

# Module 2 Lamps

# Lesson 8

## Discharge Lamps I

## Instructional Objectives

- What are Discharge Lamps?
- State Various type of Discharge Lamps
- List Types of Emission that make a Gas Conducting.
- Distinguish Line and Band Spectrum.

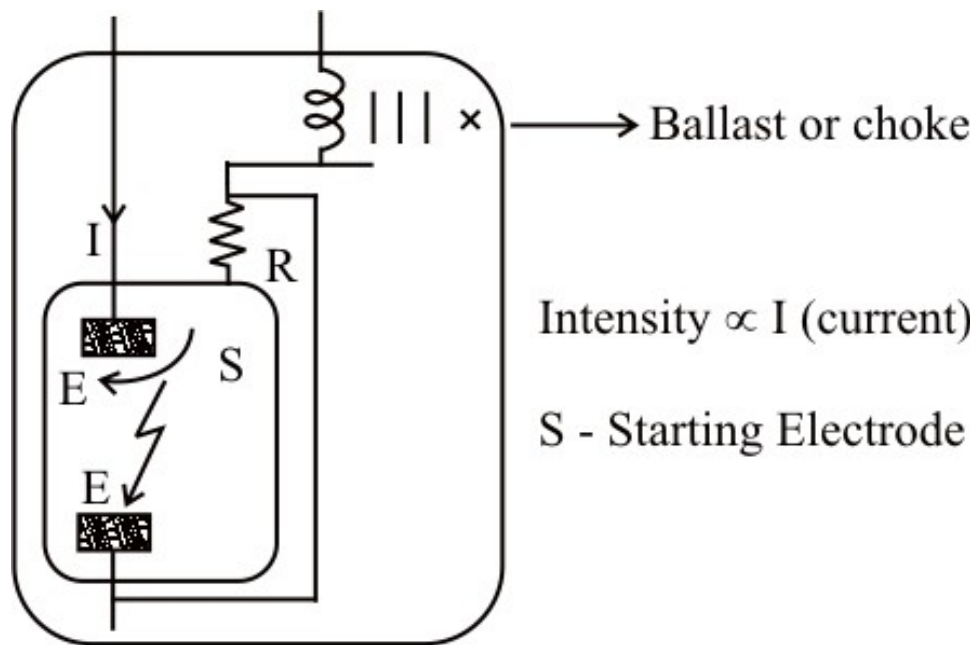
## Discharge Lamps

Incandescence was employed in Tungsten Filament lamps. Halides were employed to reduce blackening of the bulb. Luminescence and Fluorescence increase efficiency far beyond incandescence. Discharge of electricity through a tube containing a conducting medium leading to electron Flow is employed in Luminescence. This calls for an abundant supply of electrons.

