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Draft National Lighting Code of India

Part 4 Luminaires
Section 1 Classification and Selection of Luminaires

First Revision of SP 72 (Part 4 / Section 1)

Illumination Engineering and Luminaries Sectional Committee, ETD 49 Last Date for Comments: 02-03-2025

FOREWORD

(Formal clauses of the draft will be added later)

Luminaire is technically defined as an apparatus which distributes, filters or transforms the light given by the lamp and which includes all the items necessary for fixing and protecting the lamps and for connecting luminaire electrical circuit.

Lighting is undergoing a rapid transformation as Light Emitting Diodes (LED) become the number one source of light. LEDs are a new technologies introduced in the market since last 10 years. LEDs are very high efficient as compared to traditional lamps and higher lighting quality compared to fluorescent lighting. Through technology development and energy efficiency policies the LED lighting is fast penetrating the lighting market, offering energy and cost savings and higher lighting quality. The global LED lighting market is growing with maturing light culture. The market is experiencing now a shift from conventional lighting to LED lighting.

LED luminaire means the mechanical housing and integration of a light module, an LED driver, a heat sink for the LEDs and any direct connection points required for mechanical and electrical integration of the unit to its intended mounting solution within the lighting application.

Draft National Lighting Code of India

PART 4 LUMINAIRES
SECTION 1 CLASSIFICATION AND SELECTION OF LUMINAIRES

(First Revision)

1 SCOPE

This section of the code (Part 4/ Sec 1) covers the general aspects of Luminaires, selection criteria and classifications of Luminaires. Testing of luminaires and relevant Indian Standards are covered under section 2.

2 NORMATIVE REFRENCES

IS No	*Title*
10322 (Part 1): 2014	Specifications for Luminaires Part 1: General Requirement
LM - 79	Electrical and Photometric Measurements of Solid-State Lighting Products
LM - 80	Measuring Lumen Maintenance of LED Light Sources

3 TERMINOLOGY

The definitions of the terms used in this section are given in part 1 of this code.

3.1 Diffuser

Diffusers are considered as secondary optics of a fixture. It is used to distribute the light equally. Polycarbonate and Polystyrene material are popular in this aspect. New technologies are coming forward like LGP (Light Guided Plate).

3.2 Driver

An LED driver is a self-contained power supply which regulates the power required for an LED or array of LEDs. The light emitting diodes are low energy, lighting devices with a long lifespan and low energy consumption, hence the requirement for specialized power supplies.

There are two types of driver:

a) Constant current driver; and
b) Constant voltage driver

3.3 Heat Sink

Heat sinks used with LEDs are designed to absorb and disperse excess heat away from the LED diode and into the heat sink. Passive or active air then circulates around the heat sink to help to cool it.

3.4 LED

Light-emitting diode, usually called a LED, is a semiconductor diode that emits incoherent narrow-spectrum of light when electrically biased in the forward direction of the. P-N junction, as in the common LED circuit.

3.5 Lens

It redirects light in a particular direction. Lens distributes light in different amount with respect to angles. Lenses are used for outdoor products, but sometimes used with COBs for indoor luminaire like track light. It works on total internal reflection and transmit the light in a particular angle.

3.6 Light Sources

Luminaries are designed for different type of light sources, some of light sources are mentioned below:

a) Light Emitting Diode (LED);
b) Organic Light Emitting Diode (OLED);
c) Compact florescent Lamp (CFL) & Florescent Lamp;
d) High intensity discharge: Metal halide & high pressure sodium; and
e) Incandescent & Halogen Lamp.

Construction of any luminaire is depend on the source type. For LED luminaire, basic construction is explained in below mentioned Fig. 1.

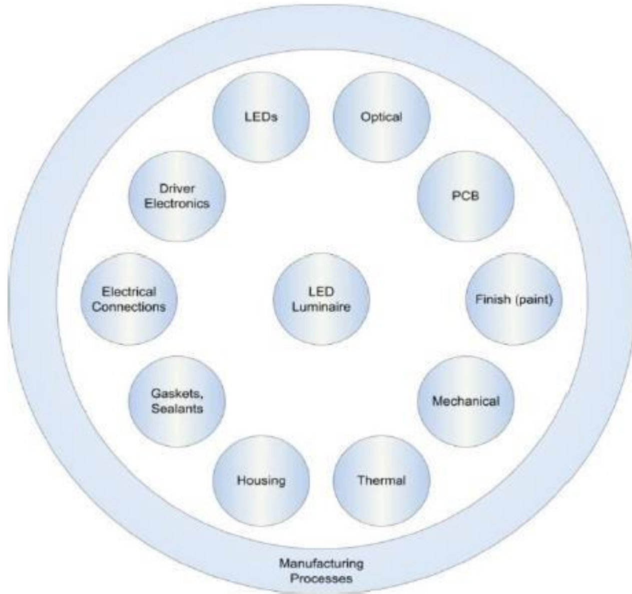


Fig. 1 Basic Parts of LED Luminaires

4 CLASSIFICATION OF LUMINAIRES

Classification of luminaires is commonly organized on the basis of application areas usually distinguished as commercial, industrial, domestic etc. Another form of classification employs the luminous intensity or flux distribution of the luminaries.

4.1 Purpose of Classification

A variety of lighting fixtures and systems are available to meet different lighting needs, ranging from simple to advanced and specialized visual requirements. The effectiveness of any lighting design largely depends on the careful selection of lamps and luminaires. Choosing a suitable luminaire for a specific application requires evaluating and considering various technical parameters.

Luminaire classification serves as a useful tool for specifiers and manufacturers to describe, organize, catalog, and retrieve information about luminaires. With the advancements in computer and information technology, the nature of luminaire classification has evolved. Modern lighting design and specification practices rely on computer-based luminaire databases that can be easily stored and accessed through websites. This enables frequent updates to luminaire data with greater convenience.

Luminaires can be classified based on their intended application or photometric characteristics. Application classification involves categorizing luminaires according to tasks, projects, environments, mounting options, construction, and so on. On the other hand, photometric characteristics refer to how the light produced by a luminaire is distributed in space.

4.2 Classification by Application

a) Indoor type luminaire
b) Outdoor type luminaire
c) Industrial type luminaire

4.2.1 *Indoor Type Luminaire*

4.2.1.1 *Recessed luminaire* — A recessed luminaire is designed in such a way that all its electrical and optical components are concealed above the ceiling or wall line. These luminaires are installed within the ceiling or wall, creating a clean and unobtrusive appearance. The primary direction of light emitted from recessed luminaires is downward, although some models can also distribute light toward a wall.

Recessed luminaires offer flexibility in terms of light distribution patterns. They can produce narrow or broad beams of light, varying in intensity and diffusion. This versatility allows them to fulfill different lighting purposes, such as providing ambient illumination, washing walls with light, or creating accent lighting effects.

Various types of recessed luminaires exist, including troffers and "luminous ceiling" models. Troffers are commonly used in commercial settings and are characterized by their rectangular shape and wide light distribution. "Luminous ceiling" luminaires are designed to create the illusion of a uniformly illuminated ceiling surface.

Other types of recessed luminaires include down lights, which direct light downward, wall wash luminaires that evenly illuminate vertical surfaces, and accent luminaires that focus light on specific objects or architectural features to highlight them. These luminaires differ in size and shape, mounting, and trim choices. Examples of recessed luminaires are given in Fig. 2

Fig. 2 Examples of Recessed Luminaires

4.2.1.2 *Surface luminaire*— Surface mounted lights are lighting fixtures that are directly attached to the ceiling or wall without the need for any screws. They are designed with a screw-less mechanism, allowing for easy installation and removal. These lights are typically mounted flush against the ceiling or wall surface, creating a sleek and seamless appearance.

The absence of visible screws gives surface mounted lights a clean and minimalist aesthetic. They are available in various shapes, sizes, and styles to complement different interior designs. Surface mounted lights are often preferred in spaces where recessed lighting is not feasible or desired, such as in concrete ceilings or spaces with limited ceiling depth.

The installation process for surface mounted lights is straightforward. They are typically mounted using a mounting bracket or plate that securely holds the fixture in place. This type of lighting is commonly used in residential and commercial settings, providing general illumination or targeted lighting effects depending on the design and specifications of the fixture.
Examples of Surface luminaires are given in Fig. 3.

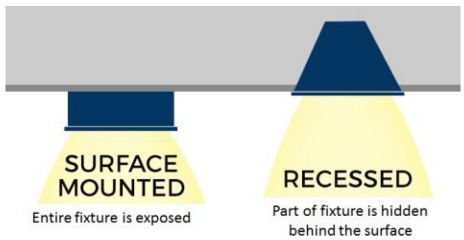


Fig. 3 Examples of Surface Luminaires

4.2.1.3 *Direct luminaries*— Direct luminaires are a type of lighting fixture where the primary direction of light distribution is downward. These luminaires are commonly installed either recessed into the ceiling or surface mounted on it. They are particularly popular in office environments with limited ceiling height.

Direct luminaires typically utilize LED or fluorescent lamps, available in linear or compact form. They offer a variety of optical control options, including diffusers, prismatic refractors, parabolic reflectors, and louvres. As a result, direct luminaires come in a wide range of luminous intensity distributions to suit different lighting needs.

Direct luminaires are designed to withstand challenging conditions such as dirt, corrosion, or hazardous environments. However, there are common issues associated with these luminaires in lighting installations. One challenge is the potential creation of a dark ceiling and poor uniformity of illuminance in obstructed spaces. This problem can be mitigated by selecting direct luminaires with some upward light output or by ensuring high reflection factors within the space.
Fig. 4 shows a selection of direct luminaires.

Fig. 4 Examples of Direct Luminaires

4.2.1.4 *Indirect luminaries* — Indirect luminaires are lighting fixtures designed with a primary light distribution that is predominantly directed upward. These luminaires can be suspended below the ceiling, mounted on walls, or placed as free-standing fixtures. They require a clean and white ceiling surface to achieve efficient operation. It's important to note that indirect luminaires are not suitable for spaces with ceiling heights less than approximately 2.6 m.

Suspended indirect luminaires typically utilize LED or linear fluorescent lamps as their light source. On the other hand, wall-mounted and free-standing indirect luminaires often incorporate high-output LEDs or discharge lamps.

Optical control in indirect luminaires focuses on ensuring that the light emitted from the fixture is widely spread across the ceiling, without any noticeable hotspots of high luminance. The aim is to achieve a uniform distribution of light throughout the space.

While indirect luminaires offer a high light output ratio, lighting installations using these fixtures tend to be less energy-efficient compared to those utilizing direct luminaires. This is due to the losses incurred by relying on the ceiling as a secondary reflector. However, this trade-off is compensated by the bright appearance of the space, a high level of illuminance uniformity, and the absence of discomfort glare.

Fig. 5 shows examples of indirect luminaires.

Fig. 5 Examples of Indirect Luminaires

4.2.1.5 *Direct/indirect luminaires*— Direct/indirect luminaires are lighting fixtures that evenly distribute light in both upward and downward directions. These luminaires offer a combination of benefits, incorporating elements from both direct and indirect lighting approaches. They provide improved energy efficiency compared to installations using solely indirect luminaires, while also addressing issues such as dark ceilings, poor illuminance uniformity, and discomfort glare.

Direct/indirect luminaires are typically suspended below the ceiling. It's important to note that they are not suitable for spaces with a ceiling height of approximately 2.7 m.

LED or linear fluorescent lamps are commonly used as light sources in direct/indirect luminaires. Optical control differs between the upward and downward light components, with a tighter focus on the downward direction to ensure precise illumination. This helps achieve optimal lighting effects.

Direct/indirect luminaires are available with the option for individual dimming of the direct component. This allows for the indirect component to provide a constant background illumination for the space while enabling flexible control of the direct lighting component.

Overall, direct/indirect luminaires provide a balanced and versatile lighting solution, combining the advantages of both direct and indirect lighting to create a visually appealing and comfortable environment.

Fig. 6 shows a selection of direct/indirect luminaires.

Fig. 6 Examples of Direct/Indirect Luminaires

4.2.1.6 *Downlights & wall washers* — Downlight luminaires are typically installed in a recessed manner within the ceiling, directing their entire light output downward. These luminaires are designed to provide focused illumination in a specific area. Some downlights feature optics or reflectors that can be tilted to wash walls or accentuate objects, similar to spotlights.

Downlights are widely used in commercial spaces such as shops and hotels, as well as in other settings where a discreet lighting installation is desired. They offer a clean and unobtrusive appearance, blending seamlessly into the ceiling.

Various light sources have been utilized in downlights, with LED being the most common choice nowadays. Compact fluorescent and metal halide lamps are also still available. The use of reflectors, louvres, lenses, and refractors allows for a wide range of beam spreads and sizes to be achieved.

Some downlights offer adjustable aiming, allowing for flexibility in directing the light for accent lighting purposes. This feature is particularly useful when highlighting specific objects or areas.

In addition, certain downlights are equipped with decorative elements positioned directly beneath the downlight aperture. These elements enhance the visual perception of brightness and add aesthetic appeal to the luminaire.

Fig. 7 shows a selection of downlights.

Fig. 7 Examples of Down Lighters

Wall washers are luminaires specifically designed to provide an even and uniform illumination level along a wall. These luminaires emit a wide beam of light that is directed towards the wall surface, creating a smooth and consistent lighting effect.

Wall washers can be recessed into ceilings or attached to a lighting track, offering flexibility in installation options. They come in various forms, including long linear units that incorporate linear LED arrays or linear fluorescent lamps, as well as spotlights that utilize compact discharge or LED lamps with appropriate optics.

To achieve their intended effect, wall washers require careful positioning or aiming. Proper alignment ensures that the light is evenly distributed across the wall surface without any significant variations or shadows. Attention to the angle and distance from the wall is crucial to optimize the lighting outcome.

Wall washers are commonly used in architectural and interior lighting applications where accentuating vertical surfaces is desired. They can enhance the appearance of textured walls, artwork, or architectural features, creating a visually appealing atmosphere.
Fig. 8 shows examples of wall washers.

