

A photograph of a street lamp with a glowing yellow light fixture, set against a dark blue sky. The lamp pole is visible on the left side of the image.

Lighting

Health & Safety

Two aspects of health and safety are relevant to lighting in the workplace

Gradual deterioration of a workers sight and performance

The increased likelihood of accidents due to a workers failing or incorrect perception

Health & Safety

The purpose of the lighting section of the The Workplace (Health, Safety and Welfare) Regulations 1992 is to consider

The quantity and quality of lighting required for a given task

The basis for lighting design and specific applications, as in the case of VDU's

Legal Requirements

Regulation 8

EVERY WORKPLACE SHALL HAVE
SUITABLE AND SUFFICIENT LIGHTING
WHICH, SO FAR AS IS REASONABLY
PRACTICABLE, SHALL BE BY NATURAL
LIGHT

Further-more, suitable and sufficient
emergency lighting shall be provided

Emergency Lighting



When normal lighting fails, immediate light output is necessary. This can be acquired only from certain lamp types such as tungsten, tungsten halogen and tubular fluorescent lamps, LEDs. Other lamp types take too long to reach full output

The lamps must have alternative electrical supply when the normal supply fails e.g. battery packs + Red - Black

Necessary Illuminance needs to be provided at appropriate places, such as emergency exits and escape routes

Direction and fire exit signs need to be illuminated

Emergency luminaries need to be mounted at least two metres above the floor but not much higher.

It is important that the lighting outside the building is adequate for safe evacuation and that the lighting itself is safe for outside use

In deciding the position and location of luminaries, those responsible for health and safety need to consider where:

Emergency exits are situated - Escape routes are located

Areas that require special attention, such as escalators, plant rooms, direction signs, fire alarm points and fire-fighting equipment.

Guidance on lighting at work can be found in Hsg38.

Maintained Emergency Light

Maintained lighting is designed to be lit continuously and will continue to work even in the event of a power failure. This allows the unit to double as a standard light fitting but still supply the necessary backup in the event of a power outage.

This type of emergency lighting is suitable for public places such as theatres, shopping malls and cinemas.

Non-Maintained Emergency Light

Non-maintained emergency lighting is designed to turn on in the event of a power failure. It is linked into the building's lighting circuitry and reacts to a power failure ensuring emergency exit routes remain illuminated.

This type of emergency lighting is mostly found in the workplace, such as offices and factories, where people are familiar with the escape routes.



Emergency Lighting

Testing according to BS5266

Monthly testing

All luminaires and signs shall be checked to ensure that they are present, clean and functioning correctly.

Annual testing

A test for the full rated duration of the emergency lights, for three hours, must be carried out. The emergency lights must still be working at the end of this test.

All results must be recorded and if failures are detected, these must be remedied as soon as possible.

Design and Types of Lighting

Design Considerations

In the design of lighting, many factors need consideration. These may include the following:-

Illuminance levels: For the principle operations within the premises and for specific parts of the premises, both externally and internally

Availability of natural lighting: Whilst it is the best form of Illuminance, it must often be considered a secondary option in lighting design owing to its unreliability

Specific areas and processes: The type of lighting and lighting needs of specific areas and/or processes should be considered e.g. access points, corridors, internal traffic lanes

Colour rendition aspects: Correct positioning and perception of colour is very important in certain areas, e.g. safety signs and notices

Glare and dazzle: Potentially hazardous where machinery is installed

Structural aspects: Items such as screens, pillars and plant may obstruct light flow reducing the Illuminance levels

Atmospheric influences: The presence of steam, fumes and mists may impair vision and reduce the lighting levels

Lamp and window cleaning: The need for frequent cleaning, replacement and maintenance of lamps Suitable access and equipment must be provided.

High risk areas: The potential for fire and explosion in certain areas may indicate the need for specialised light fittings.

Emergency lighting: Necessary in most activities.

Energy Considerations

The use of time-switches or photo-electric switching devices should be considered.

Low energy lamps such as LED's (Light emitting Diodes}

It has been proven that the quality of lighting has a direct effect on worker performance, and, more importantly, the accident potential.

Quantitative Aspects Of Lighting.

The quantity of light flowing from a source such as a light bulb or fluorescent lamp is the luminous flux or light flow. This is generally termed as "Illuminance"

The units of measurement of luminous flux were formerly foot-candles or lumens per square foot, however more recently, *the unit has become the lux, which is the metric unit* of measurement. Thus ;

Foot candles = Lumens per square foot

Lux = Lumens per square metre

10.76 Lux = 1 Lumen per square metre

1 Lux = 0.093 Lumens per square metre

Average Illuminance (hsg38)

General Activity	Typical locations types of work.	Average Illuminance Lux (Lx)	Minimum Measured Illuminance Lux (Lx)
Movement of people, machines and vehicles	Lorry parks, corridors, circulation routes.	20	5
Movement of people, machines and vehicles in hazardous areas ; rough work not requiring any perception of detail	Construction site clearance, excavation and soil work, docks, loading bays, bottling and canning plants.	50	20
Work requiring limited perception of detail	Kitchens, factories assembling large components, potteries.	100	50
Work requiring medium perception of detail	Offices, sheet metal work, bookbinding.	200	100
Work requiring high perception of detail	Drawing offices, factories assembling electronic components, textile production.	500	200

Efficacy

It has been proven that gas discharge lamps are, in general, much more efficient than the incandescent type. The efficiency of a lamp is related to the quantity of visible light emitted per watt of electrical energy consumed and is known as the **efficacy**. For example, if a 100W. incandescent lamp had a total light output of 1200 lumens, its efficacy would be 12 lumens per watt (lm/W.). Of the various types of discharge lamp, the sodium-vapour type is the most efficient, which is why it is favoured by the County Councils responsible for road lighting.

