

LECTURE -1

THE CONTENTS OF THIS LECTURE ARE AS FOLLOWS:

1.0 INTRODUCTION

2.0 TECHNICAL TERMS IN LIGHTING AND PHOTOMETRY

- 2.1 Intensity
- 2.2 Mean Spherical Candle Power
- 2.3 Mean Horizontal Candle Power
- 2.4 Illumination
- 2.5 Lumen
- 2.6 Luminous Efficiency
- 2.7 Reflection

3.0 GENERAL LIGHTING ARRANGEMENTS

4.0 STANDARDS FOR MINE LIGHTING

5.0 IMPORTANT GUIDELINES WITH RESPECT TO LUMINANCE

REFERENCES

1.0 INTRODUCTION

Mine illumination refers to the lighting up of the mine. Surface mines are sufficiently illuminated by the sun in the day times but needs to be provided with some artificial illumination during the night times. But in case of an underground mine artificial illumination is required right from the starting of the mine till its closure.

This condition of complete darkness in any underground mine is quite similar to what we experience every day after the sunset. Then why do we need to have a separate chapter devoted to mine illumination? Naturally the question arises if we can apply the same solution that we follow every day, i.e. light up the underground mine with tube lights, CFL or LED lights at frequent locations?

The answer is NO, the reason being methane gas, which can ignite and cause an underground explosion with devastating results. Consequently any illumination system must be designed to be either "intrinsically safe" or "explosion proof". An intrinsically safe light source is one in which the current feeding the light has very little energy so that any short in the circuit will not produce a spark which can ignite the methane gas. In an explosion proof lamp, any explosion triggered by the lamp's electrical activity will be contained within the device. In addition, the device itself will not become hot enough to cause an explosion.

Then how is mine lighting unique from what is being used in the other industries? It is the low level of luminance, which is usually not encountered in any other industry. In such conditions the eye is highly susceptible to glare, which will be dealt with later.

Before the invention of the flame safety lamp, naked lamps were used in underground coal and metal mines. Now a day's worker in coal mines and a large number of metal mines are using the electric cap lamps.

A flame safety lamp lights up the mine without the danger of igniting inflammable gases, especially in underground coal mines. It is also a very convenient and handy tool for detecting the presence and the percentage of fire damp in the underground coal mines.

2.0 TECHNICAL TERMS IN LIGHTING AND PHOTOMETRY

Some of the technical terms used in lighting and photometry are given as follows:

2.1 Intensity

Intensity of light is the relative amount of luminous energy given by any source and is measured in candles or candle power (cd).

A light source generally gives different intensities in different directions. Hence candle power does not convey the correct picture unless direction is specified.

2.2 Mean Spherical Candle Power

Mean Spherical Candle Power (m.s.c.p) is the average candle power of a lamp in all directions, or the candle power of a uniform source given the same total flux of light. It is directly proportional to the total light given by the lamp and is measured by taking intensity reading in all directions.

2.3 Mean Horizontal Candle Power

Mean Horizontal Candle Power (m.h.c.p) is the average candle power of lamp in all directions in a horizontal plane passing through the centre of the source and is usually obtained by rotating, the lamp about a vertical axis.

2.4 Illumination

Illumination is generally measured in meter candles or foot candles or Lux (S.I Unit). One meter candle is the intensity of illumination on a surface 1 meter away from a source of 1 candle power. Illumination at the surface is inversely proportional to the square of the distance of the surface from the source of light, and directly proportional to $\cos \phi$ where ϕ is the angle between the normal to the surface and the direction of the light rays.

Illumination of a surface (meter candle)

$$= \frac{(\text{Candle power of source})}{(\text{distance in m})^2} \times \cos \phi$$

At 2 m distance the illumination would be,

$$\frac{1}{2^2} = 0.25 \text{ Lux or meter candle.}$$

The statement that the illumination at a surface is 4 Lux implies that it is the same as if it were illuminated by a point source of four international candles placed at a distance of 1 m from it.

2.5 Lumen

Lumen(lm) is the unit of light (luminous flux) emitted by a light source.

Lumens emitted by a lamp = m.s.c.p $\times 4\pi$

1 Lux = 1 Lumen/m²

2.6 Luminous efficiency

Luminous efficiency is expressed in lumens per watt consumed and is from 10 to 20 in modern incandescent lamps, the higher values being for larger lamps.

2.7 Reflection

When light falls upon a surface, part of it is reflected and a part is absorbed. In the case of a transparent body, majority of the light passes through. Only that part of light which is reflected is useful for illumination. A white surface is a good reflector of light and in underground mines, to improve the lighting effect, the following places have to be white washed:

- Every shaft inset and shaft bottom or siding and every bypass which is in regular use.
- The top and bottom of every haulage plane, every regular stopping place, siding, landing, passbye and junction, except within 100 meters of the face.
- Every travelling roadway.
- Every room and place containing any engine, motor or other apparatus, and
- Every first aid station below ground.

The minimum amount of light required for reading, writing etc. is 10 lumen/m², i.e. the light given off by 10 international candles at a distance

of 1 m from the work. Much more light than this is required for reading without strain. In a factory in every part where persons are working or passing, illumination should be at least 65 Lux.

