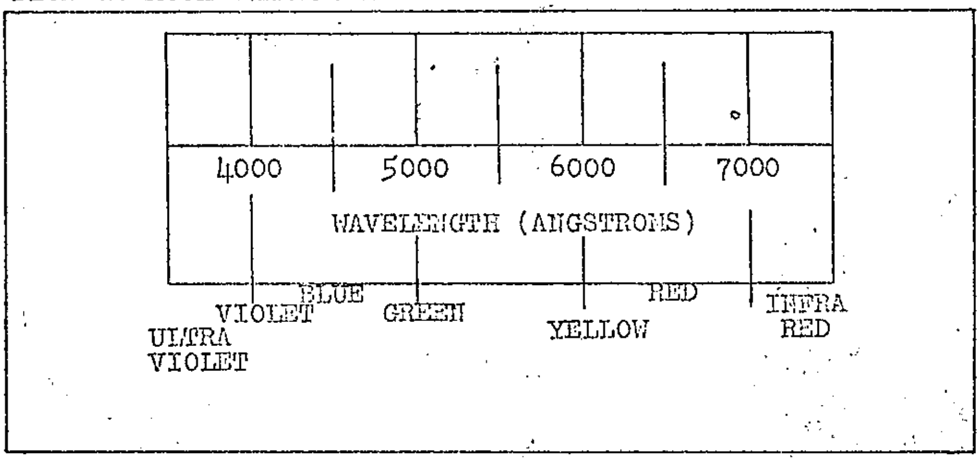
TITLE:- ILLUMINATION

LECTURER:-

DATE:-

EQUIPMENT:- Fluorescent tube, starter, choke, Mercury vapour lamp, Quartz iodine lamp, Sodium vapour lamp.

Light may be described as radiant energy, which affects our eyes so as to produce the sensation of vision. All radiant energy, travels through space at the speed of light (300,000 Km/Sec.).
The difference between different rays i.e., X-Ray, Radio waves, Gamma-rays etc. is only their wavelengths, or frequencies (no. of cycles per second).
There is a narrow band of frequencies which give us a sensation of light and colour. At one end of this band, (or SPECTRUM) is radiation called ULTRA-VIOLET, at the other end is radiation called INFRA-RED. Both of these radiations are invisible. Between ultra-violet and infra-red radiations, is what is known as the VISIBLE SPECTRUM.
The unit of wavelength is the ANGSTROM - One Angstrom is a wavelength of one hundred millionth of a centimetre.
The visible spectrum is within the spectrum between 4,000 - 7,000 Angstroms. Daylight has a spectral composition of 1/3 each of RED-GREEN-BLUE at noon summertime:



To compare the relative properties and calculations of different forms of illumination, there are four main quantities to be measured -

(1) Intensity of light in any one direction.
(2) Total flow of light in all directions from the source.
(3) Brightness of the source.
(4) Illumination of a surface.

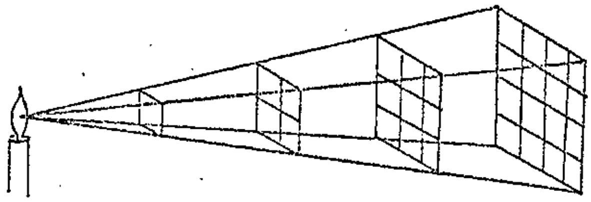
(1) CANDELA is the unit of luminous intensity, and is defined as 1/60 of the luminous intensity of a "black-body" radiator at the temperature of the solidification of platinum (2046°K). The original definition was in terms of the strength of a flame source.

Blackbody: Is a temperature radiator, which absorbs all the radiant energy that falls upon it. In practice it is a cavity, with opaque walls at uniform temperature, with a small opening for observation purposes.

Lumen: Is the unit of luminous flux, and is the time/rate flow of light. ONE LUMEN = flux on a square foot of surface, all points of which are one foot from a point source of one candola. Light sources are rated in lumens.

Inverse square law: States that the illumination at a point on a surface varies inversely with the square of the distance, between the point and the light source. $E = 1/D^2$, E = Illumination in ft.

candles at a point on the surface, I = luminous intensity in candles, D = distance between source and point on a surface.



Cosine law: is an extension of the inverse square law, and takes account of the case when the surface is not normal to the direction of the light ray. If the surface is inclined at any angle to the incident ray, the illumination becomes proportional to the cosine of the angle of incidence.

$$E = \frac{I \cos \emptyset}{D}$$

Luminaires: are complete lighting fittings, and are classified according to the amount of, and direction in which the light shines.

