UNIT2:

LIGHTING

Existing Systems

The existing lighting systems consists of single and double florescent lighting units mounted within a suspended ceiling grid. In some locations lighting level (Lux) readings are as low as 115 Lux, close to the limits of acceptability. It is certainly less than ideal in relation to the following factors:

1. **Lamp Maintenance factor:**

   The florescent tubes have a life expectancy of 5000 hours however their output decreases as they age by up to 50% within the first year. Fluorescent tubes should be changed every year.

2. **Flicker:**

   Some fluorescent tubes can flicker noticeably and produce an uneven light that may have a strobe light effect and will bother some users. Once the flicking becomes obvious to the eye, there is no choice but to replace the lamp. They also generate some background noise and are some users can be sensitive to this. In addition the overall Lux(illumination) levels are quite low and thus lighters and/or desk lamps are used to supplement the light levels delivered at the working plane. This adds to the overall electricity usage and costs.

3. **Light Distribution and Uniformity:**

   The current diffusers in the lighting units are "CATII type" and were initially designed to be used to reduce lighting reflection on monitor screens. Unfortunately this style of fluorescent light diffuser panel can produce a gloomy environment if used on its own and reduces the light distribution and uniformity.

   These diffusers are open and hence dirt collects on the diffuser and lamp, which also reduces the effectiveness of the lamp.

4. **Current lamp efficiency:**

   The current lighting units mainly consist of single and/or double 1500mm long "T8" 58 watt fluorescent tubes. Due to the power units and chokes required to drive the lighting units, the light fittings actually rate as 70watts each.

Criteria for Proposed Replacement units

1. Extensive research has been carried out by Property Services to find a suitable Light-emitting diode lamps (LED) lighting unit to replace the current lights within the Whit field Office complex.
2. To warrant replacement on the scale proposed on economic grounds it is necessary for the scheme to have a payback period of between 5 and 10 years. For such a pay-back period to be feasible it was necessary for any proposed new lighting units to be:
    (i) Purchased a minimum cost.
    (ii) Improve light output at the working plane but at a significant energy saving.
    (iii) Simple to install so that they could be installed by Civic Wardens with minimum disruption to staff.
    (iv) Capable of installation without the need to carry out modification to the existing wiring circuitry.
    (v) Capable of installation without the need to modify the ceiling grid.
    (vi) Provide an even distribution and uniform light at the working plane.
    (vii) Reduce lighting unit life costs (maintenance)

Trials have been undertaken within the Council's Offices using "off the shelf lighting units obtained from leading lighting manufactures and suppliers. These manufactures also supplied feasibility schemes together with costings, which were considered to determine the most appropriate lighting unit and manufacturer.

DEFINITIONS

PLANE ANGLE: An angle formed by two straight lines in the same plane.

SOLIDANGLE: An angle having a value equal to the area on a sphere subtended by a surface, divided by the square of the radius of that sphere. Solid angles are measured in steradians.

LIGHT: Radiant energy in form of waves which produces a sensation of vision upon the human eye.

LUMINOUS FLUX: It is defined as the energy in the form of light waves radiated per second from a luminous body. Its unit is lumen. It is denoted by $\emptyset = \frac{Q}{t}$

LUMEN: Luminous flux emitted by a source of one candle power in a unit solid angle.

ILLUMINATION OR LUMINANCE: Luminous flux falling on unit area. Unit is lumens/m^2 or lux. The british unit is lm/ft^2 or foot candle (fc).

LUX: Luminous flux per unit area. It is equal to one lumen per square metre.

LUMINOUS INTENSITY: It is the light emitting power of the lamp. The luminous flux emitted per unit solid angle.

CANDLE POWER: Number of lumens emitted by the source per unit solid angle in a given direction.

(Or)

The luminous intensity of a standard candle of surface area 1/6000,000 m^2 at the temperature of freezing platinum under a pressure of 101325 N/ m^2 in a perpendicular direction is one candla.

LUMINOUS EFFICIENCY: It is the ratio of energy radiated as light to the total energy radiated.

Luminaire: Luminaire is a device that distributes filters or transforms the light emitted from one or more lamps. The luminaire includes, all the parts necessary for fixing and protecting the lamps, except the lamps themselves. In some cases, luminaires also include the necessary circuit auxiliaries, together with the means for connecting them to the electric supply. The basic physical principles used in optical luminaire are reflection, absorption, transmission and refraction.

Ballast: A current limiting device, to counter negative resistance characteristics of any discharge lamps. In case of fluorescent lamps, it aids the initial voltage build-up, required for starting.

Ignitors: These are used for starting high intensity Metal Halide and Sodium vapour lamps.

Illuminance: This is the quotient of the illuminous flux incident on an element of the surface at a point of surface containing the point, by the area of that element. The lighting level produced by a lighting installation is usually qualified by the illuminance produced on a specified plane. In most cases, this plane is the major plane of the tasks in the interior and is commonly called the working plane. The illuminance provided by an installation affects both the performance of the tasks and the appearance of the space.

Luminous Efficacy (lm/W):

This is the ratio of luminous flux emitted by a lamp to the power consumed by the lamp. It is a reflection of efficiency of energy conversion from electricity to light form.

Color Rendering Index (RI): Is a measure of the degree to which the colours of surfaces illuminated by a given light source confirm to those of the same surfaces under a reference illuminent; suitable allowance having been made for the state of Chromatic adaptation

SPACE-HEIGHT RATIO: Ratio of horizontal distance between the adjacent lamps and height of their mountings. The space-height ratio should be taken up as 1.5 to get proper distribution of light below the lamp on the working plane.

DEPRECIATION FACTOR: It gives a measure of reduction in the light output after the lamps have deteriorated and the fittings have become dirty. Depreciation factor is used because an installation gives only a fraction of the illumination it would give when perfectly clean.

MAINTENANCE FACTOR: It is the inverse of the depreciation factor.

COEFFICIENT OF UTILIZATION OR UTILIZATION FACTOR: This factor gives a measure of the losses. The losses may be due to absorption of light by walls, floor, ceiling, equipment, furniture, etc.

REFLECTION FACTOR: It is the ratio of the reflected light to the incident light.

BEAM FACTOR: It is the ratio of lumens in the form of a projection to the lamp lumens. It takes into consideration the absorption of light by reflectors and front glass of the lamp. It lies between 0.3 and 0.6

MEAN SPHERICAL CANDLE POWER (MSCP): It is the average of the candle powers in all directions in all planes, given by MSCP= Total luminous flux in lumens/4π

MEAN HEMISPHERICAL CANDLE POWER (MHSCP): It is the average of the candle powers in all directions in all planes, given by MHSCP= Total luminous flux in lumens/2π

MEAN HORIZONTAL CANDLE POWER (MHCP): It is the average of the candle powers in all directions on horizontal plane which passes through the source.

