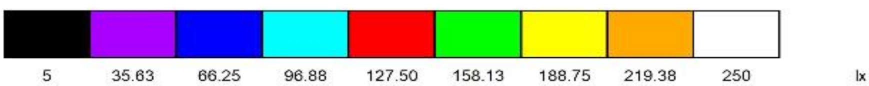
Grid: 16 x 64 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
253	150	304	0.591	0.493

Photometric Result:
In this photometric result the minimum and maximum Illuminance is 150 & 304lux. The achieved average Illuminance is 253lx (recommended ≥200 lux) and Overall Uniformity is 0.591(recommended ≥0.4).

False Colour Rendering:
It is used to describe different lux level distribution in different Colour inside cold storage room. The Colour distribution of different Lux level ranges is given.





Conclusion:
Below table provides the details of LPD value comparison of Conventional Luminaire with LED:

Name of the Product	Total Number of Quantities	Obtained LPD Values(recommended LPD Value as per ECBC:6.8W/m²)
1. 4 Foot Weather-proof Fluorescent White Reflector 32W T8 3-lamps	35	12.02W/m²
2. 4 Foot Weather-proof LED Capsule 40W	36	5.55W/m²

So, LED Luminaire Products are more energy efficient than conventional luminaire.

7.13 RAW SYRUP ROOM:

Technical details of the Luminaire (Conventional):

Luminaire Used: 2' Wide Recessed Cleanroom Fluorescent Luminaire for Standard T-Bar 140W

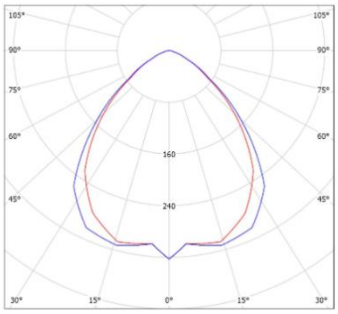


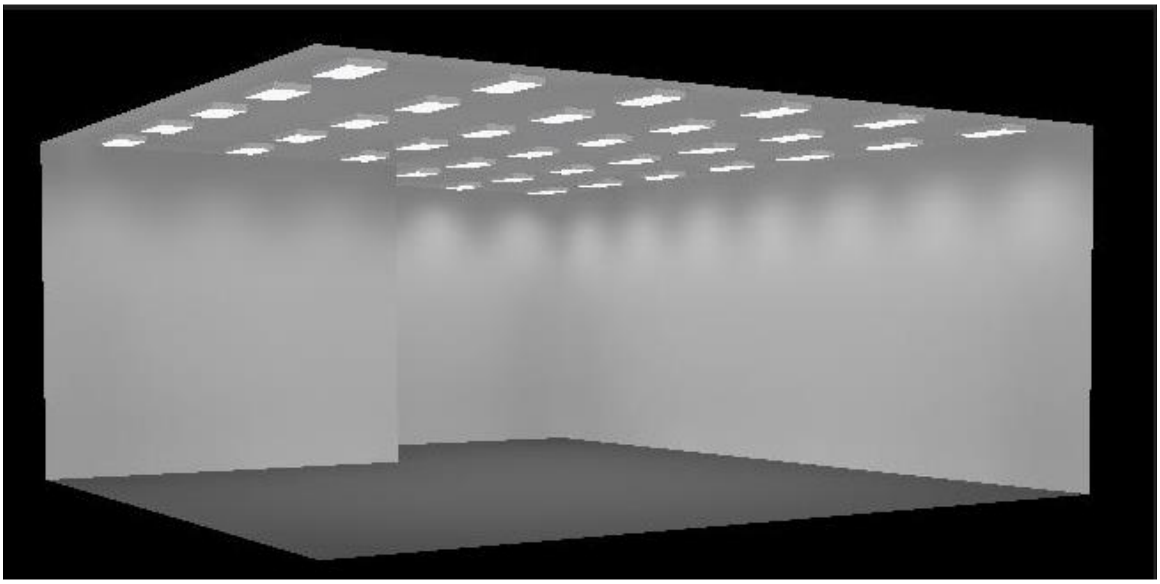
Fig. Intensity distribution curve   Fig.Image of the luminaire

Specification:
1.22 gallon cold rolled steel welded housing
2. All parts fitted and sealed
3. 20 gallon cold rolled steel door frame secured by T-hinges and positive spring loaded latches
4. Door frame sealed with neoprene gasket
5. Painted after fabrication
6. Baked white powder-coated finish
7. Minimum reflectance 90%
8. Inverted clear prismatic acrylic lens.

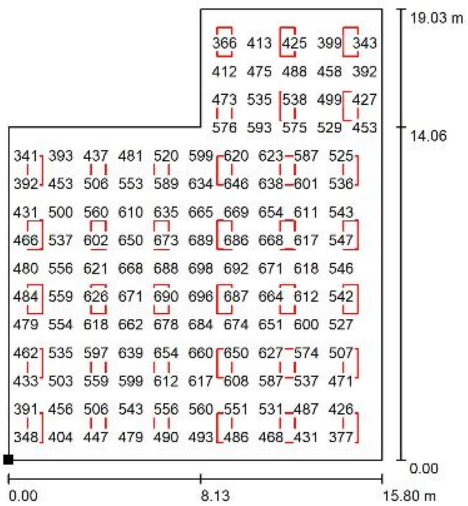
Technical Details:
1. System Wattage: 140W
2. Total System Lumen Output: 7262lumen
3. Operating Voltage is 120-277V
4. System Luminous Efficacy: 51.87lm/W
5. Lamp Life: 25,000 Burning Hours@L70

Design Consideration:
For lighting of Raw Syrup Room-Block B with the 2' Wide Recessed Cleanroom Fluorescent Luminaire 140W, following details has been considered:
1. Reflection Factors: Ceiling: 70%, Wall: 50% and Floor: 20%.
2. Height of the Room: 7m
3. Maintainace Factor: 0.70
4. Mounting Type: Recessed
5. Obstructions are considered.

The design has been done by using numbers 36 of 2' Wide Recessed Cleanroom Fluorescent Luminaire 140W .The following 3D view has been provided below.



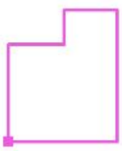
Raw Syrup / Workplane / Value Chart (E)



Values in Lux, Scale 1 : 200

Not all calculated values could be displayed.

Position of surface in room:
Marked point: (34.935 m, 37.239 m, 0.000 m)

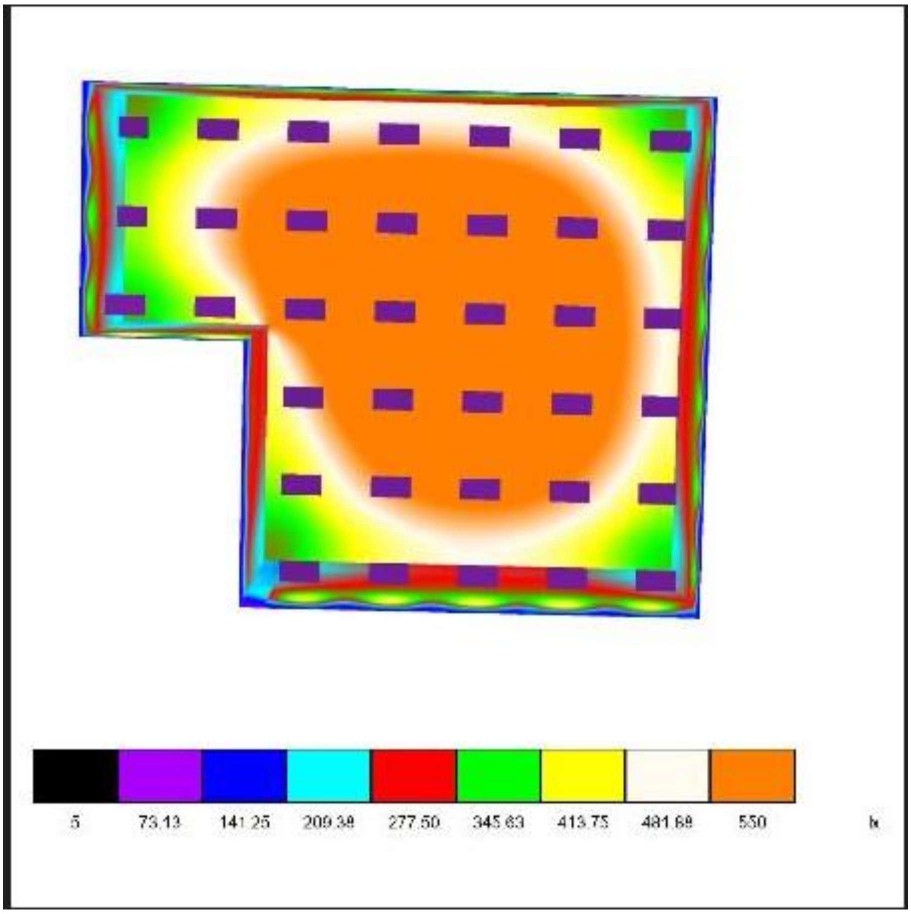


Grid: 32 x 32 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
534	318	699	0.595	0.455

Photometric Result:
In this photometric result the minimum and maximum Illuminance is 318 & 699lux. The achieved average Illuminance is 534lx (recommended ≥500 lux) and Overall Uniformity is 0.595(recommended ≥0.4).

False Colour Rendering:
It is used to describe different lux level distribution in different Colour inside Raw Syrup room. The Colour distribution of different Lux level ranges is given.



Technical details of the Luminaire (LED):

Luminaire Used: Recessed Mounting Bottom Opening Cleanroom LED Luminaire 80W

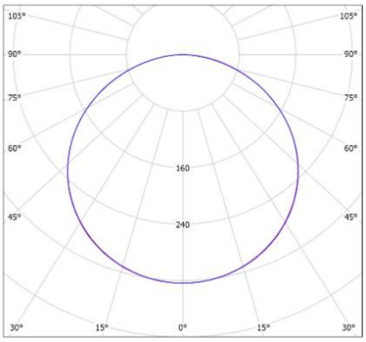


Fig.Image of the luminaire

Fig. Intensity distribution curve

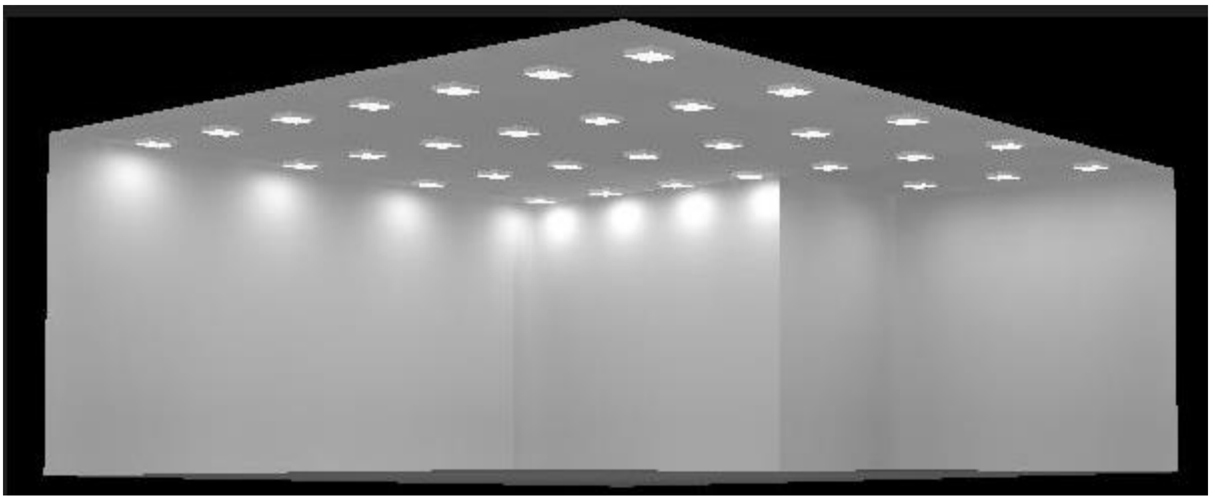
Specification:

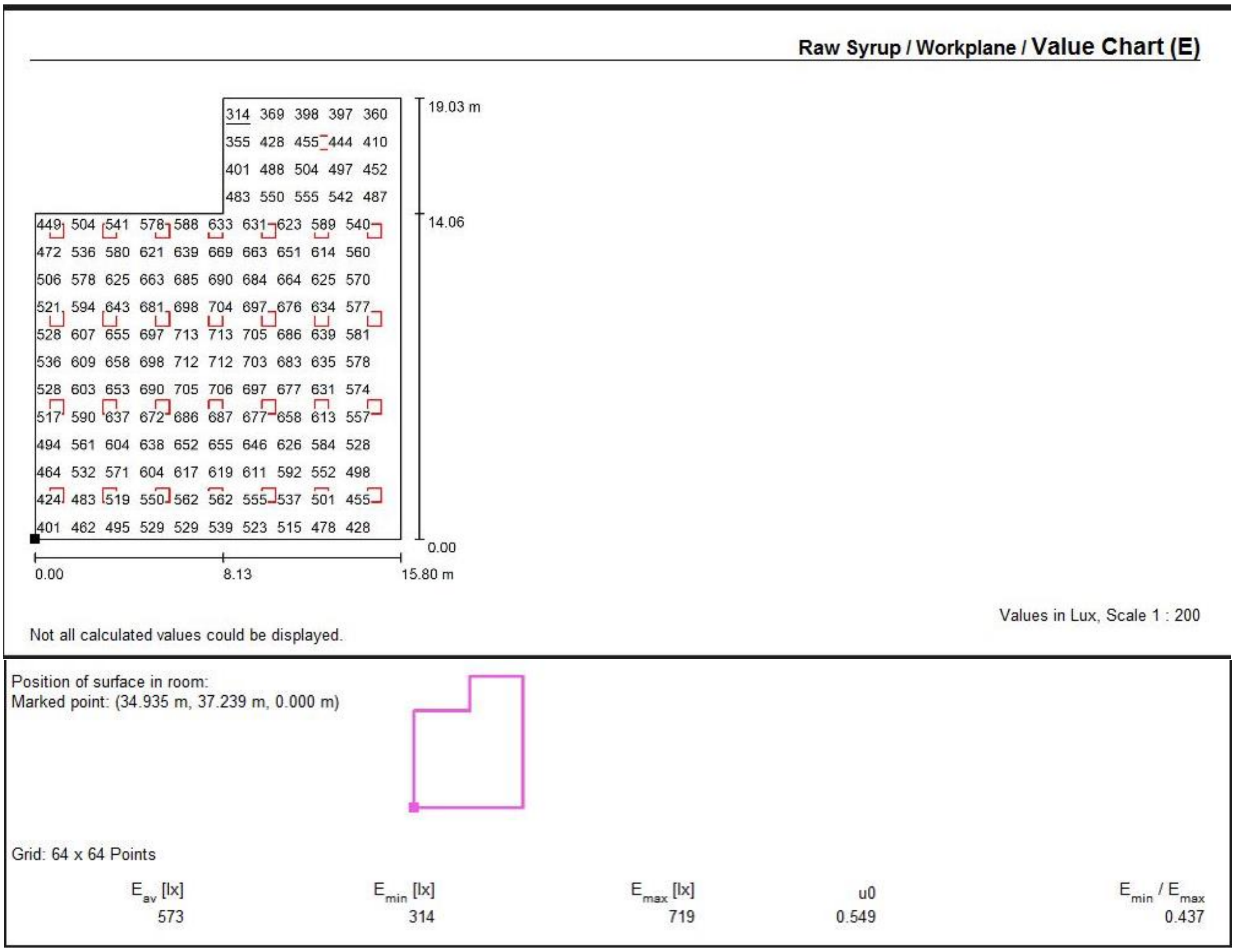
1. Recess mount bottom opening luminaire
2. Body fabricated from CRCA Sheet.
3. Epoxy powder coated finish, which helps against corrosion resistance for long life in challenging environments,
4. VHB gasket for proper and long life bonding(nonhydroscopic and antifungal gasket).

Technical Details:

1. System Wattage: 81.5W
2. Total System Lumen Output: 8801lumen
3. Operating Voltage is 120-300V
4. System Luminous Efficacy: 107.98lm/W
5. Lamp Life: 50,000 Burning Hours@L70

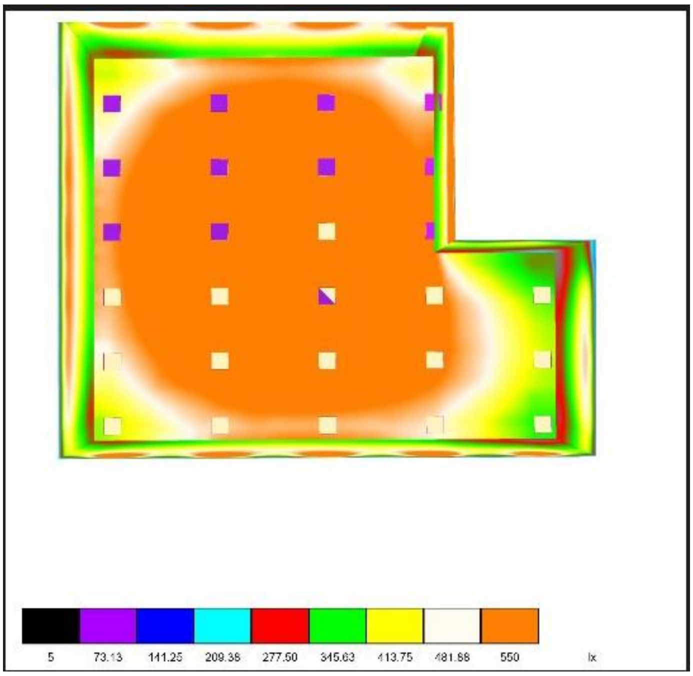
The design has been done by using 31 numbers of Recessed Mounting Bottom Opening Cleanroom LED Luminaire 80W .The following 3D view has been provided below.





Photometric Result:
In this photometric result the minimum and maximum Illuminance is 314 & 719lux. The achieved average Illuminance is 573lx (recommended ≥500 lux) and Overall Uniformity is 0.549(recommended ≥0.4).

False Colour Rendering:
It is used to describe different lux level distribution in different Colour inside Raw Syrup room. The Colour distribution of different Lux level ranges is given.



Conclusion:

Below table provides the details of LPD value comparison of Conventional Luminaire with LED:

Name of the Product	Total Number of Quantities	Obtained LPD Values
1.Clean Room Fluorescent luminaire 140W	36	19.37W/m²
2. Clean Room LED luminaire 80W	31	9.72W/m²

So, LED Luminaire Products are more energy efficient than conventional luminaire.

7.14 PULP ROOM:

Technical details of the Luminaire (Conventional):

Luminaire Used: 2' Wide Recessed Cleanroom Fluorescent Luminaire for Standard T-Bar 140W

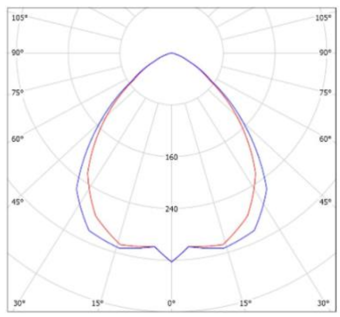


Fig. Intensity distribution curve Fig.Image of the luminaire

Specification:

1.22 gallon cold rolled steel welded housing
2. All parts fitted and sealed
3. 20 gallon cold rolled steel door frame secured by T-hinges and positive spring loaded latches
4. Door frame sealed with neoprene gasket
5. Painted after fabrication
6. Baked white powder-coated finish
7. Minimum reflectance 90%
8. Inverted clear prismatic acrylic lens.

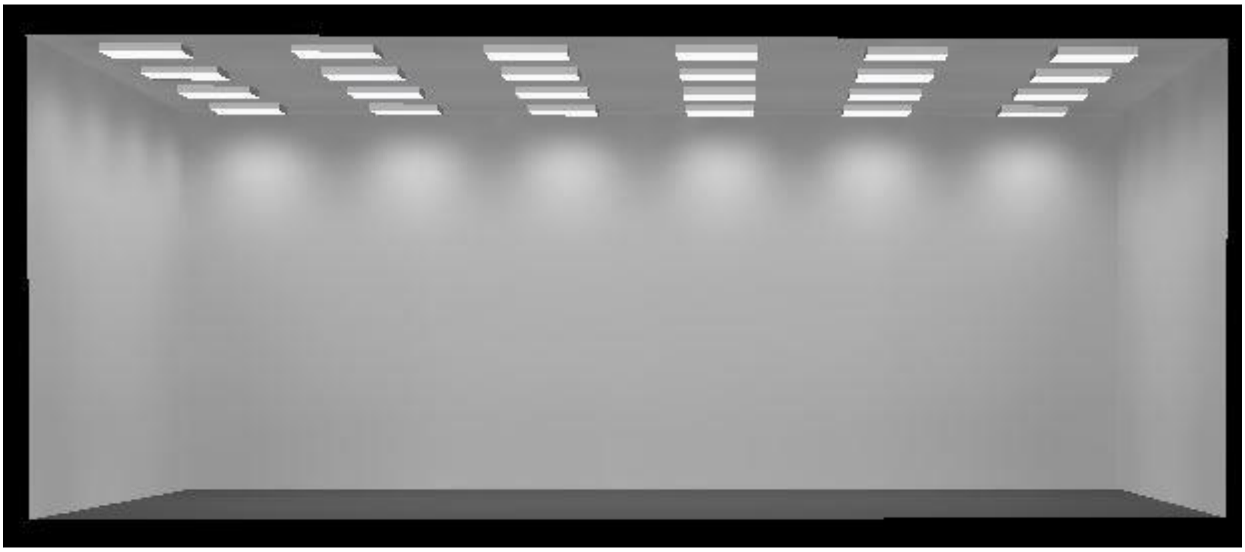
Technical Details:

1. System Wattage: 140W

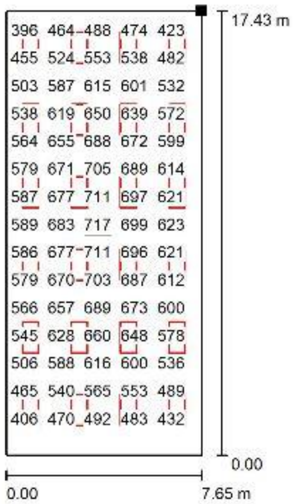
2. Total System Lumen Output: 7262lumen
3. Operating Voltage is 120-277V
4. System Luminous Efficacy: 51.87lm/W
5. Lamp Life: 25,000 Burning Hours@L70

Design Consideration:
For lighting of Pulp Room-Block C with the 2' Wide Recessed Cleanroom Fluorescent Luminaire 140W, following details has been considered:
1. Reflection Factors: Ceiling: 70%, Wall: 50% and Floor: 20%.
2. Height of the Room: 7m
3. Maintainace Factor: 0.70
4. Mounting Type: Recessed
5. Obstructions are not considered.

The design has been done by using 24 numbers of 2' Wide Recessed Cleanroom Fluorescent Luminaire 140W .The following 3D view has been provided below.



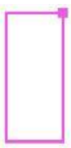
Pulp Room / Workplane / **Value Chart (E)**



Values in Lux, Scale 1 : 200

Not all calculated values could be displayed.

Position of surface in room:
Marked point: (50.691 m, 73.893 m, 0.000 m)

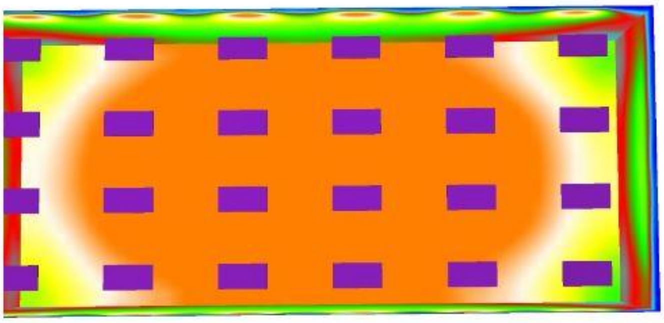


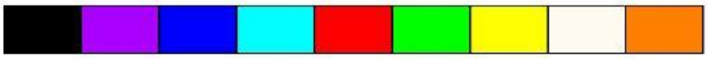
Grid: 32 x 16 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
575	367	717	0.639	0.512

Photometric Result:
In this photometric result the minimum and maximum Illuminance is 367 & 717lux. The achieved average Illuminance is 575lx (recommended ≥500 lux) and Overall Uniformity is 0.639(recommended ≥0.4).

False Colour Rendering:
It is used to describe different lux level distribution in different Colour inside Pulp room. The Colour distribution of different Lux level ranges is given.





Technical details of the Luminaire (LED):

Luminaire Used: Recessed Mounting Bottom Opening Cleanroom LED Luminaire 80W

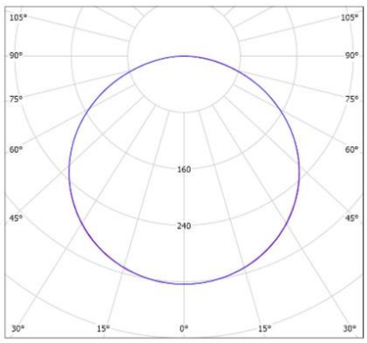


Fig.Image of the luminaire

Fig. Intensity distribution curve

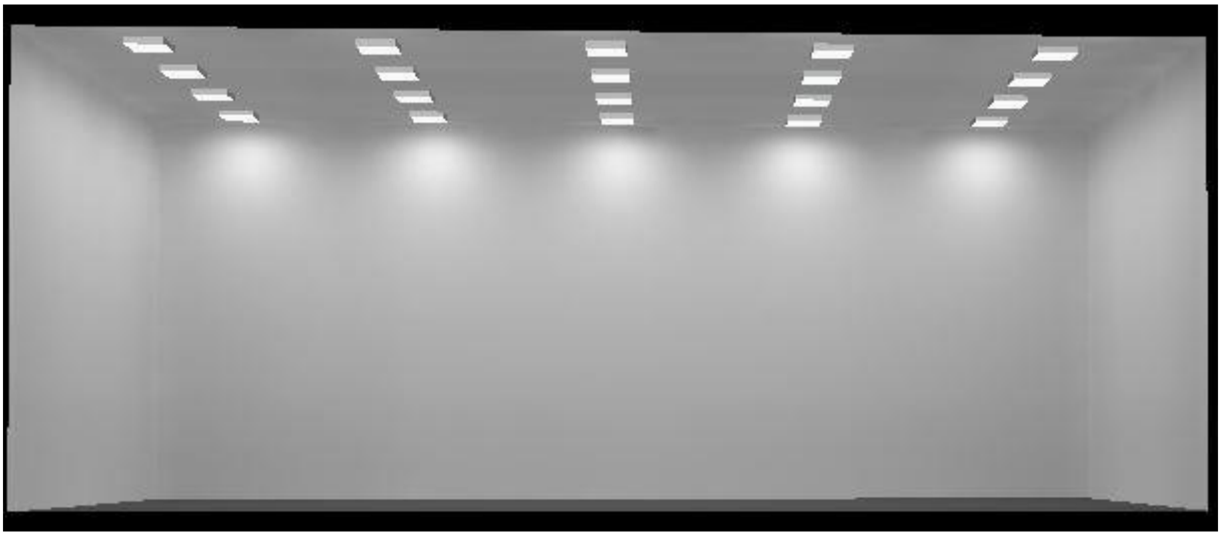
Specification:

1. Recess mount bottom opening luminaire
2. Body fabricated from CRCA Sheet.
3. Epoxy powder coated finish, which helps against corrosion resistance for long life in challenging environments,
4. VHB gasket for proper and long life bonding(nonhydroscopic and antifungal gasket).

