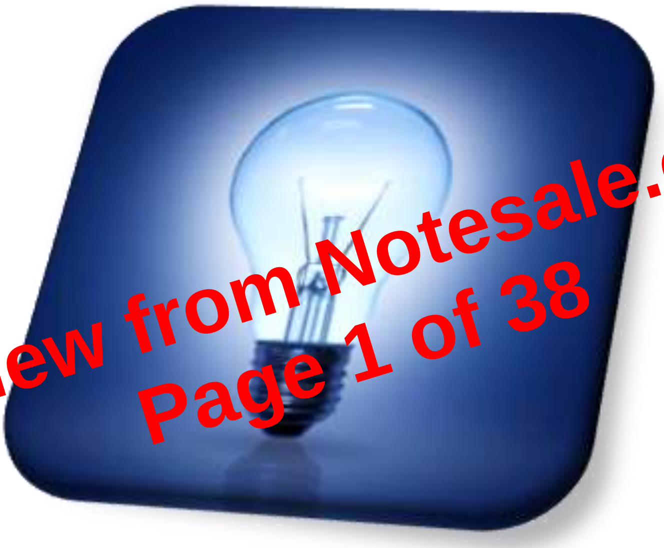
HNC Electrical and Electronic Engineering

Year Two - 2014/15

Module: UofEE

UTILISATION OF ELECTRICAL ENERGY



Illumination

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The outer bulb is made from borosilicate glass. The purpose of this is to block the harmful UV light produced by the mercury tube. The outer bulb is usually filled with low pressure nitrogen, argon-nitrogen mix, carbon dioxide (rarely) or a vacuum. The purpose is to prevent oxidisation / deterioration of seal and phosphor coatings.

1.2.3 Starting Electrode

When the lamp is turned on the open circuit voltage is applied across the main electrode and the starting (auxiliary) electrode. At this point no current flows between the main electrodes, as the gap is too large to produce the necessary arc. The starting electrode has the same polarity as the main electrode at the opposite end of the tube.

The gap between one of the main electrode and the starting electrode is much smaller and the voltage is high enough to start an arc. The current flow is limited by the resistor. This releases electrons and ions (like the heater in the florescent light) and it warms the mercury sufficiently to turn it to a gas. After several minutes there are sufficient charged particles to allow plasma to form between the main electrodes.

Higher power bulbs and ones to be used in cold climates have a starting electrode at both ends. Each starting electrode is connected via a resistor, to the main electrode at the opposite end of the tube.

1.2.4 Ballast

The resistance of a mercury lamp decreases as it gets hotter. This results in an increase in current, which results in an increase in temperature and so on. So, like the florescent lamp the current must be limited by ballast. Larger mercury lamps use external ballast which is more efficient than self-ballasted lamps. These lamp used in home lighting have ballast built into the bulb, in the form of an incandescent filament that acts as a resistor.

1.2.5 Florescent Coating

A significant portion of the light produced by mercury lamps is in the UV spectrum. This gives high pressure mercury lamps a blue hue. For some applications this isn't a problem. If a whiter light is required, a phosphor coating on the inside of the outer bulb absorbs UV and emits red light which the mercury lamp lacks.

1.2.6 Uses of High Pressure Mercury Lamps

These lamps are used to provide illumination over large areas such as street lamps, sports halls and factories.

Specialist uses include photolithography and molecular spectroscopy.

1.3 Low Pressure Sodium LPS)

1.3.1 History

1920 Arthur H. Compton, working for Westinghouse invents the first low-pressure sodium lamp (see Figure 9).

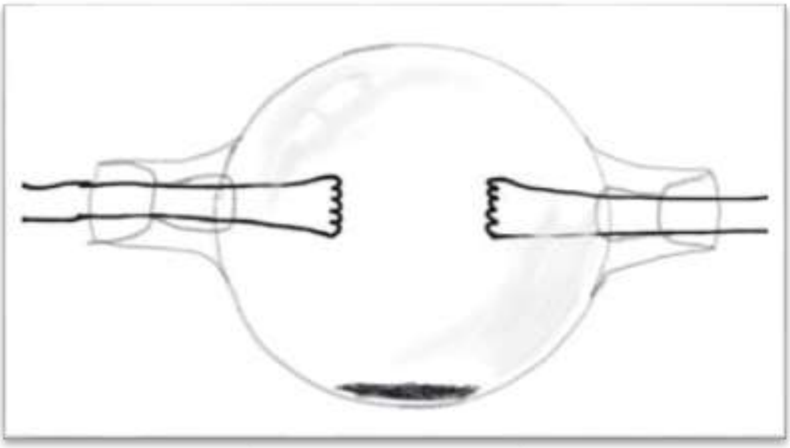

Figure 9: Compton's sodium lamp (Edison Tech Center, 2013)