Fig. 8 Examples of Wall washers

4.2.1.7 *Spotlights & track lights*— Spotlights are lighting fixtures that emit a focused beam of light with beam spreads typically ranging from 10° to 60 °. These luminaires are often mounted either on a base plate or a lighting track, offering flexibility in positioning and adjustment.

When spotlights are track-mounted, they can be designed for operation at mains voltage, low voltage, or extra low voltage. Extra low voltage spotlights require the installation of a step-down transformer to provide the appropriate voltage. This allows for a wide range of installation options and compatibility with different electrical systems.

Spotlights find wide application in various settings such as shops, hotels, and museums, where accent lighting is desired. They are commonly used to highlight specific objects, artworks, or architectural features, drawing attention to focal points within a space.

Spotlights are available with different light sources, including LED, tungsten-halogen, metal halide, and extra high-pressure sodium lamps. Some light sources come with integral reflectors, allowing them to function as spotlights on their own. Others come as bare "bulbs" and require reflectors to control the optical distribution of light. Additionally, filters can be mounted in front of spotlights to alter the color of the light, while irises and baffles can modify the beam shape.

It is important to consider glare control when using spotlights to ensure they do not cause discomfort to passers-by or create excessive glare in corridors or other areas with high pedestrian traffic. Proper positioning and shielding techniques should be implemented to minimize glare and create a pleasant lighting experience.

Fig. 9 shows a selection of spotlights.

Fig. 9 Examples of Spotlights

4.2.1.8 *Task Lights*—Task lights play an essential role in a task/ambient lighting system, which combines moderate background illumination throughout the space with localized lighting for specific tasks. These lights bring the light source closer to the task area, providing focused lighting and enhancing visibility.

The key benefit of task lights is that they give users control over the amount and distribution of light on their task. This can be achieved through features such as switching or dimming the light source and adjusting the position of the luminaire relative to the task. Certain types of LED task lights even offer the ability to adjust the color appearance of the light, allowing users to choose between warm and cool tones based on their preferences.

Task lights typically utilize LED or compact fluorescent light sources, offering energy-efficient and long-lasting illumination. The level of adjustment available in task lights can vary, as well as the amount of desk space they occupy. When selecting task lights, it is important to consider the coverage area provided by the light in common working positions and the potential for glare that could affect the user's comfort and visual performance.

By incorporating task lights into a lighting system, users can optimize lighting conditions for specific tasks, reduce eyestrain, and enhance overall productivity and well-being.
Below Fig. 10 shows a selection of task lights.

Fig. 10 Examples of Task Lights

4.2.1.9 *Accent lighting* — These luminaires are specifically crafted to create lighting patterns that enhance the intended aesthetic and psychological ambiance of a space. They serve both functional and decorative purposes, often serving as ornamental elements themselves.

Accent luminaires can be installed in various ways, including recessed into ceilings, surface mounted on walls, or suspended from pendant fixtures. They not only emit light in specific patterns but also possess decorative features, often having a visually appealing design or a luminous body that adds to the overall aesthetic of the space.

These luminaires play a crucial role in accentuating focal points, highlighting architectural details, or creating visually interesting lighting effects. By combining their functional purpose with decorative elements, they contribute to the overall design and ambiance of a room or environment. Some examples of Accent light are given in Fig. 11.

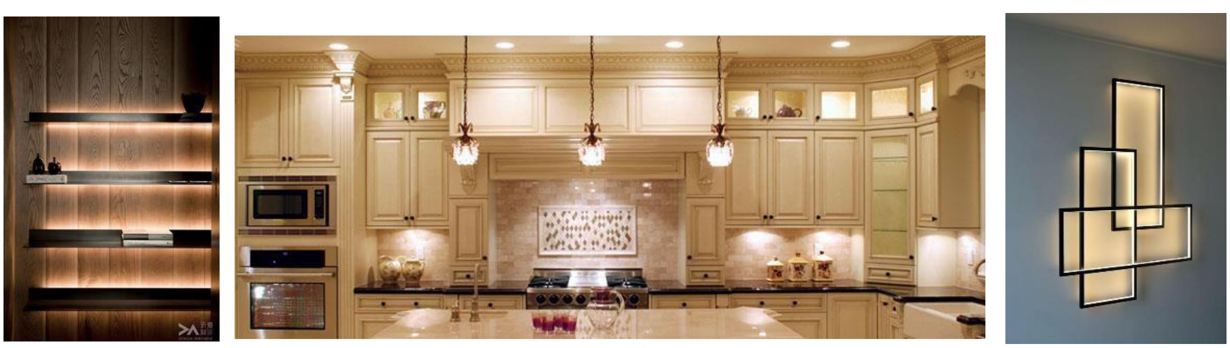


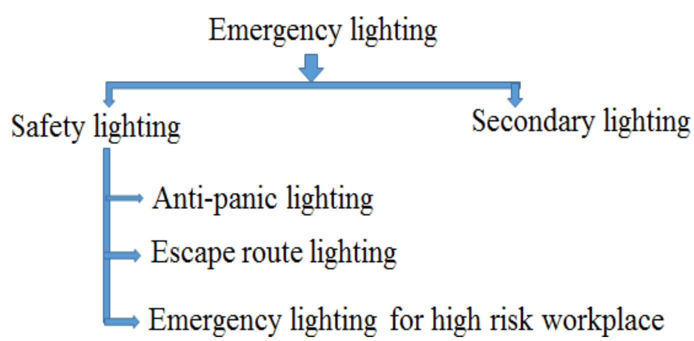
Fig. 11 Examples of Accent Lights

4.2.1.10 *Emergency lighting* — An emergency light is a lighting device equipped with a battery backup system that activates automatically in the event of a power failure. These lights serve as crucial safety measures in buildings to provide illumination during emergencies or power outages.

Emergency lights are commonly found in new commercial structures and high occupancy residential buildings, including college dormitories, apartments, and hotels. They are regarded as standard requirements in these modern constructions. Furthermore, building codes often mandate the installation of emergency lights in older buildings to ensure compliance with safety regulations.

The primary purpose of emergency lights is to maintain adequate lighting levels during critical situations, allowing occupants to safely navigate and evacuate the premises. They are strategically positioned throughout the building, typically in corridors, stairwells, exits, and other crucial areas. When a power outage occurs, the battery-powered emergency lights automatically activate, ensuring that essential pathways remain illuminated.

By having emergency lights in place, building occupants can have improved visibility and guidance during emergencies, reducing the risk of accidents or panic. These lights play a crucial role in ensuring the safety and well-being of individuals within a building when regular lighting systems are disrupted.



a) *Safety lighting* — Safety lighting plays a critical role in ensuring the well-being and security of individuals in buildings, particularly during emergencies or hazardous situations. It is designed to meet specific requirements to prevent panic, facilitate safe evacuation, and enable necessary procedures and equipment shutdown.

Anti-panic lighting is intended to maintain a minimum level of brightness within a building to prevent panic and enable occupants to navigate safely. By ensuring a certain level of illumination, anti-panic lighting helps people maintain their composure, locate exits, and find their way out of the premises efficiently.

Escape route lighting is focused on providing clear visibility along designated escape routes. It involves illuminating pathways, corridors, stairwells, and other areas critical for evacuation. This type of lighting enables individuals to easily identify and follow the designated escape routes, reducing confusion and ensuring a swift and orderly evacuation process.

Safety lighting for high-risk workplaces is tailored to specific environments where there are elevated risks or hazardous procedures involved. These lighting systems are designed to provide adequate illumination to carry out tasks safely and efficiently. They may include lighting for areas where machinery or equipment needs to be operated or shut down safely to prevent accidents or further harm.

By incorporating appropriate safety lighting measures, buildings can minimize the potential for panic, optimize escape routes, and enhance overall safety in high-risk workplaces. Compliance with safety regulations and standards regarding brightness levels, recognition of escape routes, and appropriate lighting for specific environments is essential to ensure the well-being of occupants and reduce the risks associated with emergencies.

i) Anti-panic lighting

Anti-panic lighting is specifically designed to prevent panic during power failures and ensure that occupants within a building can easily identify and navigate escape routes. It focuses on providing a minimum level of illuminance to maintain visibility and promote a sense of calm and safety.

The required illuminance level for anti-panic lighting is typically set at a minimum of 0.5 lux within the defined area. Lux is a unit of measurement that quantifies the intensity of light falling on a surface. This minimum illuminance level ensures that even in dimly lit conditions, there is enough light for individuals to discern their surroundings and locate escape routes.

By implementing anti-panic lighting with the appropriate illuminance levels, buildings can effectively mitigate panic during power failures and enhance the ability of occupants to safely evacuate. Clear recognition of escape routes contributes to the orderly and swift movement of people out of the premises, reducing the potential for accidents or confusion during emergency situations.

ii) Escape route lighting

Escape route lighting plays a crucial role in ensuring the clear recognition and safe use of safety devices and facilitating the effective evacuation of occupants during emergencies. There are specific requirements and standards set for escape route lighting to ensure its effectiveness.

Escape routes must be illuminated across a width of 2 meters. To provide sufficient visibility, an illuminance level of at least 1 lux along the center line of the path, considering a width of one meter, must be maintained. This ensures that occupants can clearly see the route and any safety devices or signage along the way.

In accordance with the EN 1838 standard, the ratio of the highest to lowest illuminance in the area covered by both anti-panic and escape route lighting must not exceed 40:1. This helps to ensure a consistent level of lighting throughout the escape route, minimizing any drastic variations in illuminance that could cause confusion or compromise safety.

The required illuminance level should be reached within a specified timeframe. After no longer than 60 seconds from the activation of the lighting, the designated illuminance level must be achieved. Additionally, at least 50 % of the required illuminance level should be reached within the first 5 seconds to provide immediate visibility and orientation during emergency situations.

The rated service time for escape route lighting is typically set at a minimum of one hour. This ensures that the lighting system can continue to operate effectively throughout the duration of an emergency, providing ample time for safe evacuation and ensuring visibility in the escape routes.

Adhering to these standards and requirements for escape route lighting is essential in creating a safe and well-illuminated environment during emergency situations, enabling occupants to navigate and evacuate the premises efficiently.

iii) Emergency lighting for high-risk workplaces

Emergency lighting in high-risk workplaces is crucial to ensure the safety of personnel and facilitate the completion of tasks during critical situations. Specific requirements are in place to determine the effectiveness of emergency lighting in such environments.

The emergency lighting system must provide a minimum illuminance level of either 10 percent of the illuminance required for the respective tasks or at least 15 lux, whichever is higher. This ensures that there is adequate light to carry out essential tasks during emergency situations.

Upon activation of the emergency lighting, it should reach the required illuminance level within a maximum switch-on delay of 0.5 seconds. This rapid response time ensures that there is immediate illumination available to assist with task performance and safe movement within the workplace.

To maintain uniformity and minimize variations in lighting levels, the ratio between the highest and lowest illuminance within the area covered by emergency lighting should not exceed 10:1. This helps to provide consistent visibility and avoid stark contrasts that could cause discomfort or hinder safety.

By meeting these requirements, emergency lighting systems in high-risk workplaces ensure that essential tasks can be carried out effectively and safely during emergency situations. The prompt activation and provision of adequate illumination enable personnel to respond appropriately and navigate the workplace without compromising their well-being.

b) *Secondary lighting* — Secondary lighting serves as an additional source of illumination in areas where power failures may occur, without posing any immediate hazards. Although not critical for safety, secondary lighting is essential for enabling ongoing work or activities to continue during temporary power outages. It temporarily assumes the role of general lighting, providing sufficient brightness for a limited period of time.

This type of lighting is commonly found in various settings such as offices, educational institutions, retail spaces, and other non-hazardous environments where uninterrupted operations are necessary. When a power failure occurs, secondary lighting systems are designed to activate automatically or be easily switched on to provide adequate illumination.

By ensuring the availability of secondary lighting, businesses and organizations can minimize disruptions and maintain productivity during temporary power outages. It allows individuals to continue working, performing tasks, or engaging in activities until the primary power supply is restored. While not directly related to safety, secondary lighting contributes to the overall functionality and continuity of operations in various settings.

4.2.1.11 *Portable lighting* — A portable luminaire refers to a lighting fixture that can be conveniently relocated from one location to another while still connected to the power supply. These luminaires are designed with features that enable easy mobility and flexibility.

A wall-mounted luminaire falls under the category of portable luminaires when it is equipped with a non-detachable flexible cable or cord and a plug for connecting to the power source. This design allows for quick and effortless disconnection and movement of the luminaire.

Additionally, luminaires that can be securely attached to their support using a wing screw, clip, or hook, and can be easily detached by hand, are also classified as portable luminaires. This means that they can be swiftly removed from their mounting point without requiring any special tools or complex procedures.

The purpose of portable luminaires is to provide convenience and adaptability in lighting setups. They offer the flexibility to adjust lighting arrangements as needed, allowing users to reposition the luminaires to different areas or rooms while maintaining a continuous power connection.

Portable luminaires find applications in various settings such as residential spaces, offices, exhibitions, and other environments where flexible lighting solutions are desired. Their easy portability and simple installation make them convenient options for users who require versatile lighting options that can be easily relocated as needed.

Fig.12 shows examples of portable lights.

Fig. 12 Examples of Portable Lights

4.2.2 *Outdoor Type Luminaries*

4.2.2.1 *Street lighting* — In road lighting, the primary objective of luminaires is to ensure proper visibility and uniform illumination of the road surface, allowing drivers to perceive the road and objects clearly, even in dark conditions. These luminaires are specifically designed to meet the requirements of traffic routes.

The main characteristic of road lighting luminaires is that they are designed to minimize direct upward light. The focus is on delivering light downward to maintain a uniform luminance on the road surface, avoiding excessive glare and light pollution.

Different areas within road networks, such as roundabouts, pedestrian zones, and residential roads, may have specific illuminance criteria that need to be met. Therefore, the light distribution from luminaires depends on their positioning relative to the road layout and specific requirements of the area.

Road lighting luminaires are typically mounted on columns positioned at regular intervals alongside the road or between crash barriers in the median. In complex junctions and large roundabouts, high mast luminaires may be used to provide optimal lighting solutions. Some installations employ a catenary system, where luminaires are suspended in a continuous series over the median.