Direct	0-10% upwards	90-100% downwards
Semi-direct	10-40% "	60-90% "
General diffuse	40-60% "	60-40% "
Semi-indirect	60-90 "	10-40% "
Indirect	90-100% "	0-10% "

TITLE:- ILLUMINATION (LAMPS)

LECTURER:-

DATE:-

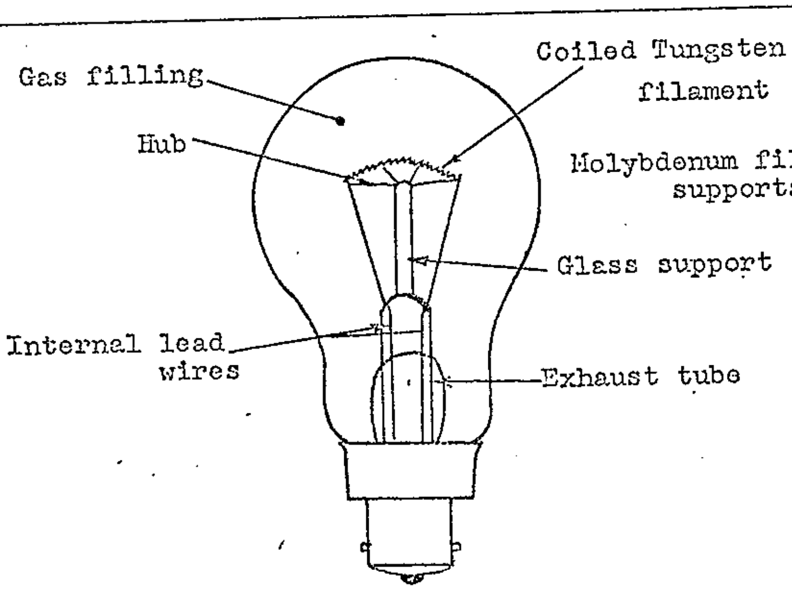
EQUIPMENT:-

Tungsten filament lamps: if sufficient current is passed through a wire, it will reach a temperature and become incandescent and emit light. Tungsten for lamp filaments has the highest melting point of all metals; 3380°C (6120°F), more than twice that of iron. The filament length and diameter, limits its range of operation between 1.5 and 300V. At 1.5 to 12 Volts, the filament is very short and thick, and is relatively rugged, it will withstand the shock of motor vehicles etc.

At a voltage of 250V, the filament is very long and thin and fragile making it difficult to support.

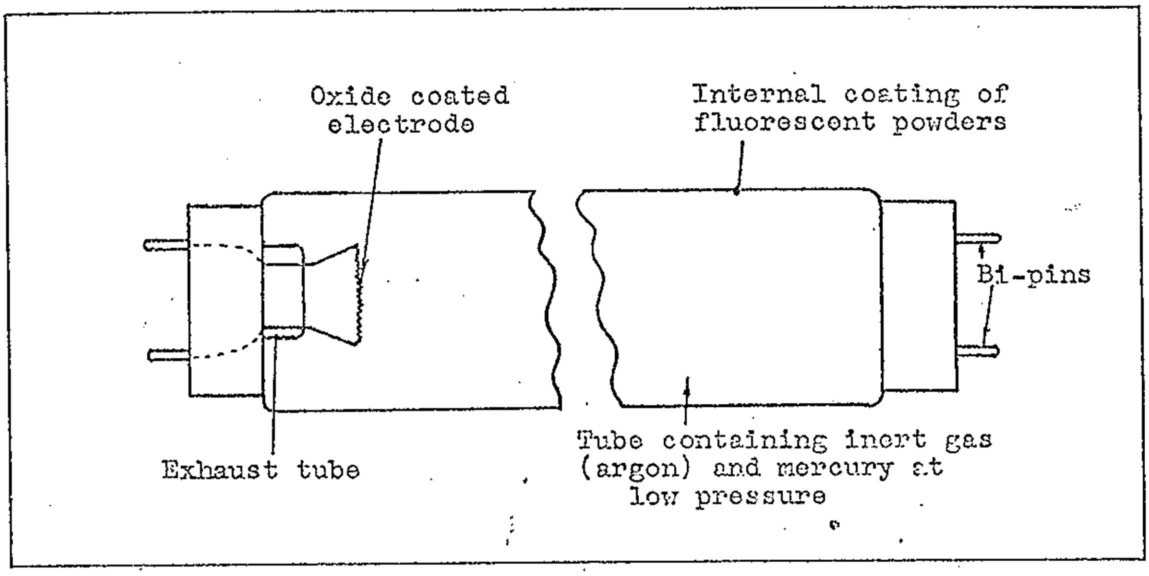
In order to obtain a reasonably efficient light source, it is necessary to operate the filament at a high temperature. Because lamp life is determined by filament evaporation, gas filled lamps are used in preference to vacuum lamps. The lamp consists of a glass container or bulb, inside of which, is an assembly, carrying the filaments and supports. This is cemented to an end cap, then evacuated of air and filled with an inert gas such as argon-nitrogen. The filament is coiled into a very tight spiral, in which the turns are so closely spaced that the flow of gas through the coil is restricted, and a coiled coil filament, in which the filament spiral is wound into another spiral, is a further step to increase the total operating time, through the reducing of the cooling effect of the gas. General service lamps up to 150W may be obtained with internal frosted or pearl bulbs, producing additional diffusion. Glare may be reduced by the use of opal glass lamps, or internal frosted bulbs. Most of the energy supplied to a tungsten filament lamp is converted as follows:-