1931 Marcello Pirani, working for Osram (Germany) developed sodium resistant glass.

1932 Philips (NE) was the first company to produce sodium commercially.

Other key advances include integrating the discharge tube within an outer vacuum bulb, and coating the inside of the outer bulb with Indium-tin to reflect infrared light (i.e. heat) back into the discharge tube. Both of these developments help to reduce heat loss and thus improve efficiency.

1.3.2 Construction

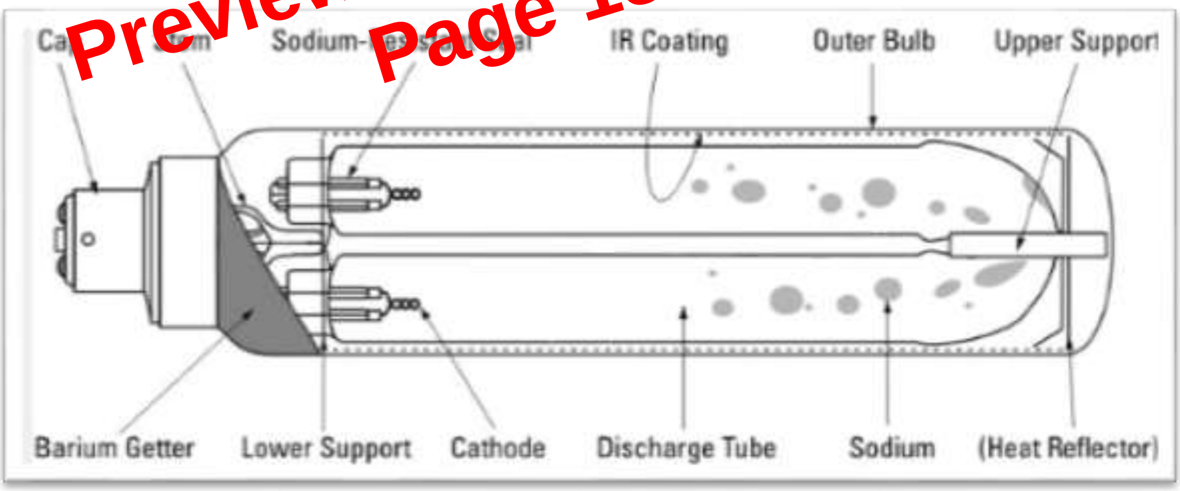

Figure 10: A low-pressure sodium lamp (Hooker, 2015)

The LPS lamp has an outer vacuum bulb, the inside of which is coated with indium tin oxide to reflect infrared light back into the lamp. It contains an inner borosilicate glass U-tube holding sodium (initially solid) and neon and argon gas.

2 Task2: Illumination Measures (Task2)

Light quality is a very subjective topic. In order to make meaningful comparisons between different light sources some well-defined measures are required. There are a number of measurements available, each focusing on a slightly different characteristic of the light source being observed. Which measure or measures are used depends upon the particular requirements of the user and environment. Some of the more common measure are further discussed.

2.1 Luminous intensity

Luminous intensity of one of the seven SI base units. Its unit is the **candela** (cd).

The candela was defined in 1979; in terms of the watt, at one specific wavelength of light. The defined is:

> *The luminous intensity, in a given direction, of a source that emits monochromatic radiation of frequency 540 x 1012 hertz and that has a radiant intensity in that direction of 1/683 watts per steradian (a unit of solid angle).* (National Physical Laboratory, 2014)

In photometry the luminous intensity is the wavelength-weighted power emitted by a light source, in a particular direction per unit solid angle. It is based upon the luminosity function, the standardised model of the sensitivity of the human eye.