Typical lighting efficacies

Incandescent : 100W Tungsten 12 lm/W

Gas Discharge

**: 250W Mercury Vapour
(low pressure) 45 lm/W**

**:250W Sodium Vapour
(low pressure) 100 lm/W**

**:250W Sodium Vapour
(high pressure) 90 lm/W**

Lumens per Watt

AURORA[®]



Lamp Types



Incandescent filament GLS

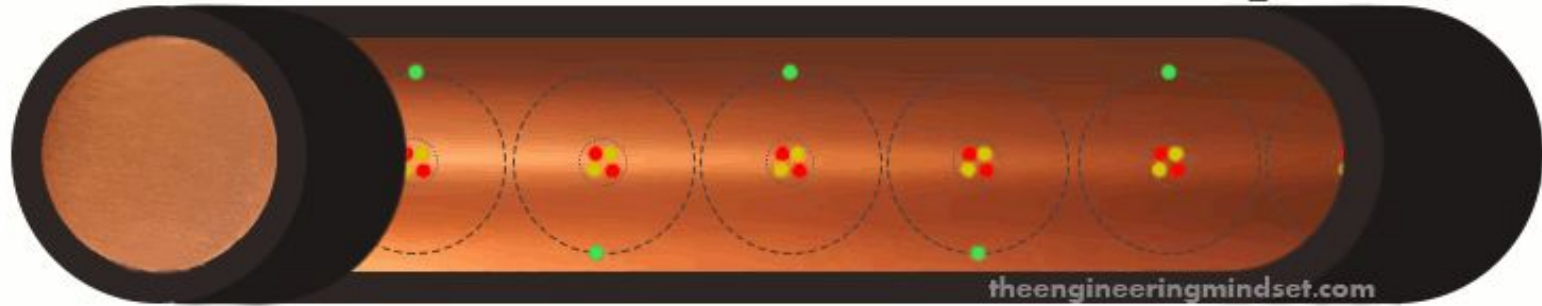


Bayonet



Edison Screw

The flow of electricity



In the illustration above, electrons flow in a synchronized and orderly manner.

In reality the atoms will not be aligned so well and they will also vibrate tiny amounts causing electrons to collide. As the electrons collide they convert their kinetic energy into heat and light. That's how incandescent filament bulb's work.

Lamp Types

Incandescent filament



PAR



Tungsten Halogen

Filament Lamps

If a material is made white hot it emits light. This is the principle of operation of the lamp which uses a tungsten filament. Tungsten has both a high melting temperature (3,380C) and the ability to be drawn into a fine wire. To prevent it oxidising and failing prematurely, all oxygen must be removed from the enclosing glass bulb. Whilst the smaller lamps are evacuated, the larger lamps are filled with argon which reduces filament evaporation at high temperatures

Note* Avoid touching the glass envelope of TH lamps as the skins natural oils can cause it to explode when it reaches operating temperature

Gas Discharge Lamps



Low Pressure Mercury Vapour (Fluorescent)



Straight Tube

T12 T8 T5

38mm 26mm 15mm



Shaped Tube

Fluorescent Lamps

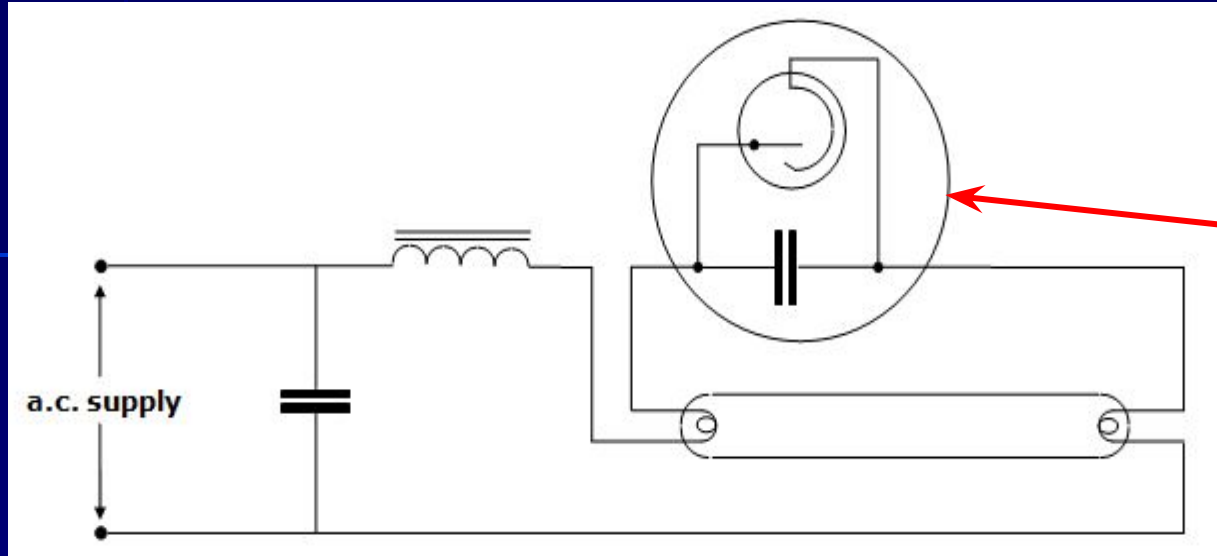


The fluorescent lamp usually consists of a long glass tube, internally coated with a fluorescent powder. The tube contains a small amount of argon together with a little mercury.