(a)	Heat lost as convection	20%
(b)	Heat lost through support & leads	5%
(c)	Heat radiated	67%
(d)	Light	8%



Beyonet cap (B.C.)

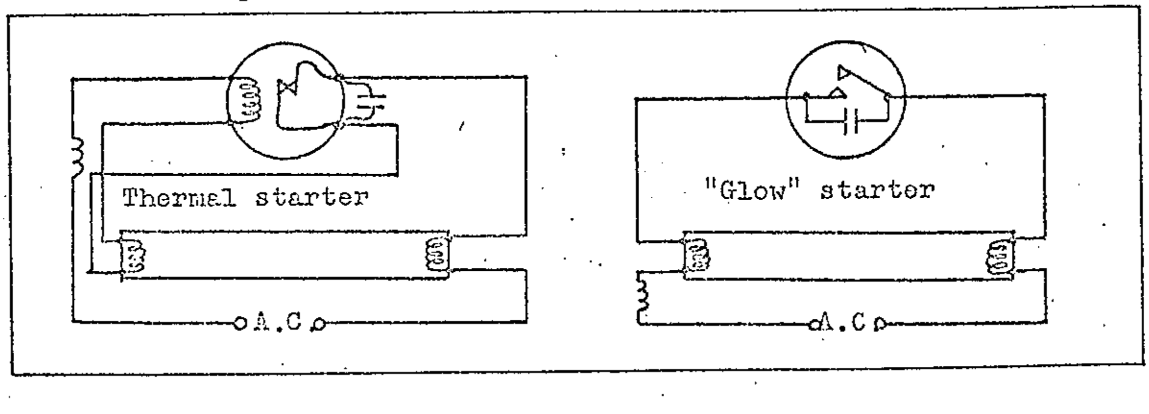
Fluorescent lamps: All fluorescent lamps are basically low-pressure mercury-discharge lamps, designed to emit a maximum portion of their energy, in the 2537 A° line of the mercury spectrum. This short-wave ultra-violet energy is converted by the phosphors coating the inside of the tube, into light.
The glass tubes, 38 mm in diameter, are cut to length, according to the wattage required:- 8, 5, 4, 3, 2, 1½ ft. and end caps (bi-pin or bayonet cap) are fitted, with the pins connected to oxide coated electrodes, (one at each end). Air is replaced with ARGON gas at a low pressure, a small amount of MERCURY is added, and the tube is sealed.



Starters: Two types are generally available, i.e., Glow type and Thermal.

Glow type starter: This is the most commonly used, as it is the most efficient, and requires less wiring. It consists of a small glass envelope, in which are two bi-metallic contacts which are not touching. The envelope is filled with NEON gas. A capacitor is connected across the terminals on the outside of the envelope. This is for radio interference suppression. When a voltage is applied, the neon gas ionises, causing heat to be generated, which bends the bi-metals, causing them to touch. This allows a heavy current to flow through the lamp circuit, ionisation ceases, and the contacts cool and open. The opening of the contacts causes a high, self-induced E.M.F. to appear at the choke, which then starts ionisation of the main tube.