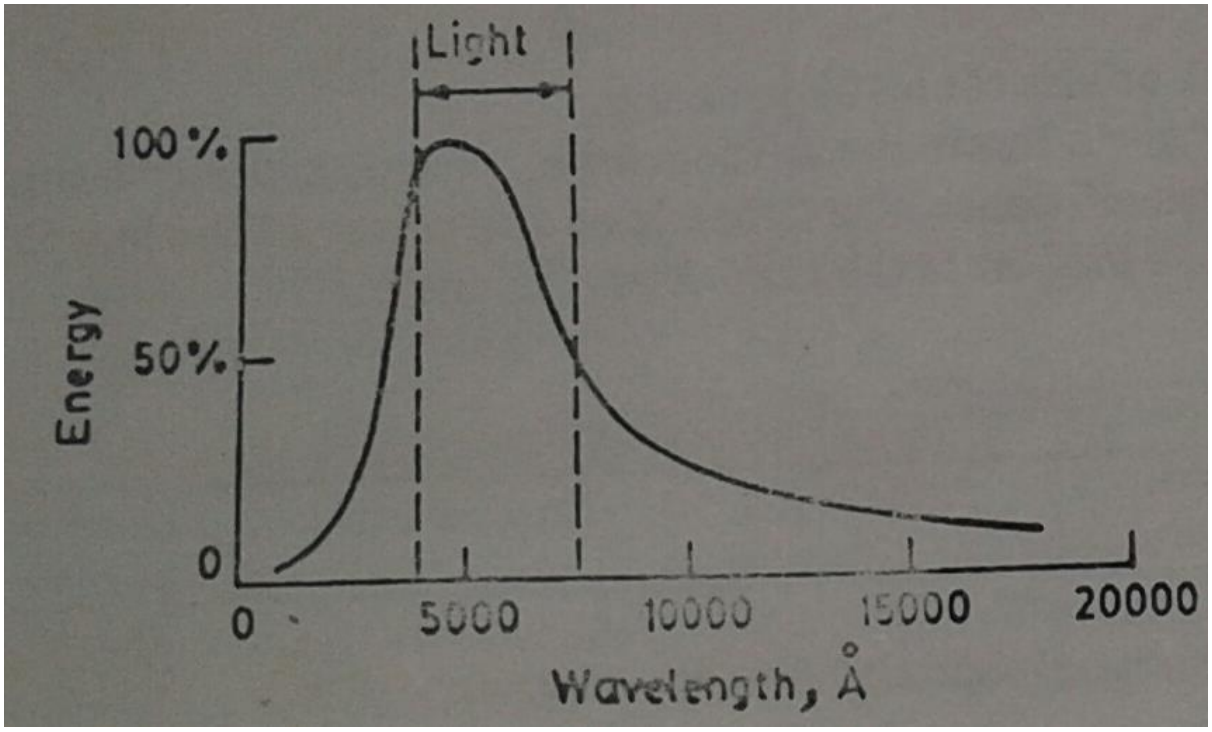
$$\text{Ruction factor} = \frac{MSCP}{MHCP}$$

$$\text{Lumens required from lamps} = \frac{lumens\ on\ working\ plane}{utilization\ factor * maintenance\ factor}$$

GLARE: If the eye is exposed to a very bright source of light, the pupil or opening of the eye contracts in order to reduce the amount of light admitted and prevents the damage of the retina. This reduces the sensitivity of the eye to see perfectly other objects within the field of the vision. This phenomenon is glare.

LUMINOUS EFFICIENCY

As shown in fig known as spectral distribution curve, suppose E_λ is the energy radiated on a wavelength of λ,and the sensitivity of the eye to colour at this wavelength is K_λ,then the energy content of the waves between λ and $\lambda + \mathrm{d}\lambda$ is $E_\lambda \, \mathrm{d}\lambda$, where $\mathrm{d}\lambda$ where is an infinitesimal increment in the wavelength. The visual effect of this energy will be 670 $K_\lambda \, E_\lambda \, \mathrm{d}\lambda$.



Integrating between two finite wavelength, λ_1 and, λ_2 the visual effect will be

$$670 \int_{\lambda_1}^{\lambda_2} \mathrm{K}_\lambda E_\lambda d\lambda \ \mathrm{lm}$$

The total energy radiated by all wavelengths of light is the energy input to the lamp.

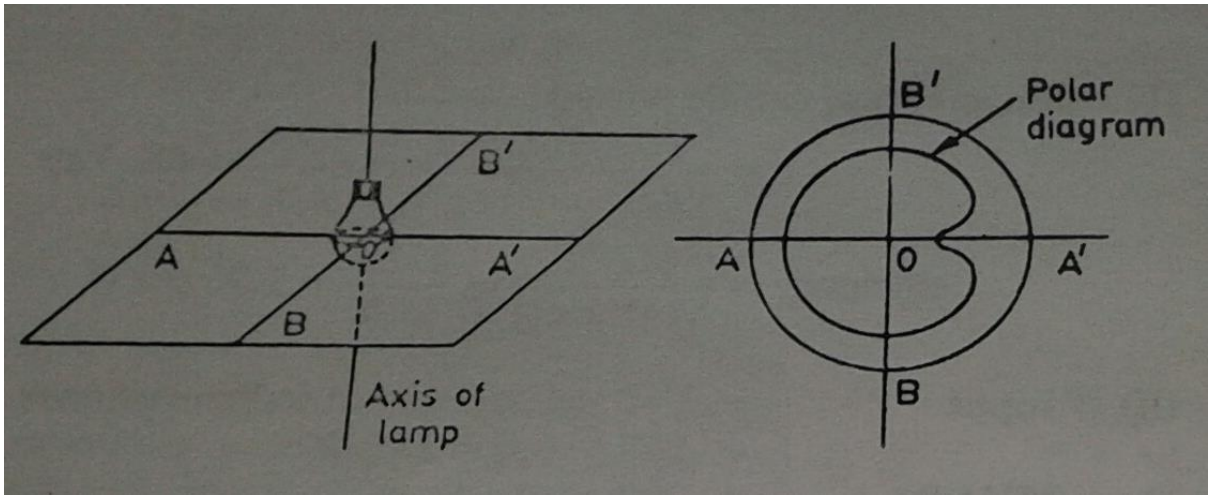
$$\int_0^\infty E_\lambda d\lambda \, \mathrm{Ws}$$

Therefore luminous efficiency of a source of light is defined as

$$\eta_{luminous} = (670 \int_{\lambda_1}^{\lambda_2} K_\lambda E_\lambda d\lambda)/(\int_0^\infty E_\lambda d\lambda)$$

Polar Curve

In most lamps the luminous intensity is not the same in all directions. Suppose that the lamp is held with its vertical and the luminous intensity is measured in all directions on a horizontal plane, through the lamp. The curve of intensity in candle power against direction is plotted as shown in Fig, which shows the horizontal polar curve of a gas-filled lamp with a horizontal circular element. The drop in candle power along OA' is due to the break in the ring where the current enters and leaves. The sensitivity of the eye to color at this wavelength is mean of the candle power in this curve gives the mean horizontal candle power (MHCP), and is found by taking the moan at the angular positions, 0, 10°, 20°, ... 350°. The luminous intensity (or candle power) in any given direction is measured by the Bunsen Photometer.



The mean spherical candle-power (MSCP) is **the mean of the candle power in** all directions radiating from the lamp, and is the **total flux divided by 4∏.** It would be very difficult to measure the **candle power** in all directions and take the mean.

Reduction factor=MSCP/MHCP

Calculation of illumination level

The illumination at a point on a surface is defined as the luminous flux per unit area at that point, the value being expressed as lumens per square meter or lumens per square foot. An illumination of 1 lm/m^2.

Suppose that a standard candle power of I *cd* is situated at O and the narrow cone is along the horizontal direction, so that the luminous flux in this cone of solid angle S is S*I lumens. The luminous intensity at any point on the cone is SI lumens per S steredians, or I lumens per steradian. The illumination at any point of the cone, at a distance *r* from O is

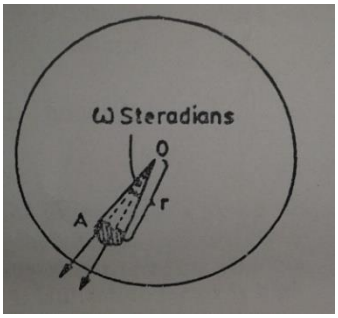


Fig. Solid angle

$$E = \frac{SI}{area} lm/area$$

Since the solid angle is *S*, the area a= Sr^2, so that the illumination is

$$E = \frac{SI}{Sr^2} = \frac{I}{r^2} lm/area$$

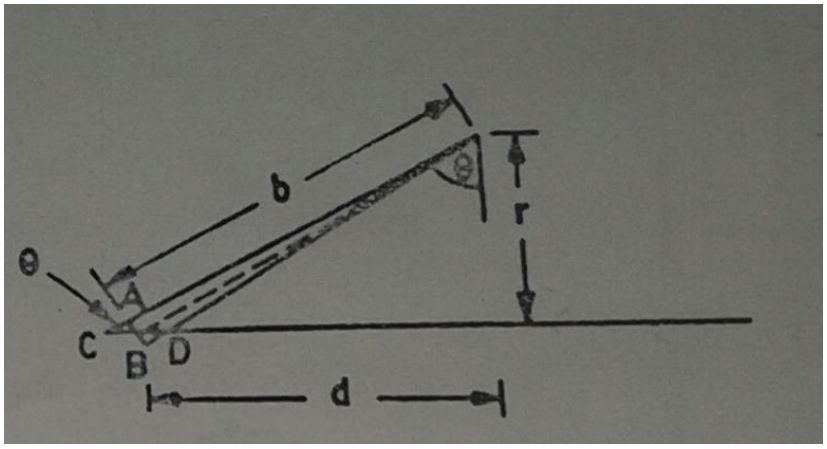
The illumination is $\frac{I}{r^2}$ lux if *r* is in metres or $\frac{I}{r^2}$ fc if *r* is in feet. Thus, the illumination varies as the inverse square of the distance from the diverging source, but the luminous intensity is constant along a fixed direction. This it is known as the inverse square law and is widely used in calculation of illumination.