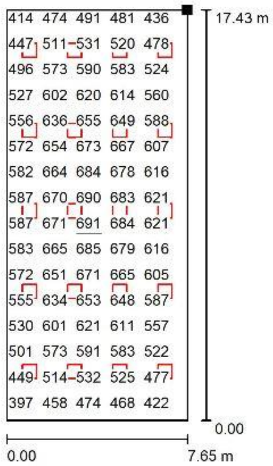
Technical Details:
1. System Wattage: 81.5W
2. Total System Lumen Output: 8801lumen
3. Operating Voltage is 120-300V
4. System Luminous Efficacy: 107.98lm/W
5. Lamp Life: 50,000 Burning Hours@L70

Design Consideration:
For lighting of Pulp Room-Block C with the Recessed Mounting Bottom Opening Cleanroom LED Luminaire 80W, following details has been considered:
1. Reflection Factors: Ceiling: 70%, Wall: 50% and Floor: 20%.
2. Height of the Room: 7m
3. Maintainace Factor: 0.85
4. Mounting Type: Recessed
5. Obstructions are not considered.

The design has been done by using 20 numbers of Recessed Mounting Bottom Opening Cleanroom LED Luminaire 80W .The following 3D view has been provided below.



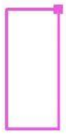
Pulp Room / Workplane / Value Chart (E)



Values in Lux, Scale 1 : 200

Not all calculated values could be displayed.

Position of surface in room:
Marked point: (50.691 m, 73.893 m, 0.000 m)

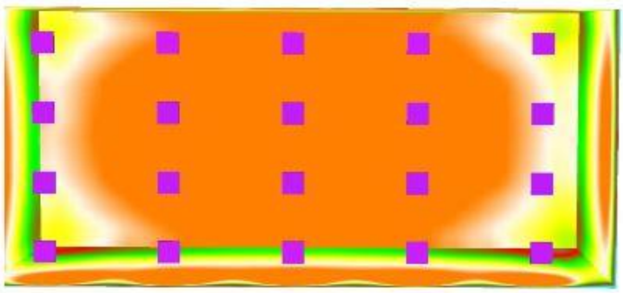


Grid: 64 x 32 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
577	384	691	0.665	0.555

Photometric Result:
In this photometric result the minimum and maximum Illuminance is 384 & 691lux. The achieved average Illuminance is 577lx (recommended ≥500 lux) and Overall Uniformity is 0.665(recommended ≥0.4).

False Colour Rendering:
It is used to describe different lux level distribution in different Colour inside Pulp room. The Colour distribution of different Lux level ranges is given.



Conclusion:

Below table provides the details of LPD value comparison of Conventional Luminaire with LED:

Name of the Product	Total Number of Quantities	Obtained LPD Values
1.Clean Room Fluorescent luminaire 140W	24	25.21W/m²
2. Clean Room LED luminaire 80W	20	12.24W/m²

So, LED Luminaire Products are more energy efficient than conventional luminaire.

7.15 FRUIT JUICE STORAGE AND BLENDING ROOM:

Technical details of the Luminaire (Conventional):

Luminaire Used: 2' Wide Recessed Cleanroom Fluorescent Luminaire for Standard T-Bar 140W

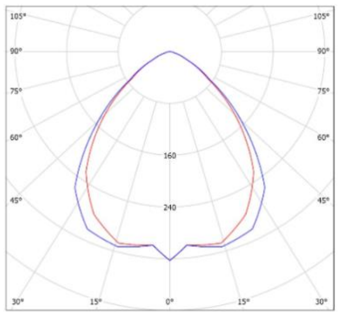


Fig. Intensity distribution curve Fig.Image of the luminaire

Specification:

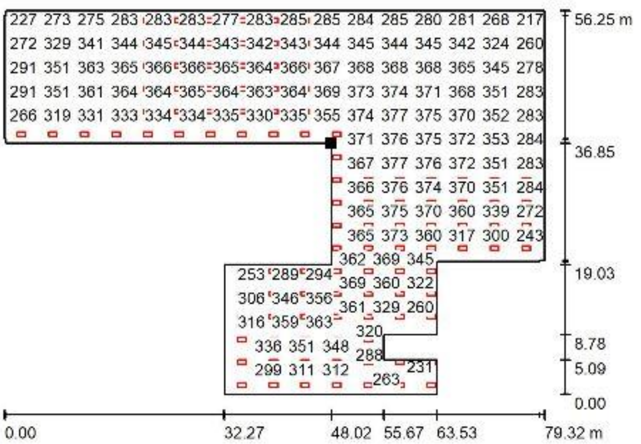
1.22 gallon cold rolled steel welded housing
2. All parts fitted and sealed
3. 20 gallon cold rolled steel door frame secured by T-hinges and positive spring loaded latches
4. Door frame sealed with neoprene gasket
5. Painted after fabrication
6. Baked white powder-coated finish
7. Minimum reflectance 90%
8. Inverted clear prismatic acrylic lens.

Technical Details:
1. System Wattage: 140W
2. Total System Lumen Output: 7262lumen
3. Operating Voltage is 120-277V
4. System Luminous Efficacy: 51.87lm/W
5. Lamp Life: 25,000 Burning Hours@L70

Design Consideration:
For lighting of Fruit juice Storage and Blending Room-Block C with the 2' Wide Recessed Cleanroom Fluorescent Luminaire 140W, following details has been considered:
1. Reflection Factors: Ceiling: 70%, Wall: 50% and Floor: 20%.
2. Height of the Room: 7m
3. Maintainace Factor: 0.70
4. Mounting Type: Recessed
5. Obstructions are not considered.

The design has been done by using numbers of 177 2' Wide Recessed Cleanroom Fluorescent Luminaire 140W .The following 3D view has been provided below.

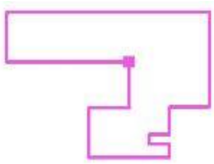
Future Juice Storage & Blending Room / Workplane / Value Chart (E)



Values in Lux, Scale 1 : 750

Not all calculated values could be displayed.

Position of surface in room:
Marked point: (66.664 m, 74.091 m, 0.000 m)

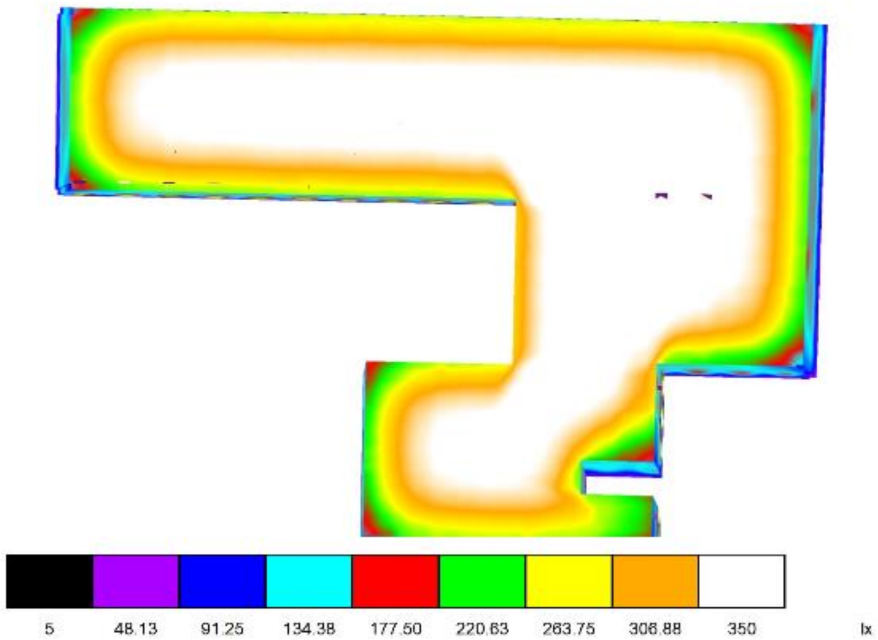


Grid: 128 x 128 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
323	129	379	0.401	0.341

Photometric Result:
In this photometric result the minimum and maximum Illuminance is 129 & 379 lux. The achieved average Illuminance is 323lx (recommended ≥300 lux) and Overall Uniformity is 0.401(recommended ≥0.4).

False Colour Rendering:
It is used to describe different lux level distribution in different Colour inside Fruit Juice Storage & Blending room. The Colour distribution of different Lux level ranges is given.



Technical details of the Luminaire (LED):

Luminaire Used: Recessed Mounting Bottom Opening Cleanroom LED Luminaire 80W

Fig.Image of the luminaire

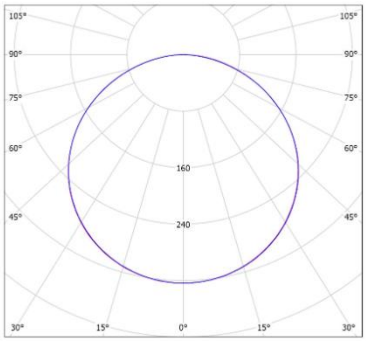


Fig. Intensity distribution curve

Specification:

1. Recess mount bottom opening luminaire
2. Body fabricated from CRCA Sheet.
3. Epoxy powder coated finish, which helps against corrosion resistance for long life in challenging environments,
4. VHB gasket for proper and long life bonding (nonhydroscopic and antifungal gasket).

Technical Details:

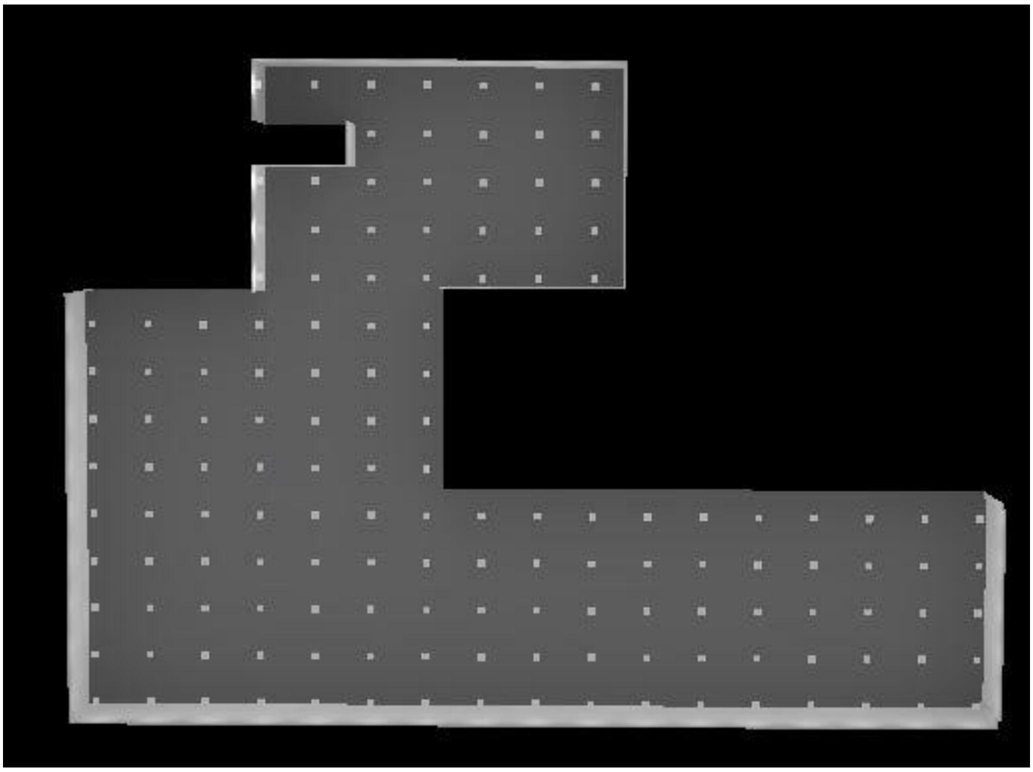
1. System Wattage: 81.5W
2. Total System Lumen Output: 8801lumen
3. Operating Voltage is 120-300V
4. System Luminous Efficacy: 107.98lm/W
5. Lamp Life: 50,000 Burning Hours@L70

Design Consideration:

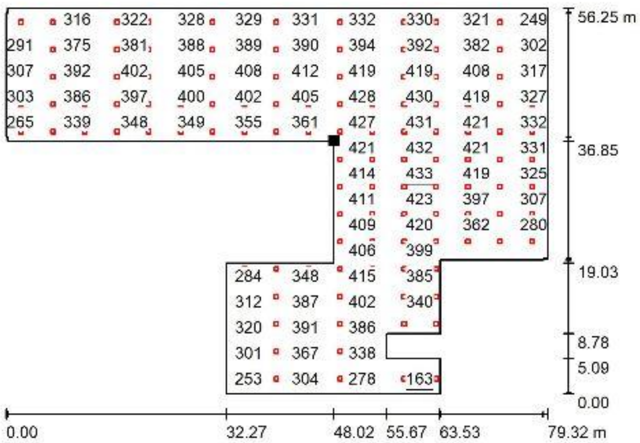
For lighting of Fruit Juice Storage and Blending Room Room-Block C with the Recessed Mounting Bottom Opening Cleanroom LED Luminaire 80W, following details has been considered:

1. Reflection Factors: Ceiling: 70%, Wall: 50% and Floor: 20%.
2. Height of the Room: 7m
3. Maintainace Factor: 0.85
4. Mounting Type: Recessed
5. Obstructions are not considered.

The design has been done by using 146 numbers of Recessed Mounting Bottom Opening Cleanroom LED Luminaire 80W .The following 3D view has been provided below.



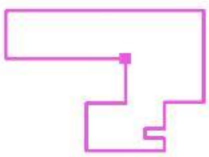
Future Juice Storage & Blending Room / Workplane / **Value Chart (E)**



Values in Lux, Scale 1 : 750

Not all calculated values could be displayed.

Position of surface in room:
Marked point: (66.664 m, 74.091 m, 0.000 m)

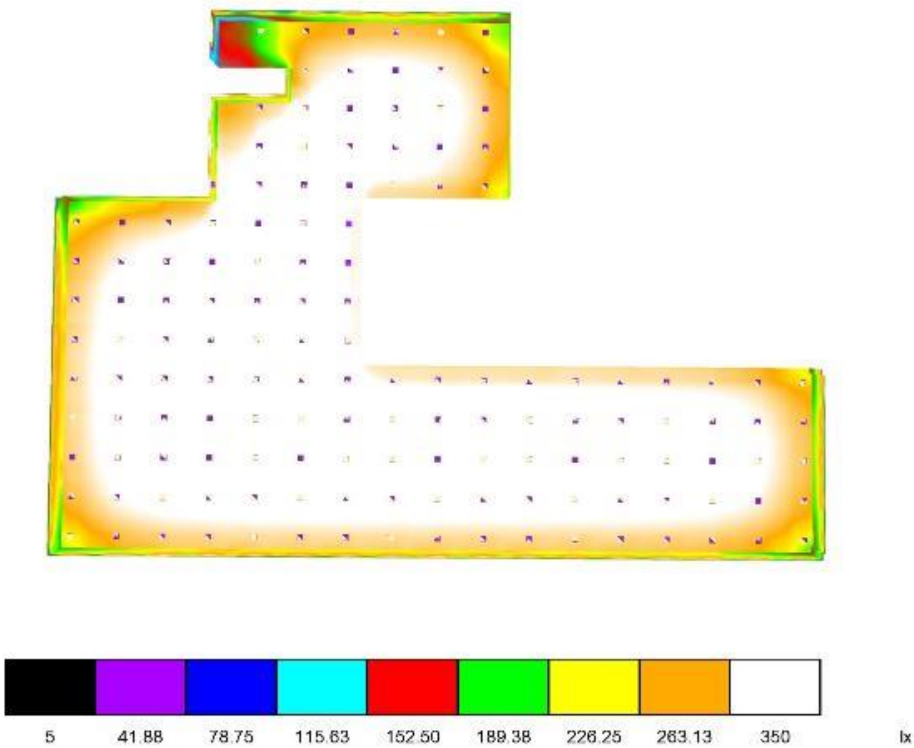


Grid: 19 x 15 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
366	163	433	0.447	0.377

Photometric Result:
In this photometric result the minimum and maximum Illuminance is 163 & 433 lux. The achieved average Illuminance is 366lx (recommended ≥300 lux) and Overall Uniformity is 0.447(recommended ≥0.4).

False Colour Rendering:
It is used to describe different lux level distribution in different Colour inside Fruit Juice Storage & Blending room. The Colour distribution of different Lux level ranges is given.



Conclusion:

Below table provides the details of LPD value comparison of Conventional Luminaire with LED:

Name of the Product	Total Number of Quantities	Obtained LPD Values
1.Clean Room Fluorescent luminaire 140W	177	9.33W/m2
2. Clean Room LED luminaire 80W	146	4.48W/m2

So, LED Luminaire Products are more energy efficient than conventional luminaire.

7.16 Wastewater Treatment Plant Area:

Technical details of the Luminaire (Conventional):
Luminaire Used: Linear Fluorescent Highbay T8 6 lamp type 32W each

Fig.Image of the luminaire

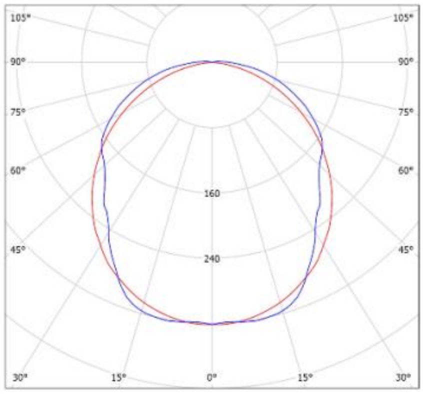


Fig. Intensity distribution curve

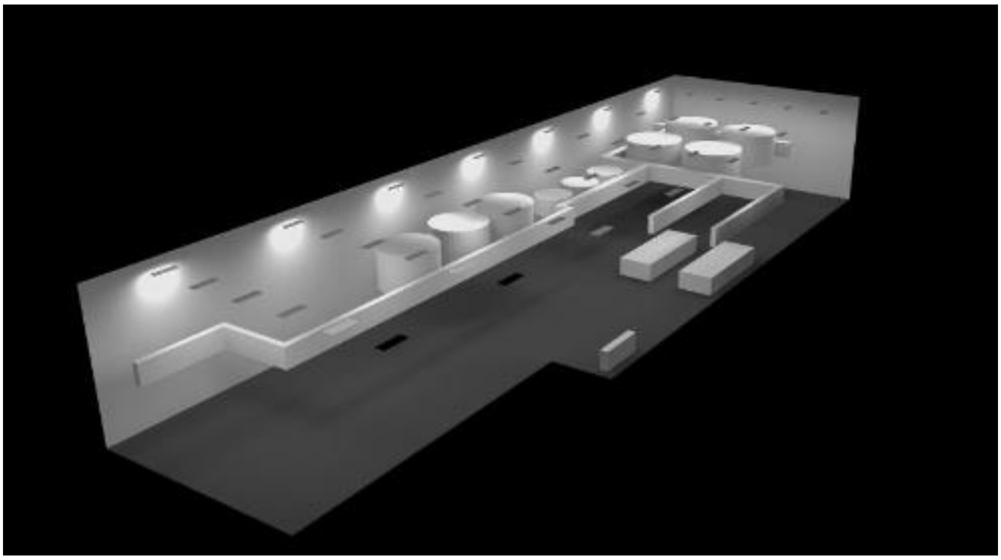
Specification:
1. The heavy-duty 20 gauge housing exceeds code gauge steel, and all components are post painted with a glossy, high reflectance white paint. Sockets include secure, positioning rotating collars.
2. The superior beam spread optic covers from narrow aisle lighting to open area general lighting.
3. It is available using a specular aluminum (SA) or a white aluminum (WA) reflector, which have a 25 year warranty.
4. The reflector options include up light or non-up light, depending on the application.
5. Ballasts are also thermally protected; sound rated and tightly secured by mounting bolts, as well as NEMA Premium and CEE qualified.
6. The baked white enamel finish is electrostatically applied and post painted with a glossy, highly reflective and durable white paint.

Technical Details:
1. System Wattage: 218.1W
2. Total Luminaire Lumen Output: 16106lumen
3. Input Voltage Range: 120-277V
4. Weight: 4.5Kg
5. Lamp Life: 25,000 Burning Hours@L70
6. System Luminous Efficacy: 73.84lm/W

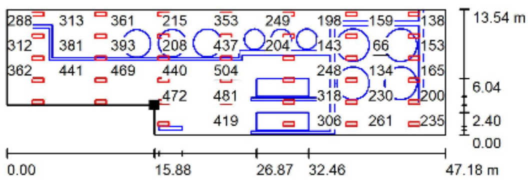
Design Consideration:
For lighting of Waste Water Treatment Area-Block C with the conventional luminaries, following details has been considered:
1. Reflection Factors: Ceiling: 50%, Wall: 30% and Floor: 10%.
2. Height of the Room: 7m

3. Maintainace Factor: 0.70
4. Mounting Type: Suspension by chain of 0.5m
5. Mounting Height of the Luminaire: 6.5m
6. Obstructions are considered.

The design has been done by using 40 numbers of Linear Fluorescent Highbay T8 6x32W .The following 3D view has been provided below.



WTP_Conventional / Workplane / **Value Chart (E)**



Values in Lux, Scale 1 : 500

Not all calculated values could be displayed.

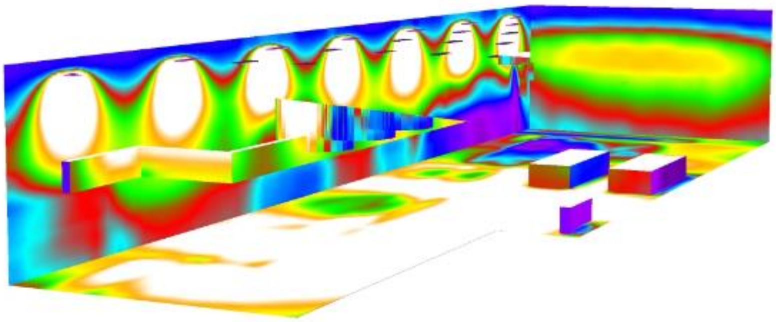
Position of surface in room:
Marked point: (66.664 m, 96.886 m, 0.000 m)

Grid: 5 x 17 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
313	66	504	0.210	0.130

Photometric Result:
In this photometric result the minimum and maximum Illuminance is 66 & 504 lux. The achieved average Illuminance is 313lx (recommended ≥300 lux) and Overall Uniformity is 0.210.

False Colour Rendering:
It is used to describe different lux level distribution in different Colour inside Waste Water Treatment room. The Colour distribution of different Lux level ranges is given.



Technical details of the Luminaire (LED) Option 1:

Luminaire Used: ROUND LED Highbay 100W 90° beam angle

Fig.Image of the luminaire

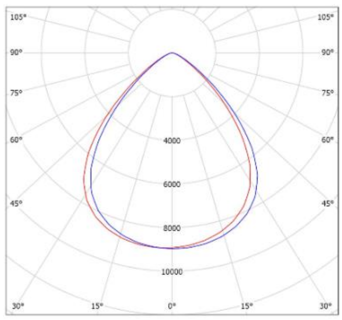


Fig. Intensity distribution curve

Specification:

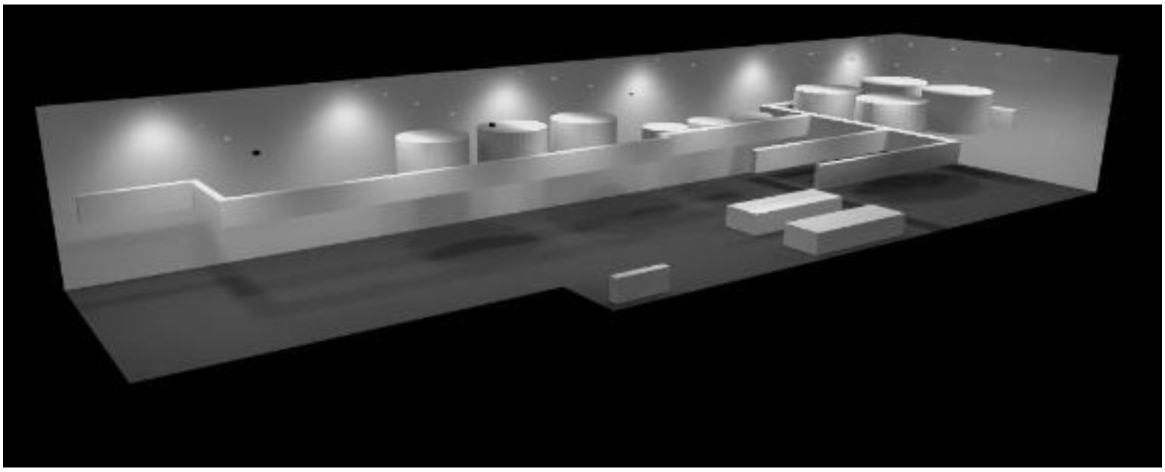
- Pressure Die cast Aluminium Housing for heat dissipation and less dust accumulation.
- Protected against corrosion and vibrations. Also luminaire is impact resistant.

- Lens technology ensures high performance photometry, soft light, no glare, will not cause eye fatigue of workers.
- Breathing port (pressure equalizer valve) for better IP Protection.

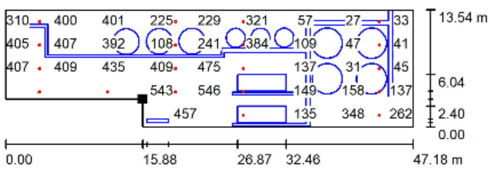
Technical Details:
1. System Wattage: 102.2W
2. Total System Lumen Output: 16320lumen
3. Operating Voltage is 100-300V
4. System Luminous Efficacy: 160lm/W
5. Lamp Life: 50,000 Burning Hours@L70

Design Consideration:
For lighting of Waste Water Treatment Plant Area-Block C with the ROUND LED Highbay 100W 90° beam angle luminaries, following details has been considered:
1. Reflection Factors: Ceiling: 50%, Wall: 30% and Floor: 10%.
2. Height of the Room: 7m
3. Maintainace Factor: 0.85
4. Mounting Type: i-bolt
5. Obstructions are considered.