The light sources commonly used in road lighting luminaires include LED, high-pressure sodium, and metal halide lamps. These luminaires often feature adjustable LED optics, lamp holders, and reflectors to optimize light distribution based on the light source and road layout.

There are two primary classes of road lighting luminaires: semi-cutoff and full cutoff. These classifications represent a balance between luminaire efficiency and the control of glare.

To ensure durability and protection against dust and moisture, road lighting luminaires are classified according to the IP (Ingress Protection) system. They are typically equipped with a photoelectric control package to enable automatic adjustment of lighting levels based on ambient light conditions.

Fig. 13 shows a selection of street lighting luminaire.

Fig. 13 Examples of Street Light

4.2.2.2 *Flood lighting* — Floodlights are versatile luminaires that serve multiple purposes, from illuminating a large surface area to highlighting specific architectural features of a building. They come in a wide range of sizes, power capacities, and light distribution characteristics.

Smaller floodlights are typically compact and feature a small LED pad with a spread reflector. They are commonly used for lighting small areas such as pub car parks and play areas. On the other end of the spectrum, larger floodlights are equipped with a substantial array of LED optics or a high-intensity discharge lamp, with power ratings in the kilowatt range. These floodlights are commonly employed for illuminating sports arenas, industrial facilities, and entertainment venues. The design of these larger floodlights often incorporates carefully shaped reflectors to optimize light output.

The light distribution of a floodlight can be classified into different categories based on its symmetry. It can be rotationally symmetric, symmetrical about one axis, or asymmetrical about one axis. Additionally, floodlights are classified as having a narrow, medium, or wide beam distribution, determining the spread and concentration of light.

Floodlights require protection against dust and moisture, and therefore, they are classified according to the IP (Ingress Protection) system, ensuring their suitability for different environmental conditions and locations.

Fig. 14 shows a selection of road lighting luminaires.

Fig. 14 Examples of Flood Lights

4.2.2.3 *Post-tops* — Post-top luminaires are a type of road lighting luminaire specifically designed for urban areas where pedestrian visibility and aesthetics are just as important as functional lighting. Unlike road lighting luminaires intended for high-speed traffic routes, post-top luminaires are focused on illuminating urban environments where both drivers and pedestrians are present.

The design of post-top luminaires aims to minimize direct upward light, ensuring that the light is directed where it is needed without causing unnecessary glare or light pollution. These luminaires are available with different light distributions, including rotationally symmetric for general area lighting and road lighting distributions for illuminating carriageways. This versatility allows the same luminaire to be used for lighting both roadways and open pedestrian spaces within a city.

Post-top lanterns come in various styles, ranging from traditional designs that blend with historic areas to contemporary designs that reflect the latest trends. The most common light sources used in post-top luminaires are LED, high-pressure sodium, and metal halide, offering a range of energy-efficient and high-performance options. To ensure durability and longevity, post-top luminaires are designed to resist dust and moisture and are classified according to the IP system.

Due to their installation at relatively low mounting heights, post-top lanterns are often constructed using materials that can withstand vandalism attempts. They are typically equipped with a photoelectric control package for automatic operation based on ambient light levels.

One common challenge with post-top lanterns is glare, which needs to be carefully managed. It is important to achieve good vertical illuminance for people's faces while minimizing direct visibility of the light source. By properly positioning the luminaires and using appropriate shielding, the issue of glare can be mitigated, ensuring comfortable and effective lighting in urban areas.

Fig. 15 shows a selection of post-top luminaires.

Fig. 15 Examples of Post top Lights

4.2.2.4 *Wall light & bulkheads*— Bulkheads are wall-mounted luminaires designed to provide a low level of illumination in the nearby area. They are commonly used for security and amenity lighting purposes. The main objective of bulkheads is to deliver a wide light distribution while minimizing upward emission of light. This is achieved through a combination of reflecting and refracting elements within the luminaire.

The light sources typically used in bulkheads are LED, high-pressure sodium, or metal halide, offering a range of efficient and effective lighting options. Given their outdoor application, bulkheads require protection against dust and moisture, and they are classified according to the IP system to ensure appropriate levels of ingress protection.

Due to their mounting at relatively low heights, bulkheads should be constructed with sturdy materials to resist vandalism attempts. They are designed to withstand external factors and maintain their functionality in various environmental conditions.

One common issue associated with bulkheads is glare, which can cause discomfort and visual disturbance. However, this problem can be mitigated by ensuring that the light source is not directly visible. Proper positioning and shielding of the luminaire can help reduce glare and improve overall lighting performance.

Overall, bulkheads are versatile luminaires that provide low-level illumination in nearby areas, offering security and amenity lighting benefits. They are designed to withstand outdoor conditions, minimize upward light emission, and address potential issues such as glare.

Fig. 16 shows a selection of Bulkheads.

Fig.16 Example of Bulkheads

4.2.2.5 *Bollard & ground burial lights* — Bollards are outdoor lighting luminaires that are typically mounted in the ground or on a surface plate with a height of around 1.2 meters. They are commonly used for illuminating pathways, gardens, and other outdoor areas. Bollards need to be constructed with a high level of robustness and protection to withstand outdoor conditions and ensure longevity. Additionally, they should be securely fitted to restrict unauthorized access or tampering with the luminaire.

The light sources used in bollards are usually LED (Light Emitting Diode), CFL (Compact Fluorescent Lamp), and small HID (High-Intensity Discharge) lamps. These light sources offer energy-efficient and durable lighting options suitable for outdoor applications.

In addition to bollards, there are also ground recessed luminaires that are installed flush with the ground surface. These luminaires are designed to emit upward light, often used for illuminating walls or architectural features. They utilize the same types of light sources as bollards, such as LED, CFL, or small HID lamps.

When selecting bollards or ground recessed luminaires, it is important to consider the maximum mechanical loads that the luminaires may experience from people or vehicles moving or standing on them. Additionally, the maximum surface temperatures of the luminaires should be within acceptable limits for the safety and comfort of users in the installation area.

Overall, bollards and ground recessed luminaires are designed to provide functional and aesthetically pleasing lighting for outdoor spaces. They offer a range of light source options, require robust construction and protection, and must be carefully chosen to meet the specific requirements of the installation area. Fig. 17 shows examples of bollards and ground-recessed luminaires.

Fig. 17 Examples of Bollard & Ground Burial Lights

4.2.3 *Industrial Luminaires*

Industrial lighting plays a crucial role in manufacturing environments such as factories, chemical plants, and refineries. It is specifically designed to meet the unique requirements of these settings. Here are some key characteristics and benefits of industrial lighting:

Hazard identification and safety: Industrial lighting is designed to provide sufficient illumination for workers to identify and avoid potential hazards or dangerous conditions in the workspace. This helps enhance safety and reduces the risk of accidents.

High brightness and visibility: Manufacturing processes often require precision and accuracy. Industrial lighting provides high levels of brightness, ensuring that workers can perform their tasks effectively and accurately. This is particularly important in tasks that require fine details or intricate work.

Energy efficiency: Industrial facilities are typically large, and energy costs can be significant. Industrial lighting solutions are designed to be energy-efficient, helping to reduce energy consumption and lower operating costs. This is achieved through the use of efficient light sources, such as LED technology, and lighting control systems that optimize energy usage.

Durability and robustness: Industrial lighting fixtures are built to withstand harsh operating conditions, including high temperatures, humidity, dust, and vibration. They are constructed using durable materials and are designed to be resistant to impact, corrosion, and other environmental factors commonly found in industrial settings.

Flexibility and adaptability: Industrial lighting systems can be customized to meet specific requirements. They can incorporate features such as adjustable mounting options, directional lighting, and dimming capabilities to provide the optimal lighting conditions for different tasks or work areas within the facility.

Maintenance and cost-effectiveness: Industrial lighting fixtures are designed for easy maintenance, minimizing downtime and reducing maintenance costs. They often feature long lifespans, reducing the frequency of bulb replacements and minimizing the need for maintenance activities in challenging environments.

Overall, industrial lighting is essential for creating a safe, productive, and efficient work environment in manufacturing facilities. It combines high brightness, energy efficiency, durability, and flexibility to meet the specific needs of industrial applications while ensuring the well-being and productivity of workers.

4.2.3.1 *Highbay & lowbay light* — High-bay lights and low-bay fixtures are designed to provide effective illumination in spaces with different ceiling heights. Here are some key points about high-bay lights and low-bay fixtures:

a) High-Bay Lights

i) High-bay lights are typically used in spaces with high ceilings, typically ranging from 20 feet to 45 feet or more.
ii) These lights are designed to deliver powerful illumination over a large area, ensuring sufficient brightness in high-ceiling environments.
iii) High-bay lights often utilize high-intensity discharge (HID) lamps, such as metal halide or high-pressure sodium, or more energy-efficient options like LED technology.
iv) They are designed to distribute light in a concentrated manner, providing uniform illumination throughout the space.
v) High-bay lights are commonly found in industrial settings, warehouses, manufacturing facilities, gymnasiums, and large retail spaces.

b) Low-Bay Fixtures

i) Low-bay fixtures are used in areas with lower ceiling heights, typically ranging from 12 to 20 feet.
ii) These fixtures are designed to provide adequate lighting for large rooms or areas with lower ceilings, such as offices, smaller retail spaces, storage facilities, or workshops.
iii) Low-bay fixtures can use a variety of light sources, including fluorescent tubes, compact fluorescent lamps (CFLs), or LED technology.
iv) They are designed to distribute light more evenly and cover a wider area compared to high-bay lights.
v) Low-bay fixtures are often installed in a grid pattern, providing consistent illumination throughout the space without creating excessive shadows or dark spots.
vi) By using high-bay lights in areas with high ceilings and low-bay fixtures in spaces with lower ceilings, you can ensure proper lighting levels and create a safe and comfortable environment for different types of applications.

Below Fig. 18 shows highbay & lowbay light

Fig. 18 Examples of Highbay & Lowbay Light

4.2.3.2 *Glass light* — Well glass lighting (*see* Fig.19) devices are commonly used as main lighting devices in mines due to their durability and resistance to harsh conditions. Here are some key points about well glass lighting in mining applications:

a) Well glass lighting devices are designed to withstand rugged environments, including mines, where they are exposed to dust, moisture, and potential impacts.

b) They are typically constructed with a robust outer glass or polycarbonate enclosure that provides protection against mechanical damage and helps maintain the integrity of the light source.
c) The design of well glass luminaires allows for efficient heat dissipation, preventing overheating and ensuring long-lasting performance.
d) Well glass luminaires often utilize high-intensity discharge (HID) lamps, such as metal halide or high-pressure sodium, which provide bright and reliable illumination in mining environments.
e) LED technology is also increasingly used in well glass luminaires for its energy efficiency, longer lifespan, and ability to withstand vibrations and shock.
f) Well glass lighting devices are usually mounted on fixed structures, such as walls or ceilings, in underground mines to provide general lighting in work areas, tunnels, or shafts.
g) They may incorporate protective features like wire guards or impact-resistant coatings to further enhance durability and safety.
h) Well glass luminaires in mines often meet specific safety standards and regulations to ensure they can withstand hazardous conditions and minimize the risk of ignition or accidents.

Overall, well glass lighting devices are a popular choice in mining applications because they offer reliable and robust illumination, capable of withstanding the challenging conditions encountered in underground mining operations.

Fig. 19 Examples of Glass Light

4.2.3.3 *Clean room lights* — Cleanroom lighting (*see* Fig.20) plays a crucial role in maintaining the cleanliness and functionality of the controlled environment. Here are some considerations regarding cleanroom lighting:

a) *Contamination control* — Cleanroom lighting fixtures should be designed to minimize particulate contamination. They should have smooth, easy-to-clean surfaces, with minimal crevices or joints where particles can accumulate. Sealed or gasketed fixtures can help prevent the ingress of contaminants.

b) *Airflow and filtration* — The installation of lighting fixtures should take into account the cleanroom's airflow patterns and filtration systems. Improperly placed or poorly designed lighting can disrupt the desired airflow patterns, causing turbulence or stagnant air zones that can lead to increased contamination risks. Collaboration between lighting designers and cleanroom engineers is essential to ensure lighting does not compromise the cleanroom's integrity.

c) *Fixture materials* — Lighting fixtures for cleanrooms are typically made of materials that are resistant to chemicals, corrosion, and shedding of particles. Non-shedding materials, such as stainless steel or high-quality plastics, are commonly used to prevent the release of contaminants into the cleanroom environment.

d) *Lighting levels* — Cleanroom lighting should meet the specific lux level requirements for the cleanroom's processes and activities. Different cleanroom classes and applications may have varying lighting intensity needs, and lighting fixtures should be selected accordingly. Uniformity of lighting distribution is also important to avoid areas of high contrast that could affect visual perception.

e) *ESD considerations* — In electrostatic discharge (ESD) sensitive cleanrooms, special attention should be given to the grounding and electrostatic properties of lighting fixtures to prevent the buildup and discharge of static electricity, which could damage sensitive equipment or products.

It's crucial to implement in cleanroom applications, during the design phase, lighting choices that align with contamination control requirements, airflow patterns, and overall cleanroom functionality

Fig. 20 Clean Room Lights

4.3 Classification by Photometry
Another form of classification uses the luminous intensity or flux distribution of the luminaire. Below methods are generally used for defining photometric characteristics of Luminaires:

4.3.1 *CIE System*
The International Commission on Illumination (CIE) has established a classification system for luminaires based on the distribution of upward and downward directed light output. This classification system is commonly used for indoor luminaires, particularly those used for general indoor lighting.

The classification is based on the percentage of luminous flux distributed above and below the horizontal plane. Here are the main classifications:

a) *Direct lighting (downlighting*) — Luminaires classified as direct lighting have a significant portion of their luminous flux directed downward, below the horizontal plane. These luminaires provide focused illumination in the downward direction.

b) *Indirect lighting (uplighting)* — Luminaires classified as indirect lighting have a significant portion of their luminous flux directed upward, above the horizontal plane. These luminaires provide illumination that is reflected off the ceiling or other surfaces, creating a diffused and indirect lighting effect.

c) *Semi-direct lighting* — Luminaires classified as semi-direct lighting have a balanced distribution of luminous flux between the upward and downward directions. These luminaires provide a combination of direct and indirect lighting, offering a balance between focused illumination and ambient lighting.

d) *Direct-indirect lighting* — Luminaires classified as direct-indirect lighting have a roughly equal distribution of luminous flux in both the upward and downward directions. These luminaires provide a combination of direct and indirect lighting, creating a balanced illumination that enhances both task visibility and overall ambiance.