Illumination of an Inclined Surface to Beam

In the previous section it was assumed that the surface upon which light was falling was at right angles to the axis of the beam, but in practice this is not usually the case,and the

conditions are then as shown in fig.. If a small element of the beam inclined at an angle to the vertical is considered, the illumination on a surface, such as AB at right angles to the beam axis can easily be calculated from

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



If, however, we consider the horizontal surface CD, it is evident that the total number of lumens falling on this is the same as on AB. It can be seen, however, that the area of this surface CD will be equal to area of AB/cos θ

Let the area of AB=$a=Sb^2$

Where S=solid angle subtended by AB at 0

Area of CD=a/cos $\theta = Sb^2/\cos\theta$

Lumens emitted by source of candle power I is SI

Therefore, illumination becomes

$$E = \frac{SI}{Sb^2/\cos\theta} = \frac{I}{b^2}\cos\theta$$

Since b can be expressed as

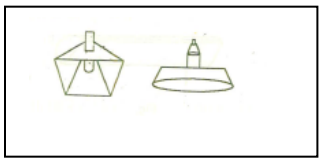
$$b = r/\cos\theta$$

where r=height of O above the plane

$$E = \frac{I}{r^2}\cos^3\theta$$

TYPES OF LIGHTING SCHEMES:

1. Direct Lighting:

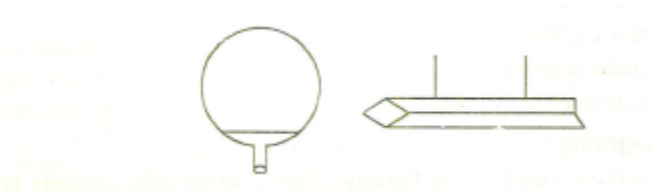


- The light falls directly on the object to be illuminated.
- It is most efficient but causes hard shadows and glare.
- The possibilities which will glare on eyes have to be eliminated while designing.
- A correct size of lamp with suitable fitting should be selected.
- The fittings are should to be cleaned regularly as the dirt if accumulated will decrease the luminous intensity.
- It is used for industrial and general outdoor lighting.

2. Indirect Lighting
   - The light does not fall directly on the object.
   - Light is thrown to the ceiling for diffuse reflection from where it reaches the object.
   - The ceiling acts as the light source and the glare is to minimum.
   - The resulting illumination is softer and more diffused the shadows are less promiinent and the appearance of room is much improved as compared to direct lighting.
   - The requirement of the light is usually more than direct lighting.
   - It is used for decoration of purposes in cinemas theatres, hotels etc

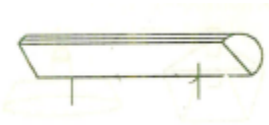


3. Semi - Direct Lighting :
   - 60% of the light is directed down wards and 40% projected upwards
   - It is suitable to rooms with high ceilings where high level of uniformly distributed illumination is desirable.
   - Glare can be avoided by employing diffusing globes
   - They improve the brightness towards the eye and efficiency of the system



4. Semi Indirect Lighting :
   - 60 to 90% of total light flux is thrown upwards to the cieling for diffuse reflection and the rest i.e. 40 to 10% reaches the working plane directly.

- It gives soft shadows and it is glare free.
- It is used for indoor light purposes.



5. General Lighting:
    - It produces equal illumination in all directions.
    - It gives soft light with little shadows.
    - Since quite large amount of light reach objects after reflection from walls and ceiling, room decoration should be in light colours and kept in good condition.
    - The mounting height should be much above eye level to avoid glare.

TYPES OF LAMPS

Incandescent Lamps

- Incandescent bulbs are the original form of electric lighting and have been in use for over 100 years.
- They are made in an extremely wide range of sizes, wattages, and voltages.
- Works on the principle of incandescence which is the emission of light caused by heating the filament
- An incandescent bulb consists of a glass enclosure containing a tungsten filament.
- An electric current passes through the filament, heating it to a temperature that produces light.
- They contain a stem or glass mount attached to the bulb's base which allows the electrical contacts to run through the envelope without gas/air leaks.
- Small wires embedded in the stem support the filament and/or its lead wires.
- The enclosing glass enclosure contains either a vacuum or an inert gas to preserve and protect the filament from evaporating.

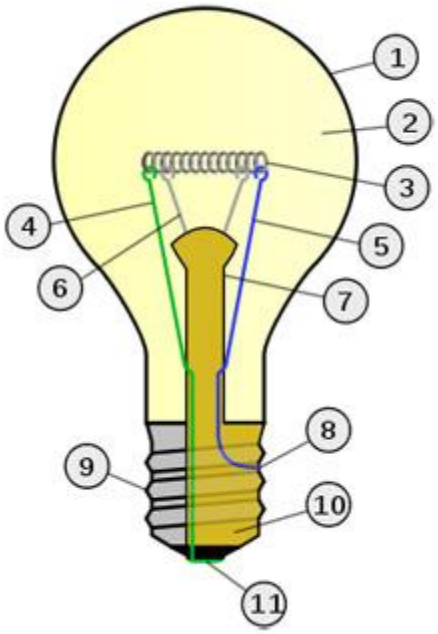


Diagram showing the major parts of a modern incandescent light bulb.

1. Glass bulb
2. Inert gas
3. Tungsten filament
4. Contact wire (goes to foot)
5. Contact wire (goes to base)
6. Support wires
7. Glass mount/support
8. Base contact wire
9. Screw threads
10. Insulation
11. Electrical foot contact

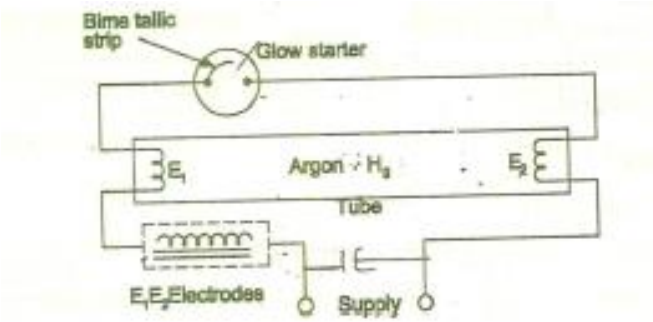
Incandescent bulbs require no external regulating equipment, have a very low manufacturing cost, and work well on either alternating current or direct current. They are also compatible with control devices such as dimmers, timers, and photo sensors, and can be used both indoors and outdoors. As a result, the incandescent lamp is widely used both in household and commercial lighting, for portable lighting such as table lamps, car headlamps, and flashlights, and for decorative and advertising lighting.

FLUORESCENT LAMP

These lamps are hot cathode low pressure mercury vapour lamp and are manufactured in form of long glass tubes.

Construction:

- It consists of tube with two electrodes. They are coated with electron emissive material.
- It contains a small quantity of argon gas at a pressure of 2.5 mm of mercury and a few drops of mercury.
- The inside surface of the tube is coated with a thin layer of fluorescent powder material known as phosphor. The phosphor used for coating depends upon the color required.
- A starter is present in the circuit. It connects the electrodes directly across the supply at the time all starting.
- A choke is connected in series with the electrodes. It provides a voltage impulse at the time of starting and acts as ballast during running.