## Electron Emission

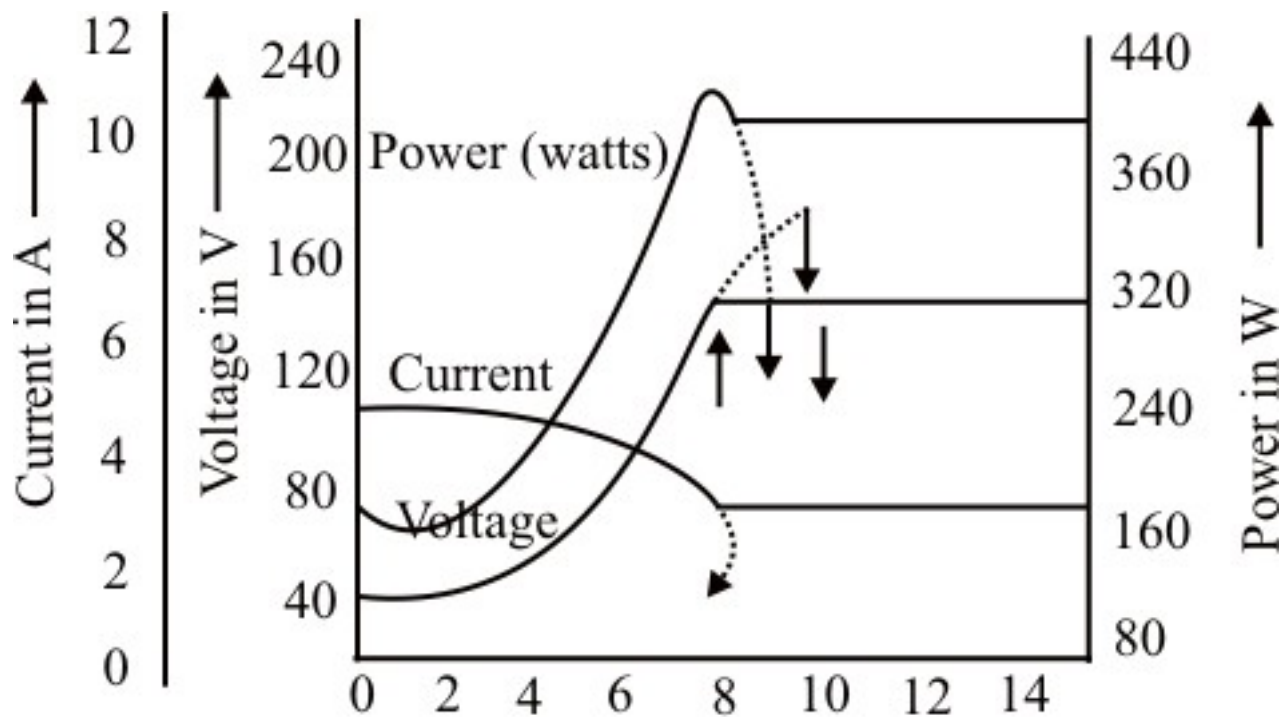
Electron emission is a process by which abundant supply of electrons is obtained. Electric Field Emission is employed in Cold cathode Lamps. Electrons are pulled out by application of High Potential. Thermionic Emission is employed in Hot cathode Lamps. Electrons are emitted even at a low voltage by heating. Barium / strontium oxide on a base of iron or Tungsten is used as Cathode. Photo electric Emission: Striking with Light Radiation of Photons, emission is achieved. Thus gas / vapor made Luminous by an electric discharge. Color / intensity of light are dependent on Gas / vapor employed. Intensity is proportional to the current. Commonly used gases are Neon, Mercury and Sodium. Cold Cathode needs large energy consumption at the cathode with decreased efficiency. This may lead to disintegration of cathode with high velocity positive ions due to large Potential drop at the cathode. Blackening of cathode does occur. They have Long Discharge Tubes with Low voltage Lamps. Mercury Vapor Lamps give light of Bluish Green, deficient in red rays. In this case color rendering (CRI) improves at high Pressures. Considerable distortion in colors occurs. Mercury – oxide coated Cathodes (Electrodes) are employed. In a typical discharge lamp coated tungsten wire electrodes with Strontium Oxide or Barium oxide coating are located at the opposite ends of a glass tube.

## Mercury Vapor Lamp



**Fig. 1: Typical Discharge Lamp**

Arc is a Constant Current Phenomenon. The starting electrodes are connected to lower electrode through a resistance (R). Arc tube contains Mercury at the desired vapor pressure. Pure Argon initiates arc prior to vaporization as pressure is increased – Radiation moves into visible spectrum. Standard Rating are 100,250, .....3000 W with a typical illumination of 35 lm / W. Arc initiation takes place at 20V at about 5A. Argon arc lasts for 2 min with a bluish Glow. At about 137 V, 3.2 A – Mercury vaporizes and takes over. Run up time or arc initiation time is up to 30 minutes. Lowest run up time is around 2 minutes. Ballast is a reactor in series that limits the current. Typical Power factor  $\approx 0.65 - 0.7$  capacitors added across the Lamp improve power factor to 0.94.