At each end of the tube there is an electrode consisting of a coiled tungsten filament.

Switch Start (Fluorescent)

TTE



The starter consists of two bi-metallic strip electrodes that bend when a voltage is applied due to the ionisation of gases in the starter. This closes the circuit and allows a relatively large current to flow in the heater coils at either end of the tube. The gases near the heater coils become ionised and the touching strips now cool down and separate. As the circuit breaks it causes a collapse of the magnetic field in the choke (ballast) which self induces (Lenz) and creates a striking voltage between 800 – 1000V. This surge in voltage is enough to ionise the remaining gases within the tube which then vaporises the mercury. The potential difference across the tube is now reduced to between 100 -110V which is insufficient to restart the starter and the current is controlled and regulated by the choke.

Capacitors in gas discharge lighting

The use of capacitors in discharge lighting reduces the inductive effect known as power factor correction.

They can also be placed in the circuit to reduce RFI Radio Frequency Interference

This is produced by the lighting components and can interfere with other electronic equipment nearby.



Photo: wikimedia user EMU



Photo: wikimedia user Durr Luchini

Other Lamp Types



High Pressure Mercury Vapour (MBF)



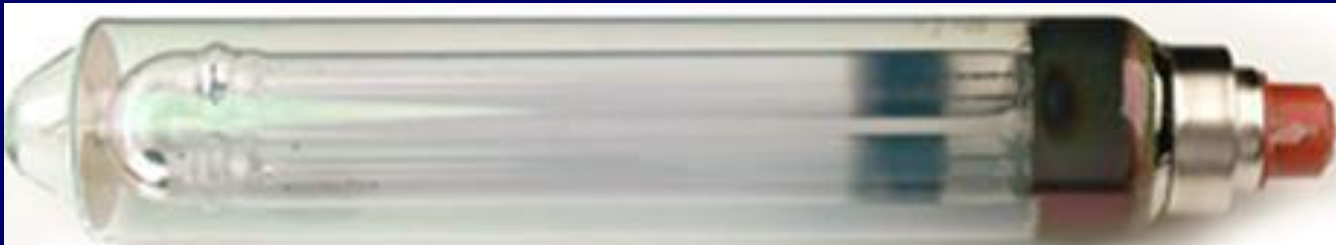
A high pressure mercury discharge lamp operates in a quartz arc tube.

MBFR lamps have a shaped outer bulb with an internal reflector coating.

Note: MBTF is a mercury discharge tube connected in series with a tungsten filament in the same outer bulb: external control gear not required.

Lamp Types

Low Pressure Sodium Vapour (SOX)



Single ended U-shaped arc tube

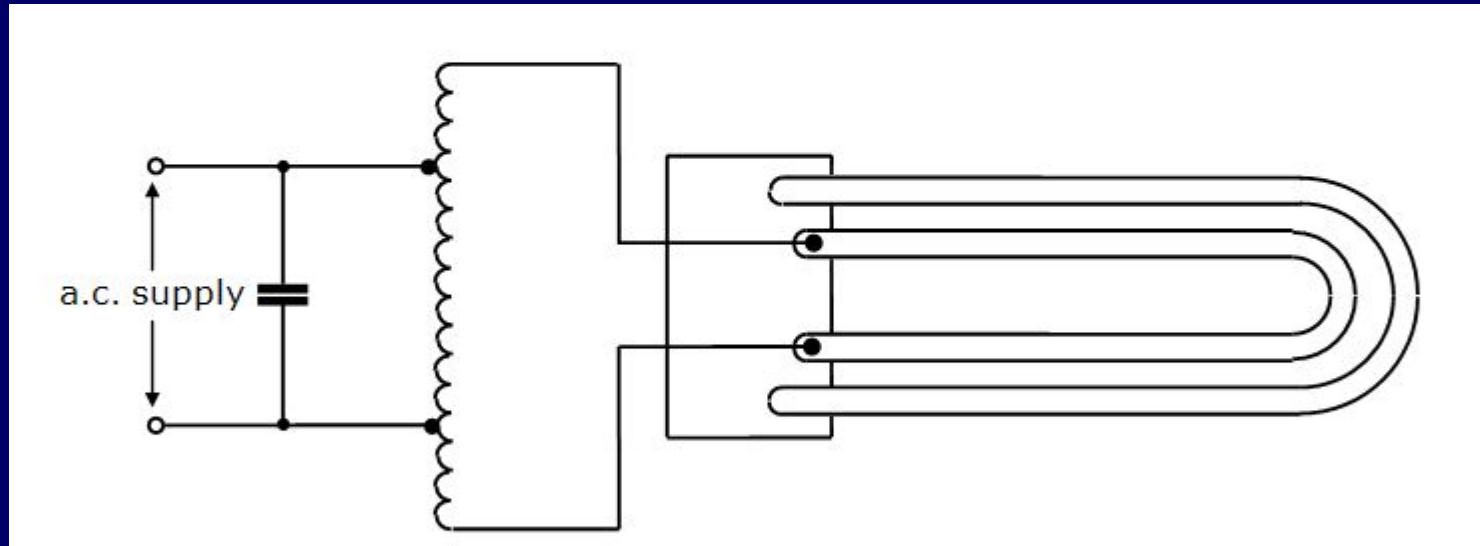
Low pressure sodium

(LPS) lamps, aka sodium oxide (SOX) lamps.

When the lamp starts (i.e. when the arc strikes) it emits a dim red/pink light to warm the sodium metal and within a few minutes turns into the familiar bright yellow/orange colour, as the sodium metal vaporises.