Thermal type starter: These are fitted with normally closed contacts, which are in close proximity to a heating filament. The filament is connected in series with the choke, and the contacts across opposite ends of the tube. Current flows through the heater, causing the contacts to open, thus providing means of obtaining the high starting voltage. The heater must remain in circuit, to keep the contacts open.



The choke: This is a coil of thousands of turns of fine gauge wire, wound on a laminated, closed loop iron core. It is used to supply a high back E.M.F. for starting the lamp, and to limit the lamp current to a safe running value.

Operation: The circuit starts from the active, which is connected to one end of the tube. The adjacent pin is connected to the starter, then from the starter to the other end of the tube. A wire from the adjacent pin of the tube goes to the choke, the other side of the choke goes to neutral.
When the power is switched on, there is no current flow, as the lamp appears as a high resistance and the starter (glow type) contacts are open. The voltage across the starter contacts is 240V, and this causes ionisation in the starter. The contacts close, and a current flows through the tube filament, starter and choke.
A magnetic field is built up in the core of the choke, and the tube filaments are heated. Since there is a current flow through the circuit, ionisation in the starter ceases and the contacts open, which causes the magnetic field in the choke to collapse, and in doing so, it induces a high e.m.f., which appears across the length of the tube. Ionisation of the argon gas occurs, and creates an ultra-violet radiation.
Because the tube is now conducting, its resistance is much lower, and the starter contacts appear as an open circuit.
The low resistance of the tube would cause excessive current flow if the choke was not in the circuit.
Phosphorescent powders change the wave-length of the ultra-violet rays, by absorbing energy and the light output is increased. 70% of energy supplied appears as light. The fluorescent is the most efficient. Heat produced is 1/3 that of a tungsten filament lamp. Glare is reduced, costs are reduced, and lamp life can be increased by reducing or minimising switching operations.

Black-light lamps: Near ultra-violet radiant energy, (energy not visible to the human eye) causes certain materials to fluoresce (emit visible light). The normal human eye is sensitive only to radiant energy between 4,000 and 7,000 A° in wavelength. Thus, lamps which produce primarily near-ultraviolet radiant energy in the 3,200-3,800 A° range, are popularly called "black" lights. This term is quite descriptive, since the ultra-violet energy from the light source cannot be seen by the human eye, but the effects of the radiation on special materials can be visually dramatic.
When "black light" is directed at a fluorescent material, an energy conversion takes place. The material or chemical, sensitive to ultra-violet energy, absorbs the energy, then re-radiates it at longer wavelengths (4,000-7,000 A° range) to which the eye is sensitive. The energy conversion is similar to that which takes place in fluorescent lamps; i.e., ultra-violet energy in the lamp, activates the fluorescent phosphor coating. to produce visible light in white or any other colour.
Black-light lamps are generally enclosed in a red-purple filter glass bulb which looks black. They are used for theatrical and advertising effects, industrial and food inspection, detection of counterfeits and forgeries, medical diagnosis, vermin traps etc.

Mercury Vapour Lamps: All electric discharge lamps operate by passing an electric current through gas or vapour. In most gaseous discharge lamps, however, the LUMINOSITY results from the GAS itself - neon, argon, krypton, mercury etc. The COLOUR of the light depends on the GAS and its PRESSURE.

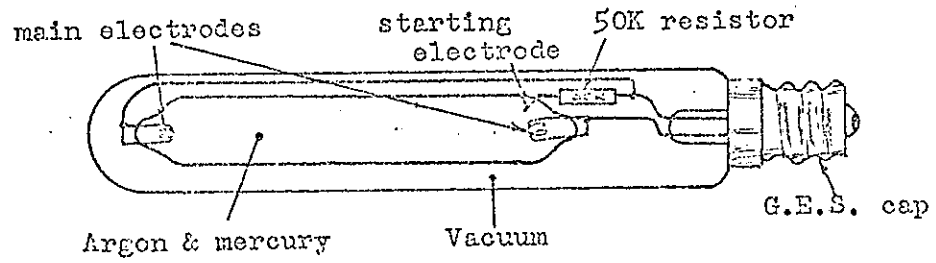
Commercial Mercury vapour lamps include 5 types:-

(1) Low pressure low voltage lamps in long tubes e.g. fluorescent lamps.

(2) High pressure high voltage lamps in short tubes - mostly for industry.