Working:

- When the supply is given, the full voltage appears across starter terminals as the resistance of the electrodes is very less.
- As the starter is filled with argon gas, it ionises and glow appears inside the starter. So the bimetallic strip in the starter is heated up and short circuits the starter. So maximum current flows through the electrodes and choke.
- Due to flow of current, the electrodes get heated up and start emitting electrons. Gradually, the potential across the starter falls to zero and cools down bimetallic strip resulting in the opening of starter terminals.
- This sudden opening of the starter terminals results in abrupt change of current (di/dt) in choke.

- Since electrons are already present in the discharge tube, this induced voltage is sufficient to breakdown the long gap thus resulting in the flow of electrons between the electrodes.
- The electrons while accelerating, collide with argon and mercury vapour atoms. The excited atoms of mercury give UV radiation.
- If this radiation is made to strike with phosphor material it produces re-emission of light radiation of different wavelength and results illumination. This phenomenon of re-emission is called flourescence and hence it is named as fluorescent tube.
- The average life of fluorescent lamp is 4000 - 5000 hours and its efficiency is about 40 lumen/watt. These lamps operate at low p.f. hence capacitor should be used.

Advantages:

- High luminous efficiency
- Long life
- Low running cost
- Low glare level
- Less heat output

Disadvantages:

- Stroboscopic effect
- Small wattage requiring large number of fittings.
- Magnetic hum associated with the choke causing disturbance

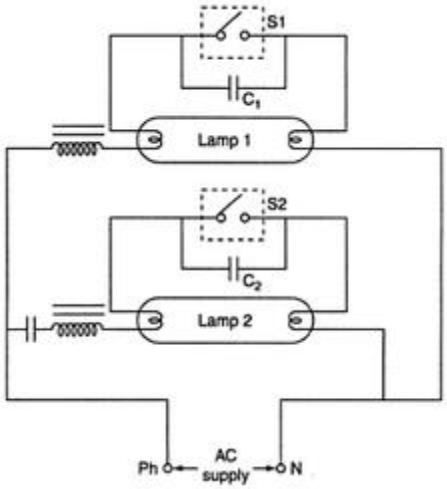
Stroboscopic effect:

Fluorescent lamps are provided with 50Hz or 60Hz ac current supply. When operating under the frequencies the lamp crosses zero wave double the supply frequency, i.e, 100 times for 50Hz frequency and 120 times for 60Hz frequency per second. Due to the persistence of vision our eyes do not notice them. However if the light falls on the moving parts due to illusion, they may appear to be either running slow, or in reverse direction or even may appear stationary. This effect is called "Stroboscopic effect".

Methods to Avoid:

This pattern of illusions is not allowed in industries as this may lead to accidents. This is the main reasons Fluorescent lamps are not preferred in industries. However this effect can be avoided by:

- If the industry is supplied with three phase supply, adjacent lamps should be fed with different phase so that the zero instants of the two lamps will not be same.
- If single phase supply is only available, then connection of two adjacent lamps are made such that the two lamps are connected in parallel with the supply and in one lamp connection a capacitor or condenser is kept in series with the choke. This makes a phase shift thereby eliminating stroboscopic effect



SODIUM VAPOUR LAMPS

A sodium-vapor lamp is a gas-discharge lamp that uses sodium in an excited state to produce light. A sodium vapour lamp is also a cold cathode low pressure lamp which gives luminous output about three times higher other lamps.

Construction:

- It consists of an inner tube made of special glass to withstand high temperature of electric discharge.
- It consists of two electrodes connected to a pin type base.
- The tube is filled with sodium and a small amount of neon at a pressure of 10 mm of Hg.

- Neon helps to start the discharge and the heat developed helps to vaporize sodium.
- The lamp operates at 300 °C. Any change in the operating temperature will affect the light given by the lamp. So the U-shaped tube is enclosed in an outer double walled glass tube.
- Before sealing the lamp, vacuum is created between the double walled glass tubes.

Working:

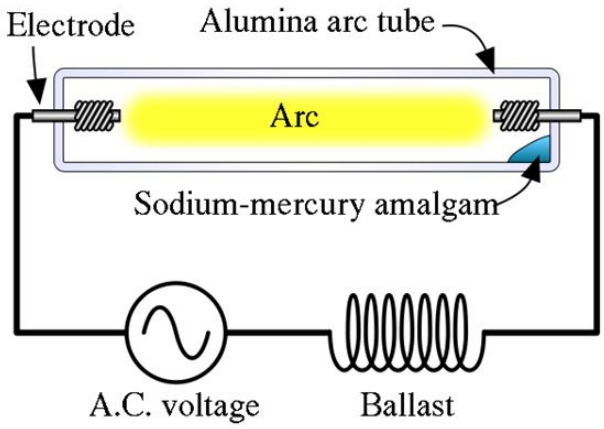
- When supply is given, the discharge is initiated through neon gas which produces reddish light.
- When cold sodium is in solid state and hence the lamp cannot be started as sodium vapour lamp.
- After sometime as the temperature gradually increases due to the discharge by neon gass, the solid sodium turns into vapour giving yellowish light.
- If switched off, it can be restarted immediately.
- The luminous efficiency of lamp is 40-50 lumen/watt. The life is approximately 3000 hours

Advantages:

- Most of the radiation is on visible region hence the efficiency is good.
- Excitation level is achieved with low voltage and requires less energy compared to other vapors.

Disadvantages:

- It gives monochromatic orange-yellow light which makes the object appear as grey.



High Pressure Mercury Vapour lamps

It is a hot cathode (filament is used to heat the electrode) gas discharge lamp.

Construction:

- It consists of two main electrodes of tungsten coated with barium oxide enclosed in hard glass tube made of borosilicate or quartz.
- There is an auxiliary starting electrode near one of the main electrode and the tube contains argon gas at low pressure and some mercury.
- The inner tube or bulb is enclosed in another glass bulb and space between the two tubes or bulbs is either partially or completely filled with vacuum prevent heat loss.
- The lamp has a screwed cap and is connected to choke coil having different tappings in series with lamp to give high starting voltage for discharge and controlling the current and voltage across the lamp after discharge.
- The p.f of the circuit is low due to choke coil. It can be improved by installing a condenser parallel to supply line.

Working:

- When the supply is given, the current does not flow through main electrodes due to high resistance of the gas.

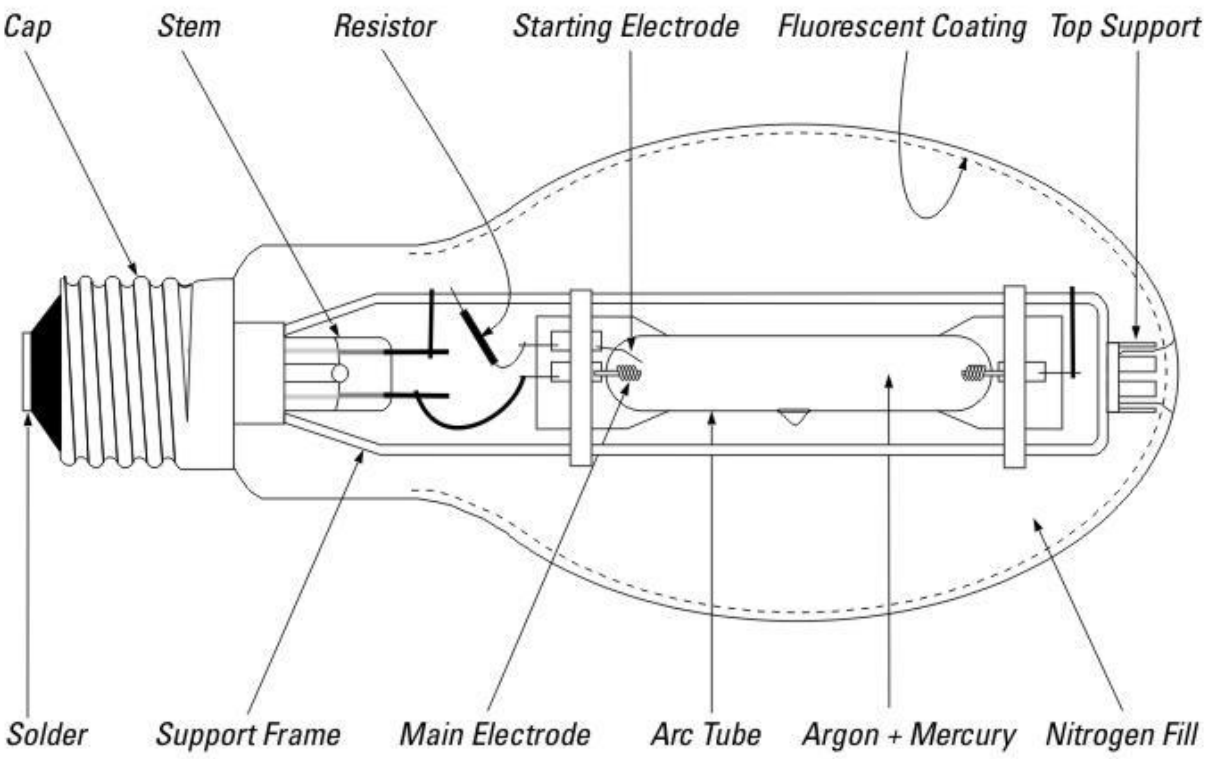
- The current starts to flow between the main electrode and auxiliary electrode through argon gas.
- The heat thus produced vaporize mercury which reduces the resistance between the electrodes.
- Due to low resistance ionised path between two main electrodes the discharge shifts from auxiliary electrode circuit to main electrodes.
- Mercury vapor lamp gives 2.5 times higher light than incandescent lamp for same power consumption.
- The life is approximately 3000 hrs and it gives illumination bluish color.
- The efficiency of the lamp is 35-40 lumens per watt are specially used for high way lighting, park lighting etc.