Low pressure sodium (LPS) SOX

When this transformer is on open-circuit, its output voltage is approximately 500V., and this is sufficient to initiate a discharge through the gas. This discharge has a reddish colour however, as the gas discharge increases the temperature, the sodium is vaporised and the discharge changes to an orange light.



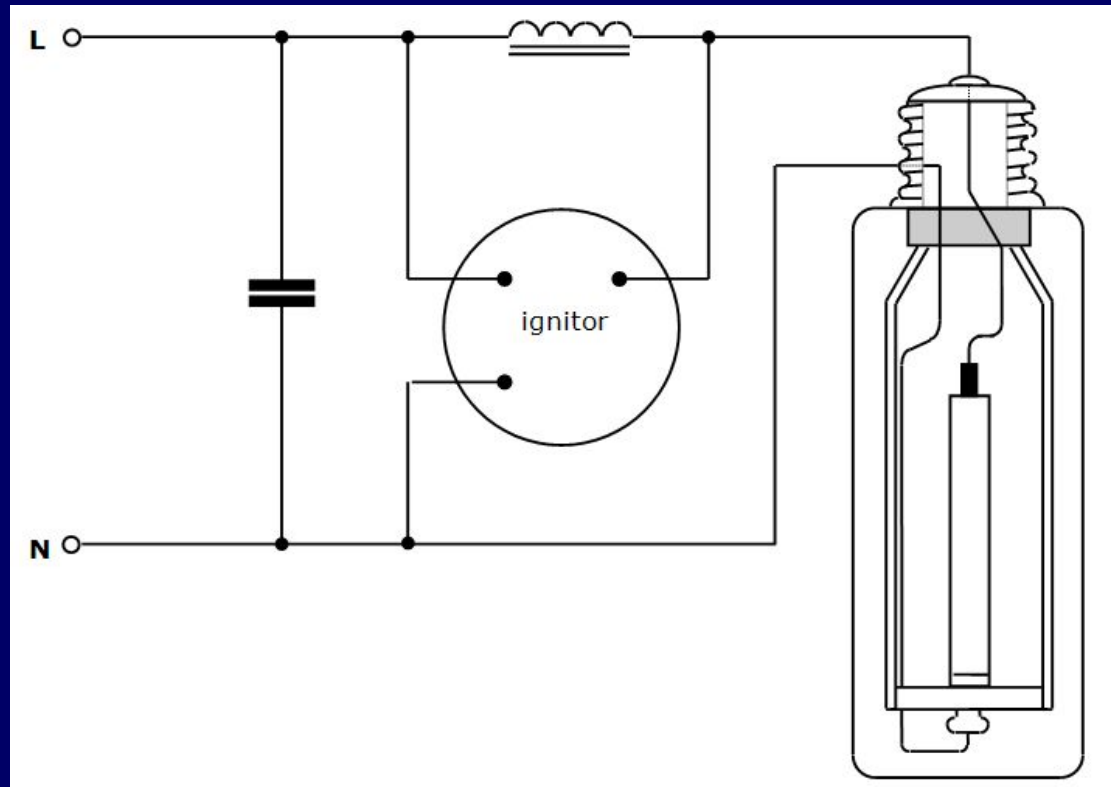
High pressure sodium (HPS) SON

These lamps are smaller than LPS lamps. They produce a dark pink glow when first struck, and a pinkish orange light when warmed.

Light is generated by an electrical discharge in a gas containing sodium and mercury (sodium amalgam) and argon or xenon gas as the "pre-heating" substance. Contained in a sintered alumina arc-tube. High pressure sodium lamps are used for road lighting, floodlighting and industrial interior lighting.

High pressure sodium (HPS) SON

Starting is effected by the ionisation of the xenon (or argon) gas by high voltage pulses (2kV. to 4.5kV.) from the ignitor in the external control circuit. The ionised gas heats the lamp and the sodium-vapour discharge takes over



Lamp Types

High Pressure Sodium Vapour (SON)