(3) High pressure high voltage lamps in long tubes - photochemical etc.
(4) Very high pressure, very high voltage lamps in short tubes e.g. Water cooled 1000W mercury vapour lamp.
(5) Very high pressure, very low voltage lamps in spherical bulbs.

The practical limit of a M.V. lamp's current carrying capacity is how high a temperature it's enclosing tube can withstand without rupturing. By connecting an impedance in series with the lamp, the current can be limited. In most lamps, about 50% of the supply voltage is absorbed by a series ballasting device.
One disadvantage of the M.V. lamp, is the effect of power supply interruptions, or voltage dips lasting more than one second. The lamp will extinguish, and will not re-ignite, until the pressure in the tube drops, after the temperature drops. This usually takes 3-4 minutes.
Lamps are constructed on similar lines, regardless of size or voltage - A glass, or quartz tube, is fitted with two large electrodes, one at each end: at one end, an additional small starting electrode is fitted and connected via a 50K resistor to the opposite electrode.
This assembly is placed inside a larger glass envelope, and sealed. The inner tube is filled with ARGON and a small amount of MERCURY. The space between the two glass walls is evacuated, to act as an insulator.

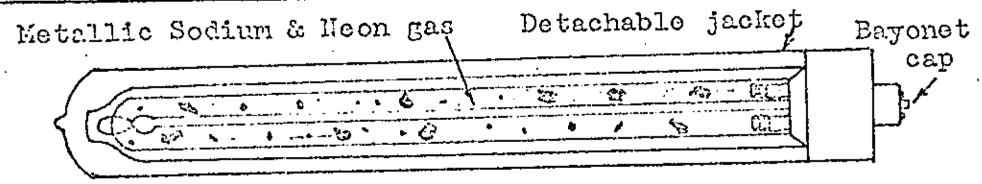


400W HIGH PRESSURE
MERCURY DISCHARGE LAMP

All M.V. lamps have coded letters printed on them. This code tells the following data:-

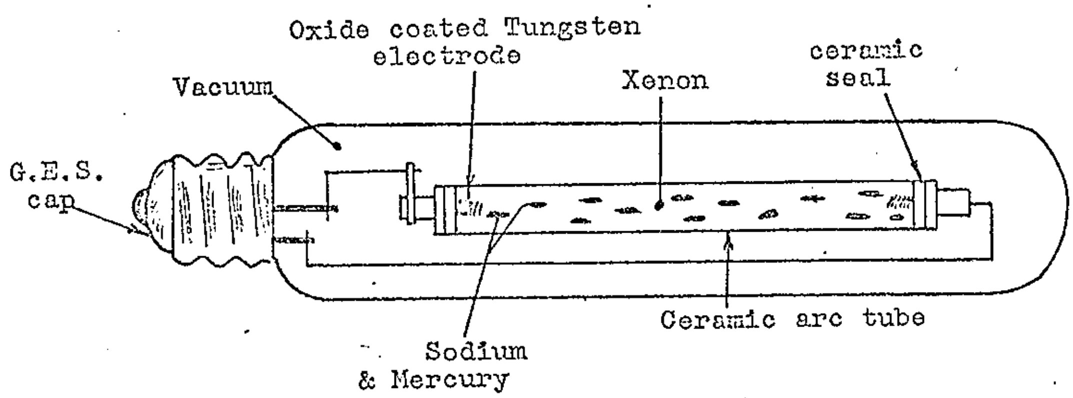
A - Glass envelope over 10W/cm. of arc length.
B - Quartz envelope below 100W/cm. of arc length.
C - Glass envelope below 10W/cm. of arc length.
D - Quartz envelope with forced liquid cooling.
E - Quartz envelope above 100W/cm. of arc length.
F - Fluorescent coating.
T - Tungsten filament lamp incorporated.
/V- Vertical cap up.
/D- Vertical cap down.
/H- Horizontal position.
/U- Any position.