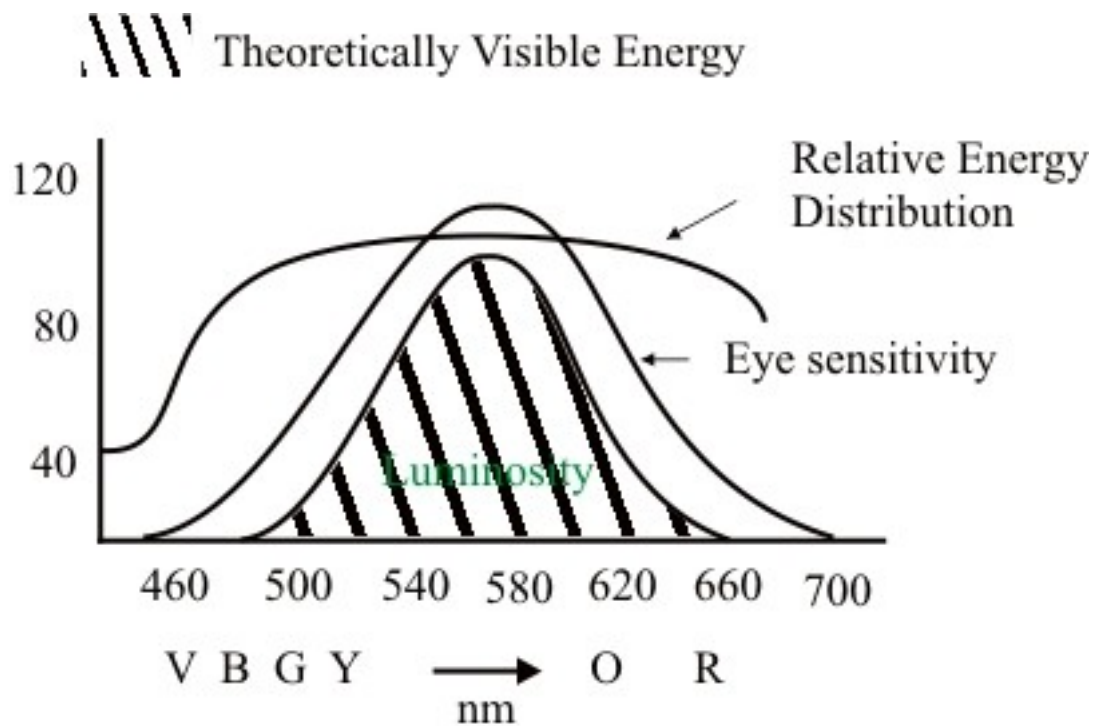


**Fig.2: Electrical characteristics of Mercury Vapor Lamp (400 W Lamp)**

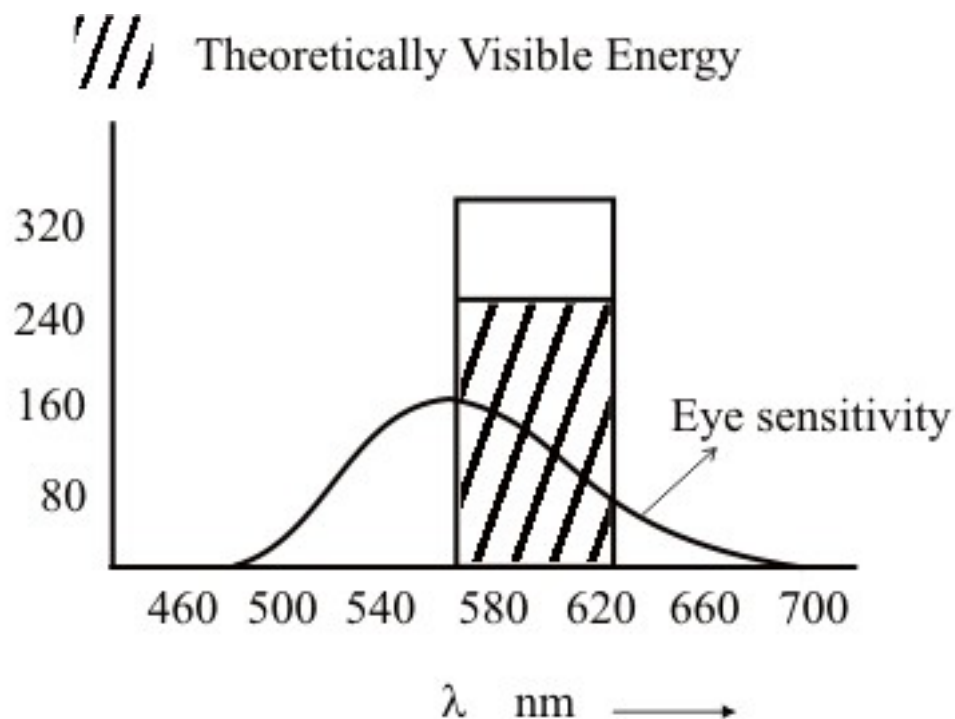
These lamps are suitable for Factory Lighting, Exterior Lighting / Flood Lighting and Street Lighting. They need 5 min of cooling before restarting. It is found that Combination Lamps – UV + Visible Light termed SUN Lamps with 3 min of Run up time and 5 min for restarting are more useful. They give out a band spectrum. Mercury – Radiates around 320 – 400 nm. Remember 365 nm is in the U.V. region.