SON E
Diffused elliptical



SON T
Clear Tube

Lamp Types



Metal Halide

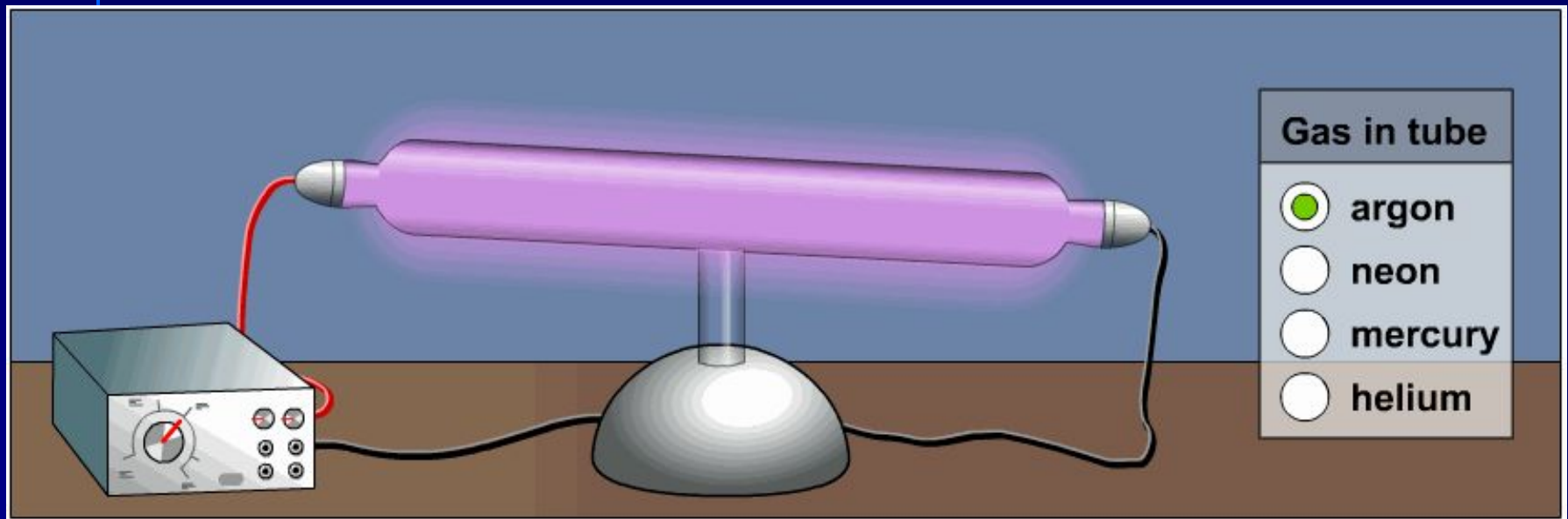


Metal Halide

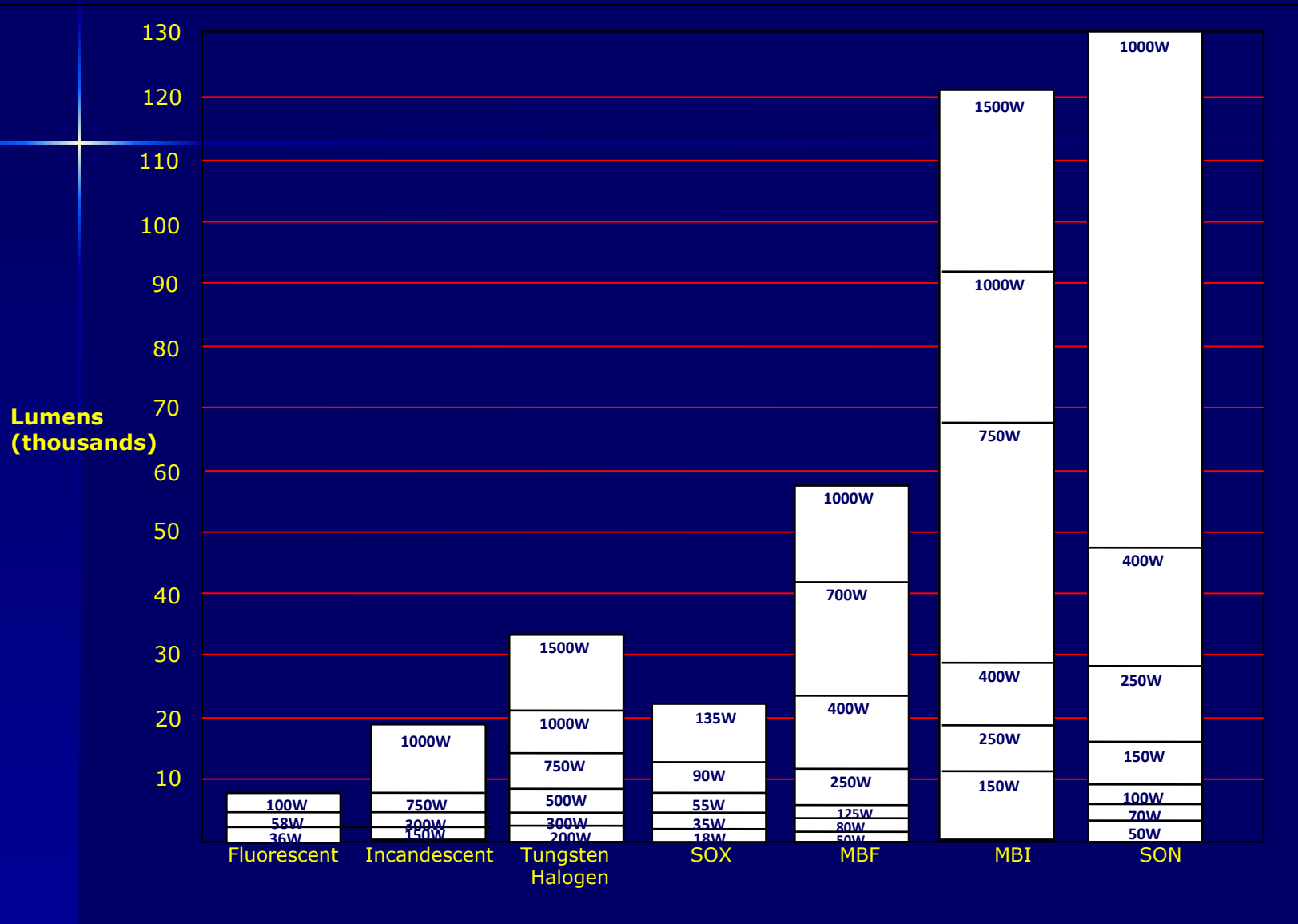
Metal Halide lamps are the most advanced high pressure discharge lamps. They have quartz or sintered alumina (ceramic) arc-tubes.