Sodium vapour lamps (Low Pressure): Metallic sodium and neon gas are enclosed in a "U" shaped glass tube, which is approx. 18 mm. dia. and 700-800 mm. long. In the ends, are inserted oxide coated electrodes, which are connected to the supply via a bayonet cap lamp-holder. The "U" tube is sealed inside another glass chamber, from which the air has been evacuated, or it may be placed inside a double walled vacuum flask. A thin strip of metal is fitted between the legs of the U-tube, and is connected to one of the electrodes. The "U" shaped tube provides more concentrated light. The vacuum flask retains heat, to enable the lamp to work at a temperature above the melting point of sodium. The thin strip of metal helps in starting, and has a capacitive effect. The oxide coated electrodes reduce the rate of evaporation.
For its operation, a transformer is necessary to step up the mains voltage, to initiate the ionisation of the gas. Heat produced by ionisation gradually melts and vaporises the sodium. The colour of the lamp changes from Red, to Orange/Yellow whilst the sodium is vaporising.
After starting, the transformer acts as a current limiting device. This is necessary, because the lamp resistance (when ON) is virtually nil: 50 and 60 watt lamps can be operated in any position whilst the 85 and 145 watt tubes must operate in the horizontal position. This is to avoid the hot sodium collecting at one end. If this occurs, the lamp will operate as a neon discharge, for the greater length of the tube, and, in addition, the sodium may attack the glass in the region of the seal wires.
Special fireproof wrappings are provided for the transport of the inner tube, to avoid fire should the tube be broken, and the sodium come in contact with moisture. When a tube has to be disposed of, it should be placed in a dry steel container and broken into small fragments. Using a hose, water should be sprayed onto the glass etc. This will cause the sodium to burn and explode, whilst in a safe place.



140W SODIUM DISCHARGE LAMP

Sodium Vapour Lamps (High Pressure): The high pressure sodium vapour lamp has different physical, electrical and photometic characteristics from those of other high pressure lamps, however light is produced in a similar manner, by the passage of an electric current through a vapour under pressure in a tube.
Similar to the low pressure lamp, this type uses a ballast for initiating ionisation in the tube. The principle radiating element in the arc of the lamp is SODIUM. Mercury is added for colour and voltage control. XENON gas is also introduced to facilitate starting. A special starting circuit is used, to supply a short, high voltage pulse, on each cycle or half cycle. This pulse has sufficient amplitude and duration, to ionize the XENON gas, and to initiate the starting sequence of the lamp. The warm-up period of this lamp is 3 - 4 minutes. During warm-up, there are several changes in the colour of the light.
Initially, there is a very dim, bluish-white glow, produced by ionized ZENON, which is quickly replaced by a typical blue, brighter mercury light. With the increase in brightness, there is a change to mono-chromatic yellow, which is characteristic of sodium at low pressure and temperature. Then as the pressure in the arc tube increases, the lamp comes to full brightness, with a golden white light. Should there be a momentary interruption of power, the "re-strike" time is approx. one minute.
Similar to M.V. and Sodium vapour (L.P.) lamps, it has "two bulb" construction, with an outer bulb "jacket", and an inner "arc tube". The ceramic arc tube contains the electrodes, sodium, and small amounts of mercury and xenon. The outer bulb of weather-resistant glass protects the arc tube from damage, and contains a vacuum, which reduces convection heat loss from the arc tube to ensure high efficiency.
The ceramic arc tube, is responsible for the high lumen output. An improved "Monolithic" seal for the arc tube eliminates the previously used metal cap, and provides excellent mechanical characteristics to withstand the high temperature discharge of metallic sodium. The new seal also provides excellent resistance to the strains of expansion and contraction, and the corrosive action of the sodium atmosphere. The electrodes are wound tungsten coils, coated with metal oxides, similar to those used in mercury lamps. The pencil thin ceramic arc-tube, is made of translucent poly-crystalline alumina ceramic, which will withstand extremely high temperatures. It is extremely resistant to the corrosive effects of hot sodium. Sodium, at these high temperatures, deteriorates quartz and similar materials very quickly.



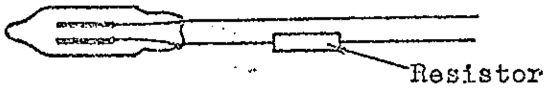
HIGH PRESSURE SODIUM VAPOUR DISCHARGE LAMP

Glow lamps: A glow lamp consists of electrodes, sealed in a glass envelope filled with gas. The most commonly used gas is NEON, which gives a reddish glow, when current flows through the lamp. Less commonly used gases, are argon, and a mixture of helium and argon, which produces a blue and violet glow respectively. The light from a glow lamp is produced by a "cushion" of luminous gas surrounding the negative electrode. In alternating current usage, the rapid switch in polarity of the electrodes, gives the impression of both electrodes glowing continuously. Glow lamps consume low wattage and are mechanically rugged. Their light output, however, is low. Like other discharge lamps, they require a current limiting device, usually a resistor.