The classification system helps designers, architects, and lighting professionals choose luminaires that align with their desired lighting goals and aesthetics. It allows for the selection of luminaires that provide the appropriate balance of direct and indirect lighting for a given space, taking into account factors such as visual comfort, task visibility, and overall lighting design.

Below Fig. 21 shows classification of Photometry

Luminaire type	% Upward flux distribution	% Downward flux distribution
Direct	0-10	90-100
Semi-direct	10-40	60-90
Direct-indirect	40-60	40-60
General diffuse	40-60	40-60
Semi-indirect	60-90	10-40
Indirect	90-100	0-10

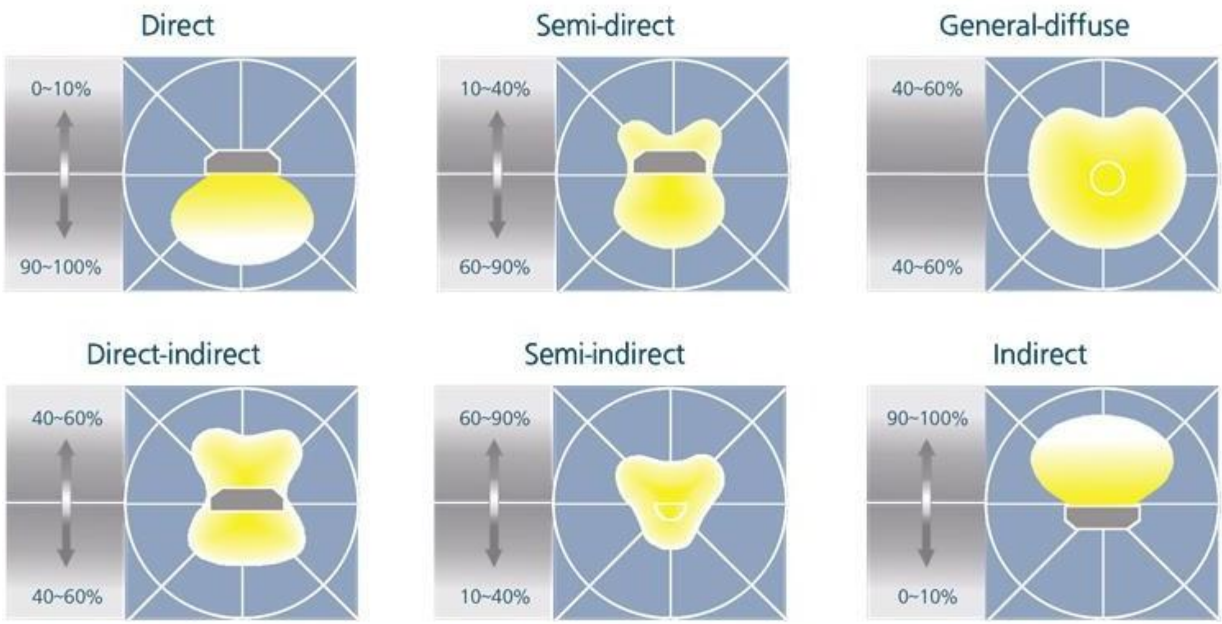


Fig. 21 Classification by Photometry

In turn, with regards to the symmetric flux emitted, a classification may be considered into two groups:

a) *Symmetrical distribution luminaires* — Those in which the luminous flux is spread symmetrically with respect to the symmetric axis and spatial distribution of luminous intensities. It may be represented as a single photometric curve.

b) *Asymmetric distribution luminaires* — Those in which the luminous flux is spread asymmetrically with respect to the symmetric axis and the spatial distribution of luminous intensities. It may expressed by a photometric solid, or, partially, by a flat curve of such a solid, depending on certain characteristic planes.

4.3.2 *NEMA Classification*

The National Electrical Manufacturers Association (NEMA) has established a system for classifying the distribution of flux within the beam produced by luminaires. This classification system is commonly used for sports lighting and floodlighting luminaires.

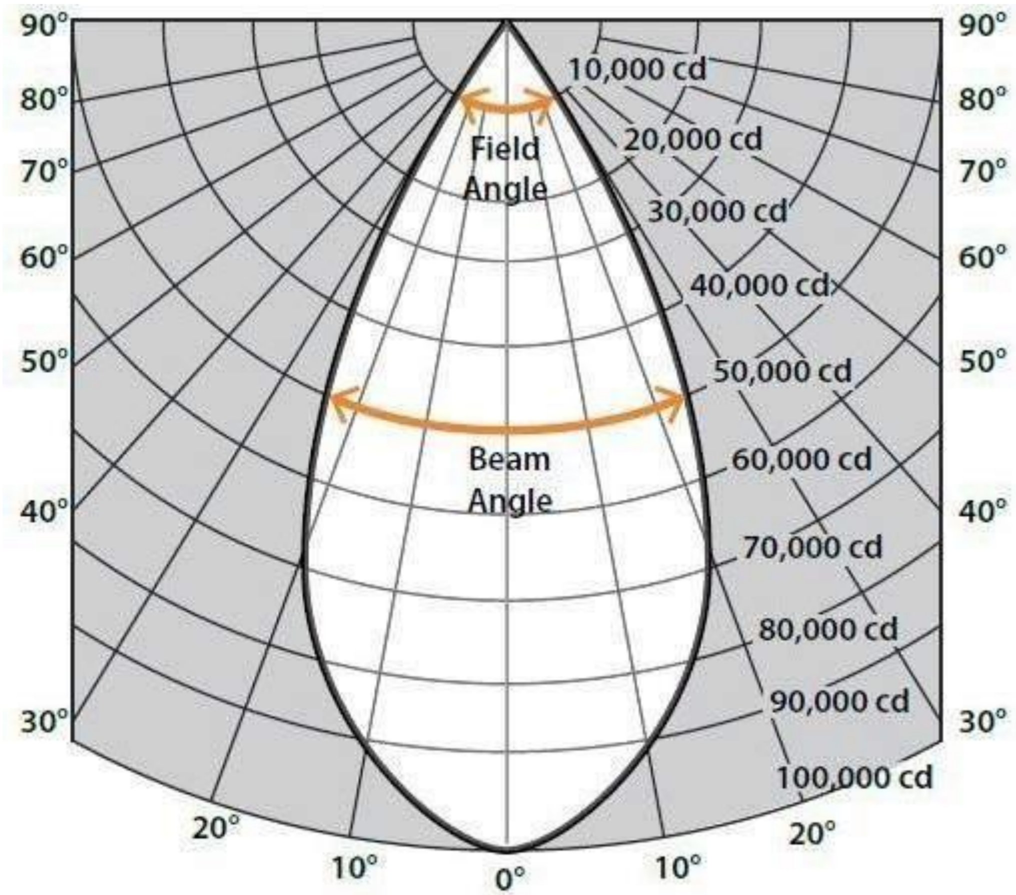
NEMA distributions are described by specifying the horizontal and vertical beam spread of a fixture. The beam spread indicates the angles at which the intensity of the light is 10% of the maximum candlepower, also known as the "field angle." These angles define two planes of light within the beam.

If a luminaire has a symmetrical distribution, only one number is given, indicating that the beam spread is the same in both the horizontal and vertical planes. For example, a NEMA 6x6 distribution means that the beam spread is 6° in both the horizontal and vertical directions, resulting in a symmetrical distribution.

If different numbers are provided for the horizontal and vertical beam spreads, it indicates an asymmetrical distribution. For instance, a NEMA 6x4 distribution means that the beam spread is 6° horizontally and 4° vertically, indicating a narrower beam in one plane compared to the other.

By specifying the NEMA distribution, lighting professionals can select luminaires that provide the desired beam spread and coverage for sports fields, large outdoor areas, or other applications where floodlighting is required. The NEMA classification system helps ensure that the lighting design meets the specific requirements of the intended area and provides optimal lighting performance.

Below Fig. 22 shows NEMA Classification



Field Angle (Degrees)	NEMA Type	Description
<10 up to 18	1	Very Narrow
>18 up to 29	2	Narrow
>29 up to 46	3	Medium Narrow
>46 up to 70	4	Medium
>70 up to 100	5	Medium Wide
>100 up to 130	6	Wide
>130 and up	7	Very Wide

Fig. 22 NEMA Classification

4.3.3. *IES Classification of Outdoor Luminaries*

The Illuminating Engineering Society (IES) has developed a classification system for outdoor luminaires, particularly for roadway and area lighting. This system is based on the shape of the area that is primarily illuminated by the luminaire and provides a comprehensive analysis of how light is distributed.

The IES classification system categorizes outdoor luminaires into different types based on their light distribution patterns. These patterns are represented by a two-letter code, where the first letter represents the primary light distribution and the second letter represents the secondary light distribution.

The primary light distribution refers to the main shape of the illuminated area, while the secondary light distribution describes any additional distribution patterns that may be present.

Following are the IES outdoor luminaire classification by intensity distribution (*see* Fig. 23 also):

a) Type I: Narrow, symmetric distribution, highest intensity usually at nadir
b) Type II: Wider distribution than Type I, highest intensity between 10° and 20° from nadir
c) Type III: Wider distribution, highest intensity between 25° and 35° from nadir
d) Type IV: Widest distribution, highest intensity at greater than 35° from nadir
e) Type V: Symmetrical; produces circular illumination pattern
f) Type VS: Produces an almost symmetric square illuminance pattern

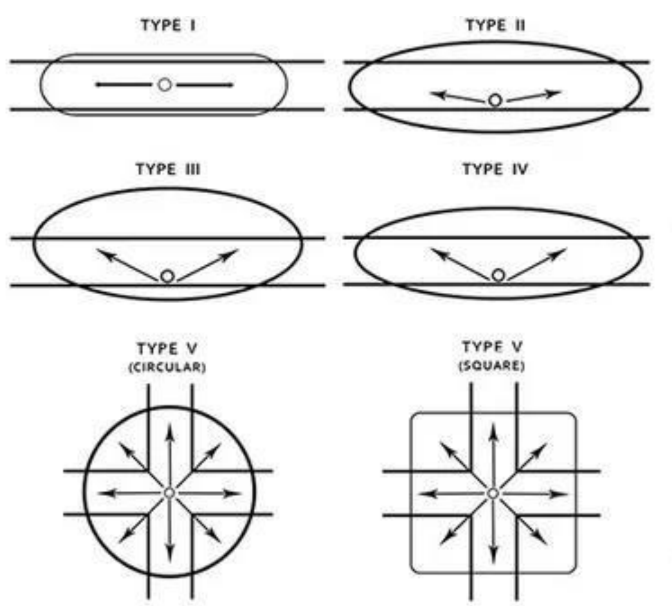


Fig. 23 IES Classification of Outdoor Luminaries

5 TECHNICAL SPECIIFCATION OF LUMINAIRE

LED luminaires are more complex than traditional lighting fixtures due to the various components and operating conditions involved. Consistency in performance claims is indeed important to ensure that customers have accurate information about the capabilities and longevity of LED luminaires.

LED luminaires are electromechanical systems that go beyond the light-emitting diodes themselves. They incorporate components for heat transfer, electrical control, optical conditioning, mechanical support, and protection, as well as aesthetic design elements. These components and materials must be designed to withstand the expected long life of the LEDs. If any of these components or materials have shorter lifespans, they can limit the overall system lifetime.

To address these complexities and ensure consistent performance, industry standards and testing procedures have been developed. These standards define criteria for measuring and reporting performance characteristics such as light output, energy efficiency, color quality, and lifespan. Organizations like the Illuminating Engineering Society (IES) and the International Electrotechnical Commission (IEC) provide guidelines and standards for testing and evaluating LED luminaires.

By following these standards and conducting thorough testing, manufacturers can provide reliable and accurate performance claims for their LED luminaires. This helps customers make informed decisions when selecting lighting products and ensures that the performance of LED luminaires meets their expectations.

5.1 Reliability

Factors affecting the luminaire performance are:

5.1.1 *LED Performance* — While LEDs do not radiate heat, with current products half or more of the input energy may be converted to heat that must be conducted away from the diodes.

5.1.2 *Optical Performance* — LEDs are directional light sources, giving the lamp or luminaire designer new challenges when compared to existing lamp technology. The use of reflectors, lenses and diffusers, or a combination there of, allows a designer to direct light in many different ways. The efficiency of the optical system must be considered and factored into the overall efficiency value of the lamp or luminaire.

5.1.3 *PCB* — A PCB is the interface between an LED and heatsink and carries with it a thermal resistance value. The higher the resistance the less efficient the system is at soaking away heat from the LED, this may well impact on the LED lumen output performance and ultimately the life, lumen maintenance and/or catastrophic failure of the LED.

5.1.4 *Finish* — The paint finish/colour may affect the heat dissipation from the luminaire.

5.1.5 *Mechanical* — The mechanical integrity of a luminaire is important in several different areas including: IPXX rating to suit the application, heat-sinking that will not become compromised with time and or lack of maintenance, vibration resistance, specifically so that the heat-sink does not become detached from the LED PCB, bonding mechanisms are suitable for the life of the lamp or luminaire.

5.1.6 *Thermal* — The performance of an LED is dependent on its temperature during operation. The design of the luminaire will influence its operating temperature and hence published characteristics.

5.1.7 *Housing* — LEDs allow new design freedom and housings can be used both for styling and heat-sinking purposes. Consideration should be made for maintenance and/or cleaning of the heat-sink, so that the overall thermal performance of the lamp or luminaire remains within specification.