## Sodium Vapor Lamp

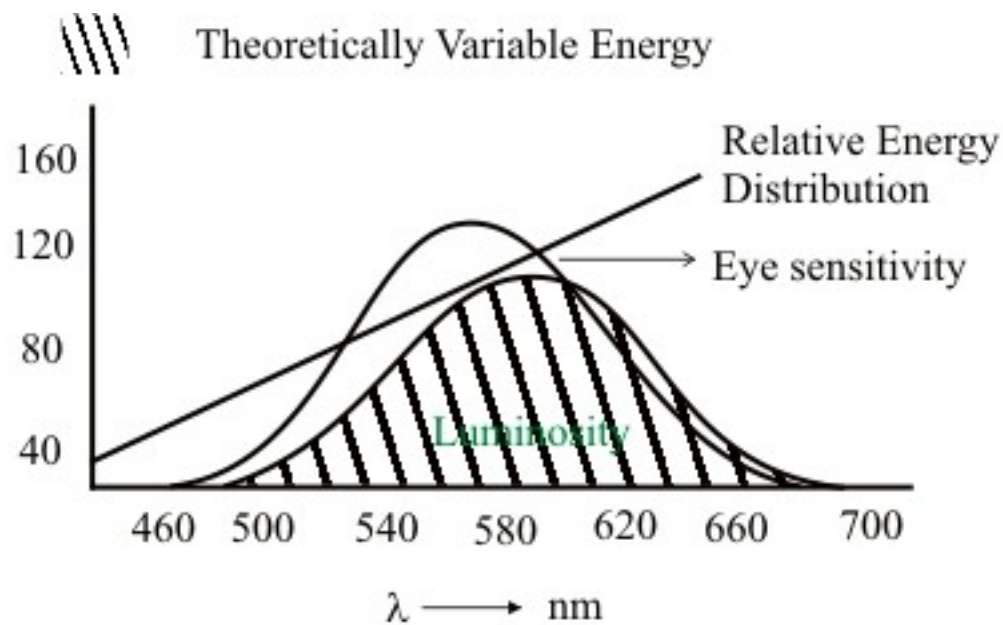
It is similar to High Pressure Mercury Vapor Lamp. It is in a hermetically sealed Glass tube with Sodium vapor. Electrodes are elliptical foil of Molybdenum and Coiled Barium oxide coated Tungsten. In one half cycle, Tungsten at the top acts as cathode, Molybdenum at the bottom acts as anode. Other Half cycle electrodes are reversed. Pure metallic sodium does not initiate arc. It needs a starting gas. Neon acts as a starter. This requires preheating, heaters are provided with in the Lamp. The Lamp glows with Red Color (Neon vapor), Orange yellow arc (sodium vapor arc). Leads to a line spectrum of radiation.