Neon - Red

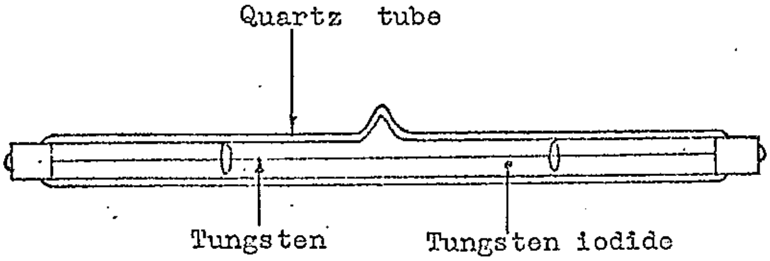
Helium - Blue

Argon - Violet



GLOW LAMP

Quartz iodine lamps: As the name suggests, the bulb of this type of lamp is made of quartz, in tubular form, and the iodine regeneration cycle is used to minimise bulb blackening. Since quartz has a melting point of 1650°C, it is ideal both for the iodine cycle and for smaller enclosures of high wattage filaments.
Ordinarily, tungsten, evaporating from a hot filament, is carried to the relatively cool bulb wall, where it accumulates and forms a black deposit.
However, with temperatures of several hundred degrees C, tungsten vapour and iodine vapour, combine to form Tungsten iodide, which does not adhere to the bulb wall, but is borne by convection currents, back to the filament, where it is reduced, and the tungsten re-deposited on the filament; the iodine vapour recirculates to continue the re-generative cycle.
Because of high temperature, the lamp should not be touched with bare hands for several minutes after it has been turned off. Portions of the bulb may reach 600°C; hence, precautions must be taken to keep combustible materials away from the bulb. Oil, grease or moisture from hands can cause early bulb failure.
Some applications of the quartz iodine lamp are:- Industrial and commercial interiors - Sports field lighting - Show windows - Building facades - Out-door work areas - Airport runways.



Wattage range :- 250 - 1500W

Life 2000 - 4000 hours

QUARTZ IODINE LAMP

TITLE:- ILLUMINATION (SAFETY)

LECTURER:-

DATE:-

EQUIPMENT:- Fluorescent tube, Sodium vapour lamp, Tungsten filament lamp.

If you have ever changed a lamp at home, you will have noticed that it becomes very hot, after operating for a short period.
Most lamps used in the works are in operation continuously, so should you have to change one, it is safest to treat it as though it had just "blown". Imagine what could happen if you were working from a high ladder and touched a hot lamp, the reflex action could cause you to lose balance and result in a serious injury. The lamps here, operate at a much higher wattage than domestic lamps, so the risk of being a victim of this type of hazard is greater. Another hazard is carrying lamps, tubes etc., inside the shirt. Admittedly, this leaves the hands free for climbing a ladder, but consider the risk should the lamp break. It is safe practice to use a hand line to bring materials and tools etc. up a ladder.
Although a fluorescent tube does not get as hot as a lamp, there is still a hazard. Should a tube break and shatter, the inside of the tube is coated with phosphorescent material, so great care must be taken when handling it. The safest method of disposing a used tube, is to put the used tube in the new tube's carton and then break it under cover; this will prevent small particles from flying out and causing an injury.
For the disposal of Sodium vapour lamps, they should be placed in a dry, steel container and broken into small fragments.
Using a hose, and from a safe distance, spray water on the fragments. This will cause the sodium to burn and explode whilst in a safe place.
New tubes are wrapped in aluminium foil, to minimise the risk of fire due to breakages and moisture in transit.
The high pressure sodium lamp, must only be used in fixtures and circuits, wired with compatible auxiliary equipment. Operation with incompatible equipment can cause the lamp to shatter, which may result in personal injury and damage to equipment.
DO NOT insert, or remove any lamp while the power is on.
If the outer bulb is broken, shut off the supply immediately, and remove lamp to prevent exposure to ultra-violet energy. This is a vacuum jacketed lamp and it may implode if broken. Do not scratch the lamp, or subject it to undue pressure, as either may cause shattering. Electrically insulate any metal support in contact with the outer bulb, to avoid glass decomposition. Although the outer bulb is made of heat resistant glass, external protection of the lamp is required, to minimise the chance of breakage, due to direct contact with water during lamp operation.