Advantages:

- The life of mercury vapor lamp is much higher than incandescent lamp.

Disadvantages:

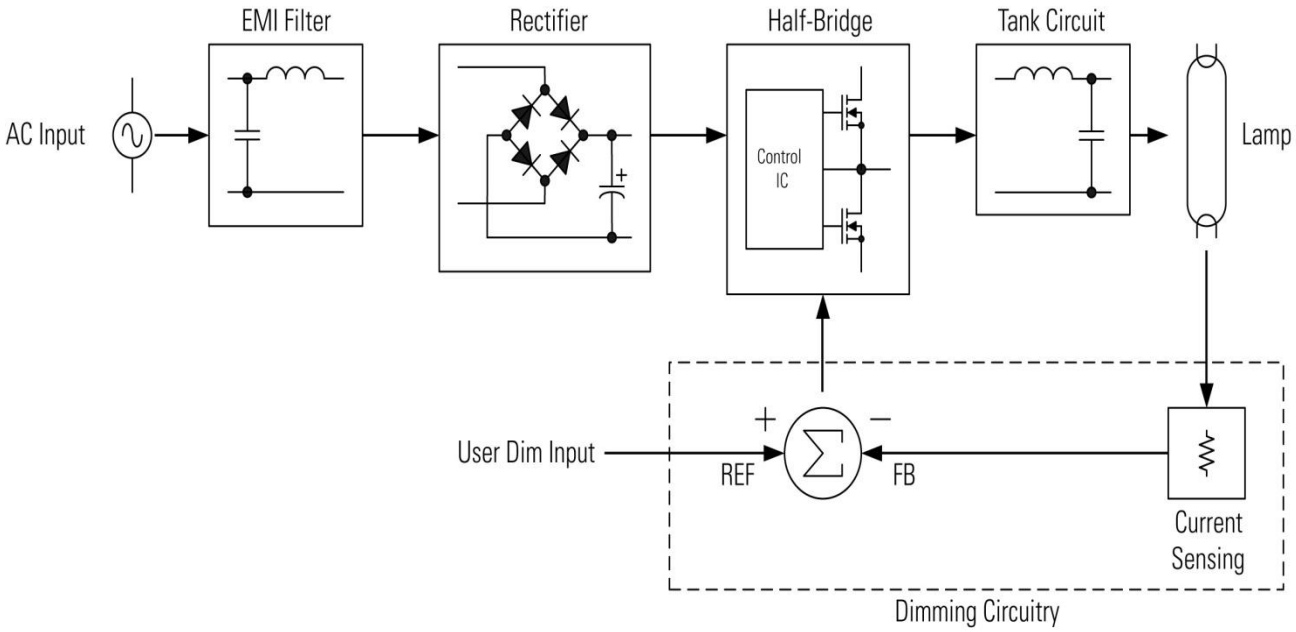
- It takes about 4-6 minutes to give full brilliance.
- The original color of the object cannot be judged.
- It takes 6 A approximately on first switching ON and after six minutes if falls to 3 A.
- It cannot be used in any standard lamp holder as there are three pins in its cap.



CFL Lamps

Principle of Operation

The electronic ballast circuit block diagram includes the AC line input voltage (typically 120 VAC/60 Hz), an EMI filter to block circuit-generated switching noise, a rectifier and smoothing capacitor, a control IC and half-bridge inverter for DC to AC conversion, and the resonant tank circuit to ignite and run the lamp. The additional circuit block required for dimming is also shown; it includes a feedback circuit for controlling the lamp current.

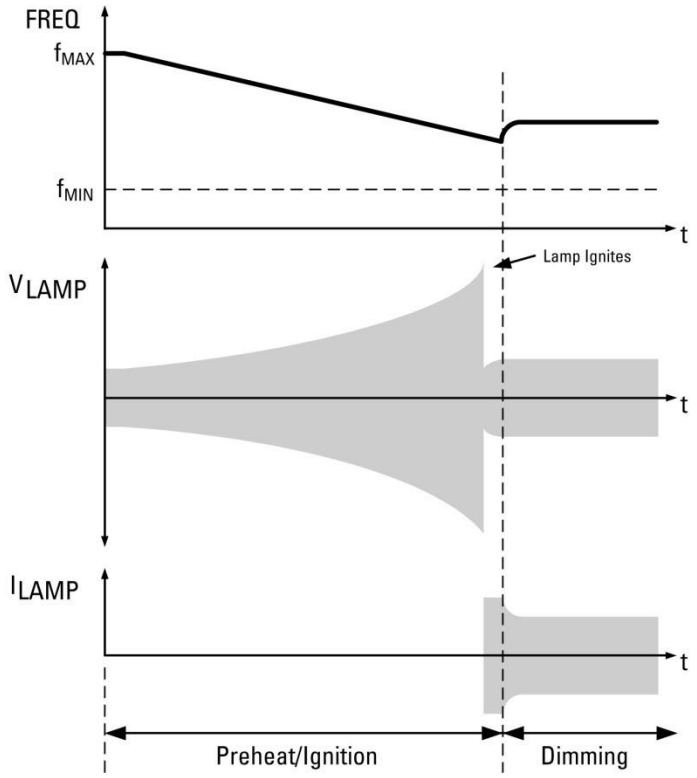


CFL electronic ballast block diagram

The lamp requires a current to preheat the filaments, a high-voltage for ignition, and a high-frequency AC current during running. To fulfill these requirements, the electronic ballast circuit first performs a low-frequency AC-to-DC conversion at the input, followed by a high-frequency DC-to-AC conversion at the output.

The AC mains voltage is full-wave rectified and then peak-charges a capacitor to produce a smooth DC bus voltage. The DC bus voltage is then converted into a high-frequency, 50% duty-cycle, AC square-wave voltage using a standard half-bridge switching circuit. The high-frequency AC square-wave voltage then drives the resonant tank circuit and becomes filtered to produce a sinusoidal current and voltage at the lamp.

When the CFL is first turned on, the control IC sweeps the half-bridge frequency from the maximum frequency down towards the resonance frequency. The lamp filaments are preheated as the frequency decreases and the lamp voltage and load current increase.



CFL operation timing diagram

The frequency keeps decreasing until the lamp voltage exceeds the lamp ignition voltage threshold and the lamp ignites. Once the lamp ignites, the lamp current is controlled such that the lamp runs at the desired power and brightness level.