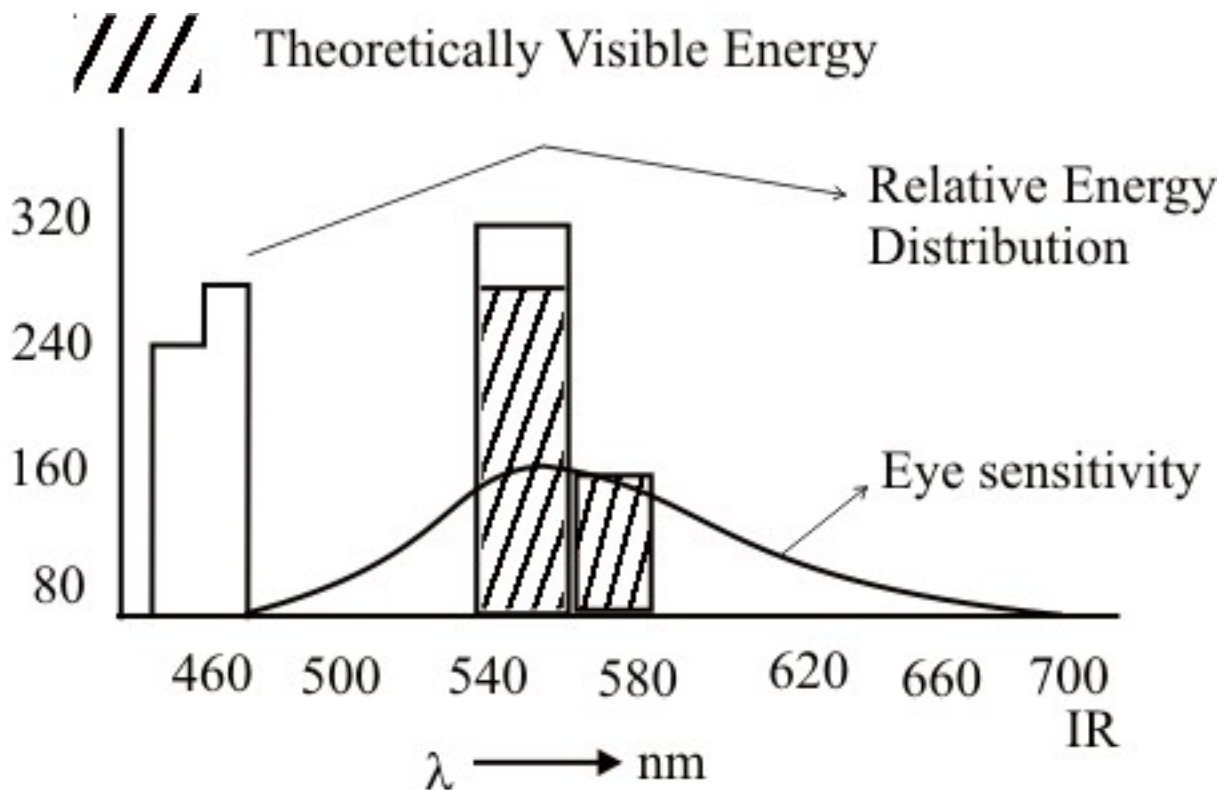
**Fig. 3: Radiation due to Sunlight**



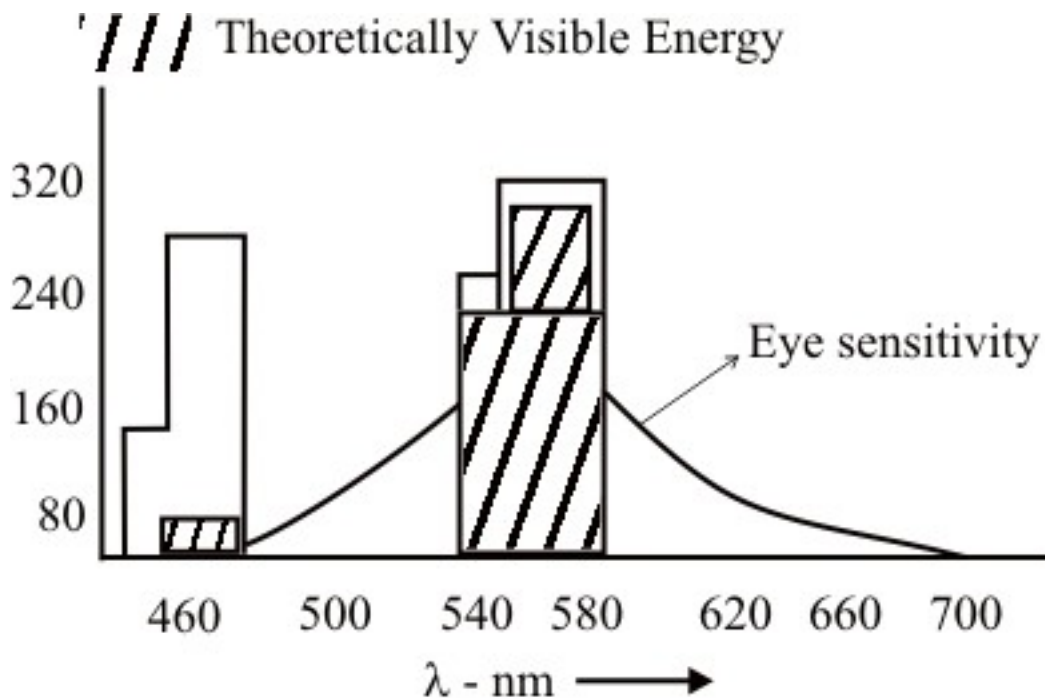
**Fig. 4: Radiation due to Sodium Vapor Lamp**