5.1.8 *Gaskets* — Many LEDs and specifically phosphor can react to different chemicals; some gaskets can out-gas chemicals that can affect the performance of some LEDs. A luminaire manufacturer should work with the LED supplier and qualify any new gasket materials

5.1.9 *Sealants* — Many LEDs and specifically phosphor can react to different chemicals; some sealants can out-gas chemicals that can affect the performance of some LEDs. A luminaire manufacturer should work with the LED supplier and qualify any new sealants materials

5.1.10 *Electrical* — Electrical overstress is now a well-known cause of catastrophic failure of LEDs. Some LEDs contain an on board Transient Voltage Suppression chip (TVS), which provides some level of protection. A well designed lamp or luminaire will feature the necessary design or protection in order to minimize damage at installation or power-up

Control Gear (Driver) For proper operation, the power supply and electronics must provide a well-controlled DC drive current and possibly other control features, and must not fail for the life of the product. Failure rate of the external control gear shall be included in the overall assessment of total life / failure rate

5.1.10.1 *Drive current* **—** Drive current affects LED operating temperature and thus life and output. Normally around 350mA is quoted but this can be higher, the higher the LED is driven the brighter it will be but it may have a shorter operation lifetime and be less efficient. Some of the new multi die led are designed to operate and perform at higher drive currents.

5.1.10.2 *Manufacturing* — There are many process variables during any manufacturing process. Experience, track record and a traceability system are a vital part of providing a user or specifier with confidence and a route to tracking any issues.

5.1.10.3 *Operational environments* — There are many different types of environments luminaires will be required to operate. Humidity can be higher in certain applications and can cause rapid degradation of materials used within the luminaire. Temperature can be higher in certain applications and can cause rapid degradation of materials used within the luminaire. The luminaire manufacturer should work with the material suppliers and qualify any new materials if the application requires operating in high humidity and/or high temperature conditions.

The reliability of the luminaire will be a combination of all of the above.

5.2 Life

5.2.1 *Lifetime Lx*— Life is the length of time during which a LED Light source, LED Module or LED Luminaire provides more than claimed percentage x of the initial luminous flux, under standard conditions. A LED product has thus reached its end of life when it no longer provides the claimed percentage of the initial luminous flux, Lx. Life is always published as combination of life at claimed lumen maintenance and failure fraction Fy, applying at the time of reaching the claimed percentage of the initial luminous flux.

There is no validated way to translate the lumen maintenance curve of an individual LED Light source into a curve for the LED Module or LED luminaire. Life testing of the LED light source is carried out according to LM-80 up to 6000h or 10000h. Beyond these values statistical predictions are made.

For general lighting applications, it is recommended to define Life as the length of time it takes an LED Module or LED Luminaire to reach (depending on the application) 90 percent or 70 percent of its initial light output (L90 or L70). For decorative lighting applications, it is recommended to define useful life as the length of time it takes to reach 50 percent of its initial output.

5.2.2 *Failure Fraction* (Fy) — This is the percentage y of a number of LED Light sources of the same type that have reached the end of their individual lives where y designates the percentage (fraction) of failures.

5.3 Measured Luminaire Data

5.3.1 *Rated Power* — Total luminaire power including drivers should be measured under standard conditions and expressed in Watts.

5.3.2 *Power Factor* — The power factor should be clearly stated in all cases. Although product standards may not require this below 5W, it should be noted that some clients, and in particular contractors and local authorities working with un-metered supplies, will require power factor correction of 0.9 or better.

5.3.3 *Rated Lumen Output* —The initial luminous flux shall be measured after thermal stabilisation of the LED luminaire.

5.3.4 *Rated Luminaire Efficacy* — Properly measured, Luminaire Efficacy combines both the light source system efficacy and luminaire efficiency, allowing for a true comparison of a luminaire regardless of the light source. Luminaire efficacy is the preferred metric for LEDs because it measures the net light output from the luminaire divided by power into the system, accounting for driver, optical, and thermal losses.

5.3.5 *Colour Temperature*— The initial colour point (x & y) of the LED and the colour temperature derived from it or bin class related to ANSI NEMA C78.377 where colour temperature values are recommended as 2700K, 3000K, 3500K, 4000K, 5000K, 6500K.

5.3.6 *Colour Rendering Index* — For the Luminaire The initial Colour Rendering Index (CRI) of a luminaire is measured. A second measurement is made after a total operation time of 25 percent of rated life (with a maximum duration of 6000 h). The measured CRI values shall not have decreased by more than 3 points from the rated CRI value for initial CRI values and 5 points from the rated CRI value for maintained CRI values.

5.3.7 *Intensity Distribution* — Applicable for luminaires which modify the distribution of the light source. Photometric data is available in two formats. Absolute Photometry does not require the use of a separate lumen output for the light source. Relative Photometry requires the LED package flux to be quoted. Both methods produce the same result. The manufacturer should state the format in which the photometric data is supplied. Absolute photometry of LED luminaires should be conducted according to IES LM-79-08 Photometric Measurements of Solid-State Lighting Products.

_Draft N_ational Lighting Code of India

Part 4 Luminaires
Section 2 Chapter I Testing and Conformance for LED Lighting
Chapter II Testing of Luminaires -Photometry, Electrical & Others

First Revision of SP 72 (Part 4/Section 2)

FOREWORD

In today's technologically advanced solid-state lighting era, adherence to testing standards and conformity is more critical than ever. In India, stringent compliance measures and regulations are now in place for LED products, attracting growing attention from all stakeholders in the lighting industry. Ensuring the safety of LED lamps and luminaires has become a mandatory legal requirement, driving a heightened awareness across the industry to produce safe, high-quality products.

Lighting quality conformity relies on accurately measuring parameters across lighting products, systems, and designs. A deep understanding of testing parameters, equipment, and conditions is crucial for implementing safety and performance standards, as well as complying with upcoming legislation. Proper data interpretation often hinges on comprehensive knowledge of the testing procedures involved.

Draft National Lighting Code of India

PART 4 LUMINAIRES
SECTION 2 CHAPTER I TESTING AND CONFORMANCE FOR LED LIGHTING CHAPTER II TESTING OF LUMINAIRES -PHOTOMETRY, ELECTRICAL & OTHERS

(First Revision)

1 SCOPE

This section of the code (Part 4/ Sec 2) covers of two chapters. Chapter I discusses Testing and Conformance for LED Lighting and Chapter II, describes the Testing of Luminaires -Photometry, Electrical & Others

Chapter I provides guidance for users in selecting appropriate LED lighting and for manufacturers in designing it correctly. It defines key aspects such as safety, performance, reliability, and outlines comprehensive testing and conformity criteria. This section covers the classification of LED lighting, detailing essential requirements including mechanical, electrical, thermal, and photobiological safety, while also offering insights into reliability and photometric standards.

To create LED lighting that is safe, reliable, and energy-efficient, it is essential that every component within the lighting system meets these standards. LED lighting products consist of four key components: the LED module, thermal management device (heat sink), control gear, and the enclosure, which includes optical and mechanical elements. A skilled lighting designer ensures that the final product meets all safety, reliability, and performance requirements. Additionally, as the luminaire is a visible part of the product, it must also meet the aesthetic and functional demands of both interior and exterior spaces.

Chapter II outlines comprehensive guidelines for testing lighting products, covering parameters, equipment, and test conditions. It includes concise descriptions of photometric, electrical, and other relevant test equipment, along with their operational methods.

2 NORMATIVE REFRENCES

IS Number	***Title***
10322(Part 1): 2014	Luminaires: Part 1 General Requirements and Tests (First Revision)
10322 (Part 5/Sec 1): 2012	Luminaires: Part 5 Particular Requirements: Sec 1 Fixed General Purpose Luminaires (First Revision)
10322 (Part 5/Sec 2): 2012	Luminaires: Part 5 Particular Requirements: Sec 2 Recessed Luminaires (First Revision)

10322 (Part 5/Sec 3): 2012	Luminaires: Part 5 Particular Requirements: Sec 3 Luminaires for Road and Street Lighting (First Revision)
10322 (Part 5/Sec 4): 1987	Specification for Luminaires: Part 5 Particular Requirements: Sec 4 Portable General Purpose Luminaires
10322 (Part 5/Sec 5): 2013	Luminaires: Part 5 Particular Requirements: Sec 5 Floodlights (First Revision)
10322 (Part 5/Sec 6): 2013	Luminaires: Part 5 Particular Requirements: Sec 6 Handlamps
10322 (Part 5/Sec 7): 2017	Luminaires: Part 5 Particular Requirements: Sec 7 Lighting Chains (First Revision)
10322 (Part 5/Sec 8): 2013	Luminaires: Part 5 Particular Requirements: Sec 8 Emergency Lighting
16105: 2012	Method of Measurement of Lumen Maintenance of Solid State Light (LED) Sources
16106: 2012	Method of Electrical and Photometric Measurements of Solid State Lighting (LED) Products
16107 (Part 1): 2012	Luminaires Performance: Part 1 General Requirement
16107 (Part 2/Sec 1): 2012	Luminaires Performance: Part 2 Particular Requirements: Sec 1 LED Luminaire
16107 (Part 2/Sec 2): 2017	Luminaries Performance Part 2 Particular Requirements Section 2 LED Street Lighting Luminarie
16102 (Part 1): 2012	Self - Ballasted led lamps for general lighting services: Part 1 safety requirements
16102 (Part 2): 2017	Self - Ballasted led lamps for general lighting services: Part 2 performance requirements (First Revision)
16108: 2012	Photobiological Safety of Lamps And Lamp Systems
16108 (Part 2): 2018	Photobiological Safety of Lamps And Lamp Systems: Part 2 Guidance On Manufacturing Requirements Relating to Non - Laser Optical Radiation Safety
16108(Part 3): 2018	Photobiological Safety of Lamps And Lamp Systems: Part 3 Guidelines For The Safe Use Of Intense Pulsed Light Source Equipment On Humans
16103 (Part 1): 2012	LED Modules for General Lighting: Part 1 Safety Requirements
16103 (Part 2): 2012	LED Modules for General Lighting: Part 2 Performance Requirements

15885 (Part 1): 2011	Safety of Lamp Controlgear: Part 1 General Requirements
15885 (Part 2/Sec 13): 2012	Safety of Lamp Controlgear: Part 2 Particular Requirements: Sec 13 D.C. or A.C. Supplied Electronic Controlgear for LED Modules
16104: 2012	D.C. or A.C. Supplied Electronic Control Gear for LED Modules - Performance Requirements
17050: 2023	Degrees of Protection Provided By Enclosures for Electrical Equipment Against External Mechanical Impacts (IK Code)
16661: 2019	Application of IS 16108/IEC 62471 for the Assessment of Blue Light Hazard to Light Sources and Luminaires
60695-2-10 : 2021	Fire Hazard Testing Part 2: Glowing Hot-Wire Based Test Methods Section 10: Glow-Wire Apparatus and Common Test Procedure
LM - 79	Electrical and Photometric Measurements of Solid-State Lighting Products
LM - 80	Measuring Lumen Maintenance of LED Light Sources

3 TERMINOLOGY

The following definitions of terms used in this section shall apply in addition to those given in Part 1 of this code.

3.1 Luminaire

Apparatus which distributes filters or transforms the light transmitted from one or more lamps and which includes, except the lamps themselves, all the parts necessary for supporting, fixing and protecting the lamps and, where necessary, circuit auxiliaries together with the means for connecting them to the electricity supply.

3.2 Design Attitude (of a Luminaire)

The attitude in which a luminaire is designed to operate as determined by reference to the manufacturer’s instructions or to common practice.

3.3 Measurement Attitude (of a Luminaire)

The attitude in which a luminaire is measured.

NOTE — If not otherwise indicated, assumed to coincide with the design attitude.

3.4 Light Centre (of a source)

Point used as origin for photometric measurements and calculations.

3.5 Photometric Centre

The point in a luminaire or lamp from which the photometric distance law operates most closely in the direction of maximum intensity.

3.6 First Axis (of a Luminaire) [Also Reference Axis]

An axis containing the photometric centre, used in photometric measurements as a reference direction to correlate the photometric measurements with the attitude of the luminaire.

3.7 Second Axis (of a Luminaire) [Also Auxiliary Axis]

An axis containing the photometric centre, perpendicular to the first (reference) axis, linked to the luminaire and used together with the first axis for defining the attitude of the luminaire.

3.8 Practical Ballast

Ballast, which is representative of the range of production ballasts appropriate to the luminaire and lamp(s) under test.

3.9 Terms Related to Measured Quantities for Luminaires

3.9.1 *Luminaire Data per 1000 lm (of Lamp Flux)*

Photometric data of a luminaire relative to a total theoretical luminous flux of 1000 lm from all the lamps of the luminaire, when these are operated outside the luminaire under reference conditions but with the same ballast(s).

3.9.2 *Luminaire Intensity Distribution (of a Luminaire)*

The distribution of luminous intensity with direction. The luminous intensity distribution may be represented by numerical tables or by graphics and is usually expressed in units of candela per 1000 lm of lamp flux.

3.9.3 *Ballast Lumen Factor (BLF)*

Ratio of the luminous flux emitted by a reference lamp when operated with a practical ballast at the rated voltage of the ballast to the luminous flux emitted by the same lamp when operated with its reference ballast.

3.9.4 *Light Output Ratio (of a Luminaire) (LOR)*

The ratio of the luminous flux of the luminaire, measured under specified practical conditions with its own lamps and equipment, to the sum of the individual luminous fluxes of the same lamps when operated outside the luminaire with the same equipment under specified conditions.

3.9.5 *Light Output Ratio Working (of a Luminaire) (LORW)*

The ratio of the luminous flux of the luminaire, measured under specified practical conditions with its own lamps and equipment, to the sum of the individual luminous fluxes of the same lamps when operated outside the luminaire under reference conditions and with reference ballast.

3.9.6 *Average Luminance*

The luminous intensity per unit projected luminous area in a given direction of a luminaire.

3.10 Terms Related to Measurements

3.10.1 *Absolute Measurement*

A measurement scale in the appropriate SI units.

3.10.2 *Relative Measurement*

A measurement obtained as a ratio of two quantities of the same type expressed in arbitrary units or a measurement in SI units relative to specified bare lamp flux.

3.10.3 *Bare Lamp Measurement*

A measurement in which a lamp is photometered separately from a luminaire in order to determine light output ratio of luminaire data per 1000 lm of lamp flux.