The mixture of halides will affect the nature of light produced, influencing the correlated colour temperature and intensity

Gas In Tube



Light output comparison



Hazards



There are many hazards associated with lights and light fittings some of which include Maintenance

1. Be careful when changing lamps, most will be at height and will require some form of access equipment such as scissor lifts and cherry pickers which require training
2. Lamps can be very hot to touch and can cause severe burns, including chemical burns i.e. Sodium
3. Lamps can be toxic i.e. Mercury
4. Glass can be a hazard if lamps are dropped or damaged
5. Other hazards associated with lights and light fittings include poor levels from incorrectly selected fittings

Stroboscopic Effect

IET Regulation 559.9

The light output of all discharge lamps fluctuates at twice the supply frequency. This fluctuation, or flicker, is known as the stroboscopic effect and it can produce undesirable effects, particularly with rotating machinery. If the machine is rotating in multiples of the speed of flicker it may appear to be rotating in reverse or, more dangerously, may appear to be stationary

Waste Disposal

All gas discharge lamps containing Mercury and Sodium must be treated as

HAZARDOUS WASTE

and must therefore be disposed of in accordance with local environmental procedures

LED'S

Light Emitting Diodes

Terminals

Anode Positive +
Long Leg

Cathode Negative -
Short Leg
Flat side of Led

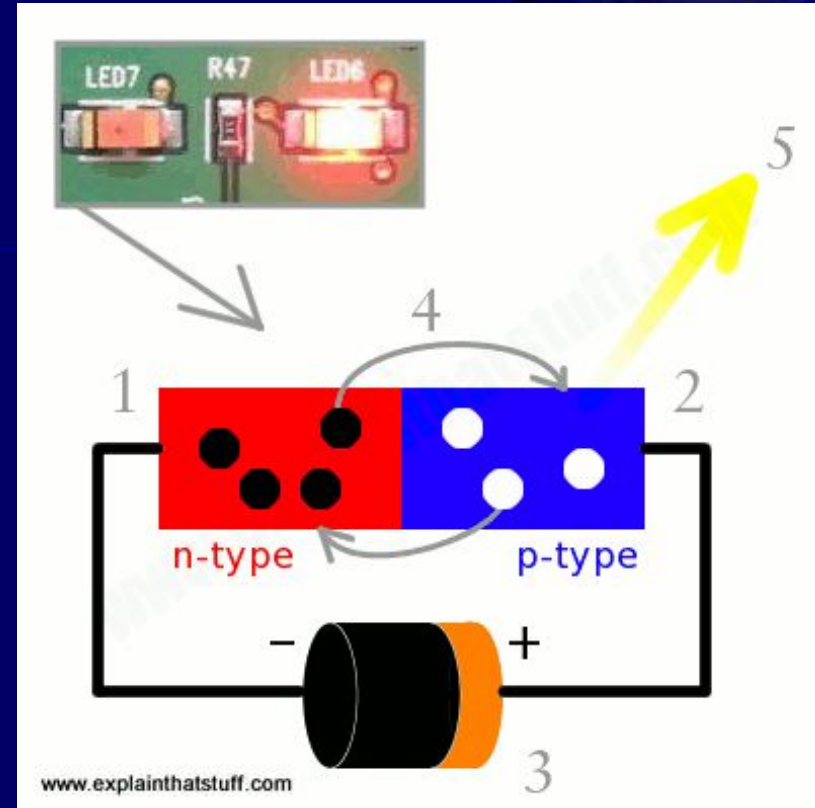


LED Working Principle

LEDs are simply diodes that are designed to give off light. When a diode is forward-biased so that electrons and holes are zipping back and forth across the junction, they're constantly combining and wiping one another out.

Sooner or later, after an electron moves from the n-type into the p-type silicon, it will combine with a hole and disappear. That makes an atom complete and more stable and it gives off a little burst of energy (a kind of "sigh of relief") in the form of photon of light.

1. N-type silicon (red) has extra electrons (black).
2. P-type silicon (blue) has extra holes (white).
3. Battery connected across the p-n junction makes the diode forward biased, pushing electrons from the n-type to the p-type and pushing holes in the opposite direction.
4. Electrons and holes cross the junction and combine.
5. Photons (particles of light) are given off as the electrons and holes recombine.



Efficiency Of Leds (Efficacy)

Lumens Per Watt (lm/W)

This figure is a useful way to measure the efficacy of lighting products by measuring the total light output in Lumens divided by the power usage in Watts.

A highly efficient led could offer a light output of 3500 Lumens for 23 Watts of power.

$$3500\text{lm}/23\text{W} = \mathbf{152\text{lm/W}}$$

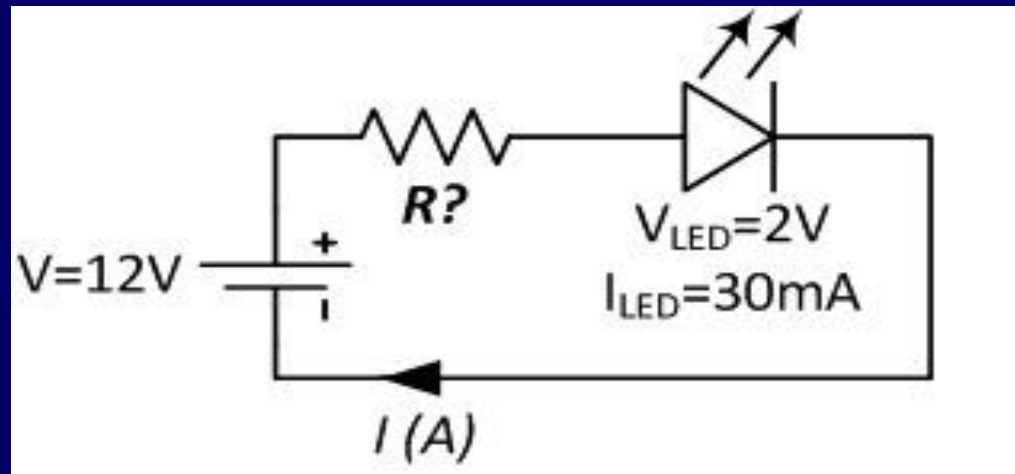
Basic LED Circuit

The simplest circuit to drive an LED is through a series resistor.