**Fig. 5: Radiation due to Incandescent Lamp**



**Fig. 6: Radiation due to Low Pressure Mercury Vapor Lamp**



**Fig. 7: Radiation due to Low Pressure Mercury Vapor Lamp**

Figs. 3 to 7 show the Radiation spectrum for various sources along with curves for human eye sensitivity. In each curve the hatched region indicates, theoretically possible radiation energy in the visible region. It may be observed that incandescent lamp has maximum energy in the visible range and has a continuous spectrum.

## Lecture Summary

- Luminescence – chemical / electrical action on gas / vapor producing radiation
- Fluorescence – radiation is absorbed at one wavelength & radiated at another wavelength
- Combination of luminescence & fluorescence increase efficiency far beyond incandescence.
- Discharge lamps consist of discharge of electricity through a tube containing a conducting medium
- Types of electron emission
  - Electric Field Emission
  - Thermionic Emission
  - Photoelectric Emission
- In a discharge lamp :
  - gas / vapor made luminous by an electric discharge
  - color / intensity are dependent on gas / vapor used
  - intensity to some extent proportional to current.
- Types of discharge lamps :
  - Mercury Vapor Lamps.



- Sodium Vapor Lamps
- Hg-lamps give a light bluish green color (deficient in red color)
- In a Hg-vapor lamp, a starting electrode is provided to initiate the arc. After a run-up time of 2 min., Hg-vapor discharge starts.
- Gas at high pressure improves the CRI (color rendering index) of discharge lamps
- With Na-lamps a pre-heating heater is provided. The lamp glows initially with red color (Ne-vapor discharge) & then turns to orange yellow arc (Na-vapor discharge)

## Tutorial Questions

- What are the different electron emission methods? What method is employed for Hg-vapor & Na-vapor lamp?  
The different methods are electric field emission, thermionic emission & photoelectric emission. In Hg-vapor lamp electric field emission & Na-vapor lamp thermionic emission
- What are the commonly used gases in discharge lamps?  
Commonly used gases are Sodium, Mercury, Neon & Argon
- What are the disadvantages of using cold cathode lamps?  
Cold cathode lamps consume large energy consumption at cathode and therefore decreased efficiency. Also it often results in disintegration of cathode.
- What do you mean by run-up time?  
The taken by the starting gases (Ne / Ar) in the discharge lamp to initiate the discharge process of the main gas (Na / Hg).
- Why do we connect a choke / ballast in series with a Hg-vapor lamp?  
It enables high potential build up at the cathode while starting & limits the current thereafter
- What steps are taken to improve the low power factor of a Hg-vapor lamp?  
Generally Hg-vapor lamps have low power factor. To improve the power factor capacitors are connected in parallel with the lamp
- What do you mean by principle line? What is the principle line for Hg-vapor lamp?  
It is the wavelength on the lamp output spectrum which gives the maximum light output. For Hg-vapor lamp it is 365nm