3.10.4 *Reference Conditions (luminaire)*

The conditions under which photometric measurements on luminaires are performed.

3.10.5 *Reference Conditions (lamp)*

The conditions under which lamp flux is measured.

3.10.6 *Reference Ballast*

Special inductive type ballast designed for the purpose of providing a comparison standard for use in testing ballasts, for selection of reference lamps and for testing regular production lamps under standardized conditions.

3.11 Terms Related to Measuring Instruments

3.11.1 *Photometer*

An Instrument for measuring photometric quantities.

3.11.2 *Goniophotometer*

Photometer for measuring the directional light distribution characteristics of sources, luminaires, media or surfaces.

3.11.3 *Photometer Head*

The part of the goniophotometer comprising the photometer itself (normally a silicon photodiode with colour filters for the spectral correction of the detector responsivity). It may also contain means for the directional evaluation of the light (for example: diffusing windows, lenses, apertures). The photometer converts the incident light into an electrical quantity.

3.11.4 *Illuminance Meter*

Photometer for the measurement of illuminance.

CHAPTER I
TESTING AND CONFORMANCE FOR LED LIGHTING

4 CLASSIFICATION

LED lighting play a vital role in addressing energy efficiency needs, as they are energy efficient and do not contain mercury like conventional fluorescent light sources do. The performance, safety, life and reliability aspects of LED chips are proven; however, these aspects are also important at the systems level.

The LED lighting classified in three categories as shown in Fig. 1

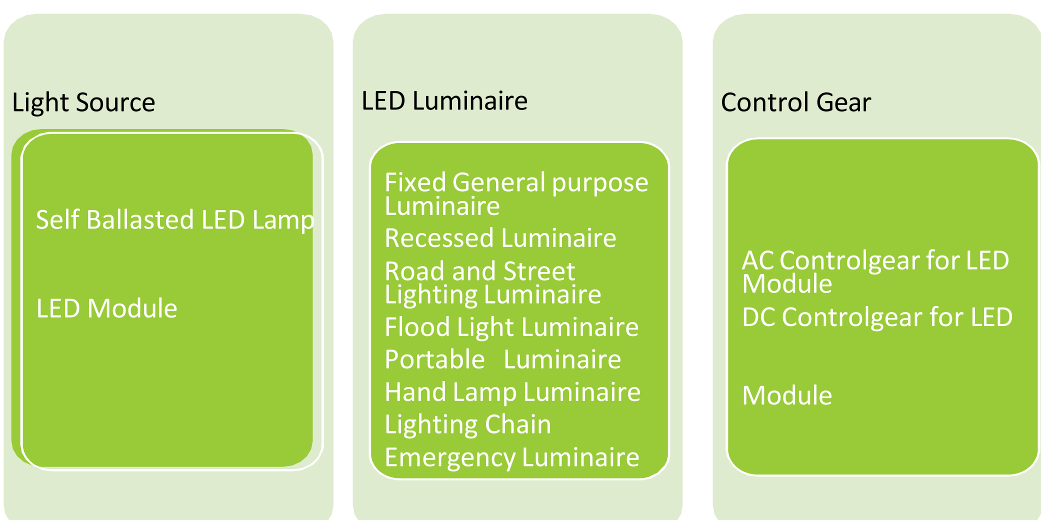


Fig. 1 LED Lighting Classification

The LED lighting has to be evaluated for the different parameters from safety , reliability and performance aspects against the applicable Indian Standard as per below Table 1

Table 1 List of Standards
(*Clause* **4**)

Sl. No. (1)	**Product** (2)	**Indian Standards** (3)	**Cover Aspects** (4)
i)	LED fixed general purpose luminaire	IS 10322 (Part 5/Sec 1), IS 10322 (Part 1)	• Electrical safety • Mechanical safety • Thermal safety • Reliability • Photometric performance
ii)	LED recessed luminaire	IS 10322 (Part 5/Sec 2) , IS 10322 (Part 1)	
iii)	LED road and street lighting luminaire	IS 10322 (Part 5/Sec 3) , IS 10322 (Part 1)	
iv)	LED portable general purpose luminaire	IS 10322 (Part 5/Sec 4) , IS 10322 (Part 1)	
v)	LED flood light luminaire	IS 10322 (Part 5/Sec 5) , IS 10322 (Part 1)	
vi)	LED hand lamp	IS 10322 (Part 5/Sec 6) , IS 10322 (Part 1)	
vii)	LED lighting chain	IS 10322 (Part 5/Sec 7) , IS 10322 (Part 1)	
viii)	LED emergency lighting luminaire	IS 10322 (Part 5/Sec 8) , IS 10322 (Part 1)	
ix)	Solid state lighting (LED) products	IS 16106	• Electrical safety , • Photometric Performance • Colorimetric parameters
x)	LED luminaire	IS 16107 (Part 2/Sec 1), IS 16107	• Reliability • Photometric performance
xi)	Self- ballasted LED lamp	IS 16102 Part 1	• Electrical safety • Mechanical safety • Thermal safety
xii)	Self- ballasted LED lamp	IS 16102 Part 2	• Performance • EMI-EMC • Reliability and life

xiii)	LED lamps and lamp systems	IS 16108, IS 16108 (Part 2), IS 16108 (Part 3)	• Photobiological safety
xiv)	LED modules for general lighting	IS 16103 (Part 1)	• Electrical safety • Mechanical safety • Thermal safety
xv)	LED modules for general lighting	IS 16103 (Part 2)	• Performance • EMI-EMC • Reliability and life
xvi)	D.C. or A.C. supplied electronic controlgear for LED modules	IS 15885 (Part 2/Sec 13), IS 15885 (Part 1)	• Electrical safety • Mechanical safety • Thermal safety
xvii)	D.C. or A.C. supplied electronic controlgear for LED modules	IS 16104	• Performance • Reliability

It is necessary to monitor the design and construction of the product for safety, reliability, durability, performance and easy maintenance. LED lighting is tested for various parameters as below:

4.1 Mechanical Requirements

LED Lighting must have the minimum mechanical strength to ensure reasonable durability, and to enhance the strength of the suspension used to mount the luminaire. Metal components must be adequately protected against corrosion and should not have any sharp edges.

4.2 Electrical Requirements

Electrical wiring of the LED Lighting should be closely monitored for safe operation. The following aspects must be addressed properly:

a) Type of insulated cable that can be used;
b) Minimum size of cables;
c) Method of connection to the supply;
d) Protection against electrical shock;
e) Minimum distance that must be maintained between live parts and adjacent metal parts; and
f) Accessories like control gear should also meet safety, reliability and performance standards

4.3 Enclosure Requirements

LED lighting for street lighting and other outdoor applications must satisfy rigorous weather-proofing requirements, and in the case of some special indoor luminaires, there must be protection against the entry of water and dust.

4.4 Thermal Requirements

Testing the thermal performance of LED lighting is crucial, as various components endure high temperatures during practical use. These tests involve placing the LED lighting in a sealed enclosure under normal operating conditions, monitoring temperature changes in different parts using a data logging system. Efficient heat management is essential, as poor performance can reduce the average luminaire output (in lumens), impacting LED lifespan. To assess LED lighting reliability, an endurance test is conducted in a draught-proof enclosure. The LED operates at 110% of its rated voltage, undergoing a seven-day 'On/Off' cycle at a specified temperature, typically ±10°C from the manufacturer's declared ambient temperature, unless stated otherwise (for example, if different from 25°C).

4.5 Marking Requirements

LED Lighting must satisfy marking requirements so that information, such as supply voltage, rated frequency, rated wattage, mounting details, etc, is readily available to the user.

4.6 Photometric and Colorimetric Requirements

To accurately evaluate the performance of LED lighting, it must meet various photometric and colorimetric requirements. These parameters are assessed using specialized equipment and reference standards

4.7 Photo-biological Requirements

The photobiological testing assesses potential optical radiation hazards, considering their impact on both the skin and eyes.

5 PARAMETERS

5.1 Electrical Parameters

These parameters are essential for understanding the electrical efficiency of LED lighting.

a) *Input power* — The amount of electrical power consumed by the LED lighting.
b) *Supply current* — The electric current supplied to the LED lighting.
c) *Supply voltage* — The voltage supplied to power the LED lighting
d) *Power factor* — A measure of how effectively electrical power is converted into useful light.
e) *Total harmonic distortion (THD)* — A measure of the distortion in the electrical waveform caused by the LED lighting's operation.

5.2 Photometric Parameters

These parameters quantify the visible light output of the LED lighting

a) *Luminous flux output* (lm) — The total amount of visible light emitted by the LED lighting, typically measured in lumens (lm).
b) *System efficacy* (lm/W) — The efficiency of the LED lighting system in converting electrical power into visible light.

5.3 Colorimetric Parameters

These parameters assess the color properties of the light produced by the LED lighting.

a) *Correlated Colour Temperature* (CCT) — Describes the color appearance of the light, typically measured in Kelvin (K).
b) *Colour Rendering Index* (CRI) — Measures the accuracy of the LED lighting in rendering colors compared to a reference light source
c) *Chromaticity coordinates* (x, y) — Defines the color point of the light in the CIE 1931 color space.
d) Luminous Intensity Distribution (Polar Curves) — These curves provide information about how light is emitted in different directions.

5.4 Photo-Biological Parameters

The photobiological testing assesses potential optical radiation hazards, considering their impact on both the skin and eyes. Here's a list of tests conducted for these biological hazards:

a) Actinic UV exposure to the skin;
b) Actinic UV exposure to the eyes;
c) UVA exposure to the eyes;
d) Retinal exposure to blue light;
e) Retinal exposure to thermal radiation;
f) Retinal exposure to thermal radiation with weak visual stimulus;
g) Infrared radiation exposure to the eyes; and
h) Thermal exposure to the skin.

To ensure the photobiological safety, reliability, and longevity of LED chips used in luminaires, they must pass the following tests:

a) Photobiological test report as per IS 16108
b) Blue light assessment as per IS 16661
c) Life test report, as per IS 16105

CHAPTER II

Testing of Luminaires -Photometry, Electrical & Others

6 PHOTOMETRIC CHARACTERISTICS

Photometric characteristics can be divided into measured characteristics that is directly measured with laboratory instruments, and derived characteristics, which can be calculated from the measured ones. The derived characteristics are more closely related to lighting applications.

7 CO-ORDINATE SYSTEMS FOR THE PHOTOMETRY OF LUMINAIRES

7.1 General Aspects

The basic photometric data of a luminaire consists of a set of values of the luminous intensity in different directions, produced by direct photometric measurements. Measurements of intensity distribution involve photometric and angular measurements (the goniophotometer), under controlled working conditions of the luminaire (electrical and temperature measurements). For such photometric measurements involving direction, it is necessary to define a spatial framework around the luminaire (the co-ordinate system).

7.2 Systems of Measurement Planes

In general, the luminous intensity of a luminaire is measured in a number of planes. From the variety of possible measurement planes three systems of planes have proven especially useful.

a) A-planes

Below Fig. 2 shows Luminaire Orientation for A, Alpha Gonio Photometry

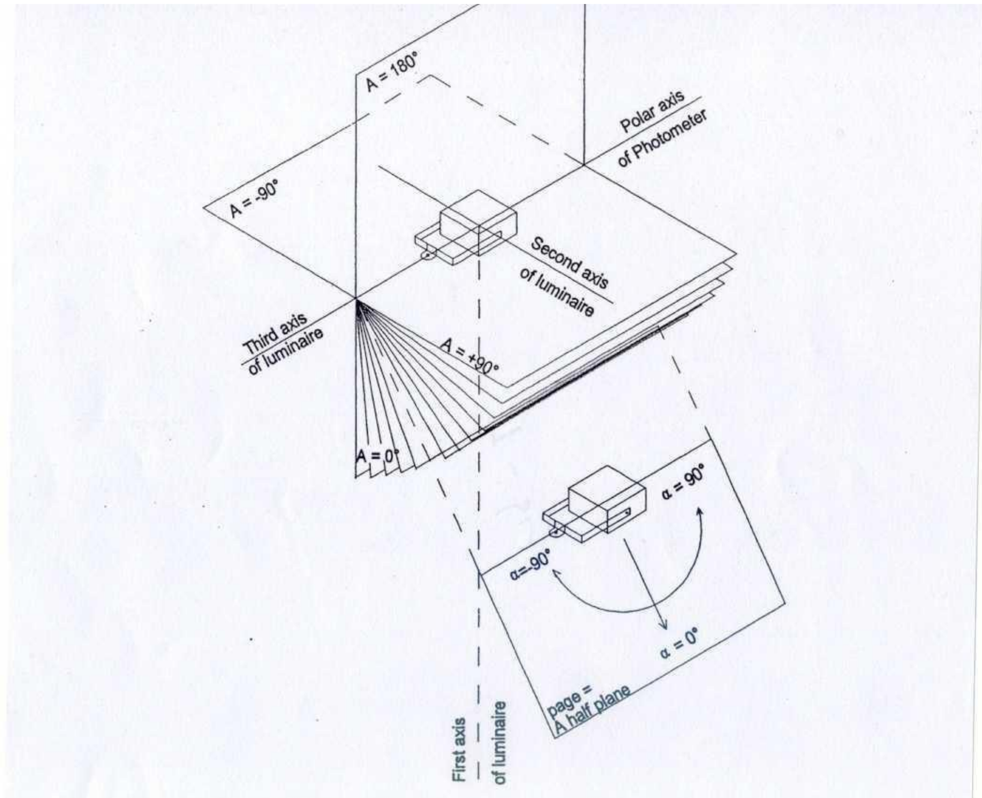


Fig.2 Luminaire Orientation for A, Alpha Gonio Photometry

The system of A-planes is a group of planes for which the line of intersection (polar axis) goes through the photometric centre and is perpendicular to the plane containing the first and the second axes of the luminaire