An LED has a voltage drop Ohms Law and Kirchhoffs's Law are used to calculate the appropriate resistor value to obtain the desired current.

$$R = \frac{V_s - V_f}{I_f}$$
$$R = \frac{12V - 2V}{30mA}$$

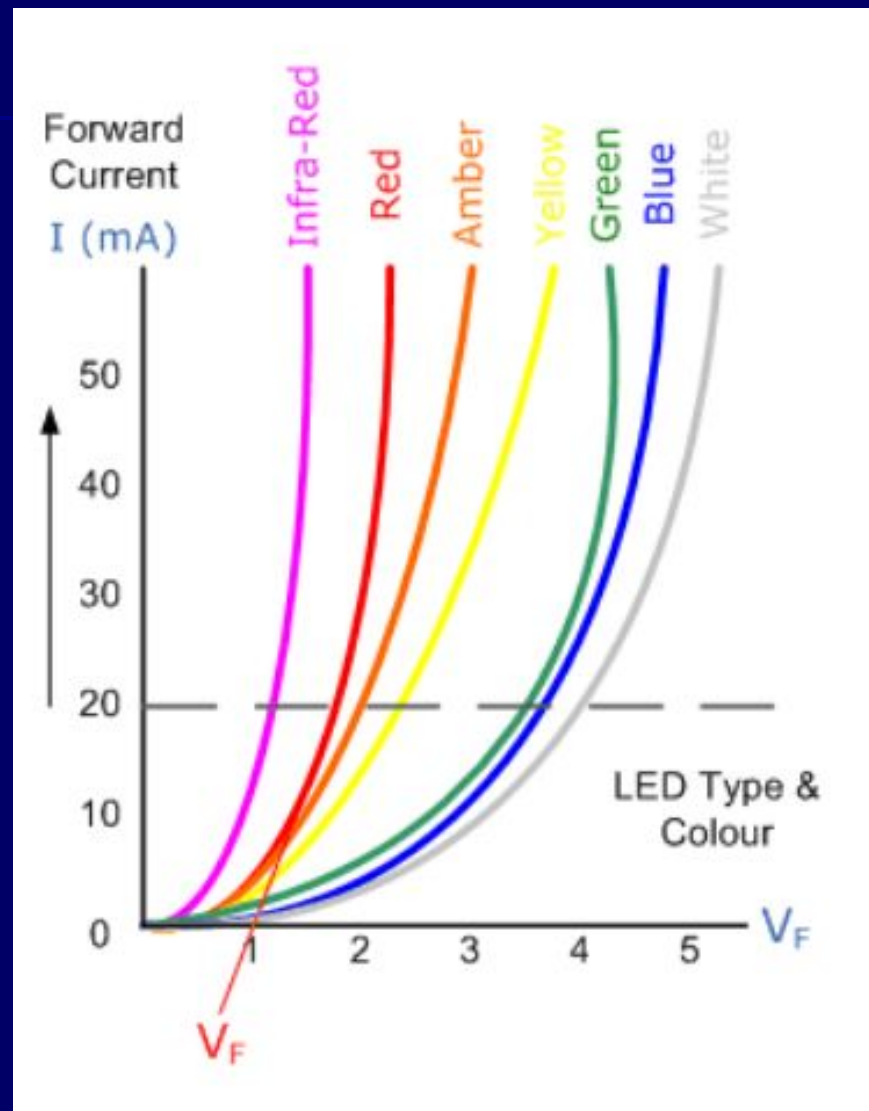
$$R = 333 \text{ Ohms}$$



You would then pick the nearest typical resistor above or equal to this value eg 360 Ohms

I-V Characteristics Curves showing the different colours available.

The actual colour of a light emitting diode is determined by the wavelength of the light emitted, which in turn is determined by the actual semiconductor compound used in forming the PN junction during manufacture. This then effects the forward biasing of the LED. Always refer to manufacturer's data.



Light Emitting Diode Colours

Typical LED Characteristics			
Semiconductor Material	Wavelength	Colour	V _F @ 20mA
GaAs	850-940nm	Infra-Red	1.2v
GaAsP	630-660nm	Red	1.8v
GaAsP	605-620nm	Amber	2.0v
GaAsP:N	585-595nm	Yellow	2.2v
AlGaP	550-570nm	Green	3.5v
SiC	430-505nm	Blue	3.6v
GaInN	450nm	White	4.0v

Connecting LEDs Together in Series

We can connect LED's together in series to increase the number required or to increase the light level when used in displays. As with series resistors, LED's connected in series all have the same forward current, I_F flowing through them as just one. As all the LEDs connected in series pass the same current it is generally best if they are all of the same colour or type.