To dim the fluorescent lamp, the frequency of the half-bridge is increased, causing the gain of the resonant tank circuit to decrease and therefore lamp current to decrease. A closed-loop feedback circuit is then used to measure the lamp current and regulate the current to the dimming reference level by continuously adjusting the half-bridge operating frequency.

Types of Lighting

A lighting installation may be classifies into four main groups:

1) General
2) Angle
3) Localized
4) Local

1) General Lighting

This is a system in which each part of an area is illuminated from a number of fittings in different directions, resulting in a fairly uniform distribution of illumination throughout the area. It is generally provided by a number of fittings symmetrically arranged over the area. Adequate wall lighting is advisable to provide bright surroundings, if the light is concentrated too much in a downward direction, or if the lamps are fitted too low, the walls will be less lighted. The light from one fitting should overlap that of the next fitting, consequently increase of the mounting height of the lamps enables them to serve a larger area and widens the possible lamp spacing, Minimum/maximum illumination ratio in the area should be about 70 per cent if possible. A large proportion of the light received at a given point will reach that point by reflection from the walls, especially if these are bright. Surfaces absorb some of the light received by them, consequently the total amount of light received by a surface will depend to some extent on the area of walls illuminated. This factor tends to reduce the efficiency of a system of general lighting with an increase of fitting height. The degree to which light received by the walls is reflected back depends on the nature and finish of the wall surfaces. The utilization factor depends on this effect.

2) Angle Lighting

This may be necessary for purposes such as the provision of good lighting on vertical surfaces, avoidance of shadows, or the creation of shadows for some specific purposes. It may be affected by using a concentrated source of light, such as spotlight, or by using a wide angle or parabolic reflector.

3) Localized Lighting

This may be adopted to give a relatively higher degree of illumination in the work area, with appreciably less light in the surrounding area. Tubular fluorescent lamps are particularly suitable for such purposes.

4) Local Lighting

This is frequently necessary to supplement general lighting where a very high degree of illumination is needed over a small working area, such as the cutting tool of a lathe.

Electric Lighting Fittings (Luminaire):

In general, an electric lamp and its fitting (globe, reflector, etc.) should be regarded as in integral whole, i.e., the lighting "unit" consists of the lamp and fitting, each designed to suit the other and to give the desired distribution of light. There are five main groups of fittings as given below: (1) Direct (2) Semi-direct (3) General (4) Semi-indirect (5) Indirect.

Direct Fittings:

These emit not less than the 70 percent of the total light flux of the lamp and fitting in the lower hemisphere. The dispersive type reflectors are useful for industrial interiors where highly polished materials are not worked. Direct light is cut off at an angle of 20 degrees below the horizontal, maximum illumination being given on tie horizontal plane. If desired the reflector may have a cover of clear to frosted glass. The height of the lamps should be about two thirds of the lamp spacing, these fittings provide fair illumination on a vertical plane.

The industrial diffusing fitting, with an enclosed diffusing bowl of opal glass, is suitable for works and offices where there is risk of glare in direct or indirect light. Lamp consumption is rather high with the diffusing fitting than with the standard disruptive reflector, but as the ceiling receives more light, the appearance of the room may be improved.

The concentrating reflector is most useful for high mounting, such as high bay foundries, and for overhead travelling cranes. Most of the light is concentrated into the 0 to 30 degrees region, the cut-off angle being about 30 degrees. A clear or frosted dustproof cover glass may be fitted

Semi Direct Fittings

These give between 50 and. 70 percent of the, total light flux in the lower hemisphere. The fittings may be made of prismatic or of opal glass, or of glass and metal, and are suitable for utility lighting of offices and shops.

General Lighting Fittings

Opal or prismatic varieties of glass are useful for the general lighting of shops, offices, and similar interiors. They emit 40 to 45 per cent of the total light flux in either hemisphere. This type allows more light to reach the ceiling than in the semi direct fitting. The spacing/height ratio may be about 1.25 to 1. The surface brightness should not exceed 1 candle per sq. cm if glare is to be avoided. This fitting gives a very pleasing effect with soft shadows.

Semi Indirect Fittings

These give 40 to 45 per cent of the total light flux in the upper hemisphere, and may be made of opal, frosted, or prismatic glass, or glass and metal. They require a higher wattage than the direct type of fittings, but give little shadow or risk of glare. Thr.:e fittings are very suitable for high class utility lighting such as offices, board rooms, etc., having light coloured ceilings.

Indirect Fittings

These emit not less than 70 per cent of their light in the upper hemisphere. With such fittings it is essential that the ceilings and upper walls be of very light colour, in which case good illumination, free from shadows, can be achieved. The fitting requires high wattage and frequent cleaning and is not advised where an extremely high degree of illumination is required. It is suitable for shops

Flood Lighting

Another application of illumination engineering is flooding of light overlarge surfaces in open air. This is carried out by means of a projector/reflector for several purposes:

1. Aesthetic flood lighting—For enhancing the beauty of a buildingby night, e.g., churches, towers and monuments.
2. Advertising — Flood lighting of commercial buildings.
3. Industrial — Flood lighting of railway yards, quarries, sports areas, etc. Arc lamps were previously used in projection lanterns for flood lighting. Nowadays special lamps having bunched filaments are used with projectors.

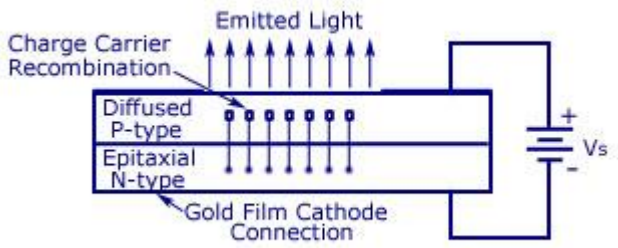
White Light LED

A light emitting diode (LED) is known to be one of the best **optoelectronic devices** out of the lot. The device is capable of emitting a fairly narrow bandwidth of visible or invisible light when its internal diode junction attains a forward electric current or voltage. The visible lights that an LED emits are usually orange, red, yellow, or green. The invisible light includes the infrared light. The biggest advantage of this device is its high power to light conversion efficiency. That is, the efficiency is almost 50 times greater than a simple tungsten lamp. The response time of the LED is also known to be very fast in the range of 0.1 microseconds when compared with 100 milliseconds for a tungsten lamp.

We know that a P-N junction can connect the absorbed light energy into its proportional electric current. The same process is reversed here. That is, the P-N junction emits light when energy is applied on it. This phenomenon is generally called electroluminance, which can be defined as the emission of light from a semi-conductor under the influence of an electric field. The charge carriers recombine in a forward P-N junction as the electrons cross from the N-region and recombine with the holes existing in the P-region. Free electrons are in the conduction band of energy levels, while holes are in the valence energy band. Thus the energy level of the holes will be lesser than the energy levels of the electrons. Some part of the energy must be dissipated in order to recombine the electrons and the holes. This energy is emitted in the form of heat and light.

The electrons dissipate energy in the form of heat for silicon and germanium diodes. But in Galium- Arsenide-phosphorous (GaAsP) and Galium-phosphorous (GaP) semiconductors, the electrons dissipate energy by emitting photons. If the semiconductor is translucent, the junction becomes the source of light as it is emitted, thus becoming a light emitting diode (LED). But when the junction is reverse biased no light will be produced by the LED, and, on the contrary the device may also get damaged.

The constructional diagram of a LED is shown below.



Advantages of LED's

- Very low voltage and current are enough to drive the LED.
- Voltage range – 1 to 2 volts.
- Current – 5 to 20 milliamperes.
- Total power output will be less than 150 milliwatts.
- The response time is very less – only about 10 nanoseconds.
- The device does not need any heating and warm up time.
- Miniature in size and hence light weight.
- Have a rugged construction and hence can withstand shock and vibrations.
- An LED has a life span of more than 20 years.