b) B-planes

Below Fig. 3 shows Luminaire Orientation for B, Beta Goniophotometry

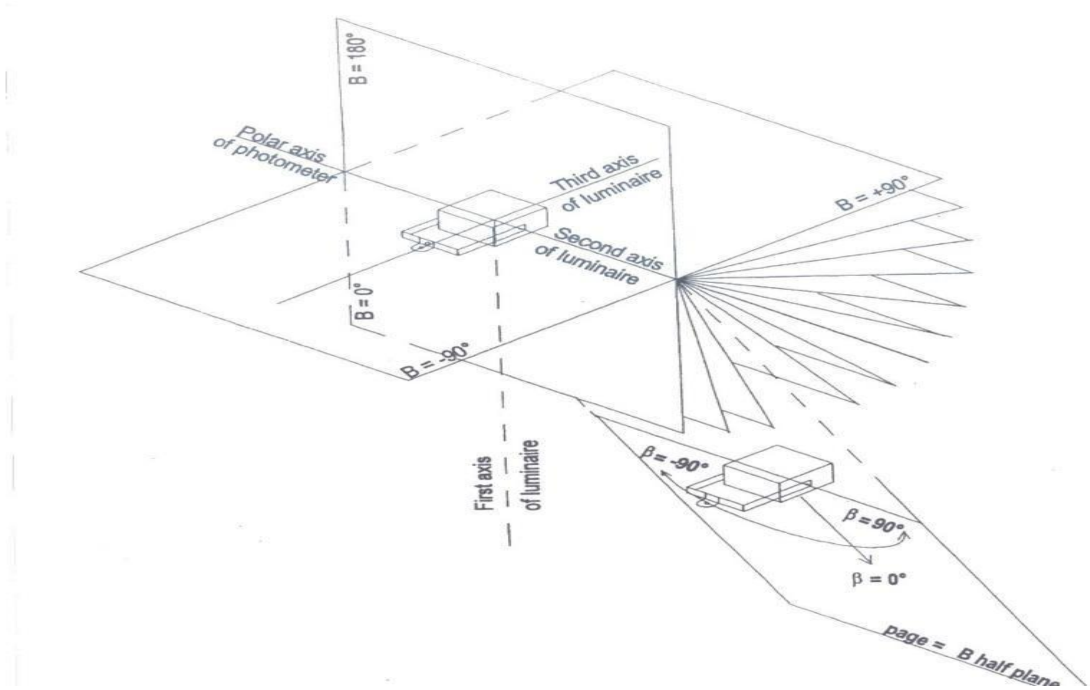


Fig. 3 Luminaire Orientation for B, Beta Goniophotometry

The system of B-planes is the group of planes for which the line of intersection (polar axis) goes through the photometric centre and is parallel to the second axis of the luminaire.

c) C-planes

Below Fig. 4 shows Luminaire Orientation for C, Gamma Goniophotometry

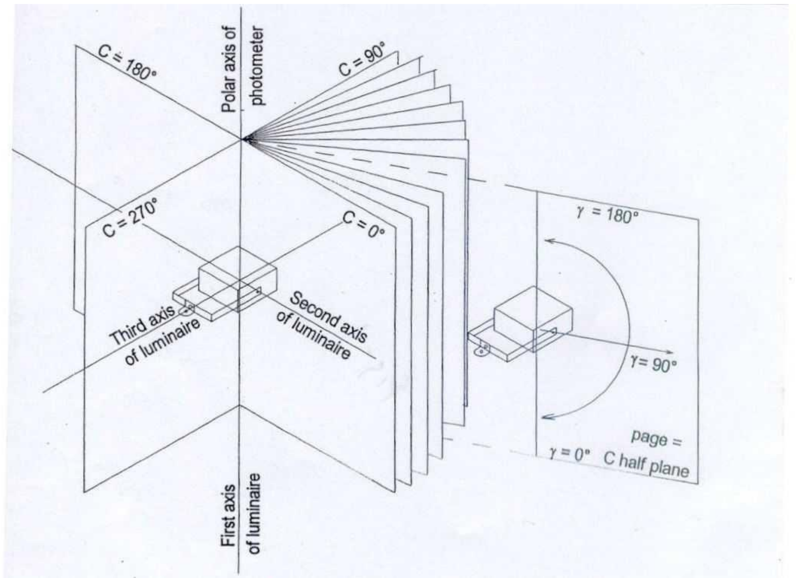


Fig. 4 Luminaire Orientation for C, Gamma Goniophotometry

8 OPTICAL PERFORMANCE

8.1 Goniophotometer

Goniophotometers (Greek word 'gonio' meaning 'directional') provide measurement of luminous intensity distribution as well as total luminous flux. Goniophotometer can measure total luminous flux of SSL products. A goniophotometer is installed in a darkroom, normally temperature controlled, and is not subject to heat accumulation from a source being measured. Care shall be taken, however, for drafts from ventilation that might affect measurement of SSL products that are sensitive to temperature. The ambient temperature must be measured and maintained Measurements with a goniophotometer are time consuming compared to a sphere photometer. Goniophotometers using broadband photopic detectors are susceptible to the spectral mismatch errors noted above. In fact, correction for spectral mismatch can be more difficult if there is significant variation in color with angle.

Goniophotometer shall be the type that maintains the burning position unchanged with respect to gravity; therefore, only Type C goniophotometer are allowable. Type C goniophotometers include moving detector goniophotometers and moving mirror goniophotometers. Care should be exercised to prevent light reflected from the mechanical structure of the goniophotometer or any other surface including secondary reflections from surfaces of the SSL product itself from reaching the photo detector. The speed of rotation of the positioning equipment should be such that it minimizes the disturbance of the thermal equilibrium of the SSL product.

Polar intensity diagrams as used in goniophotometer illustrate the distribution of luminous intensity, in candelas, for the transverse and axial planes of the luminaire.

Below Fig. 5 shows Polar Diagram

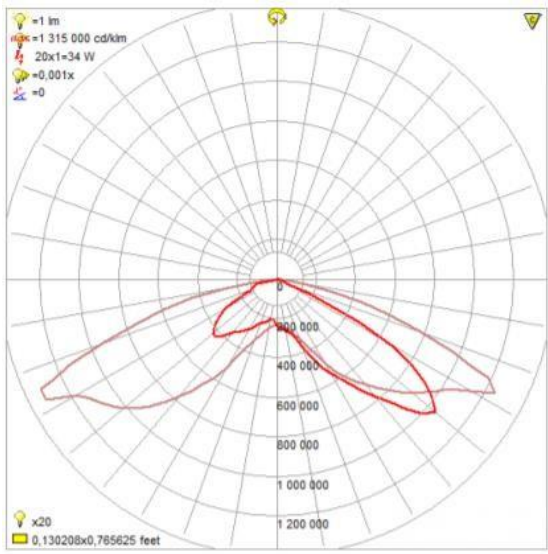


Fig. 5 Polar Diagram

8.1.1 *Test Method for C-Type Goniophotometer*

The method of goniophotometer to test total luminous flux is spectrophotometry. The principle is to test the luminous intensity of light source at different directions (or the illumination at a given distance from the light source), and then to calculate the total luminous flux by the data of luminous intensity in many different directions. According to IES LM-79 Clause 9.3.1, only type C goniophotometer with moving detector can be accepted. In this kind of goniophotometer, the photometer head is fixed, and is located in the optical axis line. During the measurement, the lamp just need to do spin motion, and the mirror rotates around the tested luminaire, and reflecting the optical signal into the detector. The tested light source and the normal of photo detector enter into a certain cone angle. Therefore, the movement airflow has less impact on the lamp temperature for this kind of goniophotometers.

During the test, the tested lamp will keep burning position and be fixed, near field detector move together with the big mirror in a line, and the far field detector will move with the big mirror synchronously. The detector will always sense the light directly from the luminaries.

8.1.1.1 *Scanning resolution*— Scanning resolution fine enough to accurately define the test sample shall be used. For typical wide-angle, smooth intensity distributions, a 22.5° lateral (horizontal) and 5° longitudinal (vertical) grids may be acceptable. Finer angle resolution (smaller test increments) shall be used where the luminous intensity from the SSL product is changing rapidly or is erratic, such as in beam forming sources.

8.1.1.2 *Angle coverage* — The range of the angular scan must cover the entire solid angle to which the SSL product emits light. A disadvantage of a goniophotometer, when measuring total luminous flux, is that a goniophotometer in general has some angular region where emission from a light source under test is blocked by its mechanism (for example, an arm for SSL product holder) so that measurement in that direction cannot be made (such angle is called dead angle). This is not a problem for SSL products that emit light only in the forward direction similar to many existing fixtures. However, this can be a problem for SSL product that emits light in all directions (for example, integrated LED lamps similar to compact fluorescent lamps). Goniophotometers with a large dead angle are not suited for total flux measurement of such SSL products.

If the dead angle is small (for example, ±10° or less), it is possible to interpolate the missing data points with an additional uncertainty. Below Fig. 6 shows block diagram & typical C type goniometer.

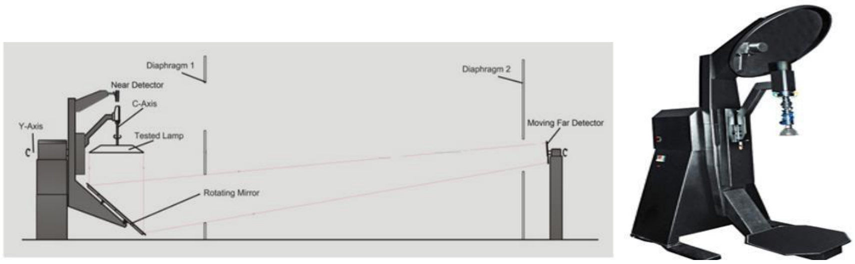


Fig. 6 Block Diagram & Typical C TYPE Goniometer

8.1.3 Following measurement can be done in Goniophotometer as described in Table 2

Table 2 Measurement Table (Electrical, Photometric and Calorimetric)
(*Clause* **8.1.3**)

Sl. No (1)	**Electrical** (2)	**Photometric** (3)	**Calorimetric** (4)
i)	Voltage	Luminous flux	Chromaticity Coordinates
ii)	Current	Luminous flux efficacy	CCT
iii)	Power	Polar Dia	CRI
iv)	Power factor	Maximum intensity	Peak wavelength
v)	Harmonics	UGR table	Color purity
vi)	-	Light distribution	Spectrum wavelength

Important points to be taken care before measurement data should be stabilized:

a) Mounting should be proper to avoid any changes in the distribution;
b) There should be a proper dark room with minimum reflection;
c) There should not be any direct air on the luminary; and
d) There should be no human intervention during the test.

8.2 Integrating Sphere

Integrating spheres (*see* Fig. 7) are hollow spherical cavities with a highly reflective and white coating that are used to measure for example the power of laser light and total luminous flux from lamps. Integrating spheres are alike cosine correctors or lenses only optics and need a detector, like a spectroradiometer, connected and calibrated to it, in order to work.

To take a measurement, a light source (the sample) is either placed in front of the sphere opening (2π) to perform an irradiance measurement or placed inside the integrating sphere (4π) to capture the entire radiant flux. In each of these measurement setups, light rays will bounce multiple times on the reflective coating to generate a homogeneous light distribution throughout the entire integrating sphere. Via a baffle, a small part of the light is reflected and captured by the detector, like a spectroradiometer.

Points to be taken care:

a) Coating inside the sphere should be proper;
b) Reflectance of the coating is > 95 percent;
c) Sphere should be properly calibrated before measurement;
d) Data should be stable before measurement;
e) Inside temperature should be maintained in specified range for the accurate reading; and
f) Sample mounting should be proper.

Below Table 3 describes integrating sphere testing capabilities.

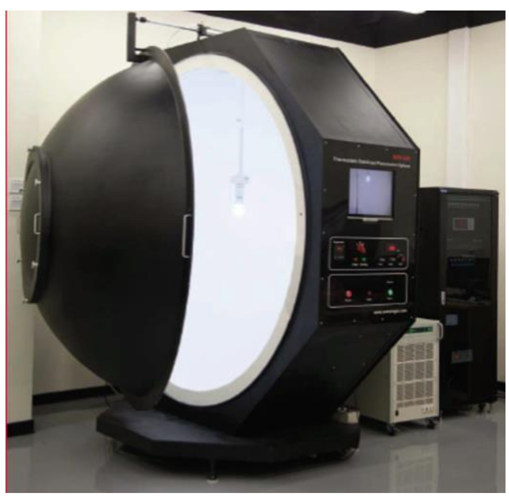


Fig.7 Integrating Sphere

Table 3 Integrating Sphere Testing Capabilities
(*Clause* **8.2**)

Sl. No (1)	**Electrical** (2)	**Photometric** (3)	**Calorimetric** (4)
i)	Voltage	Luminous flux	Chromaticity coordinates
ii)	Current	Luminous flux efficacy	CCT
iii)	Power	-	CRI
iv)	Power factor	-	Peak wavelength
v)	Harmonics	-	Color purity
vi)	-	-	Spectrum wavelength

The above mentioned measurements can be done in Goniophotometer:

9 LUX METER

Lux meter (*see* Fig. 8) is used for lighting level measurement in terms of lux. This is a simple photodetector, therefore cosine correction is very critical for accurate measurement. Some lux meters are equipped with an internal memory or data logger to record and save measurements.

Fig. 8 Luxmeter

The units that a light meter will measures in are either Lux, lumens and/or foot candle. Important applications information:

a) Instruments have to cosine correction features;
b) Regular calibration & verification of the meteris must;
c) Not to operate in an environment with gas steam or an area filled with dust;
d) Battery needs to be enough capacity; and
e) While operation one has to see that no shadow or fill light falling the detector.

10 SPECTROPHOTOMETER

A spectrophotometer is an instrument that measures the amount of light absorbed by a sample.

Below Fig. 9 shows block diagram of Spectrometer.

Most spectrophotometers are used in the UV and visible regions of the spectrum, and some of these instruments also operate into the near-infrared region as well.