The design has been done by using 28 numbers of ROUND LED Highbay 100W 90° beam angle .The following 3D view has been provided below.



WTP_100W LED 90 DEG / Workplane / Value Chart (E)



Values in Lux, Scale 1 : 500

Not all calculated values could be displayed.

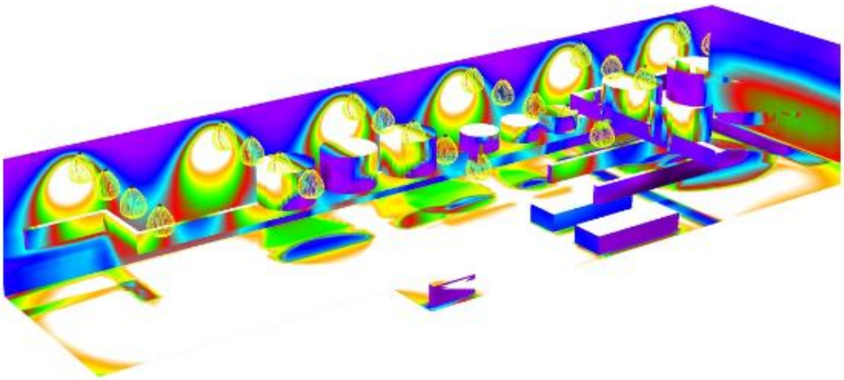
Position of surface in room:
Marked point: (66.664 m, 96.886 m, 0.000 m)

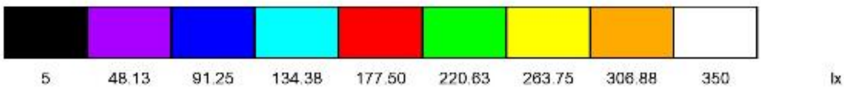
Grid: 5 x 17 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
302	27	571	0.091	0.048

Photometric Result:
In this photometric result the minimum and maximum Illuminance is 27 & 571 lux. The achieved average Illuminance is 302lx (recommended ≥300 lux) and Overall Uniformity is 0.091.

False Colour Rendering:
It is used to describe different lux level distribution in different Colour inside Waste Water Treatment room. The Colour distribution of different Lux level ranges is given.





Technical details of the Luminaire (LED) Option 2:

Luminaire Used: ROUND LED Highbay 100W 60° beam angle

Fig.Image of the luminaire

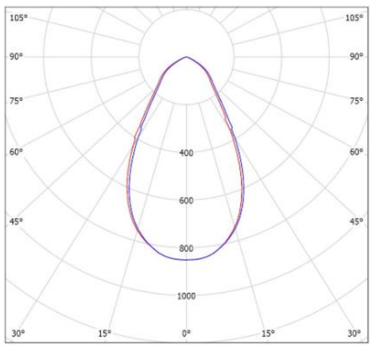


Fig. Intensity distribution curve

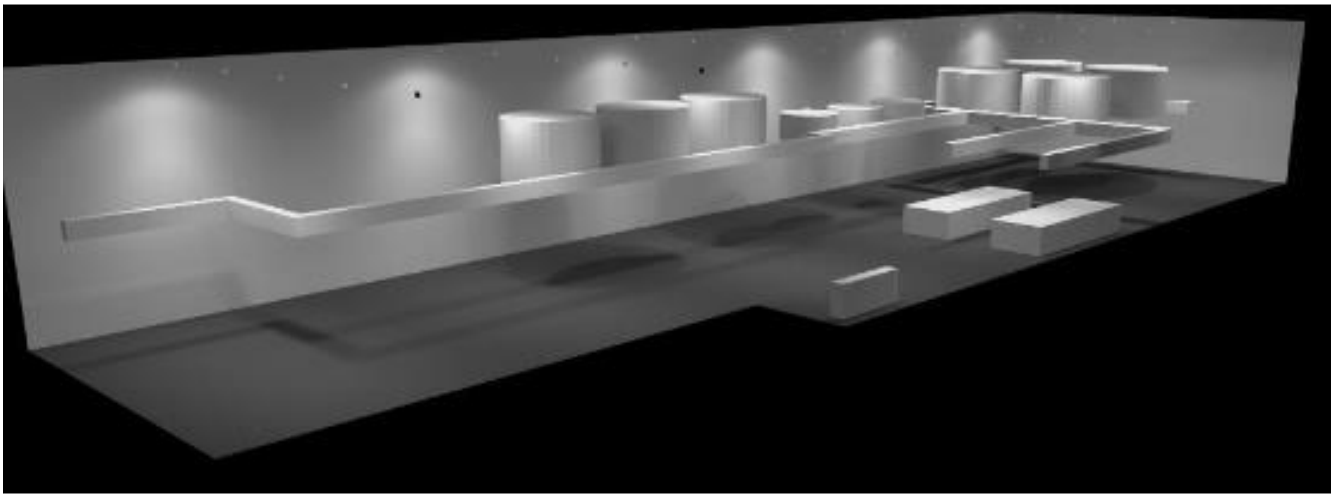
Specification:

- Pressure Die cast Aluminium Housing for heat dissipation and less dust accumulation.
- Protected against corrosion and vibrations. Also luminaire is impact resistant.
- Lens technology ensures high performance photometry, soft light, no glare, will not cause eye fatigue of workers.
- Breathing port (pressure equalizer valve) for better IP Protection.

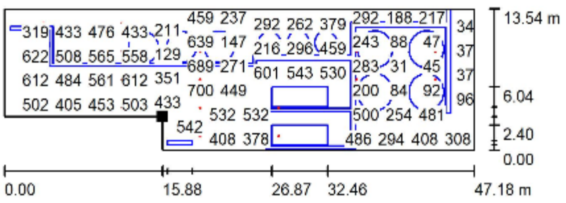
Technical Details:
1. System Wattage: 100W
2. Total System Lumen Output: 15997lumen
3. Operating Voltage is 100-300V
4. System Luminous Efficacy: 160lm/W
5. Lamp Life: 50,000 Burning Hours@L70

Design Consideration:
For lighting of Waste Water Treatment Plant Area-Block C with the ROUND LED Highbay 100W 60° beam angle luminaries, following details has been considered:
1. Reflection Factors: Ceiling: 50%, Wall: 30% and Floor: 10%.
2. Height of the Room: 7m
3. Maintainace Factor: 0.85
4. Mounting Type: i-bolt
5. Obstructions are considered.

The design has been done by using 28 numbers of ROUND LED Highbay 100W 60° beam angle .The following 3D view has been provided below.



WTP_LED 100W HIGHBAY 60DEG / Workplane / **Value Chart (E)**



Values in Lux, Scale 1 : 500

Not all calculated values could be displayed.

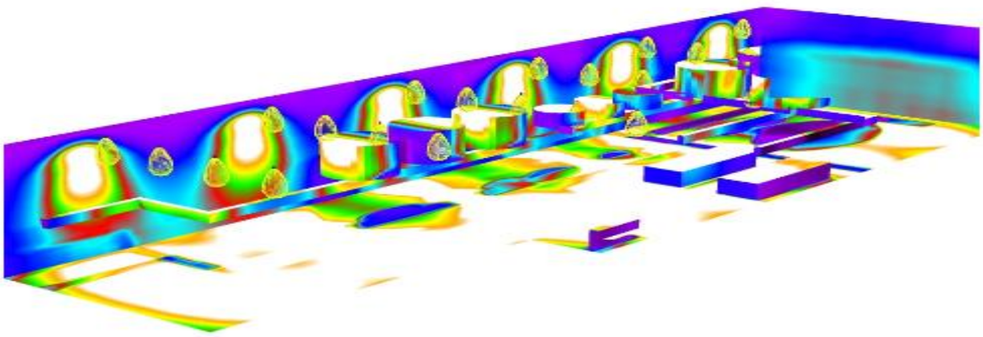
Position of surface in room:
Marked point: (66.664 m, 96.886 m, 0.000 m)

Grid: 128 x 128 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
346	24	705	0.071	0.035

Photometric Result:
In this photometric result the minimum and maximum Illuminance is 24 & 705 lux. The achieved average Illuminance is 346lx (recommended ≥300 lux) and Overall Uniformity is 0.071.

False Colour Rendering:
It is used to describe different lux level distribution in different Colour inside Waste Water Treatment room. The Colour distribution of different Lux level ranges is given.



Conclusion:

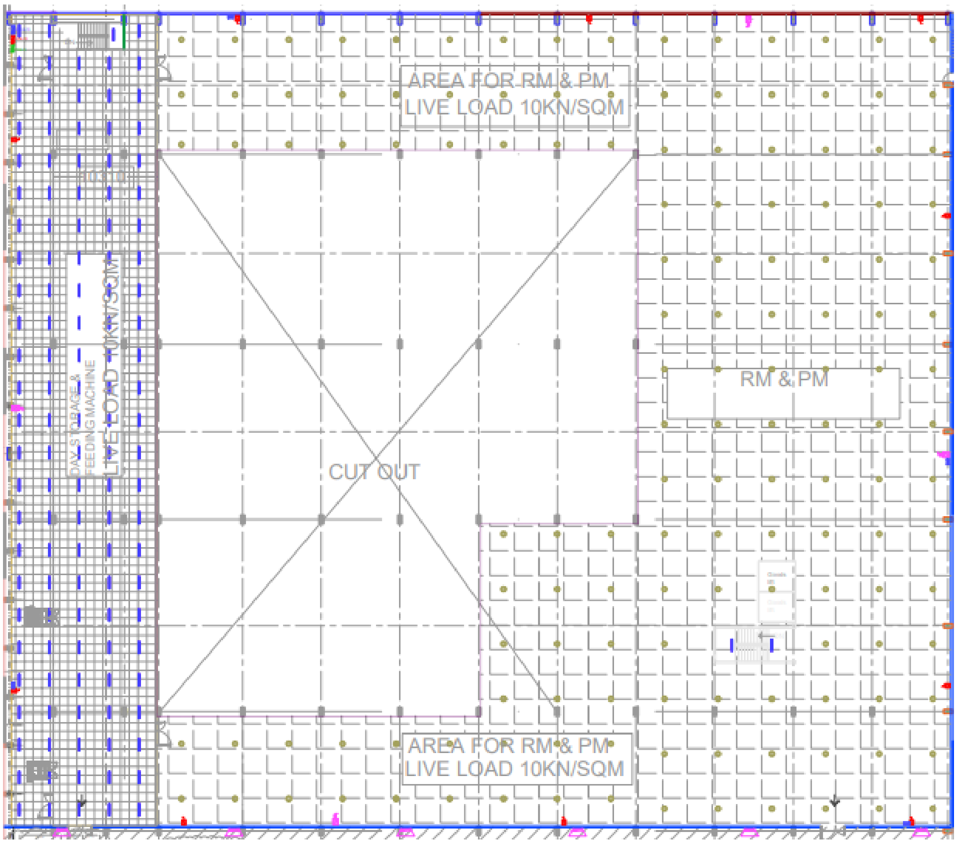
Below table provides the details of LPD value comparison of Conventional Luminaire with LED:

Name of the Product	Total Number of Quantities	Obtained LPD Values
1. Linear Fluorescent Highbay T8 6 lamp type 32W	40	14.85W/m2
2.Round LED Highbay 100W 90°	28	4.87W/m2
3.Round LED Highbay 100W 60°	28	4.77W/m2

So, LED Luminaire Products are more energy efficient than conventional luminaire.

FIRST FLOOR-BLOCK C

7.17 AutoCAD Layout:



7.18 Dry Storage & Feeding Machine Room:

Technical details of luminaire (Conventional):

Luminaire Used: 4 Foot Weather-proof Fluorescent White Reflector 32W T8 3-lamps HBF single packed

Fig. 1.Image of the luminaire

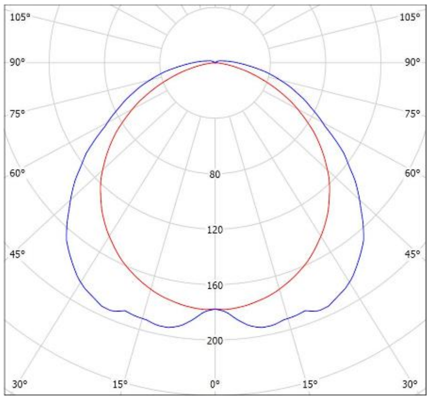


Fig.2. Intensity distribution curve

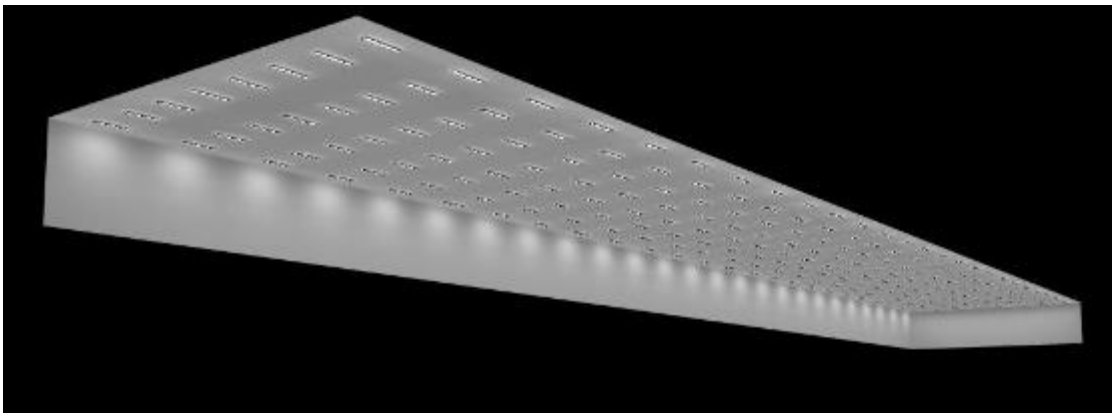
Specifications:
1. The gasketed enclosure is constructed of a fiberglass upper body and acrylic diffuser, with a continuous poured gasket.
2. The diffuser and upper components are locked by retaining latches, which ensures a tight seal.
3. Sockets include secure, positioning rotating collars.
4. The superior beam spread optics is ideal for an open area, general lighting.
5. The Wet Location fixture comes standard with a white channel cover, and is available using specular aluminum.
6. The Wet Location fixture is IP65 and IP67 rated, dust and moisture-resistant, making it ideal for harsh environments where humidity or moisture is present.

Technical Details:
1. System Wattage: 86.7W
2. System Lumen Output: 5403 lumen
3. Input Voltage Range: 120V-277V
4. Weight: 4.5Kg
5. Luminaire Life: 25,000 Burning Hours@ L70
6. System Luminous Efficacy: 62.3 lm/W

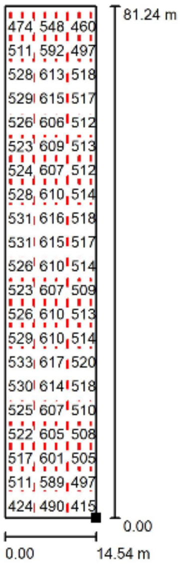
Design Consideration:
For Lighting of Dry Storage & Feeding Machine with the conventional luminaires, following details has been considered:
1. Reflection Factors: Ceiling: 50%, Wall: 30%, Floor: 10%
2. Height of the Room: 3.5m
3. Maintainace Factor: 0.70

4. Mounting Type: Ceiling at a height of 3.5m
5. Obstructions are not considered

The design has been done by using 200 numbers of 3x32W Fluorescent Weather-proof Luminaire. The following 3D view has been provided below.



Dry storage& Feeding Machine_conventional wet luminaire / Workplane / Value Chart (E)



Values in Lux, Scale 1 : 750

Not all calculated values could be displayed.

Position of surface in room:
Marked point: (27.750 m, 14.152 m, 0.000 m)

Grid: 128 x 32 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
531	254	618	0.479	0.411

Photometric Result:
In this photometric result the minimum and maximum Illuminance is 254 & 618lux. The achieved average Illuminance is 531lx (recommended≥ 500 lux) and Overall Uniformity is 0.479(recommended ≥0.4).

False Colour Rendering:
It is used to describe different lux level distribution in different Colour inside Dry Storage & Feeding Machine room. The Colour distribution of different Lux level ranges is given.

Technical details of luminaire (LED):
Luminaire Used: 4 Foot Weather-proof LED 2X20W T8 packed

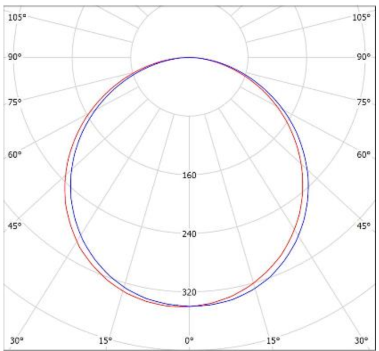


Fig. 1.Image of the luminaire

Fig.2. Intensity distribution curve

Specification:

1. Housing made up of corrosion resistant unbreakable polycarbonate body.
2. Made from impact-resistant and UV-stabilized polycarbonate is highly durable, completely leak-proof.
3. “Clear” version with transparent casing, guarantees high-quality appearance.

Technical Details:

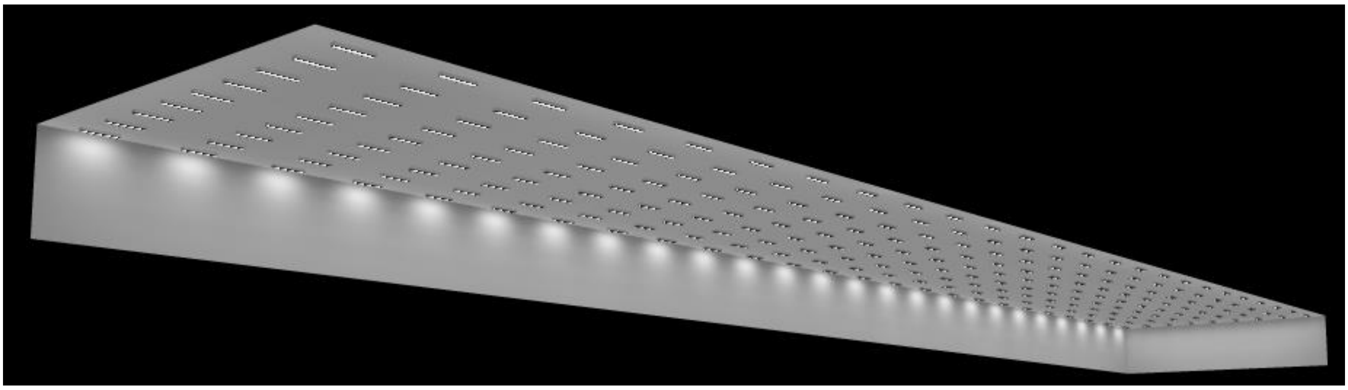
1. System Wattage: 38.9W
2. System Lumen Output: 4278 lumen
3. Input Voltage Range: 100V-300V
4. System Luminous Efficacy: 110lm/W
5. LED Life: 50,000 Burning Hours @L70

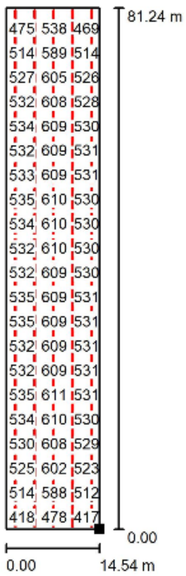
Design Consideration:

For Lighting of Dry Storage & Feeding Machine Room with the LED luminaires, following details has been considered:

1. Reflection Factors: Ceiling: 50%, Wall: 30%, Floor: 10%
2. Height of the Room: 3.5m
3. Maintainace Factor: 0.85
4. Mounting Type: Ceiling at a height of 3.5m
5. Obstructions are considered

The design has been done by using 205 numbers of 2x20W LED Weather-proof Luminaire. The following 3D view has been provided below.





Values in Lux, Scale 1 : 750

Not all calculated values could be displayed.

Position of surface in room:
Marked point: (27.750 m, 14.152 m, 0.000 m)

Grid: 128 x 32 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
536	245	612	0.457	0.400

Photometric Result:
In this photometric result the minimum and maximum Illuminance is 245 & 612lux. The achieved average Illuminance is 536lx (recommended ≥500 lux) and Overall Uniformity is 0.457(recommended ≥0.4).

False Colour Rendering:
It is used to describe different lux level distribution in different Colour inside Dry storage and Feeding Machine room. The Colour distribution of different Lux level ranges is given.

Conclusion:
Below table provides the details of LPD value comparison of Conventional Luminaire with LED:

Name of the Product	Total Number of Quantities	Obtained LPD Values(Recommended as per ECBC code: 6.8W/m2)
1. 4 Foot Weather-proof Fluorescent 3 lamp 32W	200	14.68W/m2
2. 4 Foot Weather-proof LED 2X20W T8 packed	205	6.76W/m2

So, LED Luminaire Products are more energy efficient than conventional luminaire.

7.19 Raw Material and Package Material:

Technical details of the Luminaire (Conventional):
Luminaire Used: Linear Fluorescent Highbay T8 6 lamp type 32W each and Stairwell T8 Tube 68W

Fig. 1.Image of the luminaire

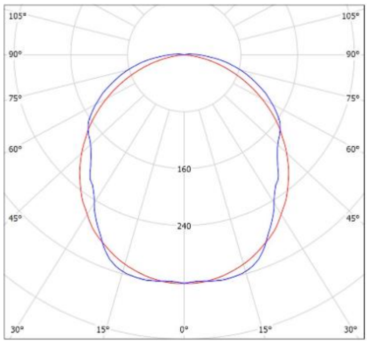


Fig.2. Intensity distribution curve

Fig. 1.Image of the luminaire

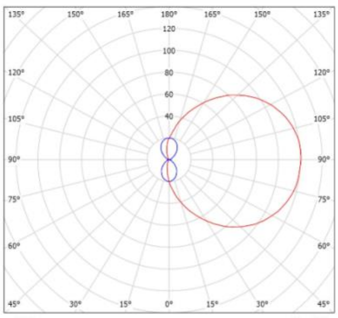


Fig.2. Intensity distribution curve

Specification:
For Linear Fluorescent Highbay T8 6 lamp type 32W:
1. The heavy-duty 20 gauge housing exceeds code gauge steel, and all components are post painted with a glossy, high reflectance white paint. Sockets include secure, positioning rotating collars.
2. The superior beam spread optic covers from narrow aisle lighting to open area general lighting.
3. It is available using a specular aluminum (SA) or a white aluminum (WA) reflector, which have a 25 year warranty.
4. The reflector options include up light or non-up light, depending on the application.
5. Ballasts are also thermally protected; sound rated and tightly secured by mounting bolts, as well as NEMA Premium and CEE qualified.
6. The baked white enamel finish is electrostatically applied and post painted with a glossy, highly reflective and durable white paint.

For Stairwell T8 Tube 68W:
1. The Stairwell fixture is constructed of heavy-duty 20 gauge steel, which is post painted with a baked white enamel finish that is electrostatically applied. Ample knockouts are provided for wiring and mounting.
2. The white perforated steel diffuser uses one piece of UV stabilized acrylic to provide an even light distribution pattern.
3. Sockets include secure, positioning rotating collars

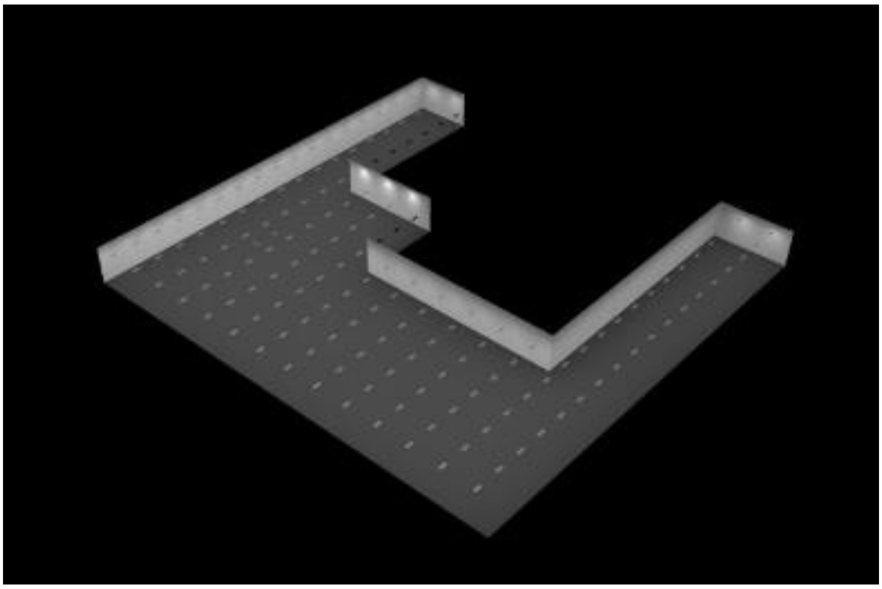
Technical Details:
For Linear Fluorescent Highbay T8 6 lamp type 32W:
1. System Wattage: 218.1W
2. Total Luminaire Lumen Output: 16106lumen
3. Input Voltage Range: 120-277V
4. Weight: 4.5Kg
5. Lamp Life: 25,000 Burning Hours@L70
6. System Luminous Efficacy: 73.84lm/W

For Stairwell T8 Tube 68W:
1. System Wattage: 68.8W
2. Total Luminaire Lumen Output: 2605lumen
3. Input Voltage Range: 120-277V
4. Weight: 4.5Kg
5. Lamp Life: 25,000 Burning Hours@L70
6. System Luminous Efficacy: 37.86lm/W

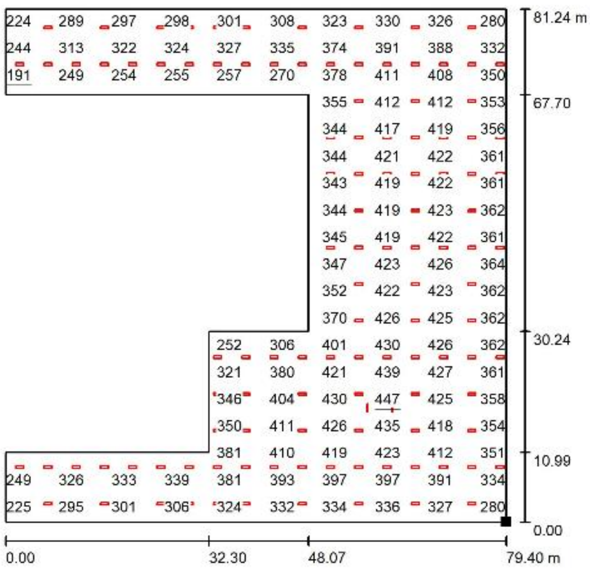
Design Consideration:
For lighting of Raw Material and Package Material Area-Block B with the conventional luminaries, following details has been considered:
1. Reflection Factors: Ceiling: 50%, Wall: 30% and Floor: 10%.
2. Height of the Room: 7m
3. Maintainace Factor: 0.70

4. Mounting Type: Suspension by chain of 0.5m and two stairwell batten ceiling mounted.
5. Mounting Height of the Luminaire: 6.5m
6. No obstruction is considered.