Disadvantages

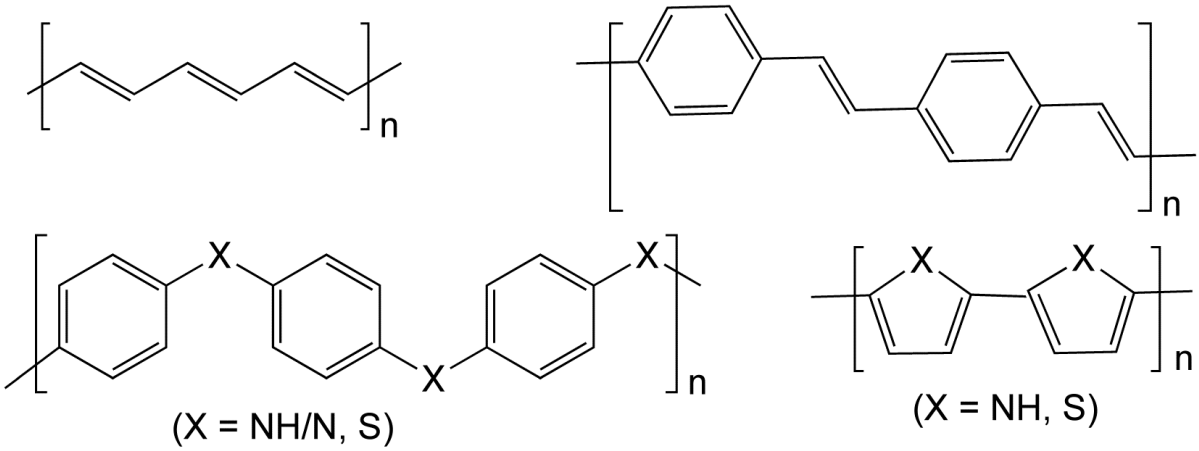
- A slight excess in voltage or current can damage the device.
- The device is known to have a much wider bandwidth compared to the laser.
- The temperature depends on the radiant output power and wavelength.

A mix of red, green and blue LEDs in one module according to the RGB colour model, white light is produced by the proper mixture of red, green and blue light. The RGB white method produces white light by combining the output from red, green and blue LEDs. This is an additive colour method

Conducting Polymers:

Conductive polymers or, more precisely, **intrinsically conducting polymers** (ICPs) are organic polymers that conduct electricity. Such compounds may have metallic conductivity or can be semiconductors. The biggest advantage of conductive polymers is their process ability, mainly by dispersion. Conductive polymers are generally not thermoplastics, *i.e.*, they are not thermo formable. But, like insulating polymers, they are

organic materials. They can offer high electrical conductivity but do not show similar mechanical properties to other commercially available polymers. The electrical properties can be fine-tuned using the methods of organic synthesis and by advanced dispersion techniques.



Due to their poor processability, conductive polymers have few large-scale applications. They have promise in antistatic materials and they have been incorporated into commercial displays and batteries, but there have had limitations due to the manufacturing costs, material inconsistencies, toxicity, poor solubility in solvents, and inability to directly melt process. Literature suggests they are also promising in organic solar cells, printing electronic circuits, organic light-emitting diodes, actuators, electro chromism, super capacitors, chemical sensors and biosensors, flexible transparent displays, electromagnetic shielding and possibly replacement for the popular transparent conductor indium tin oxide

Energy Conservation Measures:

1. Design, installation, and operation of effective lighting systems have complex scientific,management, engineering, and architectural considerations. Of the many elements that must be considered in providing an adequate visual environment of acceptable cost, energy conservation is only one. Other elements that must be taken into account are the visual tasks to be performed, the psychological state and perceptual skill of the observer, the design of task and surrounding areas the availability of daylight, the level of illumination and the lighting system quality with regard to spectral characteristics, glare, reflections and geometrical factors. These complexities limit the degree to which simple guidelines for energy conservatior in lighting can be applied in all cases. However, in most situations they are very useful in providing the

guidance necessary to achieve substantial savings in lighting energy and cost while also providing an adequate visual environment.

2. In the design of new lighting systems modifying existing ones, the most efficient light sources tha can provide the illumination required should be selected. As a general rule, the efficiencies of some available lamp types rank according to the following list, with the most efficient given first, (a) high pressure sodium vapour, (I)) fluorescent (c) mercury, and (d) incandescent. Many a replacement of the existing low efficiency lamp types with lower voltage more efficient types will result in reduced total costs and improved lighting. See Table for detailed example.

3. Maximum control over lighting systems can be accomplished by using switches to control the turning off of unnecessary lighting. Large general areas should not be under the exclusive control of a single switch, if turning off small portions would permit substantial energy savings when they are not occupied. Lights should be turned off as a regular practice when buildings are not occupied, such as after working hour's or on weekends and holidays. When opportunities for existing daylight exist, lights could be turned off. Occupants of buildings should be educated and periodically reminded to adopt practices which will save lighting energy, such as turning off lights when leaving a room.

Frequent switching on or off of a lamp shortens its life. Therefore, there is an optimum point between energy cost savings and the cost of lamps and replacement labour. Variations in energy prices, labour costs, and convenience influence the decision. However, under typical working conditions the break-even point for fluorescent lamps is reached in five to ten minutes where replacement costs are low and in 20 to 30 minutes where costs are high.

4. Proper luminaire placement in the design of new lighting systems and the removal of unnecessary lamps in existing installations are examples of energy conservation measures. Luminaires should be positioned to minimize glare and reflection, and work stations should be oriented and grouped to utilize light most effectively. Daylight should be used when available, maxi-mum switching control should be provided to the user, and light colours should be used on walls, ceilings and floors. Tasks should be designed to Present high contrast to the observer.

5. Determination in the illumination level due to dirt accumulation in lighting equipment should be prevented by adequate maintenance program-mes, cleaning lamps and luminaires, and

replacement of lamps. As a part of maintenance programs, periodic surveys of installed lighting with respect to lamp positioning and illumination level should be conducted to take ad-vantage of energy conservation opportunities as user requirements change. To summarize, a checklist to reduce loss from lamps and devices would include the following points.

1. Is the highest efficiency lamp being used?

2. Is the highest powered lamp available being used?

3. Is the most efficient luminaire, consistent with good glare control, being used?

4. Have adequate provisions been made for maintaining and cleaning lighting equipment and lamps.?

ADDITIONAL MATERIAL

PRINCIPLES OF LIGHT CONTROL

When light falls on a surface, depending upon the nature of the surface, some portion the energy is reflected, some portion is transmitted through the medium of the surface and the rest is absorbed. It is advantageous to direct the whole of the light output on to surface to be illuminated, to diffuse the light in order to prevent glare or to change its color. The four general methods of light control are:

I) Reflection
II) Refraction
III) Diffusion
IV) Absorption

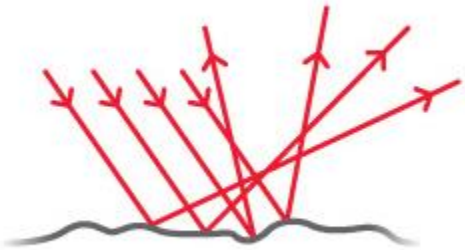
Reflection can be used to change the direction of light through a large angle. Reflection is the change in direction of a wavefront at an interface between two different media so that the wavefront returns into the medium from which it originated. The reatio of reflected light energy to the incident light energy is known as reflection factor. There are two types of reflection: Specular reflection and Diffuse reflection

Specular reflection: The angle at which the wave is incident on the surface equals the angle at which it is reflected. Mirrors exhibit specular reflection. For a smooth surface, reflected light rays travel in the same direction. This is called specular reflection.

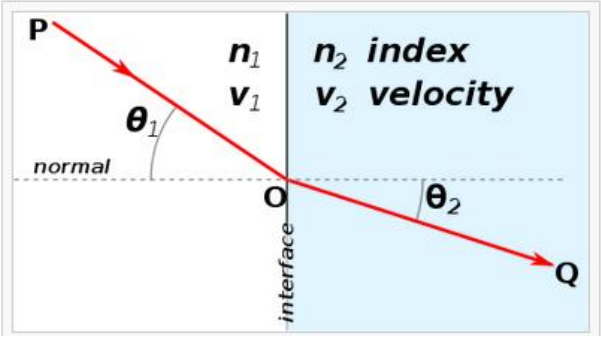


Diffuse reflection is when light hits an object and reflects in lots of different directions. This happens when the surface is rough. Most of the things we see are because light from a source has reflected off it.