Connecting LED's in Series



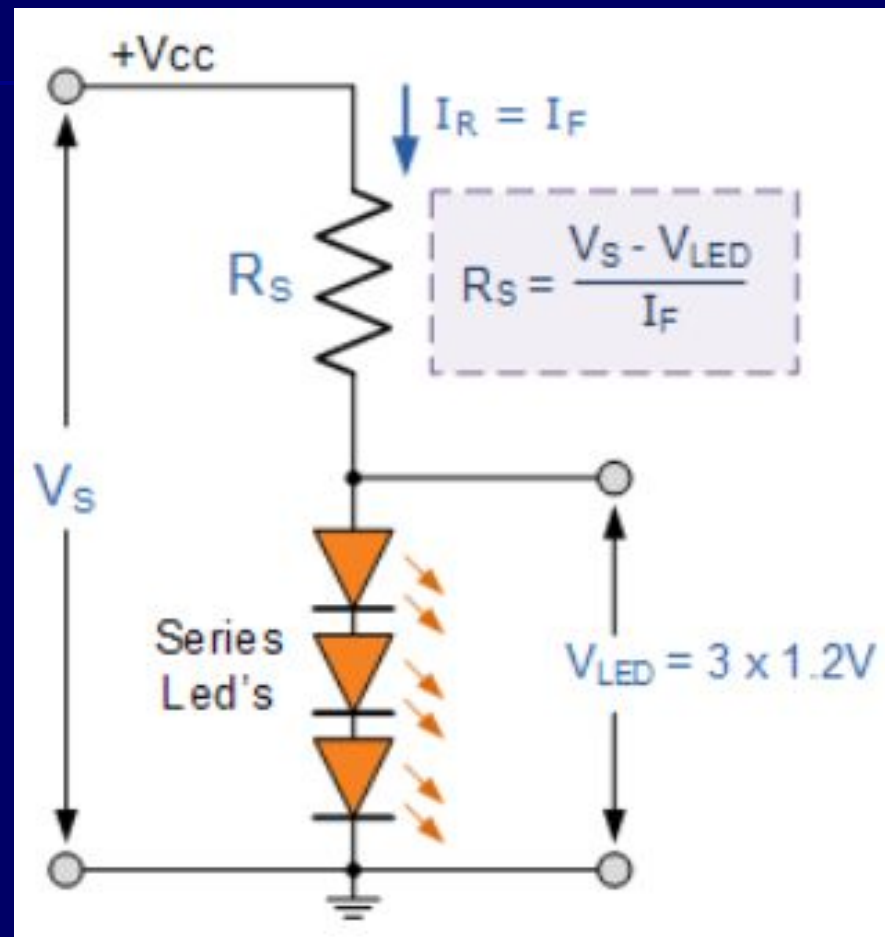
Although the LED series chain has the same current flowing through it, If we assume that each LED has a voltage drop across it of 1.2 volts, then the voltage drop across all three will be $3 \times 1.2\text{v} = 3.6$ volts.

A supply of 5 volt with a forward current of about 10mA. Then the voltage drop across the resistor, R_s and its resistance value will be calculated as:

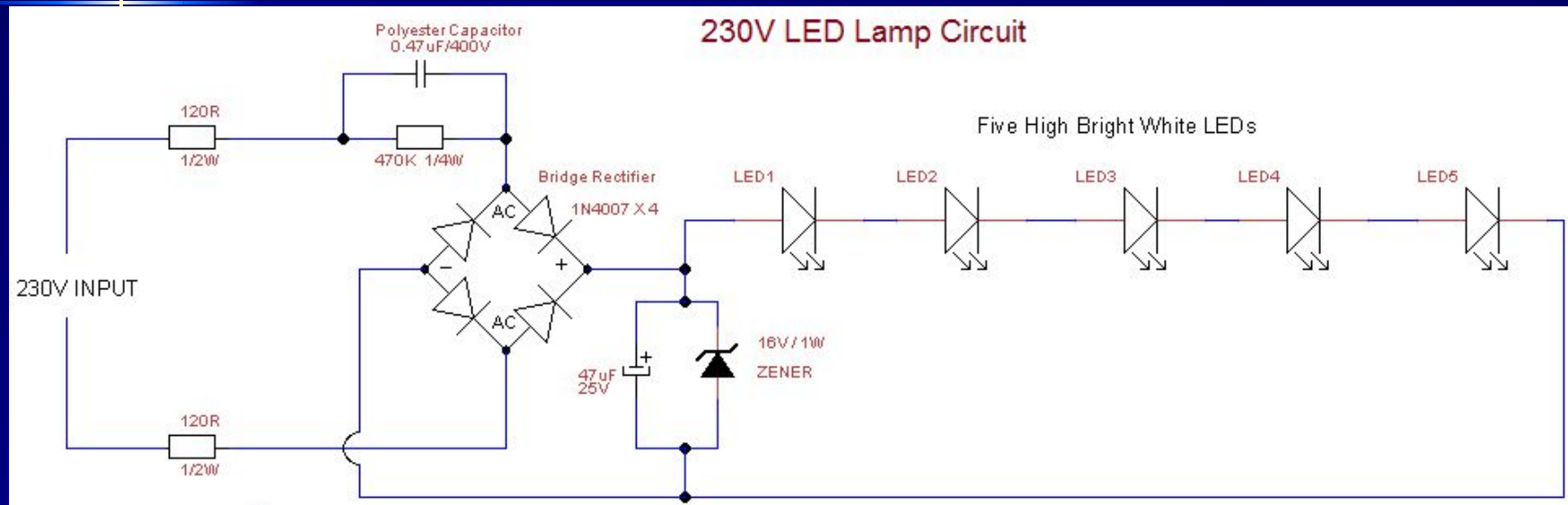
$$V_{\text{Led}} = 3 \times 1.2\text{V} = 3.6\text{V}$$

$$R_s = V_s - V_{\text{Led}} = 5 - 3.6 = 1.4\text{V}$$

$$R_s = 1.4\text{V} / 10\text{mA} = 140 \text{ Ohms}$$



A typical circuit to connect an LED to AC



When working with LEDs, be sure to check the datasheet from the manufacturer for the proper voltage and current requirements for your particular LED.



LED 101