The design has been done by using 154 numbers of Linear Fluorescent Highbay T8 6x32W and 2 numbers of Stairwell T8 Tube 68W .The following 3D view has been provided below.



RM&PM / Workplane / Value Chart (E)



Values in Lux, Scale 1 : 750

Not all calculated values could be displayed.

Position of surface in room:
Marked point: (107.354 m, 14.153 m, 0.000 m)

Grid: 19 x 19 Points

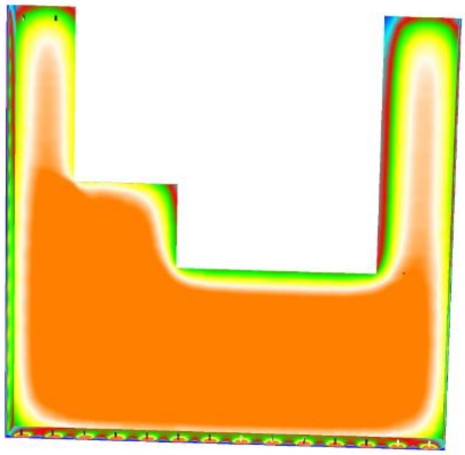
E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
361	191	447	0.528	0.426

Photometric Result:

In this photometric result the minimum and maximum Illuminance is 191 & 447lux. The achieved average Illuminance is 361lx (recommended ≥300 lux) and Overall Uniformity is 0.528(recommended ≥0.4).

False Colour Rendering:

It is used to describe different lux level distribution in different Colour inside Raw Material and Packaging Material room. The Colour distribution of different Lux level ranges is given.



Technical details of the Luminaire (LED) Option 1:

Luminaire Used: ROUND LED Highbay 100W 90° beam angle and 40W LED Batten

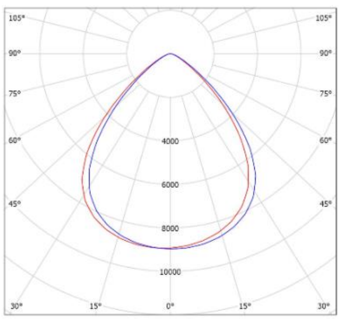


Fig. 1.Image of the luminaire

Fig.2. Intensity distribution curve

Fig. 1.Image of the luminaire

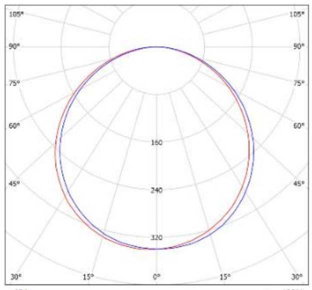


Fig.2. Intensity distribution curve

Specification:

For Round LED Highbay 100W 90° beam angle:

- Pressure Die cast Aluminium Housing for heat dissipation and less dust accumulation.
- Protected against corrosion and vibrations. Also luminaire is impact resistant.
- Lens technology ensures high performance photometry, soft light, no glare, will not cause eye fatigue of workers.
- Breathing port (pressure equalizer valve) for better IP Protection.

For 40W LED Batten:

- Led Batten is direct replacement of existing fluorescent system
- Batten is offered with variety of colour temperatures for flexibility for all types of application.
- Designed for higher efficacy and more brightness.
- High efficacy polycarbonate diffuser with aluminium body for efficient heat dissipation.

Technical Details:

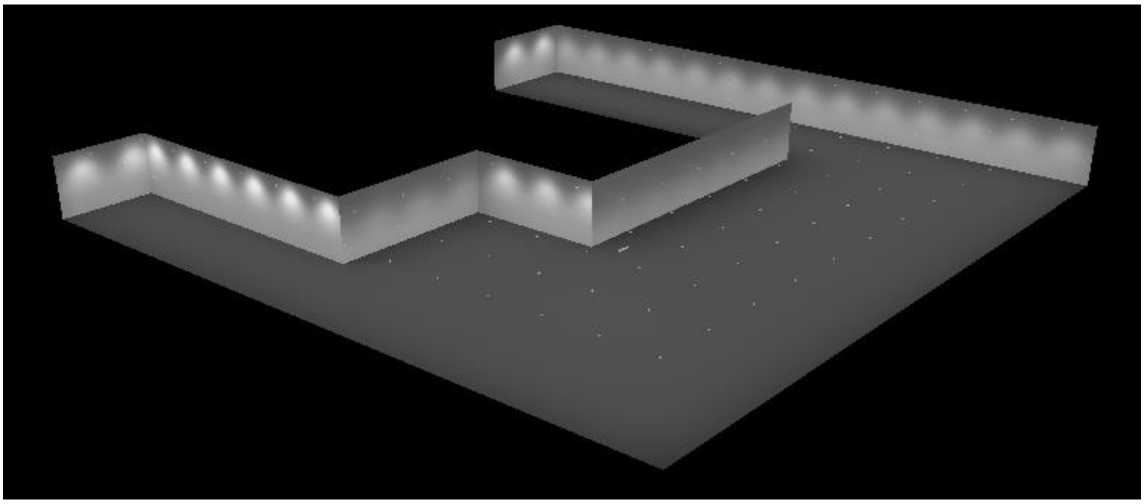
For Round LED Highbay 100W 90° beam angle:
1. System Wattage: 102.2W
2. Total System Lumen Output: 16320lumen
3. Operating Voltage is 100-300V
4. System Luminous Efficacy: 160lm/W
5. Lamp Life: 50,000 Burning Hours@L70

For 40W LED Batten:
1. System Wattage: 38.9W
2. Total System Lumen Output: 3815lumen
3. Operating Voltage is 100-300V
4. System Luminous Efficacy: 98lm/W
5. Lamp Life: 50,000 Burning Hours@L70

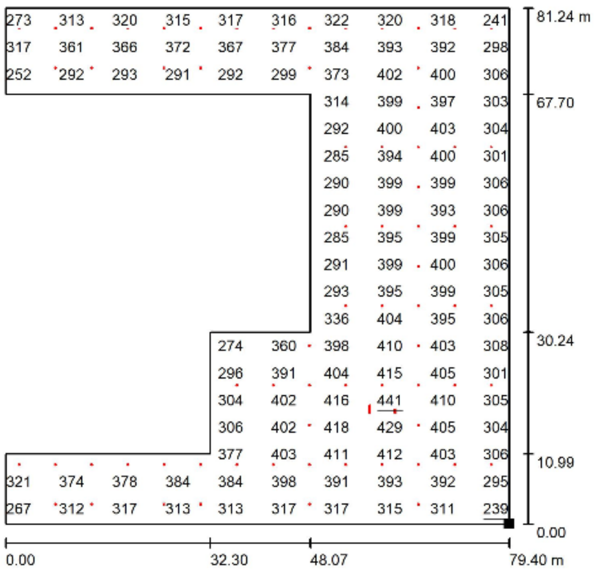
Design Consideration:
For lighting of Raw Material and Packing Material Area-Block C with the ROUND LED Highbay 100W 90° beam angle and 40W LED Batten luminaries, following details has been considered:
1. Reflection Factors: Ceiling: 50%, Wall: 30% and Floor: 10%.

2. Height of the Room: 7m
3. Maintainace Factor: 0.85
5. Mounting Type: i-bolt
6. No obstruction is considered.

The design has been done by using 110 numbers of ROUND LED Highbay 100W 90° beam angle and 2 numbers of 40W LED Batten. The following 3D view has been provided below.



RM&PM Area_100W 90Deg / Workplane / Value Chart (E)



Values in Lux, Scale 1 : 750

Not all calculated values could be displayed.

Position of surface in room:
Marked point: (107.354 m, 14.153 m, 0.000 m)

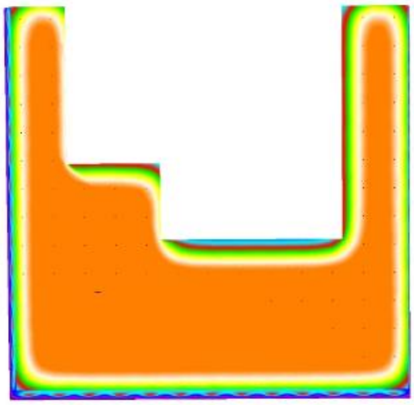
Grid: 19 x 19 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
356	239	441	0.669	0.542

Photometric Result:

In this photometric result the minimum and maximum Illuminance is 239 & 441lux. The achieved average Illuminance is 356lx (recommended ≥300 lux) and Overall Uniformity is 0.669(recommended ≥0.4).

False Colour Rendering:
It is used to describe different lux level distribution in different Colour inside Raw Material and Packaging Material room. The Colour distribution of different Lux level ranges is given.



Technical details of the Luminaire (LED) Option 2:

Luminaire Used: ROUND LED Highbay 100W 60° beam angle and 40W LED Batten

Fig. 1.Image of the luminaire

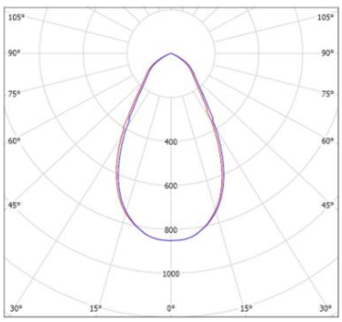


Fig.2. Intensity distribution curve

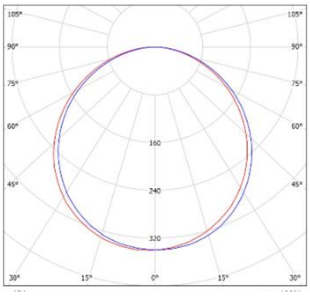


Fig. 1.Image of the luminaire

Fig.2. Intensity distribution curve

Specification:

For Round LED Highbay 100W 60°:

- Pressure Die cast Aluminium Housing for heat dissipation and less dust accumulation.
- Protected against corrosion and vibrations. Also luminaire is impact resistant.
- Lens technology ensures high performance photometry, soft light, no glare, will not cause eye fatigue of workers.
- Breathing port (pressure equalizer valve) for better IP Protection.

For 40W LED Batten:

- Led Batten is direct replacement of existing fluorescent system
- Batten is offered with variety of colour temperatures for flexibility for all types of application.
- Designed for higher efficacy and more brightness.
- High efficacy polycarbonate diffuser with aluminium body for efficient heat dissipation.

Technical Details:

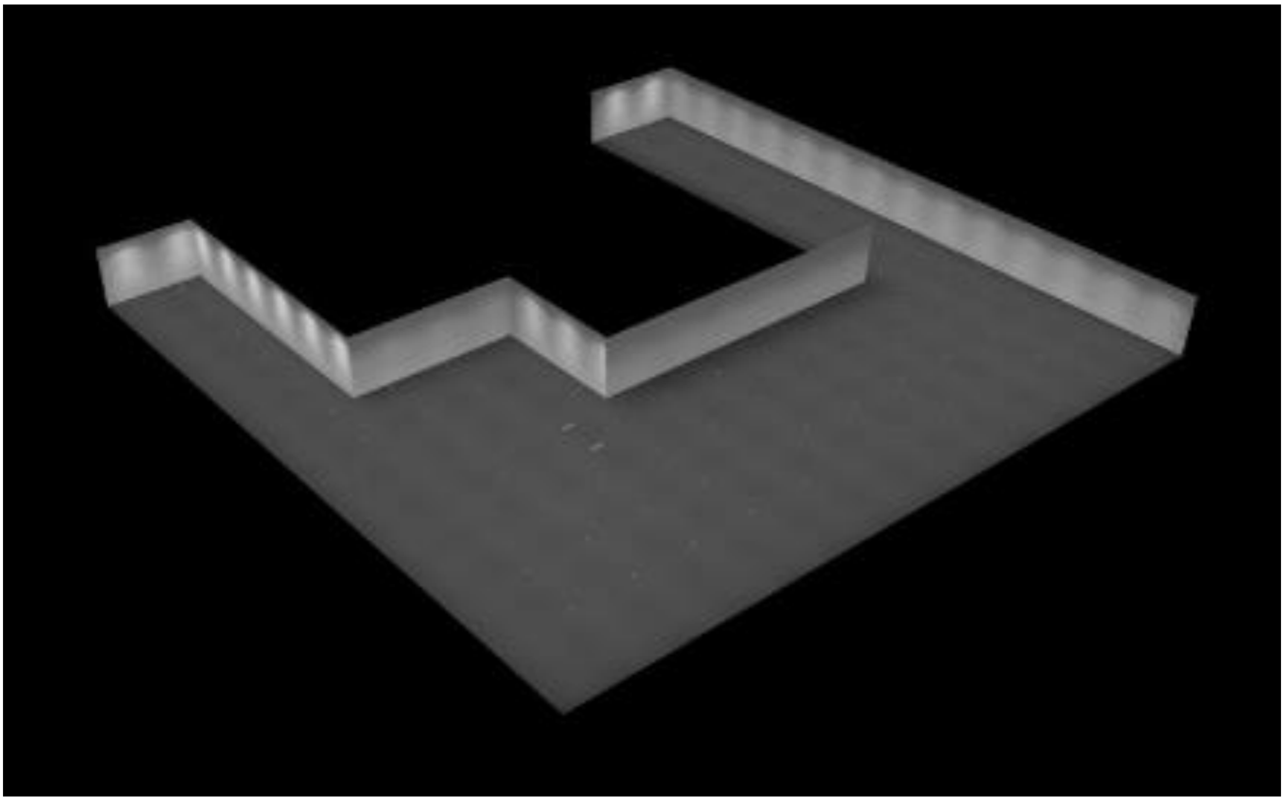
For Round LED Highbay 100W 60°:
1. System Wattage: 100W
2. Total System Lumen Output: 15997lumen
3. Operating Voltage is 100-300V
4. System Luminous Efficacy: 160lm/W
5. Lamp Life: 50,000 Burning Hours@L70

For 40W LED Batten:
1. System Wattage: 38.9W
2. Total System Lumen Output: 3815lumen
3. Operating Voltage is 100-300V
4. System Luminous Efficacy: 98lm/W
5. Lamp Life: 50,000 Burning Hours@L70

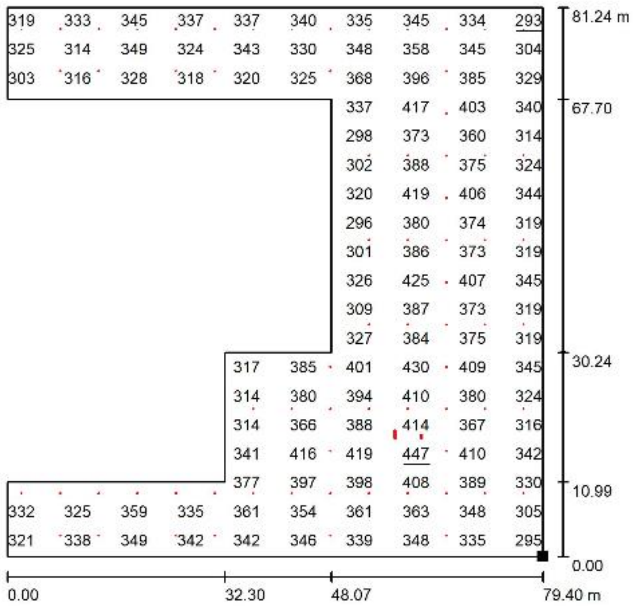
Design Consideration:
For lighting of Raw Material and Package Material Area-Block B with the ROUND LED Highbay 100W 60° beam angle and 40W LED Batten luminaries, following details has been considered:

1. Reflection Factors: Ceiling: 50%, Wall: 30% and Floor: 10%.
2. Height of the Room: 7m
3. Maintainace Factor: 0.85
4. Mounting Type: i-bolt
5. No obstruction is considered.

The design has been done by using 110 numbers of ROUND LED Highbay 100W 60° beam angle and 2 numbers of 40W LED Batten .The following 3D view has been provided below.



RM&PM Area _100W 60Deg / Workplane / Value Chart (E)



Values in Lux, Scale 1 : 750

Not all calculated values could be displayed.

Position of surface in room:
Marked point: (107.354 m, 14.153 m, 0.000 m)

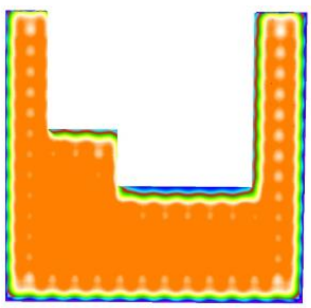
Grid: 19 x 19 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
358	293	447	0.819	0.656

Photometric Result:

In this photometric result the minimum and maximum Illuminance is 293 & 447lux. The achieved average Illuminance is 358lx (recommended ≥300 lux) and Overall Uniformity is 0.819(recommended ≥0.4).

False Colour Rendering:
It is used to describe different lux level distribution in different Colour inside Raw Material and Packaging Material room. The Colour distribution of different Lux level ranges is given.



Conclusion:
Below table provides the details of LPD value comparison of Conventional Luminaire with LED:

Name of the Product	Total Number of Quantities	Obtained LPD Values
1. Linear Fluorescent Highbay T8 6 lamp type 32W each and Stairwell T8 Tube 68W	156	8.37W/m²
2. ROUND LED Highbay 100W 90° beam angle and 40W LED Batten	112	2.81W/m²
3. ROUND LED Highbay 100W 60° beam angle and 40W LED Batten	112	2.75W/m²

So, LED Luminaire Products are more energy efficient than conventional luminaire.

7.20 Workshop Area-Outside Internal Room:

Technical details of luminaire (Conventional):

Luminaire Used: 4 Foot Weather-proof Fluorescent White Reflector 32W T8 3-lamps HBF single packed

Fig. 1.Image of the luminaire

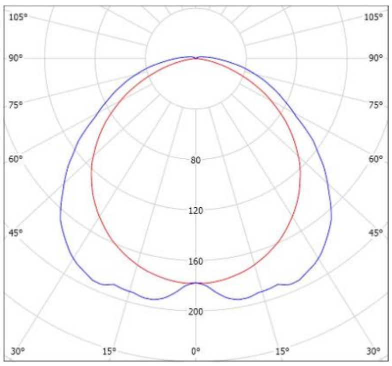
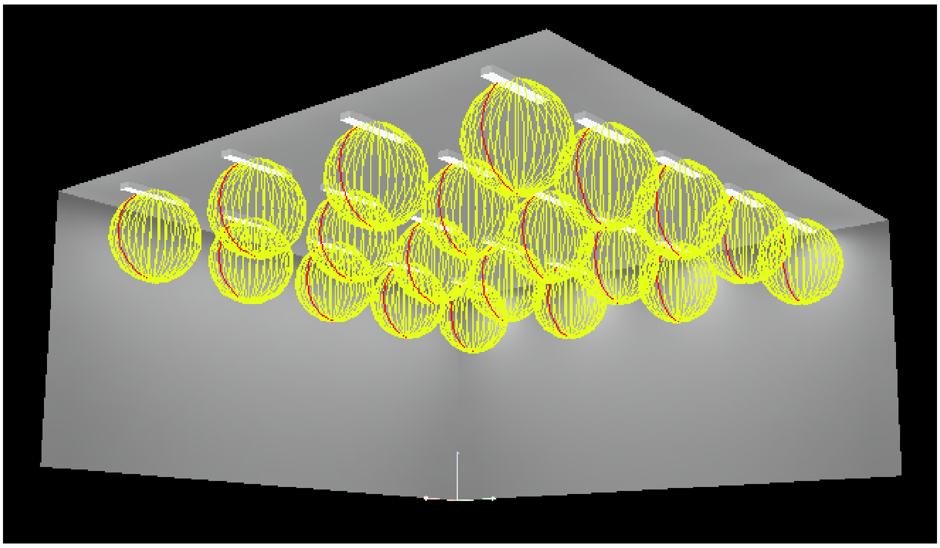


Fig.2. Intensity distribution curve

Specifications:
1. The gasketed enclosure is constructed of a fiberglass upper body and acrylic diffuser, with a continuous poured gasket.
2. The diffuser and upper components are locked by retaining latches, which ensures a tight seal.
3. Sockets include secure, positioning rotating collars.
4. The superior beam spread optics is ideal for an open area, general lighting.
5. The Wet Location fixture comes standard with a white channel cover, and is available using specular aluminum.
6. The Wet Location fixture is IP65 and IP67 rated, dust and moisture-resistant, making it ideal for harsh environments where humidity or moisture is present.

Technical Details:
1. System Wattage:86.7W
2. System Lumen Output: 5403 lumen
3. Input Voltage Range: 120V-277V
4. Weight:4.5Kg
5. Luminaire Life: 25,000 Burning Hours@ L70
6. System Luminous Efficacy: 62 lm/W

Design Consideration:
For Lighting of Workshop Area with the conventional luminaires, following details has been considered:
1. Reflection Factors: Ceiling: 50%, Wall: 30%, Floor: 10%
2. Height of the Room: 4.5m
3. Maintainace Factor: 0.70
4. Mounting Type: Ceiling at a height of 4.5m
5. Obstructions are not considered
The design has been done by using 16 numbers of 3x32W Fluorescent Weather-proof Luminaire. The following 3D view has been provided below.



10.00 m

223	239	263	280	294	303	308	311	310	306	300	289	274	255	229
244	262	287	306	319	329	334	337	336	332	325	313	298	277	251
266	288	316	337	352	364	370	372	371	367	359	346	328	305	275
283	305	332	355	372	383	389	392	391	386	378	365	346	321	291
292	317	345	369	386	398	404	407	406	402	393	378	359	333	301
296	321	349	374	390	403	409	412	411	406	398	382	364	337	306
304	330	360	385	402	415	422	425	424	418	410	394	374	347	314
305	331	360	386	403	416	423	426	425	419	411	395	376	347	315
301	327	356	381	398	411	417	420	419	414	405	389	370	343	311
293	317	346	370	387	400	406	409	408	403	395	380	360	334	302
287	311	340	363	379	392	398	401	400	395	387	372	354	328	297
272	295	323	345	361	373	379	382	381	376	368	354	337	312	282
255	275	301	321	335	346	352	354	353	349	342	329	313	291	262
229	246	271	289	304	313	318	321	320	316	310	299	282	263	236
221	236	260	276	289	298	304	306	305	301	296	285	270	252	227

0.00

0.00 10.00 m

Values in Lux, Scale 1 : 100

Not all calculated values could be displayed.

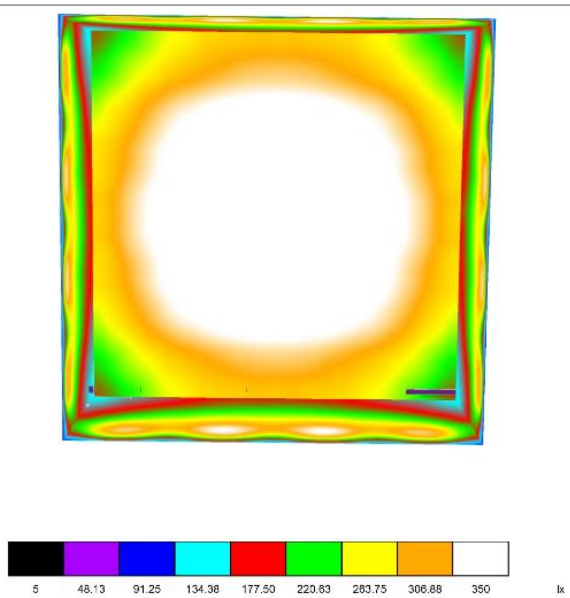
Position of surface in room:
Marked point: (0.000 m, 0.000 m, 0.000 m)

Grid: 32 x 32 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
330	203	426	0.615	0.476

Photometric Result:
In this photometric result the minimum and maximum Illuminance is 203 & 426lux. The achieved average Illuminance is 330lx (recommended ≥300 lux) and Overall Uniformity is 0.615(recommended ≥0.4).

False Colour Rendering:
It is used to describe different lux level distribution in different Colour inside Workshop Area. The Colour distribution of different Lux level ranges is given.



Technical details of luminaire (LED):

Luminaire Used: 4 Foot Weather-proof LED 2X20W T8 packed

Fig. 1.Image of the luminaire

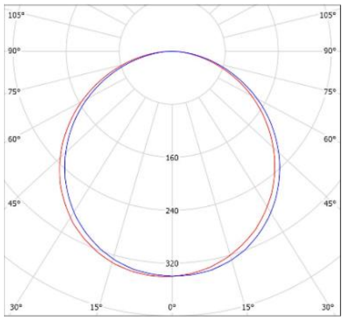


Fig.2. Intensity distribution curve

Specification:

1. Housing made up of corrosion resistant unbreakable polycarbonate body.
2. Made from impact-resistant and UV-stabilized polycarbonate is highly durable, completely leak-proof.
3. “Clear” version with transparent casing, guarantees high-quality appearance.

Technical Details:

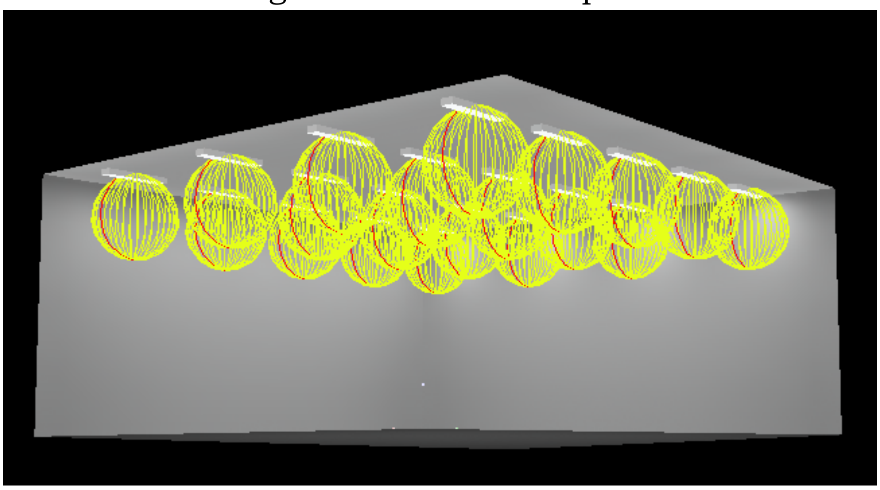
1. System Wattage: 38.9W
2. System Lumen Output: 4278 lumen
3. Input Voltage Range: 100V-300V
4. System Luminous Efficacy: 110lm/W
5. LED Life: 50,000 Burning Hours @L70

Design Consideration:

For Lighting of Workshop Area with the LED luminaires, following details has been considered:

1. Reflection Factors: Ceiling: 50%, Wall: 30%, Floor: 10%
2. Height of the Room: 4.5m
3. Maintainace Factor: 0.85
4. Mounting Type: Ceiling at a height of 4.5m
5. Obstructions are not considered

The design has been done by using 20 numbers of 2x20W LED Weather-proof Luminaire. The following 3D view has been provided below.