For example, if you look at a bird, light has reflected off that bird and travelled in nearly all directions. If some of that light enters your eyes, it hits the retina at the back of your eyes. An electrical signal is passed to your brain, and your brain interprets the signals as an image.



Refraction: When light travels from one transparent medium to another having different density, the light rays will deviate. **Refraction** is the change in direction of propagation of a wave due to a change in its transmission medium. Angle of ray with the vertical in the dense medium is less than that in the rare medium. When waves travel from a medium with a given refractive index (the ratio of the velocity of light in a vacuum to its velocity in a specified medium) to a medium with another at an oblique angle, the phase velocity of the wave changes and so the direction of the wave changes at the boundary between the media.



Refraction is described by Snell's law, which states that for a given pair of media and a wave with a single frequency, the ratio of the sines of the angle of incidence θ_1 and angle of refraction θ_2 is equivalent to the ratio of phase velocities (v_1 / v_2) in the two media, or equivalently, to the opposite ratio of the indices of refraction (n_2 / n_1)

$$\frac{\sin\theta_1}{\sin\theta_2} = \frac{v_1}{v_2} = \frac{n_1}{n_2}$$

Diffusion: When light is reflected from a mirror, the angle of reflection equals the angle of incidence. When light is reflected from a piece of plain white paper; however, the reflected beam is scattered or **diffused**. Because the surface of the paper is not smooth, the reflected light is broken up into many light beams that are reflected in all directions.

To prevent glare from a light source, a diffusing glass screen can be introduced between the observer and light source or light may be reflected from a diffusing screen which may be a lamp bulb enclosed in diffusing glass fitting. In diffused reflection, a ray of light is reflected in all directions and therefore such surface appears luminous from all possible directions. The diffusing glass employed is of two types: opal glass and frosted glass.

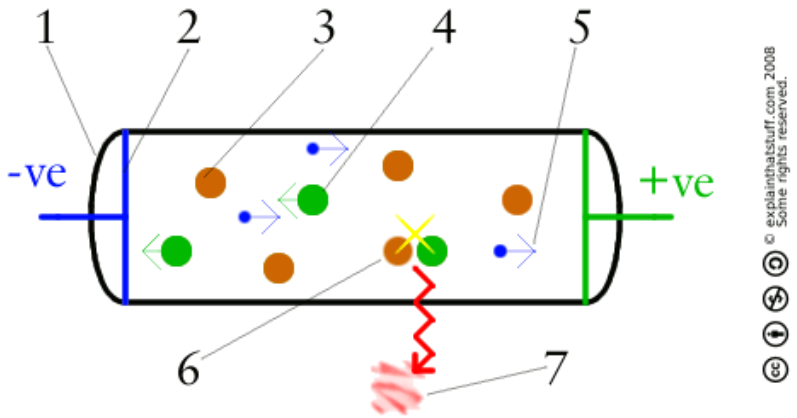
Absorption : For certain purposes such as color matching in dyeworks and in other industries, an artificial light is required which approximates very closely to that of daylight . The ordinary filament lamp has an excess radiation and this problem can be avoided by production of reflector or screen which will absorb precisely the correct amount of the unwanted wavelengths without interfering. The absorption may be carried out by using special bluish coloured for the bulb of an ordinary filament lamp or by using an ordinary bulb in a fitting of special glass.

Neon Lamps

A neon lamp is a sealed glass tube filled with neon gas, which is one of the so-called "noble" (inert or unreactive) gases on the far right of the Periodic Table. (There are minute quantities of neon in the air around us: take a deep breath and you'll breathe in a volume of neon as big as an orange pip!)

There are electrical terminals at either end of a neon tube. At one end, there's a negative terminal ("-ve", shown blue); at the other end there's a positive terminal ("+ve", shown green).

When the tube is switched off, it contains ordinary atoms of neon gas (brown circles).



Rig the terminals up to a high-voltage power supply (about 15,000 volts—because you need a lot of "electrical force" to make things happen) and switch on, and you'll literally start pulling the neon atoms apart. Some of the atoms will lose electrons to become positively charged ions (big green dots). Being positively charged, these neon ions will tend to move toward the negative electrical terminal.

The electrons the neon atoms lose (small blue dots) are negatively charged, so they hurtle the opposite way toward the positive terminal at the other end of the tube.

In all this rushing about, atoms, ions, and electrons are constantly colliding with one another. Those collisions generate a sudden smash of energy that excites the atoms and ions and makes them give off photons of red light.

So many collisions happen with such rapidity that you get a constant buzzing of red light from the tube. You also get quite a lot of energy given off as heat. If you've ever stood near a neon light, you'll know they can get very hot. That's because the atoms are giving off quite a bit of invisible infrared radiation (in other words, heat) as well as visible radiation (better known as red light).

Type of light source	Typical Luminous Efficiency (lm/W)
Incandescent bulb	8-18
Fluorescent Lamp	46-60
Mercury Vapour Lamp	44-57
CFL	40-70
Sodium Vapour Lamp (Low Pressure or LPSV)	101-175
Sodium Vapour Lamp (High Pressure or HPSV)	67-121
Metal Hallide	60-80
LED	30-50
Best LED	105

Residential		Commercial	
Kitchen	200	Classroom	300-400
Bathroom	300	Jewellery Work	700-800
Bedroom	300	Entrance Foyers	150-200
Dining	150	Office	200-300
Stairs	100	Hospital Treatment Room	400-500
Study	300	Stairs	80-100
Drawing Hall	300	Laboratories	300-400
Living	300		

Depreciation of light

Sl. No.	Premises	Percentage light losses due to dust accumulation for			Causes
		3 months	6 months	9 months	
1	Steel works	12	18	22	Oil vapours in atmosphere
2	Cotton mills	12	20	25	Fluff
3	Drawing office	17	20	22	Dust
4	Office	15	20	23	Dust
5	Weaving mill	20	28	33	Thread bits
6	Type factory	45	60	60	Greasy layer of powdered rubber
7	Foundry	52	59	60	Smoke and dust
8	Machine shop	25	37	42	Oil vapours in atmosphere
9	Carpenters shop	20	28	34	Sawdust

Symptoms	*Causes*	*Remedies*
1. Blinking on & off (new lamp.)	1. Low voltage.	If necessary change tapping of ballast.
	2. Loose contact.	Check all connections.
	3. Defective starter.	Change starter.
	4. Defective lamp.	Change Lamp.
	5. Wrong connections.	Check with diagram.
(Old lamp)	1. Defective lamp.	Change lamp.
2. Ends of lamp remain lighted.	1. Defective starter.	Change starter.
3. Lamp does not start	1. Loose or no contact of bipin with holder or in starter.	Turn tube through 90°. Try another starter and check connections.
	2 Starter heater coil broken.	Change starter.
	3. Defective lamp.	Change lamp.

Symptoms	*Causes*	*Remedies*
4. End blackening (early life)	1. Too low or too high voltage.	Adjust ballast tapping.
	2. Blinking due to wrong voltage.	Check and remedy under symptom 1.
(normal life)	3. Mercury deposits at ends.	It will evaporate as lamp operates.
5. Burnt out electrodes.	1. Control unit not in circuit or choke short circuited.	Check with new choke and remedy accordingly.
6. Dark streaks along lamp.	1. Mercury globules.	Rotate lamp through 180°.
7. Snaking spiralling. (with glow type starter)	1. Insufficient heating due to either starter opening quickly or wrong tappings made on the ballast.	Renew starter or ballast. In case of new lamp, it cures after few days.

Coef. of utilisation η in%

Type of fitting	Direct		Semi direct		Semi indirect		Indirect	
Room Index a/h	A	B	A	B	A	B	A	B
1	25	18	17	9	21	13	15	8
1·5	36	30	25	16	27	17	20	11
2	41	36	29	19	31	21	23	14
2·5	44	40	33	23	35	24	26	16
3	47	43	36	25	38	26	28	17
4	51	47	41	30	42	30	31	20
5	53	49	44	33	46	33	34	22
6	55	52	48	37	...	...	...	...
8	58	54	53	41	...	...	...	...

Where *a* is the side of square room.