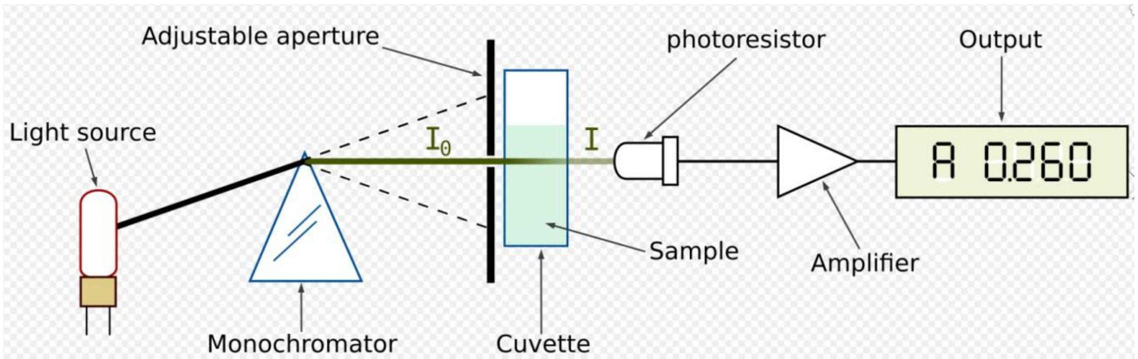


Fig. 9 Block Diagram of Spectrometer

11 LUMINANCE METER

A luminance meter (*see* Fig. 10) is a device used in photometry that can measure the luminance in a particular direction and with a particular solid angle. The simplest devices measure the luminance in a single direction while imaging luminance meters measure luminance in a way similar to the way a digital camera records color images. Below Fig. 11 shows block diagram of light measurement.

Fig. 10 Luminanace Meter

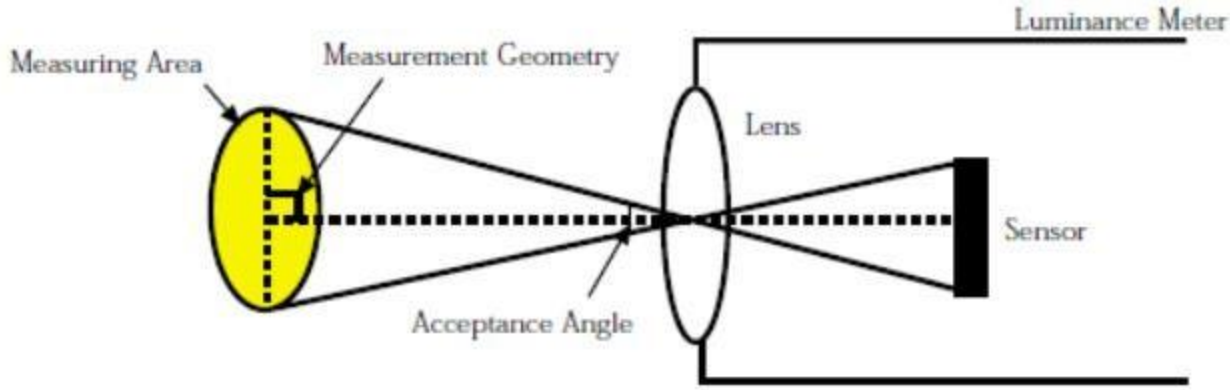


Fig. 11 Block Diagram of Light Measurement

12 COLOUR MEASUREMENT LIMIT

Below Table 4 shows limit of colour temperature.

Table 4 Limit of Colour Temperature
(*Clause* **12**)

Sl. No	**Nominal CCT Categories**		
	Nominal CCT[1)]	**Target CCT and Tolerance (K)**	**Target Duv and Tolerance**
(1)	(2)	(3)	(4)
i)	2700 K	2725 ± 145	0.000 ± 0.006
ii)	3000 K	3045 ± 175	0.000 ± 0.006
iii)	3500 K	3465 ± 245	0.000 ± 0.006
iv)	4000 K	3985 ± 275	0.001 ± 0.006
v)	4500 K	4503 ± 243	0.001 ± 0.006
vi)	5000 K	5028 ± 283	0.002 ± 0.006
vii)	5700 K	5665 ± 355	0.002 ± 0.006
viii)	6500 K	6530 ± 510	0.003 ± 0.006
ix)	Flexible CCT (2700 - 6500 K)	T[2)] ± Δ T[3)]	D_{uv}[4)] ± 0.006

13 ELECTRICAL & OTHER TEST MEASUREMENTS & EQUIPEMENTS

13.1 Electrical measurement basically taken care of product or system the power consumption, system efficacy, safety and reliability including life measurement.

13.1.1 *Insulation Resistance and Electric Strength*

The insulation resistance and the electric strength of luminaires shall be adequate as per IS 10322-1.

Insulation resistance measurement is non-destructive under normal test conditions. Carried out by applying a DC voltage with a smaller amplitude than for dielectric testing, and gives a result expressed in KΩ , MΩ , GΩ or TΩ . This resistance indicates the quality of the insulation between two conductors. Because it is non-destructive, it is particularly useful for monitoring insulation aging during the operating life of electrical equipment or installations. This measurement is performed using an insulation tester, also called a megohmmeter.

Dielectric strength testing, also called "breakdown testing", measures an insulation's ability to withstand a medium-duration voltage surge without sparkover occurring. The main purpose of this test is to ensure that the construction rules concerning leakage paths and clearances have been followed. This test is often performed by applying an AC voltage but can also be done with a DC voltage. This type of measurement requires a hipot tester. The result obtained is a voltage value usually expressed in kilovolts (kV). Dielectric testing may be destructive in the event of a fault, depending on the test levels and the available energy in the instrument. For this reason, it is reserved for type tests on new or reconditioned equipment.

13.2 Thermal Management

All electronic devices and circuitry generate excess heat and thus require thermal management to improve reliability and prevent premature failure.

13.2.1 *Test Method*

The luminaire shall be tested in a draught-proof enclosure (*see* Fig. 12) or alternative constructions for draught-proof enclosure designed to avoid excessive changes in ambient temperature.

Fig. 12 Thermal Test Chamber

The operating position shall be the thermally most onerous operating position.

Measurements shall not be taken until the luminaire has stabilized thermally, i.e. temperatures are changing at a rate less than 1 °C per hour.

Temperatures of solid materials are usually measured by means of thermocouples.

13.2.2 *Thermal Imager Camera*

A thermal imager (also known as a thermal camera) is essentially a heat sensor that can detect tiny differences in temperature. The device collects the infrared radiation from objects in the scene and creates an electronic image based on information about the temperature differences.

Thermal imager is useful at the time of development where designer can see the hot and cold surface of the luminaries. But for actual temperature we need to a proper measurement with thermocouple and proper draught proof chamber.

14 INGRESS PROTECTION

Ingress protection determines if an electrical product's exterior case or enclosure will protect the working parts from water, dust or solid object intrusion, keeping the product electrically safe and lasting longer. Ingress protection testing, or IP testing, provides a repeatable test standard to compare the enclosure protection; IP testing should always be performed at an accredited test laboratory. Below Fig. 13 shows IP Rating chart.

Fig. 13 IP Rating Chart

14.1 Important Points to be taken care before IP:

a) Check the dielectric strength test after the test;
b) Sample should be thermal stabilized before test;

c) Luminaires shall be mounted and wired as in normal use and placed in the most unfavorable position;
d) All gland and screw are tightening w.r.t standard not more than this; and
e) Entry Cable length should be sufficient.

Below Fig. 14 shows dust & rain chamber.

Fig. 14 Typical Dust & Rain Chamber

15 IK TESTING FOR LIGHTING PRODUCTS

Ratings that demonstrate the degree of Impact Protection (IK) critical for street, roadway and other lighting products. IK ratings are required in specific applications when high impact glass provides protection for the enclosed lamp. Table 5 describes the relation between IK Code and impact energy.

IS 17050 specifies the way enclosures should be tested for IK ratings which are defined as the level of protection the enclosures provided against external mechanical impacts.

Table 5 Relation between IK code and Impact Energy
(*Clause* **15**)

IK code	**IK00**	**IK01**	**IK02**	**IK03**	**IK04**	**IK05**	**IK06**	**IK07**	**IK08**	**IK09**	**IK10**
Impact energy, J	*	0.14	0.2	0.35	0.5	0.7	1	2	5	10	20
* Not protected according to this standard.											

Below Fig. 15 shows IK Test.

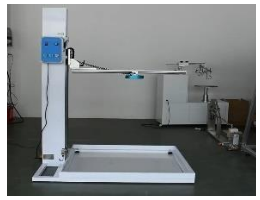


Fig. 15 Typical IK Test

16 ELECTROMAGNETIC RADIATION

16.1 Electromagnetic Interference

EMI is a disturbance that interrupts or degrades the performance of a system (the "victim" system) due to electromagnetic energy generated by an outside source. This energy is transferred to the victim system by either electromagnetic radiation or electromagnetic conduction. Conducted EMI only results from actual physical contact between the source and the victim systems. Example paths for this type of interference include transmission lines, wires, cables, and PCB traces. This type of interference can be corrected by breaking the contact between the two systems (where possible) or implementing in-line filters to block the interference signal.

16.2 Electromagnetic Compatibility (EMC) Test

Electromagnetic compatibility (EMC) lighting testing helps ensure your LED light doesn't emit excessive electromagnetic interference during use. High electromagnetic interference can disrupt or damage other electronics.

Lighting product radiate and conduct emissions shouldn't affect other products within the same environment, lighting testing or should it be affected by their emissions.

The recommended sample size for this test is five to eight units. This test should be conducted in an isolated room, or ideally, a specialized EMC lighting testing chamber.

a) Electromagnetic conducted interferences from 9kHz to 30MHz (127V and 220V)
b) Electromagnetic radiated interferences from 9kHz to 30 MHz (127V and 220V)
c) Electromagnetic radiated interferences from 30MHz to 300MHz (127V and 220V)

Below Fig. 16 shows typical flicker test & harmonic current emission set up

Fig. 16 Typical Flicker Test & Harmonic Current Emission Set Up

Below Fig. 17 shows magnetic loop antenna, line impudence, impedance stabilization network & EMI receiver

Fig. 17 Typical Magnetic Loop Antenna, Line Impudence, Impedance Stabilization Network & EMI Receiver

Below Fig. 18 shows surge, voltage dips, voltage variation test & ring wave test - generator, i phase CDN & 3 phase CDN

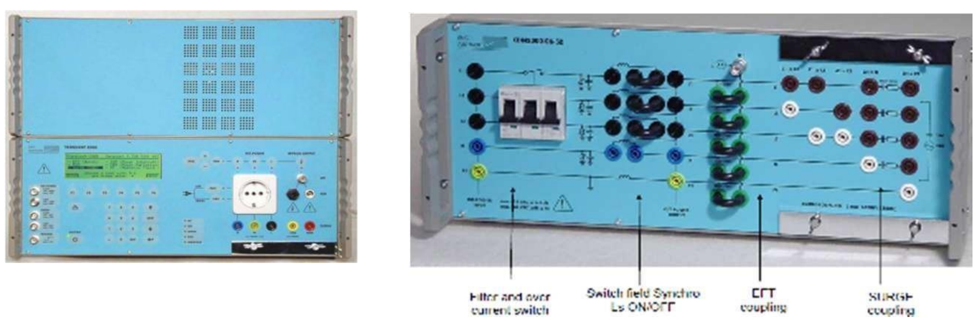


Fig. 18 Surge, Voltage Dips, Voltage Variation Test & Ring Wave Test - Generator, I Phase CDN & 3 Phase CDN

17 SURGE TEST

Outdoor lights are susceptible to transient spikes by lightning strikes that are inductively coupled onto power lines. Surges can be caused by direct lightning, indirect lightning or switching OFF/ON of mains supply.

Besides surges, if HV line touches LV line or if neutral connection is weak or floating the phase-Neutral voltages can go higher than prescribed limits of luminaire. Surge voltage transients can destroy LED power supplies as well as the LED's themselves.

Due to the sensitive nature of LED lights, It is needed to provide over voltage, over current, surge protection for LED lighting systems, the most common type of surge protector contains a component called a metal oxide varistor or MOV, which diverts the extra voltage & energy away from the device it is protecting. In case of LED lights, it will protect LED driver or LED itself.

17.1 Significance of Surge test

Surge protector is used to protect luminaries from Lightening or electrical storms.

17.2 The Working Principle of Surge Protectors

Our surge protector devices consist of well-designed assemblies of electronic components, including MOV.

Connected at the very first stage of the luminaire's power input, the SPD will get the hit first and react rapidly.

MOVs inside the SPD made up of a ceramic mass of zinc oxide grain packed between two metal plates will start digging and eliminating the surge energy.

18 GLOW WIRE TEST

This test method is generally used for testing the solid insulating materials for fire hazards testing. Covered in BIS standards for all safety of all lighting products also primarily as a guideline from IS/IEC 60695-2-10.

A nickel/chromium wire is heated to 650°centigrade and insulating materials is pushed against it with a force of 1 newton. It is checked that the insulating materials does not attain certain temperature or catches fire so as to prevent fire hazards in its vicinity. Below Fig. 19 shows glow wire test set up.

Fig. 19 Glow Wire Test Set Up

19 MECHANICAL TEST

Following tools & equipment are used to conduct the various mechanical test.

Accessibility probe, Force tester, impact ball, force tester, impulse generator as shown in Fig. 20.

Fig. 20 Typical Mechanical Test Tools and Equipment

20 HUMIDITY TEST

The purpose of humidity chamber (*see* Fig. 21) is to test the influence of varying environments on products to determine the length of their usefulness and what point they will fall. The collected data assist engineers in adjusting their designs and selecting more resilience materials. Aso product validation of third party test it gives the compliance of the product as per specification given in the tender.

A humidity chamber is creating the different environments preciously the specific temperature and humidity condition for doing the test at that condition. Test condition may be static or dynamic as required so accordingly the times to given as per different standards requirement. It may be spread over weeks to months.

Fig. 21 Typical Humidity Chamber

21 LIFE TEST RACK

Fig. 22 Typical Life Test Rack for Lamps

This is a very critical test set up for the evaluation of life the lamp and even lighting system. The following features need to be made in the testing rack:

a) That needs to be fully automized life test racks for getting right result;
b) Individual lamp is monitor throughout its life during testing in the life test and actual life of lamp is capture in case of failure;
c) The monitoring of life test area and report generation is customized as per standards need; and
d) The racks operate under the controlled electrical power supply (voltage, frequency) on UPS and controlled environmental conditions specified in the standards.