10.00 m

254	280	300	318	330	335	339	339	336	330	319	302	283	257	232
283	312	335	352	365	371	375	375	371	365	353	335	314	286	259
304	335	360	379	393	400	404	404	400	393	380	361	337	306	277
322	354	380	401	416	423	427	427	423	417	403	382	357	325	295
334	368	396	417	433	440	445	445	441	434	419	397	370	337	305
341	375	404	425	440	448	453	453	448	441	426	405	377	344	311
346	380	409	430	446	454	459	459	454	447	432	410	382	348	314
347	381	410	431	448	455	460	460	456	448	432	411	383	349	315
344	378	407	428	444	452	457	457	452	445	429	408	380	346	313
339	373	402	424	439	447	452	452	447	439	424	402	375	343	310
329	362	389	410	426	433	438	438	433	426	411	390	363	330	297
314	346	371	391	406	413	417	417	413	405	391	372	347	315	285
294	324	348	366	379	386	390	390	386	379	366	348	325	293	265
268	296	317	335	347	354	357	357	354	347	335	317	296	269	242
243	269	288	304	315	320	324	323	320	314	303	287	268	243	218

0.00

0.00 10.00 m

Values in Lux, Scale 1 : 100

Not all calculated values could be displayed.

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

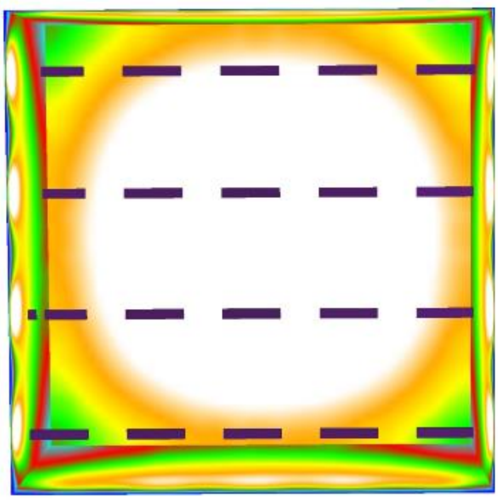
Grid: 32 x 32 Points

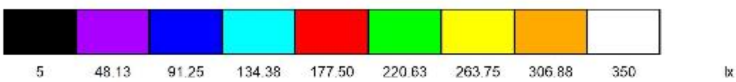
E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
360	212	461	0.590	0.460

Photometric Result:

In this photometric result the minimum and maximum Illuminance is 212 & 461lux. The achieved average Illuminance is 360lx (recommended ≥300 lux) and Overall Uniformity is 0.590(recommended ≥0.4).

False Colour Rendering:
It is used to describe different lux level distribution in different Colour inside Workshop Area. The Colour distribution of different Lux level ranges is given.





Conclusion:

Below table provides the details of LPD value comparison of Conventional Luminaire with LED:

Name of the Product	Total Number of Quantities	Obtained LPD Values(Recommended as per ECBC code: 14.1W/m²)
1. 4 Foot Weather-proof Fluorescent 3 lamp 32W	16	13.87W/m²
2. 4 Foot Weather-proof LED 2X20W T8 packed	20	7.79W/m²

So, LED Luminaire Products are more energy efficient than conventional luminaire.

7.21 Diesel Generator Area-Outside Internal Room:

Technical details of luminaire (Conventional):

Luminaire Used: 4 Foot Weather-proof Fluorescent White Reflector 32W T8 3-lamps HBF single packed

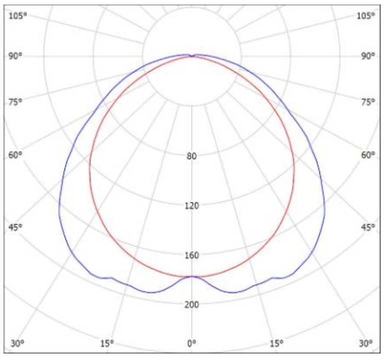


Fig. 1.Image of the luminaire

Fig.2. Intensity distribution curve

Specifications:

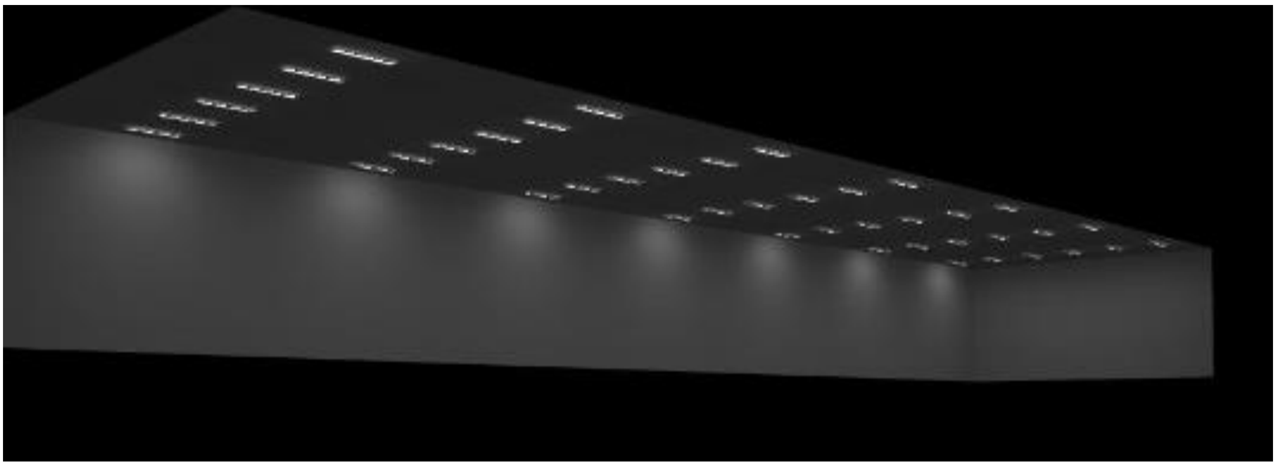
1. The gasketed enclosure is constructed of a fiberglass upper body and acrylic diffuser, with a continuous poured gasket.
2. The diffuser and upper components are locked by retaining latches, which ensures a tight seal.

3. Sockets include secure, positioning rotating collars.
4. The superior beam spread optics is ideal for an open area, general lighting.
5. The Wet Location fixture comes standard with a white channel cover, and is available using specular aluminum.
6. The Wet Location fixture is IP65 and IP67 rated, dust and moisture-resistant, making it ideal for harsh environments where humidity or moisture is present.

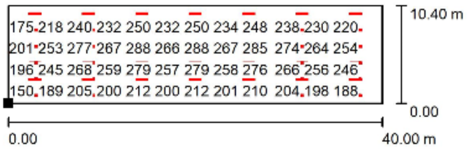
Technical Details:
1. System Wattage: 86.7W
2. System Lumen Output: 5403 lumen
3. Input Voltage Range: 120V-277V
4. Weight:4.5Kg
5. Luminaire Life: 25,000 Burning Hours@ L70
6. System Luminous Efficacy: 62 lm/W

Design Consideration:
For Lighting of Diesel Generator Area with the conventional luminaires, following details has been considered:
1. Reflection Factors: Ceiling: 10%, Wall: 10%, Floor: 10%
2. Height of the Room: 5m
3. Maintainace Factor: 0.70
4. Mounting Type: Ceiling at a height of 5m
5. Obstructions are not considered

The design has been done by using 42 numbers of 3x32W Fluorescent Weather-proof Luminaire. The following 3D view has been provided below.



DG Room_Weatherproof Luminaire / Workplane / **Value Chart (E)**



Values in Lux, Scale 1 : 500

Not all calculated values could be displayed.

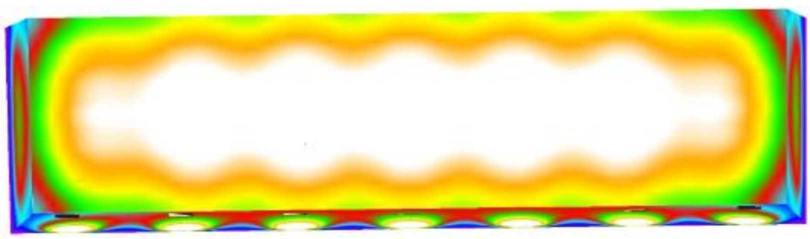
Position of surface in room:
Marked point: (0.000 m, 0.000 m, 0.000 m)

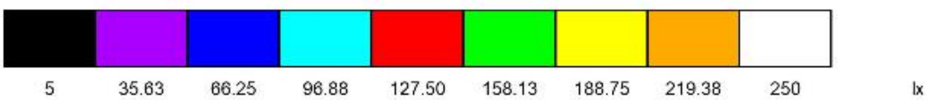
Grid: 128 x 32 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
226	103	289	0.453	0.356

Photometric Result:
In this photometric result the minimum and maximum Illuminance is 103 & 289lux. The achieved average Illuminance is 226lx (recommended ≥200 lux) and Overall Uniformity is 0.453(recommended ≥0.4).

False Colour Rendering:
It is used to describe different lux level distribution in different Colour inside Diesel Generator Area. The Colour distribution of different Lux level ranges is given.





Technical details of luminaire (LED) Option 1& Option 2:

Luminaire Used: Flameproof LED 45W Well glass

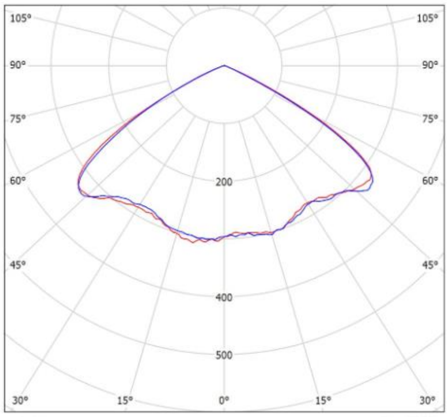


Fig. 1.Image of the luminaire

Fig.2. Intensity distribution curve

Specification:

1. Fixture: Aluminium Casting
2. Heat Sink: Aluminium Extrusion LM6
3. Optics type : Glass Diffuser
4. Secondary Optics: Toughened Glass
5. Weight:6.2Kg
6. IP Rating: IP65

Technical Specification:

1. System Wattage: 41.7W
2. Total System Lumen: 4837 lumen
3. Total System Luminous Efficacy: 116 lm/W
4. Input Voltage: 230V, 50Hz

Design Consideration:

For Lighting of Diesel Generator Area with the LED luminaires, following details has been considered:

1. Reflection Factors: Ceiling: 10%, Wall: 10%, Floor: 10%
2. Height of the Room: 5m
3. Maintainace Factor: 0.85
4. Mounting Type: Ceiling at a height of 5m and Wall mounted at a height of 4.5m
5. Obstructions are not considered

The design has been done by using 36 numbers of 45W LED Flameproof Well glass Luminaire for Ceiling mounted type and 50 numbers of 45W LED Flameproof Well glass Luminaire for wall mounted type. The following 3D view has been provided below.

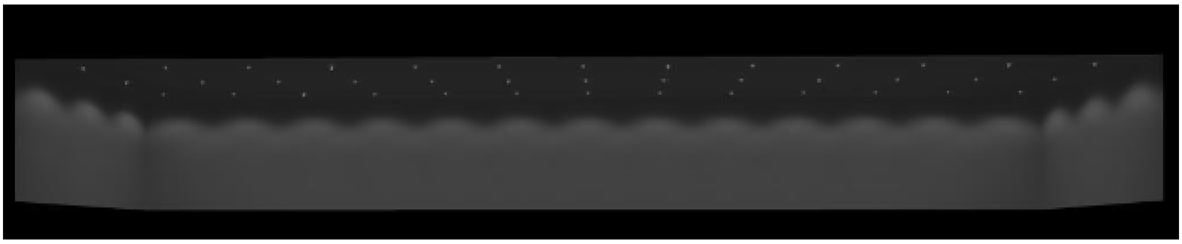


Fig: For Ceiling Mounted

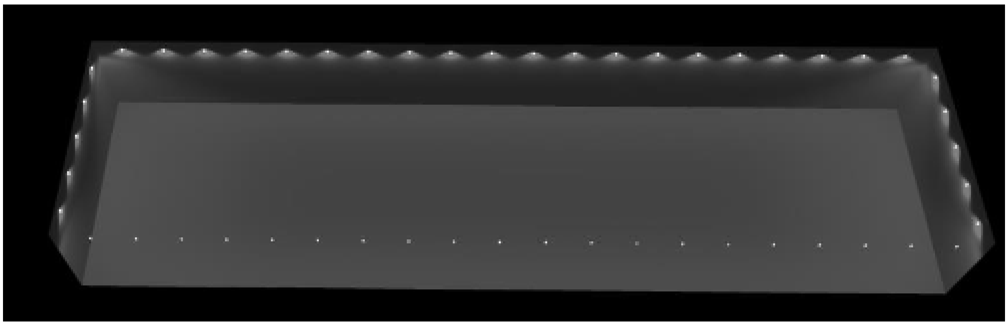


Fig: For Wall Mounted

DG Room_Ceiling Mounted / Workplane / Value Chart (E)

178	236	262	264	265	266	266	266	265	266	259	226
196	261	292	296	296	298	297	298	297	298	290	252
192	252	279	282	283	283	283	283	283	283	275	240
154	204	225	227	227	228	228	228	227	227	222	194

10.40 m

0.00

0.00 40.00 m

Values in Lux, Scale 1 : 500

Not all calculated values could be displayed.

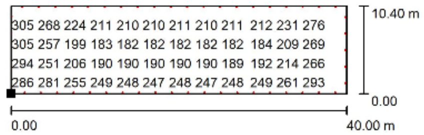
Position of surface in room:
Marked point: (0.000 m, 0.000 m, 0.000 m)

Grid: 128 x 32 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
241	104	300	0.431	0.346

Fig: Work plane Value chart for Ceiling Mounted Luminaire

DG Room_Flameproof wall mounted / Workplane / **Value Chart (E)**



Values in Lux, Scale 1 : 500

Not all calculated values could be displayed.

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

Grid: 128 x 32 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
237	180	315	0.758	0.571

Fig: Work plane Value chart for Wall Mounted Luminaire

Photometric Result:

- For Ceiling Mounted Design photometric result the minimum and maximum Illuminance is 104 & 300lux. The achieved average Illuminance is 241lx (recommended ≥200 lux) and Overall Uniformity is 0.431(recommended ≥0.4).
- For Wall Mounted Design photometric result the minimum and maximum Illuminance is 180 & 315lux. The achieved average Illuminance is 237lx (recommended ≥200 lux) and Overall Uniformity is 0.758(recommended ≥0.4).

False Colour Rendering:
It is used to describe different lux level distribution in different Colour inside Diesel Generator Area. The Colour distribution of different Lux level ranges is given.

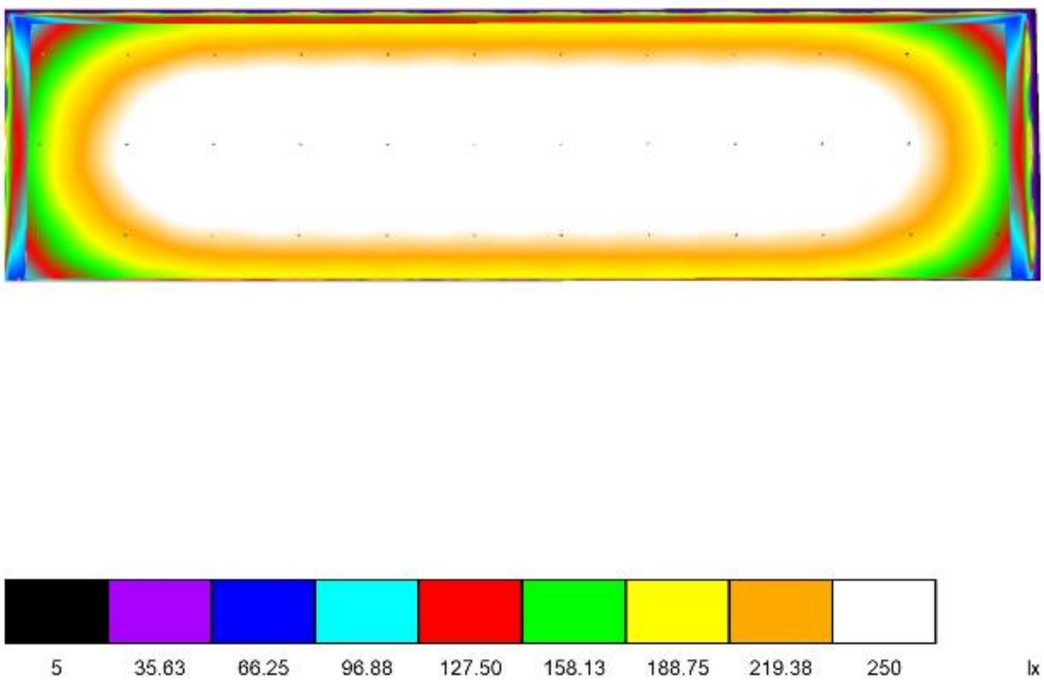


Fig: False Colour Rendering observed for Ceiling mounted Type

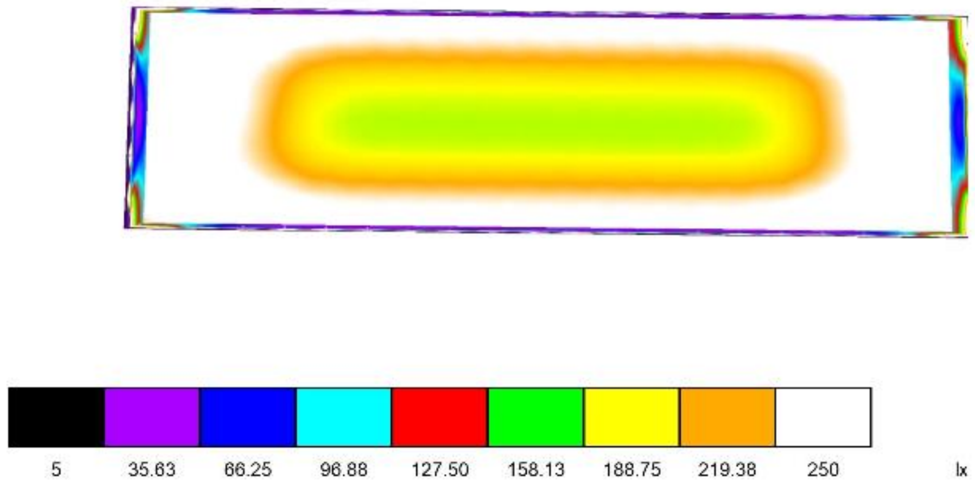


Fig: False Colour Rendering observed for Wall mounted Type

Conclusion:

Below table provides the details of LPD value comparison of Conventional Luminaire with LED:

Name of the Product	Total Number of Quantities	Obtained LPD Values(Recommended as per ECBC code: 14.1W/m²)
1. 4 Foot Weather-proof Fluorescent 3 lamp 32W	42	8.75W/m²
2. Flameproof LED 45W Well glass(Ceiling mounted Type)	36	3.61W/m²
3. Flameproof LED 45W Well glass(Wall mounted Type)	50	5.01W/m²

So, LED Luminaire Products are more energy efficient than conventional luminaire.

7.22 Boiler Room:

Technical details of the Luminaire (Conventional):

Luminaire Used: Linear Fluorescent Highbay T5HO 4 lamp type 54W each

Fig. 1.Image of the luminaire

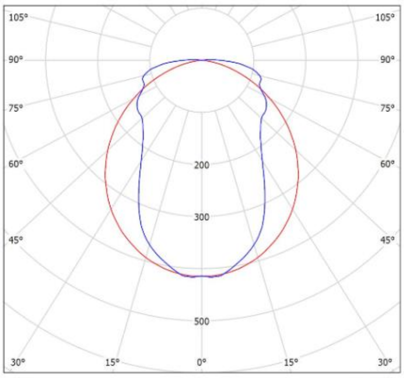


Fig.2. Intensity distribution curve

Specification:

1. The heavy-duty 20 gauge housing exceeds code gauge steel, and all components are post painted with a glossy, high reflectance white paint. Sockets include secure, positioning rotating collars.
2. The superior beam spread optic covers from narrow aisle lighting to open area general lighting.
3. It is available using a specular aluminum (SA) or a white aluminum (WA) reflector, which have a 25 year warranty.
4. The reflector options include up light or non-up light, depending on the application.
5. Ballasts are also thermally protected; sound rated and tightly secured by mounting bolts, as well as NEMA Premium and CEE qualified.
6. The baked white enamel finish is electrostatically applied and post painted with a glossy, highly reflective and durable white paint.

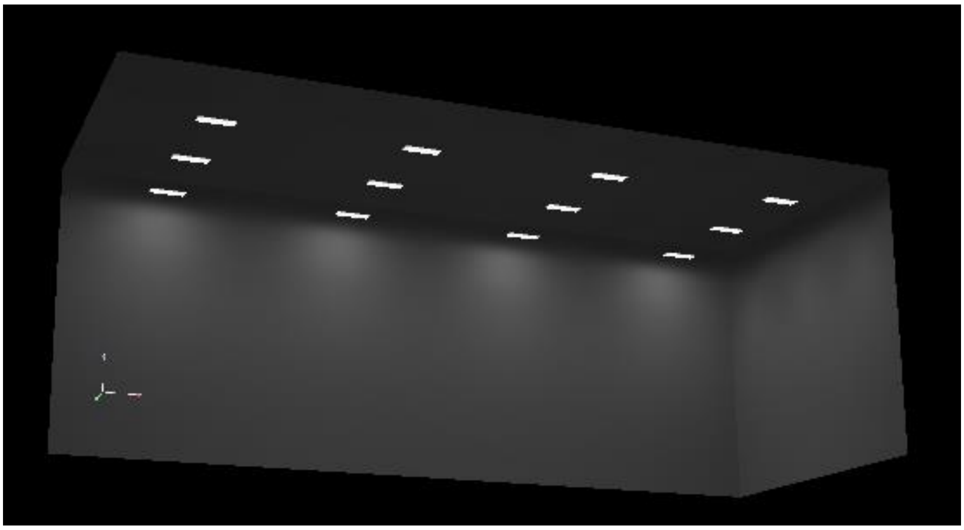
Technical Details:

1. System Wattage: 230.8W
2. Total Luminaire Lumen Output: 17386lumen
3. Input Voltage Range: 120-277V
4. Weight: 4.5Kg
5. Lamp Life: 25,000 Burning Hours@L70
6. System Luminous Efficacy: 75.32lm/W

Design Consideration:
For lighting of Boiler Room-Block A with the conventional luminaries, following details has been considered:

1. Reflection Factors: Ceiling: 10%, Wall: 10% and Floor: 10%.
2. Height of the Room: 10m
3. Maintainace Factor: 0.70
4. Mounting Type: Suspension by chain of 1m
5. Mounting Height of the Luminaire: 9m
6. No obstruction is considered.

The design has been done by using 12 numbers of 4x54W Linear Fluorescent Highbay T5HO Luminaire. The following 3D view has been provided below.



Boiler Room_Ceiling mounted Type_Conventional / Workplane / **Value Chart (E)**

138	160	177	194	203	213	219	224	226	229	229	228	228	225	221	214	207	196	184	166	147
152	177	197	214	225	235	242	249	251	253	253	252	253	249	245	237	229	217	204	184	161
163	190	211	230	242	253	260	266	269	271	271	271	271	267	263	255	246	233	219	197	173
171	199	222	242	254	266	273	281	283	285	285	285	285	281	276	268	259	245	230	207	182
175	205	228	248	260	272	280	288	291	292	292	291	292	288	283	275	265	251	236	213	186
173	202	225	245	257	269	276	284	287	288	288	288	289	285	280	271	262	248	233	210	184
166	193	215	234	247	258	265	271	274	276	277	276	276	272	268	260	251	237	223	201	176
155	181	202	220	231	242	249	256	258	260	259	259	260	256	252	243	235	223	210	189	165
142	165	184	200	210	220	226	232	235	237	236	236	236	232	229	222	214	203	191	171	151
126	146	161	176	185	194	199	204	206	208	209	208	208	205	201	196	189	178	168	151	134

10.20 m

0.00

0.00

26.70 m

Values in Lux, Scale 1 : 200

Not all calculated values could be displayed.

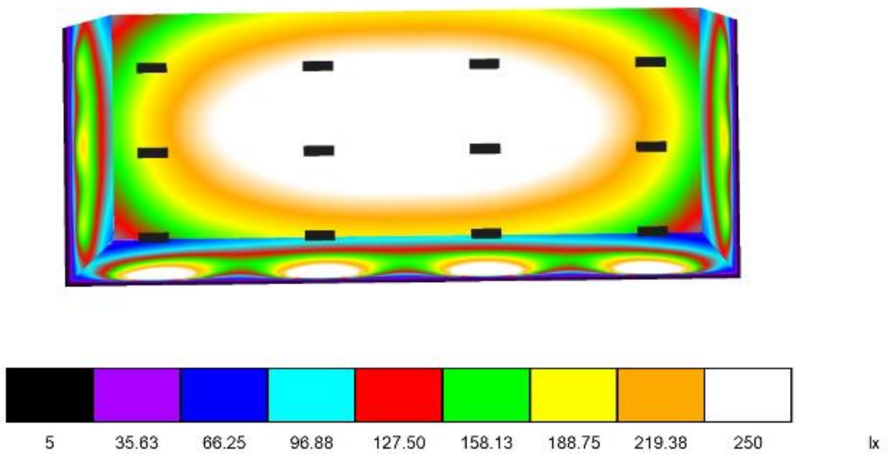
Position of surface in room:
Marked point: (0.000 m, 0.000 m, 0.000 m)

Grid: 64 x 32 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
225	116	292	0.516	0.396

Photometric Result:
In this photometric result the minimum and maximum Illuminance is 116 & 292lux. The achieved average Illuminance is 225lx (recommended ≥200 lux) and Overall Uniformity is 0.516(recommended ≥0.4).

False Colour Rendering:
It is used to describe different lux level distribution in different Colour inside Boiler Room Area. The Colour distribution of different Lux level ranges is given.