$$1\ candela = \frac{1\ lumen}{unit\ solid\ angle}$$

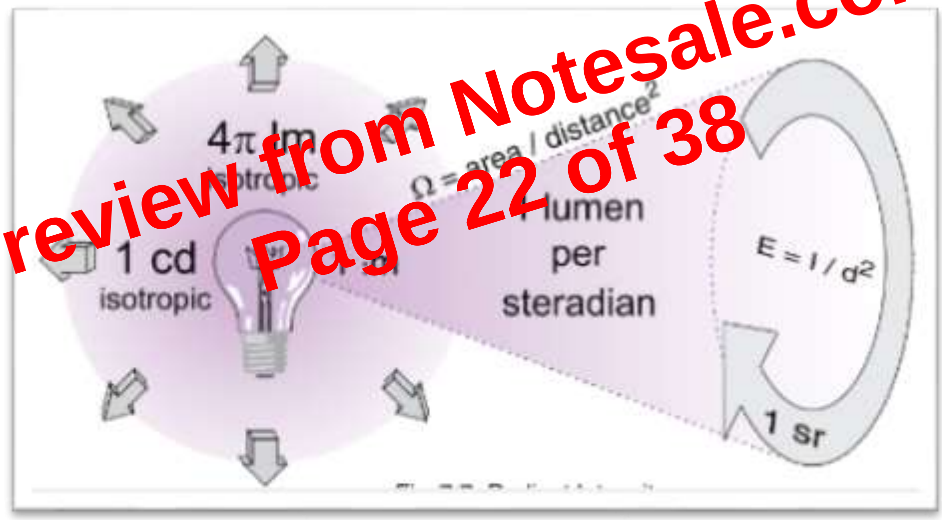

Figure 15: Radiant and luminous intensity

2.1.1 A Steradian

A steradian (sr) is the cone of light spreading out from the source. One steradian would illuminate one square meter of the inner surface of a sphere of 1 m radius around the light source. In terms of other SI units the steradian is m^2/m^2 and is, therefore, dimensionless. The steradian is a derived SI unit.

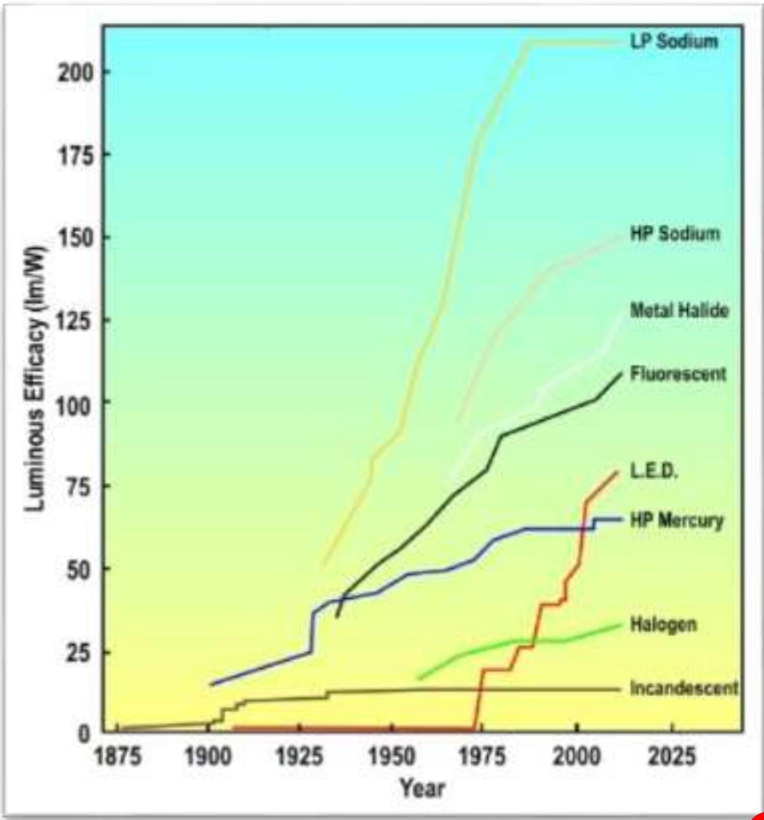

Figure 22: Efficacy of Light Sources as technology improves (Hooker, 2013)

2.5 Coefficient of utilisation

The coefficient of utilization is defined as:

> *The percent of the lumens from the lamp that finally find their way to the work plane.* (General Electric Company, 2014)

The value is dependent upon a number of factors:

- The number of lamps in the fixture.
- The fixture type and design.
- Lenses and diffusers used
- Room shape (Room Cavity Ratio, RCR)
- How reflective the ceiling (Rc), walls (Rw) and floor (Rf) are.
- How clean the lighting fixture is (Dirt Depreciation Factor)
- Any other factors resulting in light loss.