Technical details of luminaire (LED):

Luminaire Used: Flameproof LED 45W Well glass

Fig. 1.Image of the luminaire

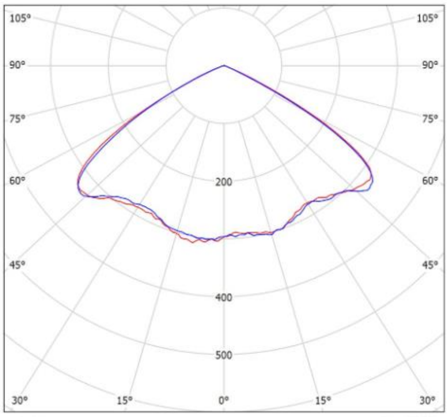
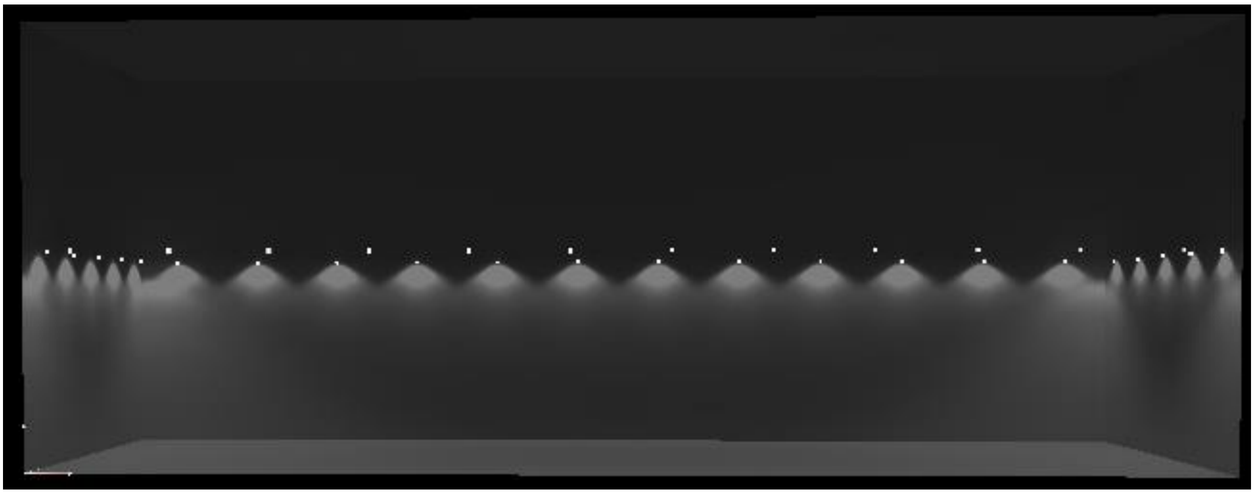


Fig.2. Intensity distribution curve

Specification:
1. Fixture: Aluminium Casting
2. Heat Sink: Aluminium Extrusion LM6
3. Optics type: Glass Diffuser
4. Secondary Optics: Toughened Glass
5. Weight: 6.2Kg
6. IP Rating: IP65

Design Consideration:
For lighting of Boiler Room with the LED luminaries, following details has been considered:
1. Reflection Factors: Ceiling: 10%, Wall: 10% and Floor: 10%.
2. Height of the Room: 10m
3. Maintainace Factor: 0.85
4. Mounting Type: Wall mounted Type at a height of 5m
5. Mounting Height of the Luminaire: 5m
6. No obstruction is considered.

The design has been done by using 34 numbers of 45W LED Flameproof Well glass Luminaire. The following 3D view has been provided below.



267	277	267	258	248	236	224	215	214	209	211	210	211	213	218	228	240	252	258	266	269
275	278	266	255	242	230	214	205	201	198	199	198	200	201	209	218	234	246	257	268	275
278	278	264	252	239	223	206	195	190	188	187	188	188	191	199	211	229	243	256	267	278
281	279	265	251	237	219	201	189	185	182	182	182	182	186	194	208	227	242	255	269	281
281	279	265	251	236	218	199	187	182	180	179	180	180	184	192	206	226	242	256	269	281
281	277	262	248	234	216	198	186	182	179	178	179	180	183	191	205	224	240	253	268	281
275	275	260	246	232	216	199	189	184	182	181	182	183	185	194	205	223	237	251	265	276
273	272	260	247	236	221	206	197	192	191	189	191	191	194	201	211	228	238	252	263	275
262	271	261	252	241	230	217	210	206	204	204	204	205	207	214	222	235	245	254	264	266
245	260	253	249	239	231	221	213	213	208	212	209	211	212	216	225	233	244	247	255	248

10.20 m
0.00
0.00
26.70 m

Values in Lux, Scale 1 : 200

Not all calculated values could be displayed.

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

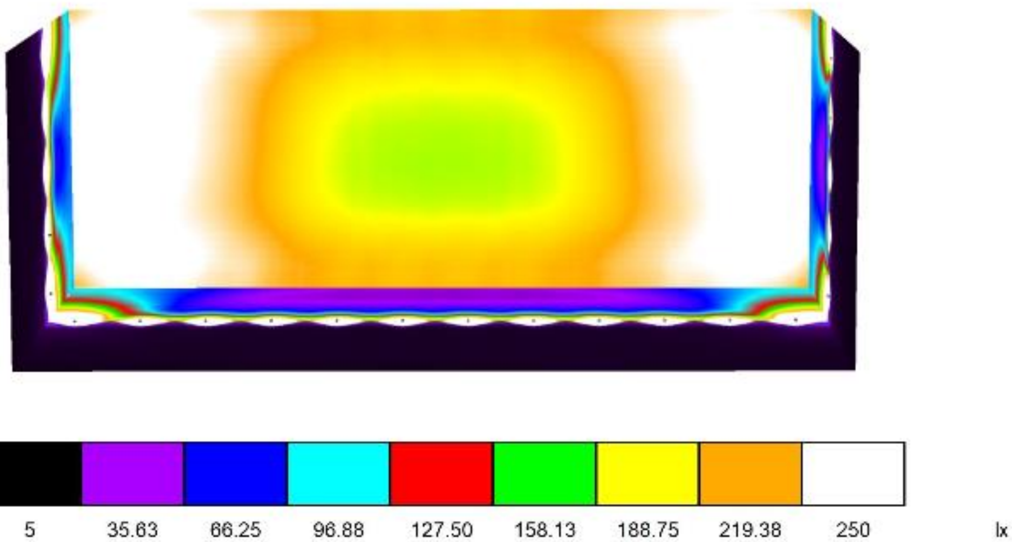
Grid: 64 x 32 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
228	178	284	0.782	0.627

Photometric Result:
In this photometric result the minimum and maximum Illuminance is 178 & 284lux. The achieved average Illuminance is 228lx (recommended ≥200 lux) and Overall Uniformity is 0.782(recommended ≥0.4).

False Colour Rendering:
It is used to describe different lux level distribution in different Colour inside Boiler Room Area. The Colour distribution of different Lux level ranges is given

.



Conclusion:
Below table provides the details of LPD value comparison of Conventional Luminaire with LED:

Name of the Product	Total Number of Quantities	Obtained LPD Values
1. 6x54W Linear Fluorescent Highbay T5HO Luminaire	12	10.17W/m²
2. 45W LED Flameproof Well glass	34	5.21W/m²

So, LED Luminaire Products are more energy efficient than conventional luminaire.

OFFICE AREA-OUTSIDE INTERNAL ROOM:

7.23 AutoCAD Layout:

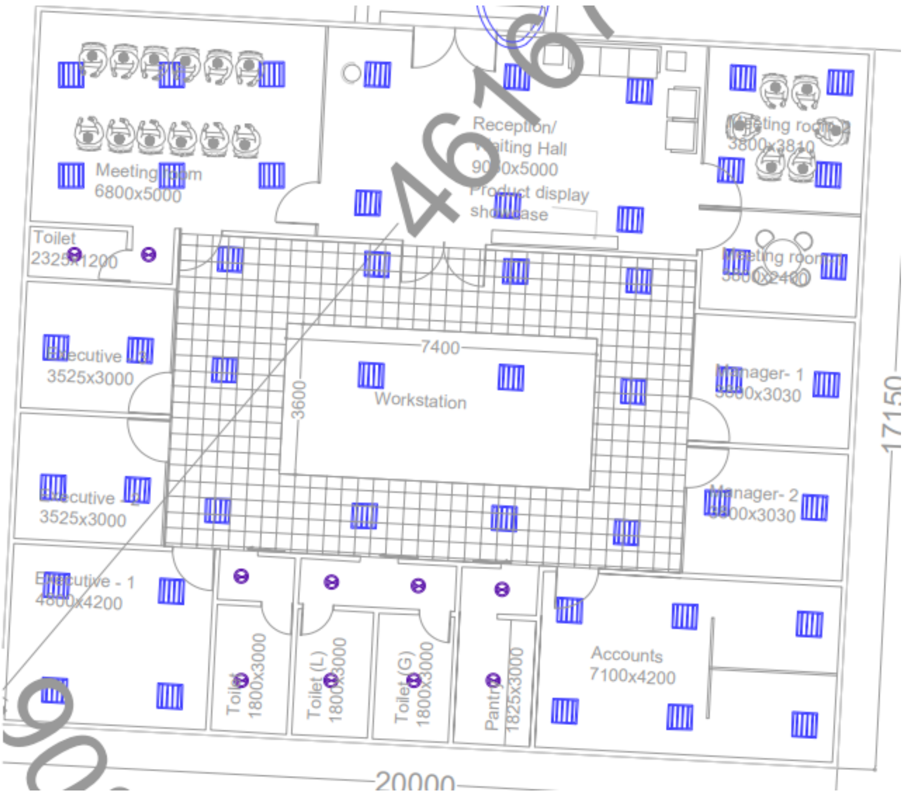


Fig. AutoCAD layout of Office Area

7.24 Meeting Room:

Technical details of luminaire (Conventional):

Luminaire Used: Conventional Surface mounted 74W luminaire with matt optic double parabolic louver closed.

Fig. 1.Image of the luminaire

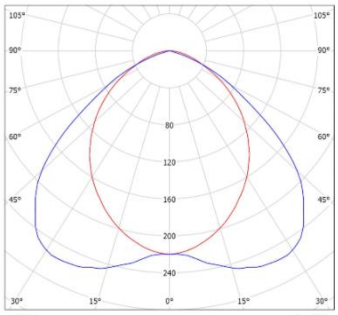


Fig.2. Intensity distribution curve

Specification:

1. Housing made of CRCA sheet steel, powder coated white, accommodating all electrical accessories pre-wired up to a terminal block.
2. Innovative corner brackets made of engineering plastic to enhance the aesthetics.
3. Specially designed optical system of high purity aluminium, with matte lamellae. The reflector is fixed to the housing by mirror holding clips and can be hinged to the housing during installation / maintenance.
4. High efficiency mirror optic reflector of high quality aluminium with diffuse lamellae designed for high optical efficiency and widespread light distribution.

Technical Details:

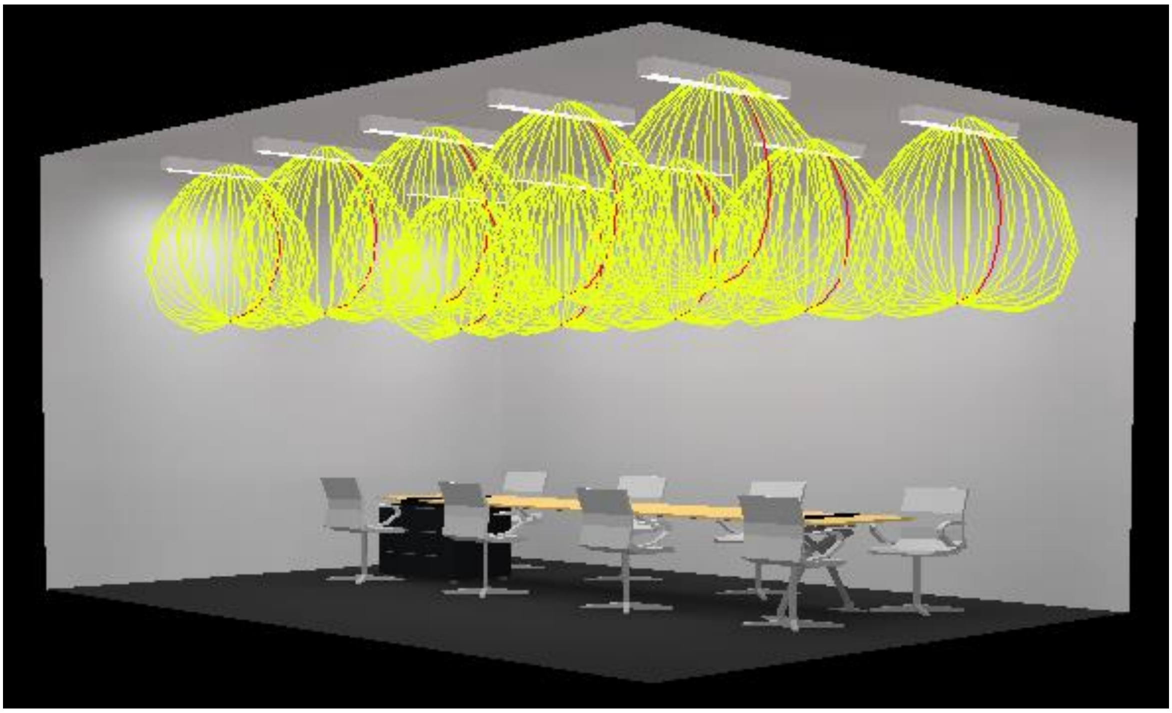
1. System Wattage: 74W
2. Total System Lumen: 3858lumen
3. System Luminous Efficacy: 52lm/W
4. IP20
5. System Voltage: 230V,50Hz

Design Consideration:

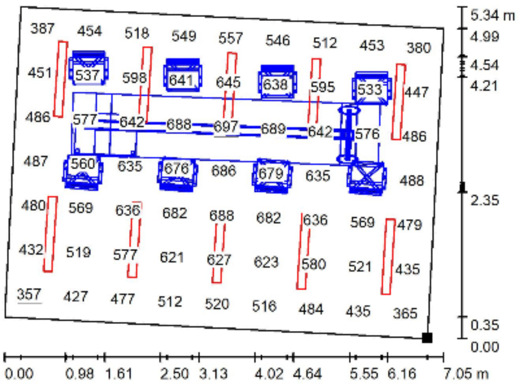
For lighting of Meeting Room with the Conventional luminaries, following details has been considered:

1. Reflection Factors: Ceiling: 70%, Wall: 50% and Floor: 10%.
2. Height of the Room: 3.5m
3. Maintainace Factor: 0.70
4. Mounting Type: Ceiling Surface mounted at a height of 3.5m
5. Mounting Height of the Luminaire: 3.5m
6. General obstructions are considered.

The design has been done by using 10 numbers of Surface mounted 74W Conventional luminaire. The following 3D view has been provided below.



Meeting Room / Workplane / Value Chart (E)



Values in Lux, Scale 1 : 75

Not all calculated values could be displayed.

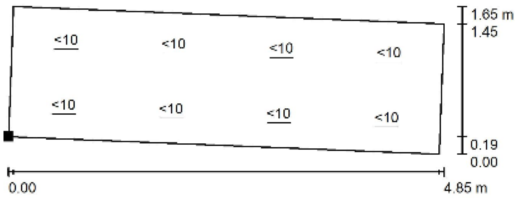
Position of surface in room:
Marked point: (71.473 m, 155.445 m, 0.760 m)

Grid: 9 x 7 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
552	357	697	0.647	0.512

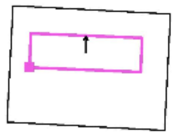
Fig : Value chart of the Work plane of Meeting Room

Meeting Room / UGR Calculation Area 1 / Value Chart (UGR)



Scale 1 : 50

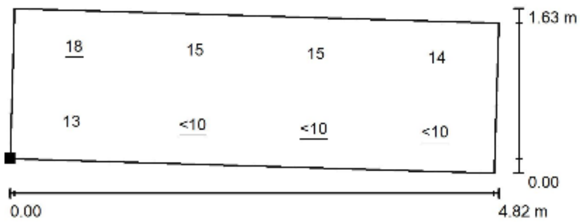
Position of surface in room:
Marked point: (65.661 m, 158.145 m, 1.200 m)



Grid: 4 x 2 Points

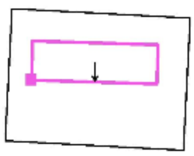
Min	Max
/	<10

Meeting Room / UGR Calculation Area 2 / Value Chart (UGR)



Scale 1 : 50

Position of surface in room:
Marked point: (65.692 m, 158.092 m, 0.700 m)



Grid: 4 x 2 Points

Min	Max
<10	18

Fig: UGR Calculation 1 & 2

Meeting Room / Vertical illuminance at 270 Deg / Value Chart (E, Vertical)

258	292	313	329	329	327	305	277	236
231	269	302	324	325	323	295	255	212
220	258	287	305	301	298	273	248	214
226	257	261	280	268	274	251	237	211
188	198	205	210	209	205	194	180	166
134	136	142	147	147	146	140	132	126
121	131	143	151	152	152	147	136	124

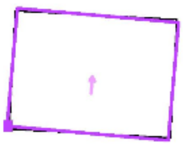
2.50 m

-2.50

-3.40 3.40 m

Values in Lux, Scale 1 : 50

Position of surface in room:
Marked point: (64.601 m, 155.923 m, 0.000 m)



Grid: 9 x 7 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
224	121	329	0.54	0.37

Meeting Room / Vertical illuminance / Value Chart (E, Vertical)

126	138	149	155	155	153	145	133	125
136	155	156	175	166	178	162	165	150
187	222	250	275	280	285	271	247	213
224	274	319	345	347	345	319	282	237
214	243	262	279	278	277	260	243	220
214	238	256	272	275	277	267	255	233
236	271	296	312	315	316	306	287	256

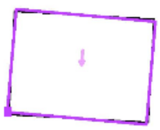
2.50 m

-2.50

-3.40 3.40 m

Values in Lux, Scale 1 : 50

Position of surface in room:
Marked point: (64.601 m, 155.923 m, 0.000 m)

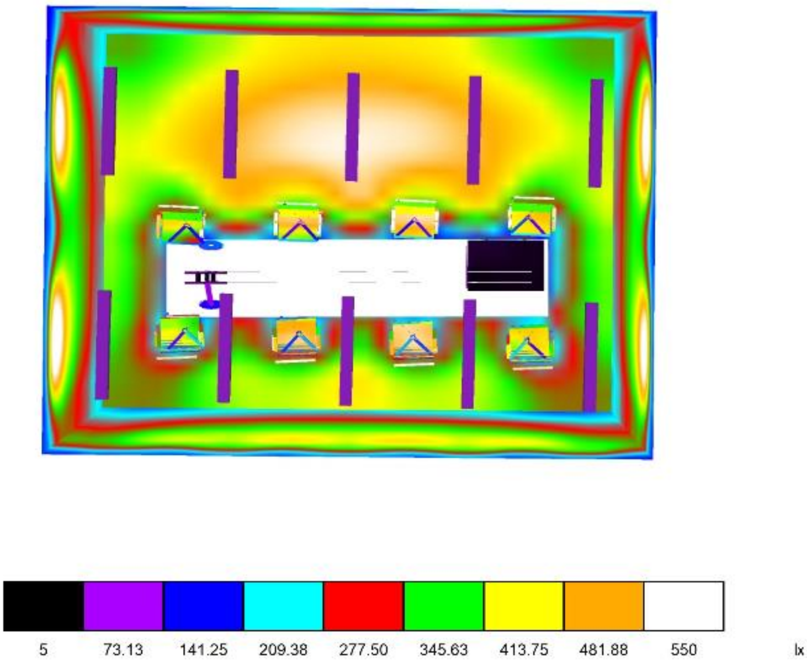


Grid: 9 x 7 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
235	125	347	0.53	0.36

Photometric Result:
In this photometric result the minimum and maximum Illuminance is 357 & 697lux. The achieved average Illuminance is 552lx (recommended ≥500 lux) and Overall Uniformity is 0.647(recommended ≥0.4). UGR value is calculated at a height of 1.2m with observation eye at a z-axis of 90° which results into value <10(recommended UGR<19). UGR value is calculated at a height of 1.2m with observation eye at a z-axis of -90° which results into value max UGR is 18(recommended UGR<19).Achieved Vertical Illuminance is ≥200lux.

False Colour Rendering:
It is used to describe different lux level distribution in different Colour inside Meeting room. The Colour distribution of different Lux level ranges is given.



Technical details of luminaire (LED):

Luminaire Used: 2’x2’ LED PANEL 36W

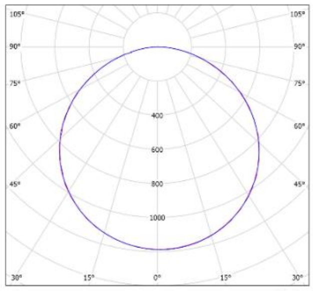


Fig. 1.Image of the luminaire

Fig.2. Intensity distribution curve

Specification:
1. Non yellowing opal polycarbonate diffuser for better light distribution.
2. Suitable for recess or surface.
3. CRCA housing with white powder coated finishing.
4. High transmittance diffuser for glare free symmetric light distribution.

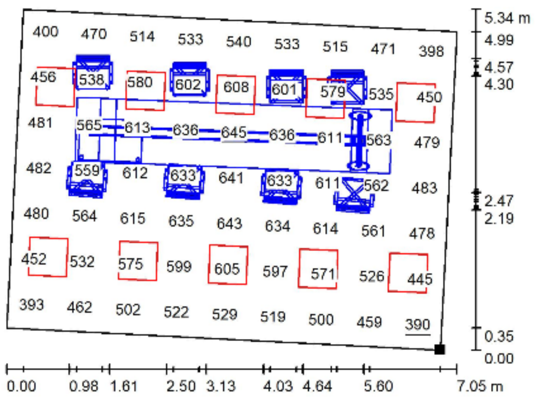
Technical Details:

1. System Wattage: 36.6W
2. Total System Lumen: 3526lumen
3. LED Life:50,000 Burning Hours@L70
4. System Voltage:230V,50Hz

Design Consideration:
For lighting of Meeting Room with the LED luminaries, following details has been considered:
1. Reflection Factors: Ceiling: 70%, Wall: 50% and Floor: 10%.
2. Height of the Room: 3.5m
3. Maintainace Factor: 0.85
4. Mounting Type: Ceiling Surface mounted at a height of 3.5m
5. Mounting Height of the Luminaire: 3.5m
6. General obstructions are considered.

The design has been done by using 10 numbers of 2’x2’ LED Panel. The following 3D view has been provided below.

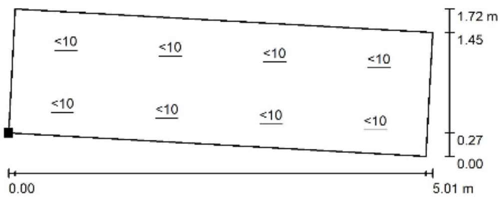
Meeting Room / Workplane / Value Chart (E)



Grid: 9 x 7 Points

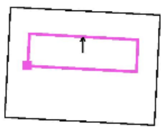
E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
542	390	645	0.719	0.604

Meeting Room / UGR Calculation Area 1 / Value Chart (UGR)



Scale 1 : 50

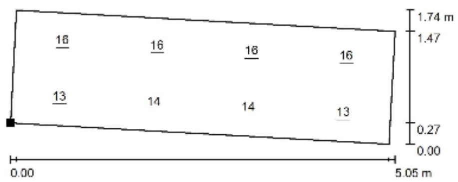
Position of surface in room:
Marked point: (65.728 m, 158.130 m, 1.200 m)



Grid: 4 x 2 Points

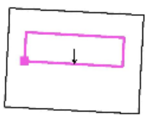
Min	Max
/	<10

Meeting Room / UGR Calculation Area 2 / Value Chart (UGR)



Scale 1 : 50

Position of surface in room:
Marked point: (65.697 m, 158.110 m, 1.200 m)



Grid: 4 x 2 Points

Min	Max
13	16

Meeting Room / Vertical illuminance at 90Deg / Value Chart (E, Vertical)

143	154	163	167	168	167	161	151	142
143	148	155	160	163	165	164	161	158
198	217	233	243	250	252	250	242	226
238	261	277	285	288	287	280	266	244
231	248	260	267	268	265	257	244	227
217	234	248	257	263	266	264	258	244
255	290	311	323	330	330	324	309	281

2.54 m, -2.54; -3.47, 3.47 m

Grid: 9 x 7 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
232	142	330	0.61	0.43

Meeting Room / Vertical illuminance at 270Deg / Value Chart (E, Vertical)

288	314	328	332	331	323	310	287	254
242	254	260	262	260	255	245	232	217
233	251	264	272	275	272	266	252	234
247	269	282	288	289	284	275	258	235
220	234	240	241	238	230	219	203	185
150	152	155	157	157	155	151	144	139
139	149	160	166	168	166	163	152	140

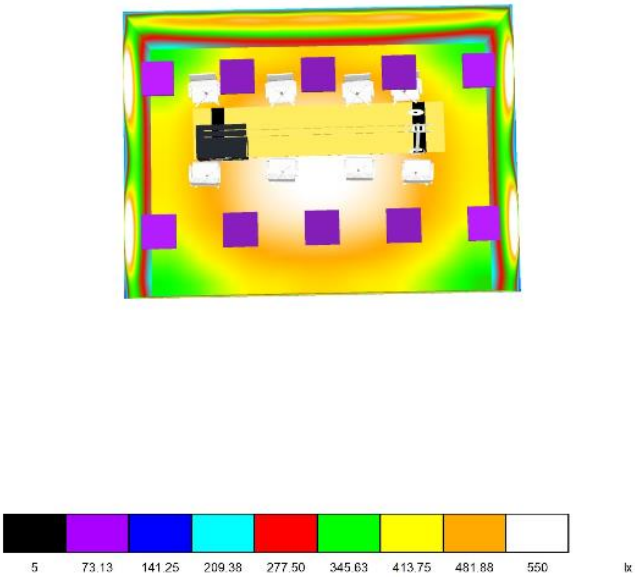
2.54 m, -2.54; -3.47, 3.47 m

Grid: 9 x 7 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
230	139	332	0.60	0.42

Photometric Result:
In this photometric result the minimum and maximum Illuminance is 390 & 645lux. The achieved average Illuminance is 542lx (recommended ≥500 lux) and Overall Uniformity is 0.719(recommended ≥0.4). UGR value is calculated at a height of 1.2m with observation eye at a z-axis of 90° which results into value <10(recommended UGR<19). UGR value is calculated at a height of 1.2m with observation eye at a z-axis of -90° which results into value max UGR≤16(recommended UGR<19).Achieved Vertical Illuminance is ≥200lux.

False Colour Rendering:
It is used to describe different lux level distribution in different Colour inside Meeting room. The Colour distribution of different Lux level ranges is given.



Conclusion:

Below table provides the details of LPD value comparison of Conventional Luminaire with LED:

Name of the Product	Total Number of Quantities	Obtained LPD Values (Recommended ECBC Code: 11.5W/m2)
1. Conventional Surface mounted 74W luminaire	10	21.77W/m2
2. 2'x2' LED PANEL 36W	10	10.76W/m2

So, LED Luminaire Products are more energy efficient than conventional luminaire.

7.25 Manager Cabin:

Technical details of luminaire (Conventional):

Luminaire Used: Conventional Surface mounted 74W luminaire with matt optic double parabolic louver closed.

Fig. 1.Image of the luminaire

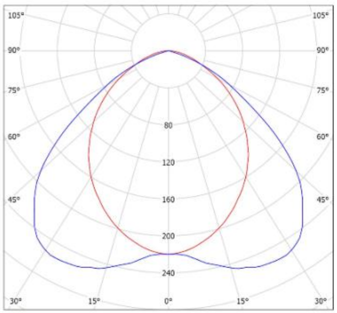


Fig.2. Intensity distribution curve

Specification:

1. Housing made of CRCA sheet steel, powder coated white, accommodating all electrical accessories pre-wired up to a terminal block.
2. Innovative corner brackets made of engineering plastic to enhance the aesthetics.
3. Specially designed optical system of high purity aluminium, with matte lamellae. The reflector is fixed to the housing by mirror holding clips and can be hinged to the housing during installation / maintenance.
4. High efficiency mirror optic reflector of high quality aluminium with diffuse lamellae designed for high optical efficiency and widespread light distribution.

Technical Details:

1. System Wattage: 74W
2. Total System Lumen: 3858lumen
3. System Luminous Efficacy: 52lm/W
4. IP20
5. System Voltage: 230V,50Hz

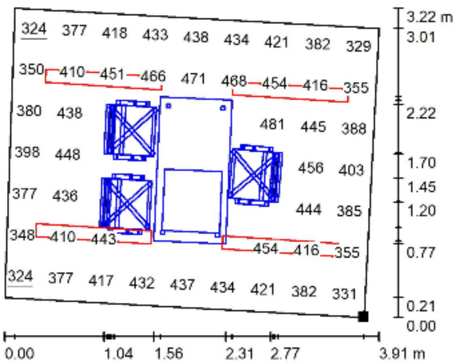
Design Consideration:

For lighting of Manager Cabin with the conventional luminaries, following details has been considered:

1. Reflection Factors: Ceiling: 70%, Wall: 50% and Floor: 10%.
2. Height of the Room: 3.5m
3. Maintainace Factor: 0.70
4. Mounting Type: Ceiling Surface mounted at a height of 3.5m
5. Mounting Height of the Luminaire: 3.5m
6. General obstructions are considered.

The design has been done by using 4 numbers of Surface mounted 74W Conventional luminaire. The following 3D view has been provided below.

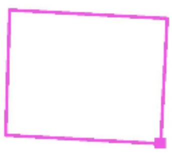
Manager Cabin / Workplane / Value Chart (E)



Values in Lux, Scale 1 : 50

Not all calculated values could be displayed.

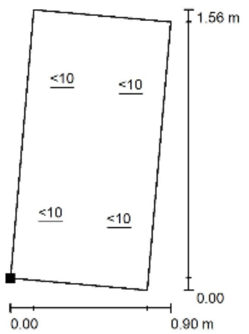
Position of surface in room:
Marked point: (84.183 m, 150.368 m, 0.760 m)



Grid: 9 x 7 Points

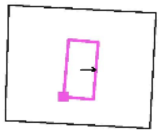
E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
422	324	504	0.766	0.642

Manager Cabin / UGR Calculation Area 1 / Value Chart (UGR)



Scale 1 : 25

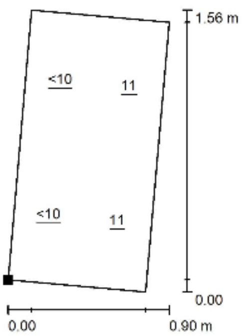
Position of surface in room:
Marked point: (81.951 m, 151.185 m, 1.200 m)



Grid: 2 x 2 Points

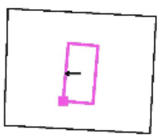
Min	Max
/	/

Manager Cabin / UGR Calculation Area 2 / Value Chart (UGR)



Scale 1 : 25

Position of surface in room:
Marked point: (81.955 m, 151.196 m, 1.200 m)



Grid: 2 x 2 Points

Min	Max
/	11

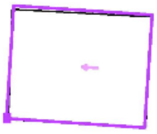
Manager Cabin / Vertical Illuminance 2 / Value Chart (E, Vertical)

212	203	197	189	158	127	114
235	225	228	213	167	131	121
252	246	257	241	185	137	125
246	241	247	232	178	136	122
229	219	213	203	169	133	115

1.55 m
-1.55
-1.89
1.89 m

Values in Lux, Scale 1 : 50

Position of surface in room:
Marked point: (80.378 m, 150.604 m, 1.200 m)



Grid: 7 x 5 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
190	114	257	0.60	0.44

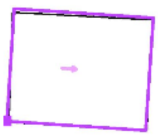
Manager Cabin / Vertical Illuminance 1 / Value Chart (E, Vertical)

113	130	166	198	206	212	225
119	132	175	222	237	230	242
126	135	183	240	262	247	252
123	131	175	224	244	230	237
115	126	158	194	204	206	215

1.55 m
-1.55
-1.89
1.89 m

Values in Lux, Scale 1 : 50

Position of surface in room:
Marked point: (80.378 m, 150.604 m, 1.200 m)

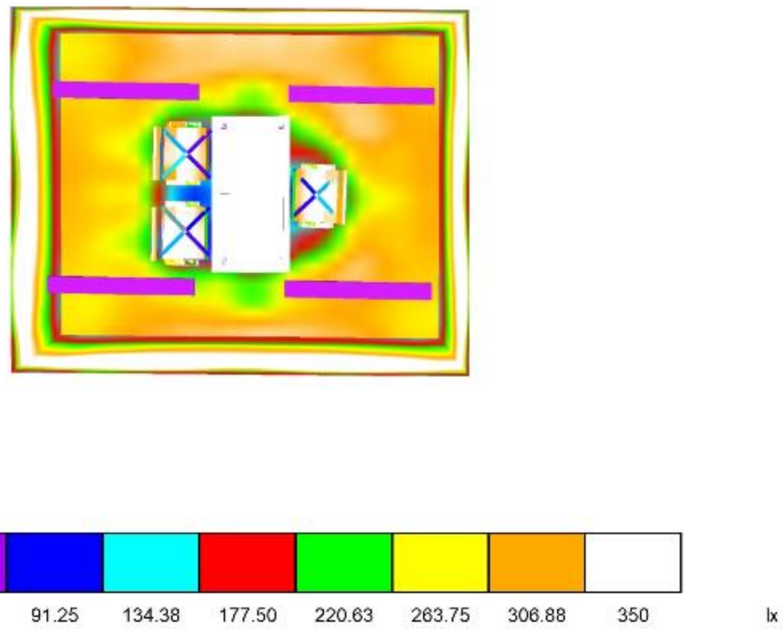


Grid: 7 x 5 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
190	113	262	0.60	0.43

Photometric Result:
In this photometric result the minimum and maximum Illuminance is 324 & 504lux. The achieved average Illuminance is 422lx (recommended value: 300-500-750 lux) and Overall Uniformity is 0.766(recommended ≥0.4). UGR value is calculated at a height of 1.2m with observation eye at a z-axis of 0° which results into value <10(recommended UGR<19). UGR value is calculated at a height of 1.2m with observation eye at a z-axis of 180° which results into value max UGR<11(recommended UGR<19). Vertical Illuminance value obtained ≥100lux.

False Colour Rendering:
It is used to describe different lux level distribution in different Colour inside Manager Cabin. The Colour distribution of different Lux level ranges is given.



Technical details of luminaire (LED):
Luminaire Used: 2'x2' LED PANEL 36W

Fig. 1.Image of the luminaire

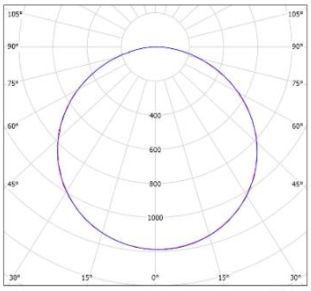


Fig.2. Intensity distribution curve

Specification:

1 Non yellowing opal polycarbonate diffuser for better light distribution.
2. Suitable for recess or surface.
3. CRCA housing with white powder coated finishing.
4. High transmittance diffuser for glare free symmetric light distribution.

Technical Details:

a. System Wattage: 36.6W

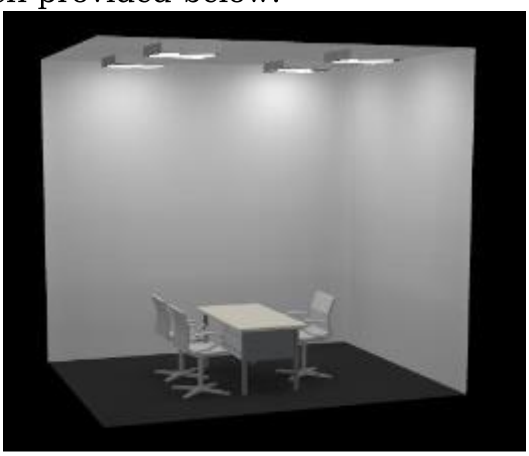
b. Total System Lumen: 3526lumen

c. LED Life:50,000 Burning Hours@L70

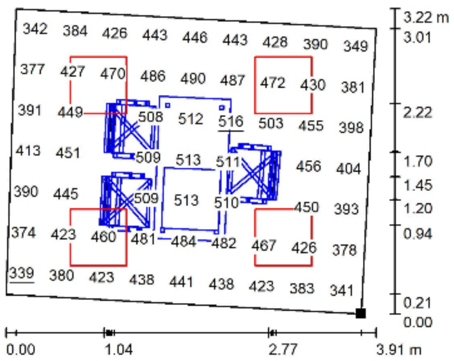
d. System Voltage:230V,50Hz

Design Consideration:
For lighting of Meeting Room with the LED luminaries, following details has been considered:
1. Reflection Factors: Ceiling: 70%, Wall: 50% and Floor: 10%.
2. Height of the Room: 3.5m
3. Maintainace Factor: 0.85
4. Mounting Type: Ceiling Surface mounted at a height of 3.5m
5. Mounting Height of the Luminaire: 3.5m
6. General obstructions are considered.

The design has been done by using 4 numbers of 2'x2' LED Panel. The following 3D view has been provided below.



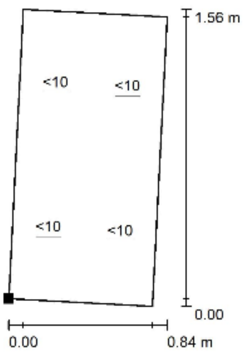
Manager 1 / Workplane / Value Chart (E)



Grid: 9 x 7 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
439	339	516	0.773	0.658

Manager 1 / UGR Calculation Area 1 / Value Chart (UGR)



Manager 1 / UGR Calculation Area 2 / Value Chart (UGR)

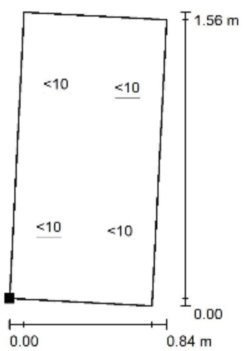


Fig.UGR Calculation 1 &2

Manager 1 / Calculation Grid 1 / Value Chart (E, Vertical)

126	135	180	214	221	227	252
136	139	194	241	256	246	271
140	140	197	253	274	258	275
138	136	189	240	259	241	262
126	130	167	208	220	216	234

1.50 m
-1.50
-1.88
1.88 m

Grid: 7 x 5 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
204	126	275	0.62	0.46

Manager 1 / Calculation Grid 1 / Value Chart (E, Vertical)

239	219	218	209	175	133	126
268	244	249	238	189	139	136
278	258	268	257	206	144	138
275	255	258	249	199	144	135
255	234	223	217	186	140	126

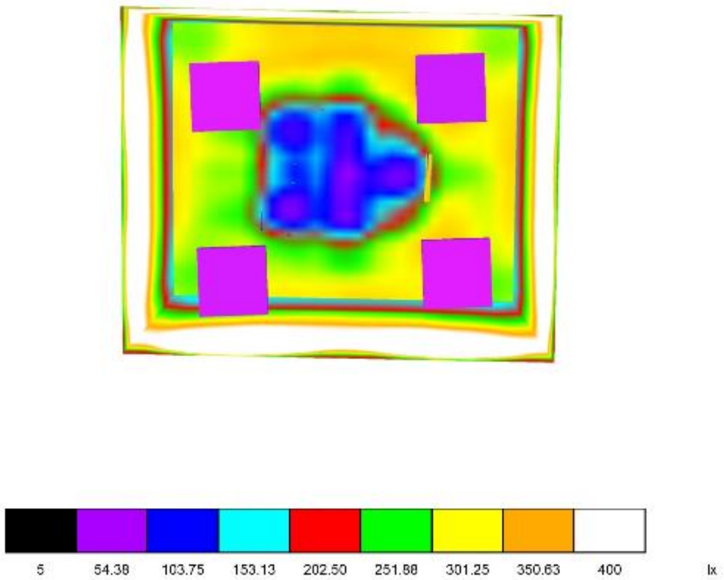
1.50 m
-1.50
-1.88
1.88 m

Grid: 7 x 5 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
207	126	278	0.61	0.45

Photometric Result:
In this photometric result the minimum and maximum Illuminance is 339 & 516lux. The achieved average Illuminance is 439lx (recommended value: 300-500-750 lux) and Overall Uniformity is 0.773(recommended ≥0.4). UGR value is calculated at a height of 1.2m with observation eye at a z-axis of 0° which results into value <10(recommended UGR<19). UGR value is calculated at a height of 1.2m with observation eye at a z-axis of 180° which results into value max UGR<10(recommended UGR<19). Vertical Illuminance value obtained ≥200lux.

False Colour Rendering:
It is used to describe different lux level distribution in different Colour inside Manager Cabin. The Colour distribution of different Lux level ranges is given.



Conclusion:

Below table provides the details of LPD value comparison of Conventional Luminaire with LED:

Name of the Product	Total Number of Quantities	Obtained LPD Values (Recommended ECBC Code: $11.5W/m^2$)
1. Conventional Surface mounted 74W luminaire	4	$25.98W/m^2$
2. 2'x2' LED PANEL 36W	4	$12.84W/m^2$

So, LED Luminaire Products are more energy efficient than conventional luminaire.

7.26 Reception & Waiting Room:

Technical details of luminaire (Conventional):

Luminaire Used: Conventional Surface mounted 74W luminaire with matt optic double parabolic louver closed.

Fig. 1.Image of the luminaire

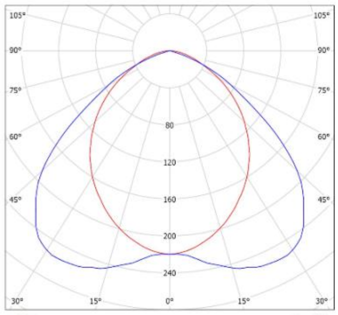


Fig.2. Intensity distribution curve

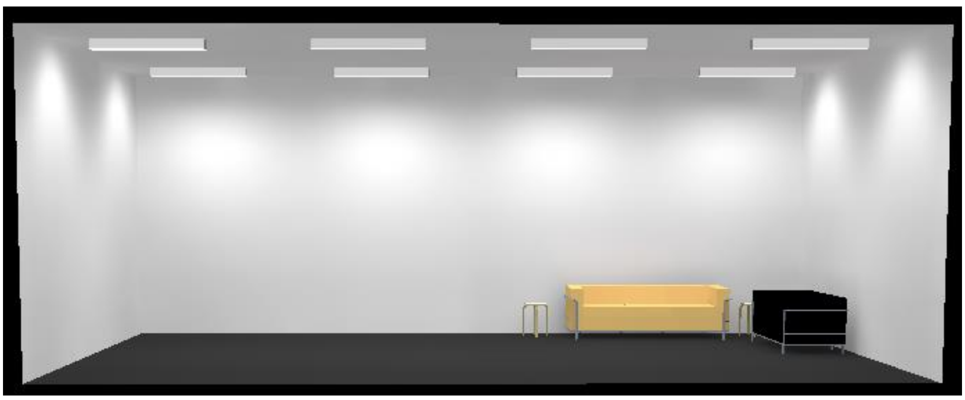
Specification:

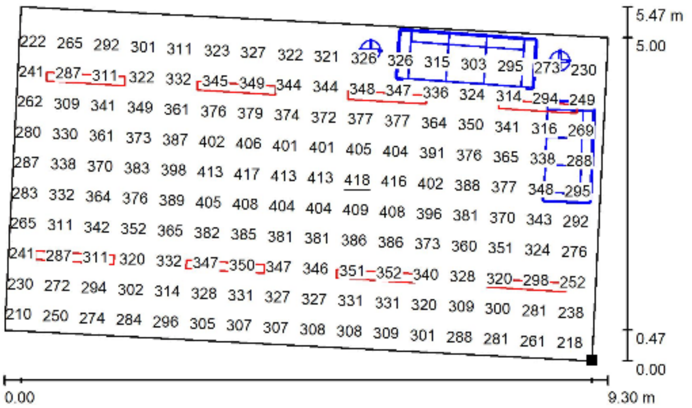
1. Housing made of CRCA sheet steel, powder coated white, accommodating all electrical accessories pre-wired up to a terminal block.
2. Innovative corner brackets made of engineering plastic to enhance the aesthetics.
3. Specially designed optical system of high purity aluminium, with matte lamellae. The reflector is fixed to the housing by mirror holding clips and can be hinged to the housing during installation / maintenance.
4. High efficiency mirror optic reflector of high quality aluminium with diffuse lamellae designed for high optical efficiency and widespread light distribution.

Technical Details:

1. System Wattage: 74W
2. Total System Lumen: 3858lumen
3. System Luminous Efficacy: 52lm/W
4. IP20
5. System Voltage: 230v,50Hz

The design has been done by using 8 numbers of Surface mounted 74W Conventional luminaire. The following 3D view has been provided below





Values in Lux, Scale 1 : 75

Not all calculated values could be displayed.

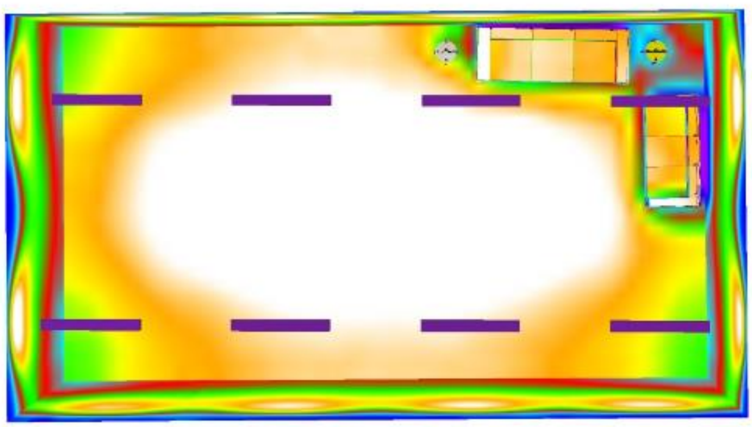
Position of surface in room:
Marked point: (80.574 m, 154.972 m, 0.760 m)

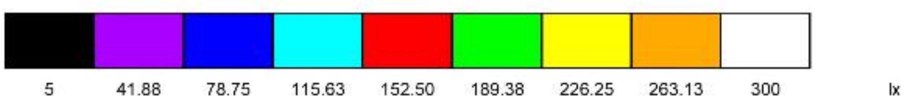
Grid: 64 x 32 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
330	199	418	0.601	0.475

Photometric Result:
In this photometric result the minimum and maximum Illuminance is 199 & 418lux. The achieved average Illuminance is 330lx (recommended ≥300 lux) and Overall Uniformity is 0.601(recommended ≥0.4).

False Colour Rendering:
It is used to describe different lux level distribution in different Colour inside Reception/Waiting Hall. The Colour distribution of different Lux level ranges is given.





Technical details of luminaire (LED):

Luminaire Used: 2’x2’ LED PANEL 36W

Fig. 1.Image of the luminaire

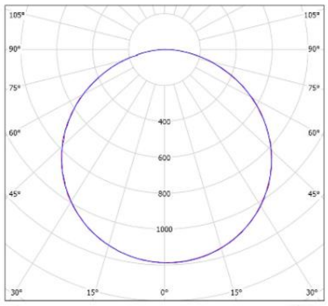


Fig.2. Intensity distribution curve

Specification:

1. Non yellowing opal polycarbonate diffuser for better light distribution.
2. Suitable for recess or surface.
3. CRCA housing with white powder coated finishing.
4. High transmittance diffuser for glare free symmetric light distribution.

Technical Details:

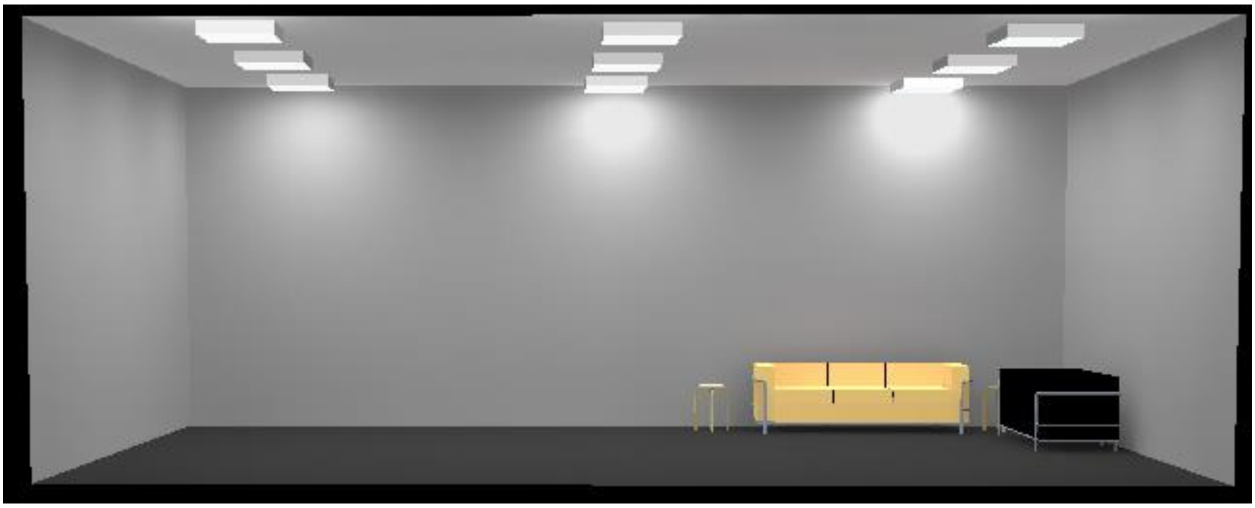
1. System Wattage: 36.6W
2. Total System Lumen: 3526lumen
3. LED Life:50,000 Burning Hours@L70
4. System Voltage:230V,50Hz

Design Consideration:

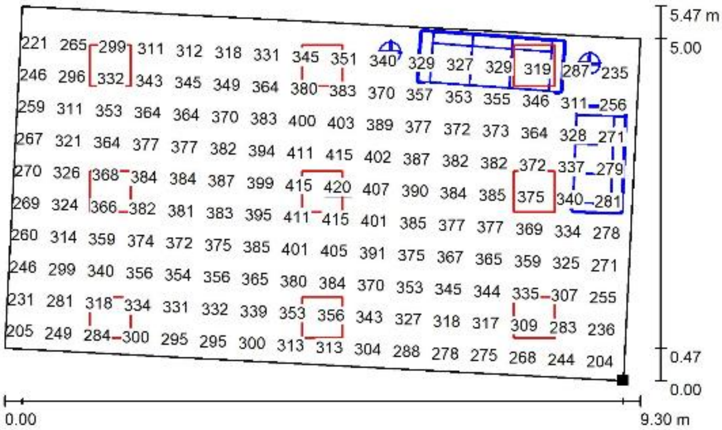
For lighting of Reception/Waiting Room with the LED luminaries, following details has been considered:

1. Reflection Factors: Ceiling: 70%, Wall: 50% and Floor: 10%.
2. Height of the Room: 3.5m
3. Maintainace Factor: 0.85
4. Mounting Type: Ceiling Surface mounted at a height of 3.5m
5. Mounting Height of the Luminaire: 3.5m
6. General obstructions are considered.

The design has been done by using 9 numbers of 2’x2’ LED PANEL 36W luminaire. The following 3D view has been provided below



Reception/Waiting Hall / Workplane / **Value Chart (E)**



Values in Lux, Scale 1 : 75

Not all calculated values could be displayed.

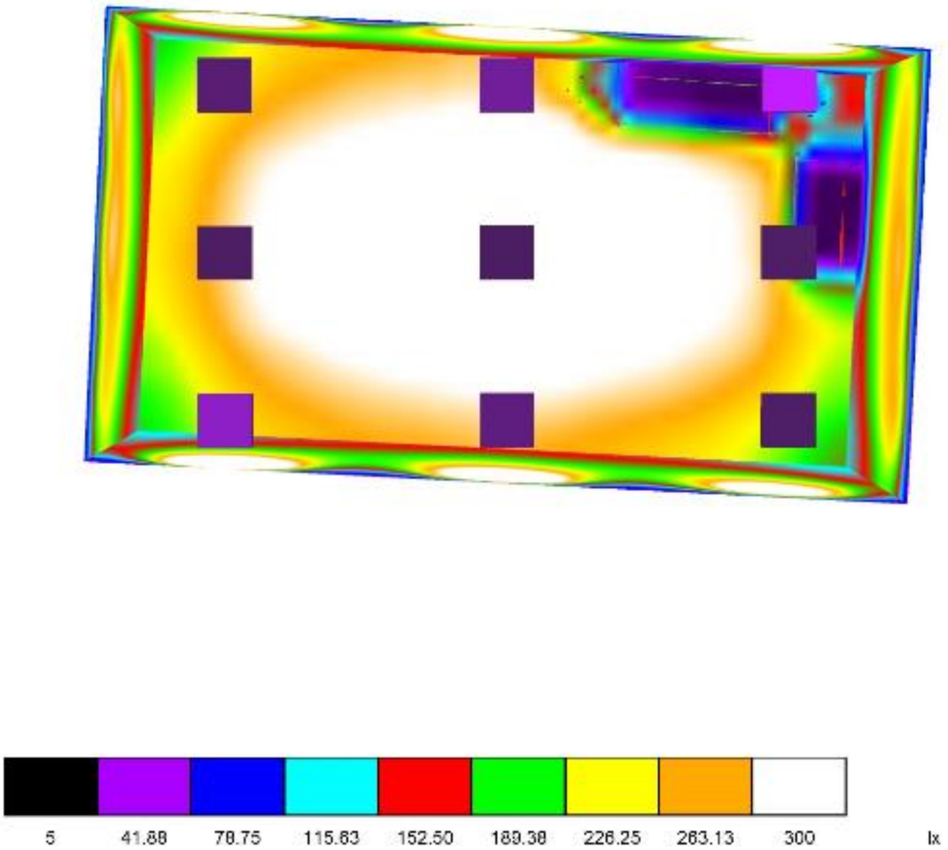
Position of surface in room:
Marked point: (80.574 m, 154.972 m, 0.760 m)

Grid: 64 x 32 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
334	180	420	0.537	0.428

Photometric Result:
In this photometric result the minimum and maximum Illuminance is 180 & 420lux. The achieved average Illuminance is 334lx (recommended ≥300 lux) and Overall Uniformity is 0.537(recommended ≥0.4).

False Colour Rendering:
It is used to describe different lux level distribution in different Colour inside Reception/Waiting Hall. The Colour distribution of different Lux level ranges is given.



Conclusion:

Below table provides the details of LPD value comparison of Conventional Luminaire with LED:

Name of the Product	Total Number of Quantities	Obtained LPD Values
1. Conventional Surface mounted 74W luminaire	8	13.07W/m2
2. 2'x2' LED PANEL 36W	9	7.26W/m2

So, LED Luminaire Products are more energy efficient than conventional luminaire.

7.27 Workspace Room:
Technical details of luminaire (Conventional):

Luminaire Used: Conventional Surface mounted 74W luminaire with matt optic double parabolic louver closed.

Fig. 1.Image of the luminaire

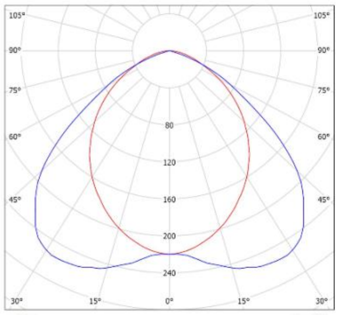
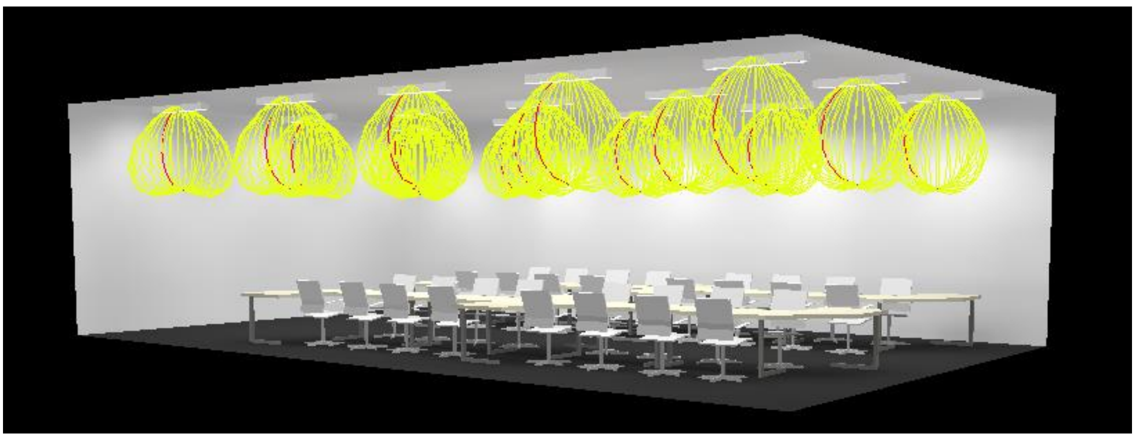


Fig.2. Intensity distribution curve

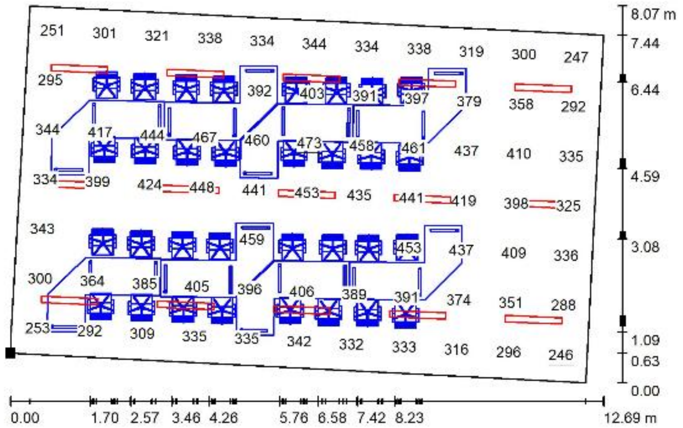
Specification:
1. Housing made of CRCA sheet steel, powder coated white, accommodating all electrical accessories pre-wired up to a terminal block.
2. Innovative corner brackets made of engineering plastic to enhance the aesthetics.
3. Specially designed optical system of high purity aluminium, with matte lamellae. The reflector is fixed to the housing by mirror holding clips and can be hinged to the housing during installation / maintenance.
4. High efficiency mirror optic reflector of high quality aluminium with diffuse lamellae designed for high optical efficiency and widespread light distribution.

Technical Details:
1. System Wattage: 74W
2. Total System Lumen: 3858lumen
3. System Luminous Efficacy: 54lm/W
4. IP20
5. System Voltage: 230v,50Hz

The design has been done by using 15 numbers of Surface mounted 74W Conventional luminaire. The following 3D view has been provided below



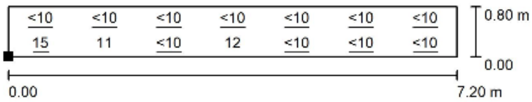
Workstation / Workplane / Value Chart (E)



Grid: 11 x 7 Points

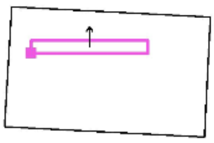
E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
373	246	473	0.659	0.519

Workstation / UGR Calculation Area 1 / Value Chart (UGR)



Scale 1 : 75

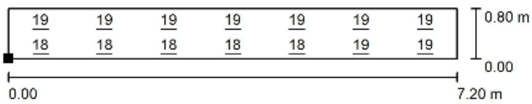
Position of surface in room:
Marked point: (69.500 m, 152.594 m, 1.200 m)



Grid: 7 x 2 Points

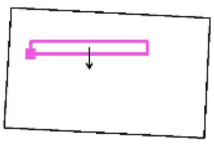
Min	Max
/	15

Workstation / UGR Calculation Area 1 / Value Chart (UGR)



Scale 1 : 75

Position of surface in room:
Marked point: (69.506 m, 152.599 m, 1.200 m)



Grid: 7 x 2 Points

Min	Max
18	19

Workstation / Calculation Grid 1 / Value Chart (E, Vertical)

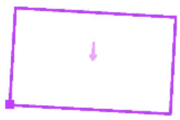
87	94	99	105	103	104	103	105	98	92	85
104	122	127	137	147	144	143	153	141	129	118
156	203	218	231	230	238	228	229	187	173	153
150	165	167	173	190	176	168	164	151	145	134
168	191	199	209	218	217	209	220	211	191	170
157	198	214	225	229	230	224	226	189	167	149
162	198	199	212	225	216	205	205	189	181	162

3.73 m / -3.73

-6.15 / 6.15 m

Values in Lux, Scale 1 : 100

Position of surface in room:
Marked point: (67.860 m, 148.073 m, 1.200 m)



Grid: 11 x 7 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
171	85	238	0.50	0.36

Workstation / Vertical Illuminance / Value Chart (E, Vertical)

162	172	180	186	192	189	180	189	175	158	144
165	200	213	222	229	230	223	221	183	171	159
191	206	206	213	222	213	202	205	186	179	166
135	144	151	156	162	159	154	160	155	140	133
165	195	208	218	225	224	214	218	188	169	159
137	153	150	155	159	151	140	140	123	117	110
88	93	97	103	102	105	102	102	96	92	90

3.73 m / -3.73

-6.15 / 6.15 m

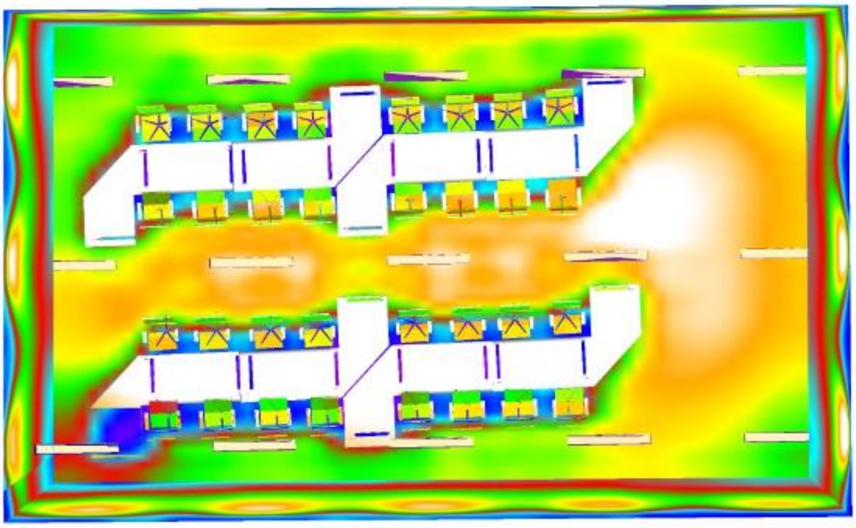
Grid: 11 x 7 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
166	88	230	0.53	0.38

Photometric Result:

In this photometric result the minimum and maximum Illuminance is 246 & 473lux. The achieved average Illuminance is 373lx (recommended ≥300 lux) and Overall Uniformity is 0.659(recommended ≥0.4). Achieved Vertical Illuminance is ≥100lux.UGR values for both sides ≤19.

False Colour Rendering:
It is used to describe different lux level distribution in different Colour inside Workstation. The Colour distribution of different Lux level ranges is given.



Technical details of luminaire (LED):

Luminaire Used: 2'x2' LED PANEL 36W

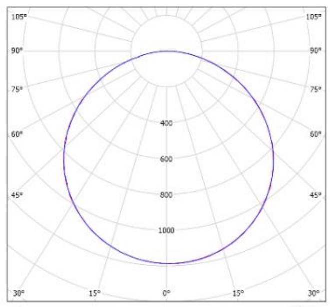


Fig. 1.Image of the luminaire

Fig.2. Intensity distribution curve

Specification:
1. Non yellowing opal polycarbonate diffuser for better light distribution.
2. Suitable for recess or surface.
3. CRCA housing with white powder coated finishing.
4. High transmittance diffuser for glare free symmetric light distribution.

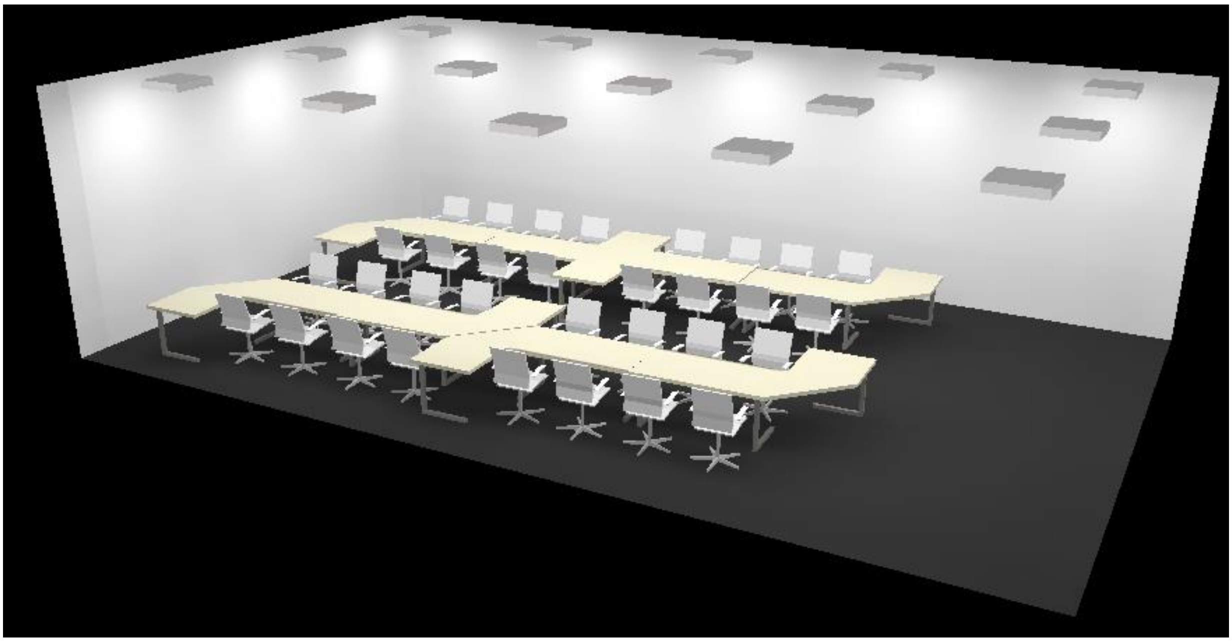
Technical Details:

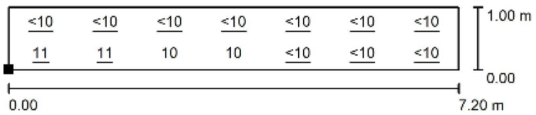
1. System Wattage: 36.6W
2. Total System Lumen: 3526lumen
3. LED Life:50,000 Burning Hours@L70
4. System Voltage:230V,50Hz

Design Consideration:
For lighting of Workstation Room with the LED luminaries, following details has been considered:

1. Reflection Factors: Ceiling: 70%, Wall: 50% and Floor: 10%.
2. Height of the Room: 3.5m
3. Maintainace Factor: 0.85
4. Mounting Type: Ceiling Surface mounted at a height of 3.5m
5. Mounting Height of the Luminaire: 3.5m
6. General obstructions are considered.

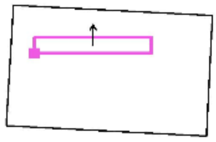
The design has been done by using 15 numbers of 2'x2' LED PANEL 36W luminaire. The following 3D view has been provided below.





Scale 1 : 75

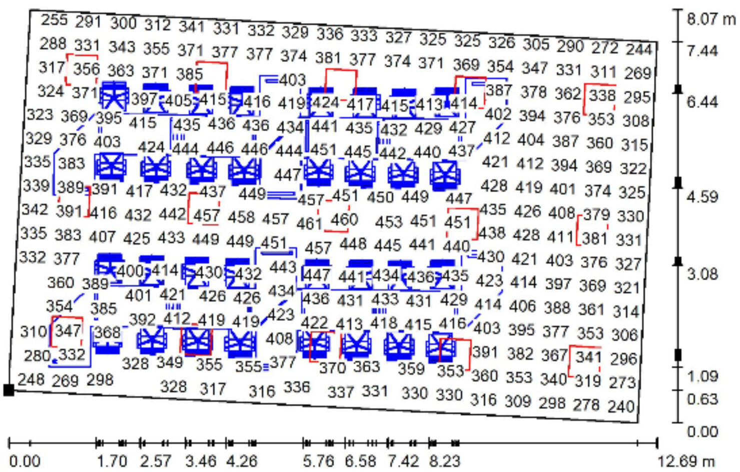
Position of surface in room:
Marked point: (69.600 m, 152.500 m, 1.200 m)



Grid: 7 x 2 Points

Min	Max
/	11

Fig. UGR calculation 1



Values in Lux, Scale 1 : 100

Not all calculated values could be displayed.

Position of surface in room:
Marked point: (67.867 m, 148.040 m, 0.760 m)

Grid: 128 x 128 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
381	200	468	0.524	0.427

Fig. Value chart of Work plane of Workstation

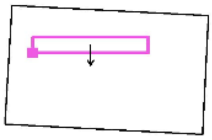
Workstation / UGR Calculation Area 2 / Value Chart (UGR)

17	17	17	17	17	18	18
17	17	17	17	17	18	18

1.00 m
0.00
0.00
7.20 m

Scale 1 : 75

Position of surface in room:
Marked point: (69.600 m, 152.500 m, 1.200 m)



Grid: 7 x 2 Points

Min	Max
17	18

UGR Calculation 2

Workstation / Calculation Grid 1 / Value Chart (E, Vertical)

98	104	109	114	111	112	110	111	105	100	95
110	118	124	132	132	139	138	143	140	139	136
154	166	171	177	175	179	175	177	171	166	155
142	149	154	158	159	162	161	162	160	156	152
174	191	198	207	205	211	207	209	203	198	184
166	179	185	190	189	190	187	186	180	173	161
166	186	195	205	205	212	209	212	208	202	189

3.75 m
-3.75
-6.17
6.17 m

Grid: 11 x 7 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
163	95	212	0.58	0.45

Workstation / Calculation Grid 1 / Value Chart (E, Vertical)

196	210	216	221	218	221	213	213	202	193	171
165	176	183	189	190	194	192	193	188	181	168
188	201	207	214	211	216	209	211	202	194	177
156	161	163	165	164	165	161	160	155	149	141
155	166	170	177	175	179	175	177	171	164	153
137	140	141	144	140	141	135	133	125	119	110
91	96	101	106	107	110	109	110	106	101	96

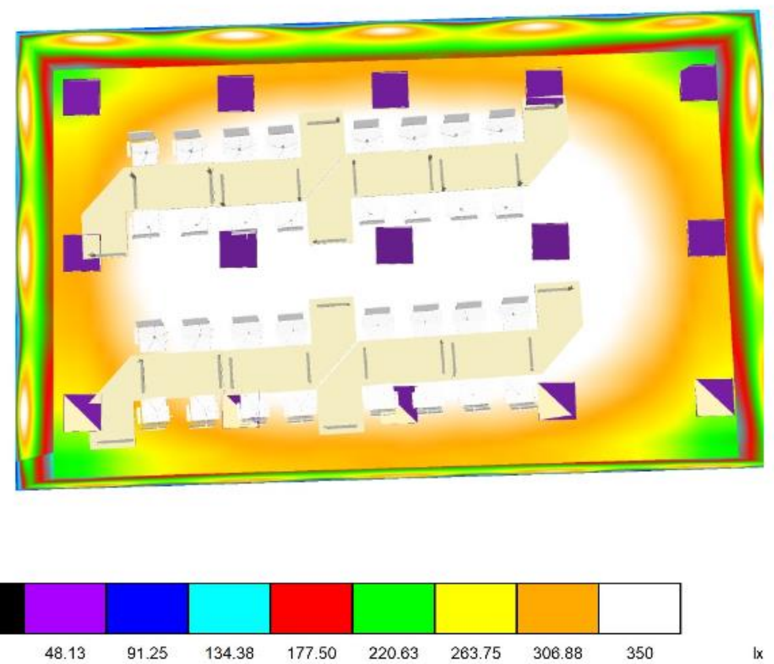
3.75 m
-3.75
-6.17
6.17 m

Grid: 11 x 7 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
165	91	221	0.55	0.41

Photometric Result:
In this photometric result the minimum and maximum Illuminance is 200 & 468lux. The achieved average Illuminance is 381lx (recommended ≥300 lux) and Overall Uniformity is 0.524(recommended ≥0.4). For UGR calculation, Calculation 1 the maximum value is 11(recommended UGR<19) and Calculation 2 the maximum value is 18(recommended UGR<=19).Vertical Illuminance values are ≥100.

False Colour Rendering:
It is used to describe different lux level distribution in different Colour inside Workstation. The Colour distribution of different Lux level ranges is given.



Conclusion:

Below table provides the details of LPD value comparison of Conventional Luminaire with LED:

Name of the Product	Total Number of Quantities	Obtained LPD Values (Recommended ECBC Code: 11.5W/m²)
1. Conventional Surface mounted 74W luminaire	15	12.10W/m²
2. 2'x2' LED PANEL 36W	15	5.98W/m²

So, LED Luminaire Products are more energy efficient than conventional luminaire.

Chapter 8

ENERGY STATISTICS IN FOOD PROCESSING INDUSTRY (CONVENTIONAL vs. LED)

8.1Energy Saving of Warehouse by Using LED over Conventional Luminaire:

Calculation has been done by considering Warehouse-Block A area:

Product Used: Conventional Fluorescent Highbay and 2'x2'LED Highbay

Payback Calculation:

Inputs considered for calculation			
S.N.	**Description**	**Conventional Luminaire**	**LED Luminaire**
1	Quantity of Luminaire under consideration	171	144
2	Wattage of Each Luminaire (W)	340	179
3	Cost of Luminaire in INR	9,000	19,000
4	Lamp Life in Hours (Hr)	25,000Hr	50,000Hr
5	Working hours per day on Normal Power (Hr/day)	12	12
7	Working Days per Annum (Day / Annum)	365	365
8	Per Unit Electrical Cost for Normal Power (Rs./KW-Hr)	8	8

A	Savings on Direct Power Consumption		
S.N.	**Description**	**Conventional Luminaire**	**LED Luminaire**
1	Total no's of Luminaires	171	144
2	Power Consumption of Each Luminaire (W)	340	179
3	Total Power Consumption (Kw)	58.14	25.77
4	Working Hours Per Day on Normal Power (Hr)	12	12
6	Working Days per Annum (Days)	365	365
7	Total Working Hours per Annum on Normal Power (Hr)	4380	4380
9	Electrical Units consumed per Annum on Normal Power (KwHr)	254653.2	112872.6
11	Per Unit Electrical Cost of Normal Power (Rs./KW-Hr)	8	8
13	Total Electricity Cost per Annum (Rs.)	2037225.6	902980.8
14	Electrical Savings with Use of LED per annum (Rs.)		**1134244.8**

B	**Savings on Lamp Replacement Cost**		
S.N.	**Description**	**Conventional Luminaire**	**LED Luminaire**
1	Hours of operation under analysis (Hr)	4380	4380
2	Life of each lamp (Hr)	25000	50000
3	Number of lamp replacement per fixture for 50000 Hr operation	2	0
4	Total number of lamps required for replacment	2052	0
5	Cost of unit lamp (Rs)	500	0
6	Lamp replacement cost per lamp (Rs)	50	0
7	Total cost of maintenance for 50K hrs (Rs)	1128600	0
8	Savings in cost of maintenance for 50000 Hr operation (Rs)		1128600
9	Savings in cost of maintenance (Rs/annum)		**98865.36**

C	**Financial Savings**		
S.N.	**Description**	**Conventional Luminaire**	**LED Luminaire**
1	Unit Cost of product inclusive of lamp (Rs)	9000	19000
2	Quantity	171	144
3	Total initial investment (Rs)	1539000	2736000
4	Additional investment in LED (Rs)		1197000
5	Savings due to LED usage per annum (Rs)		1233110.16
6	Payback Period in Years		**0.9707 years**
8	Life of LED system in years considering 50000 burning hours		**11.41 years**

So, we can conclude that payback period will be **11.6484 months** with LED option and life of LED system in years considering 50,000 Burning Hours is **11.41 years.**

Chapter 9

Conclusion

Conclusion:

In this modern era electrical energy is getting scarce day by day. As it is the backbone of lighting, the lighting designers should be more concerned about energy efficient lighting. Without compromising much, LED is the best achieved solution till date. Since, LED consumes less power than the conventional luminaires & maintains almost the same lighting level output. So, lighting designers are introducing LED luminaires into their designs now days. Lighting, along with architecture, is improving the world regularly in terms of visualization. Lighting designers are trying their best to offer a beautiful world to the present & future generation, keeping in mind about energy efficient lighting solution. In Industrial areas the main purpose of lighting is utility or need based, whereas for retail and residential aesthetics plays an important part.

Thus in this thesis highlights food processing industry lighting designs through various case studies across diverse areas. During practical implementation of these designs however minor changes may occur due to practical site constraints faced during installation. Considering the possibility of such slight variations, in several instances the measured values have been maintained at a higher level compared to the required level.

Luminaires should be constructed such that no part of the luminaire can fall into the foodstuffs, even when the luminaire is opened for lamp changing purpose. The luminaires in the food industry should be capable of being washed or hosed down in safety. Lamps suitable for operation at low temperatures will be necessary for some food storage areas. Some of the Lamps and luminaires suitable for hot and humid conditions may be required for some other areas. Areas containing a dust explosion hazard may be present; proper luminaires for that area should be chosen.

In last 20 years, it is quite visible that LED has replaced the conventional light source as it has advantages over conventional light source i.e.

- LED gives more lumen output for a particular wattage than the conventional light source, i.e., LED has better efficacy (lumen/watt) than conventional light source.
- LED does not contain any toxic material inside it, while conventional light source contains toxic materials like mercury. And for some cases this is one of the most vital factors for choosing LED over conventional light source. E.g., If conventional light source is used inside a biscuit factory and somehow if the luminaries breaks then the toxic material may fall on the food products.
- Controlling a LED is very easy than the conventional light source.
- The life span of LED is very impressive than the conventional light source, in general LED has a life span of 50000 hours, while conventional light source has a life span of 20000-25000 hours. Thus using LED over a conventional light source will decrease the maintenance cost, so it will be more economical option to use.

So, LED is the only solution on the basis of energy and vision.

Chapter 10
<u>FUTURE SCOPE & REFERENCE</u>

Future Scope:

1. Integration with IOT and Industry 4.0

There is a growing trend toward the incorporation of internet of things (IOT) and Industry 4.0 technology into industrial lighting systems. By using IOT technology are able to gather and analyze data on energy use, occupancy patterns and maintenance requirements.

2. Daylight Integration:

Day light integration with artificial light is the future of lighting design in near future, as it brings some added advantages inside the factory or industrial area.

- It reduces the electric lighting loading, i.e. LPD will be under control during day time.
- It brings improved lighting conditions, i.e. Colour rendition, CCT etc.
- It is scientifically proved that, under daylight workers feel more active, so production rate will increase while damage is less.
- It reduces maintenance and operation cost.

ANNEXURE-I

REFERENCE:

1. National Lighting Code 2010 (SP 72: 2010), Bureau of Indian Standards

2. IS 3646(Part I): 1992 – Code of practice for Interior Illumination

3. Energy Conservation Building Code 2007/2017, Bureau of Energy Efficiency

4. IESNA Lighting Handbook, 9th Edition.

5. Tcpi.com/TCP Lighting Website

6. DIALux: Light building software: about DIALux
www.dial.de/DIAL/en/dialux-international-download.html\

7. www.magiklights.com/Magik Lighting Website

8. www.eledlights.com

9. www.LA lighting.com

10. www.erco.com

11. www.agcled.com