3.0 GENERAL LIGHTING ARRANGEMENTS

We have to ensure the provision of adequate general lighting arrangements during working hours:

- a) *On surface*, at places with insufficient natural light, in every engine house, in the vicinity of every working shaft, at every opencast working and at places where workers are employed.
- b) *Underground*:
 - i. At every shaft inset and shaft bottom or siding which is in regular use.
 - ii. In every travelling roadway in which 50 or more miners travel in any shift, and, in every working stope, in metalliferous mines.
 - iii. At every place on a haulage roadway, at which tubs are regularly coupled or uncoupled, or attached to or detached from a haulage rope.
 - iv. At every place where mechanical filling of the tubs is being carried out.
 - v. At the top and bottom of every self-acting incline, which is in regular use.
 - vi. At every first aid station in the underground.
 - vii. At every room and place where engine, motor or any other apparatus is present.
 - viii. In coal mines, at every place where pillar is under extraction.

As per the Indian Electricity Rules, in every mine illuminated by electricity, one or more flame safety lamps, or other lights, approved by the Regional Inspector, should be maintained in a state of continuous illumination at all places where failure of the electric light at any time would be prejudicial to safety.

Some salient points of the Indian Electricity Rules regarding lighting are:

- i. In case of a fault in a circuit, electricity must be switched off till the same has been rectified.
- ii. The supply must be disconnected when the lamp is being changed.
- iii. Lamp-holders must not be connected with any metallic part of a portable hand lamp.
- iv. All electric lamps must be airtight and glasses completely sealed, at places where gas exists.

In coal mines, electric lighting from a source of supply external to the lighting unit may be used –

- a) On any roadway or place ventilated by the intake air.
- b) On any other roadway or place not within 270 m of the nearest face.

The arrangement of lighting in mines should as far as possible ensure the prevention of glare and eye-strain.

4.0 STANDARDS FOR MINE LIGHTING

It is a well-established fact that for safe and efficient working in underground mines, good lighting is necessary. Every country generally specifies their requirements regarding, what constitutes a safe mine lighting system, especially in underground gassy coal mines where methane emissions are common. The minimum and maximum standards for illumination levels are obtained from the laboratory experiments simulating both the mine environment and the working tasks. These experiments can be repeated in any country based on the mining tasks, mining environment, and mining equipment, to arrive at the required lighting levels.

For any given visual task, the recommended levels of lighting are specified in two ways. First we define an absolute minimum light level at which any

visual task can be performed at ease. In the second method we define a range of levels between a maximum and a minimum value for various mining tasks.

International bodies concerned with lighting, such as the Illumination Engineering Society (IES) and the International Commission on Lighting (CIE) specifies guidelines for mine lighting. The CIE stresses that the quality of light being received by the eye is as important as the quantity and provides formulas to ascertain whether glare may be a factor in visual performance.

Different countries have laid down specific standards for the amount of light required for various tasks. However, these standards vary greatly in the amount of light that is provided in various working places.

Each country may have different organizations laying down the standards for the lighting to be provided to various industries. In India, the Directorate General of Mines Safety (DGMS) prescribes the standards for the lighting in mines. The standards prescribed are for both underground and surface mines.

The Chief Inspector specifies the type of lamp to be provided to any specified categories of persons in the mine and also the standard of lighting to provide at any specified areas or places in the mine.

In order to prevent complete darkness in case of power failure, individual lightings are provided at night to the workers in opencast workings also, in addition to the ground lighting scheme. Moving flood lights are installed in open cast mines to light the areas near high benches. The recommended standards of general lightings in underground and in opencast mines as stipulated by DGMS are given in Table 1 and Table 2 respectively.

Table1 Recommended standards of general lightings in underground

Place	Minimum average illumination level (lux or lumens/m ²)
1. Pit bottom	10
2. Main junction	15
3. Roadways	4.5
4. Haulage engine room	
i. Floor	10
ii. Drum	25
iii. controller	20

5.0 IMPORTANT GUIDELINES WITH RESPECT TO LUMINANCE

- Where traffic is light and mechanization is minimal but general lighting is desirable because of safety considerations: 0.05 cd/m²
- Where mechanized equipment normally operates: 0.2 cd/m²
- Underground chambers where precision work is not performed: 10 cd/m²
- Underground chambers where precision work is being carried out: 20 cd/m²

Table 2 Recommended standards of general lightings in opencast mines

S.No	Place/area to be illuminated	Manner in which it is to be illuminated	Minimum standard Illumination (Lux)	Plane/Level in which illumination is to be provided
1.	General working areas as determined by the manager in writing	-	0.2	At the level of the surface to be illuminated
2.	Work place of heavy machinery	So as to cover the depth and height through which the machinery of the rig operates.	5.0	Horizontal
3.	Area where drilling rig works	So as to illuminate the full height of the rig.	10.0	Vertical
4.	Area where bull dozer or other tractor mounted machine works.	-	10.0	At the level of the crawler tracks.
5.	Places where manual work is done.	To be provided at the level of the surface on which such work is done.	5.0	Horizontal
			10.0	Vertical
6.	Places where loading, unloading or transfer loading of dumpers, trucks or train is carried on	-	3.0	Horizontal
7.	Operator cabins of machines or mechanisms	To be provided up to a height of 0.8 meters from the surface	30.0	Horizontal
8.	At hand picking points along a conveyor belt.	To be provided up to a distance of not less than 1.5 meters from the picker	50.0	On the surface of the conveyor belt
9.	Truck haulage roads	To be provided at the level of the road	0.3 to 3.0	Horizontal
10.	Rail haulage track in the pit	To be provided at the level of the rail head	0.5	Horizontal
11.	Roadways and footpaths from bench to bench	-	3.0	Horizontal
12.	Permanent paths for use of persons employed, etc.	-	1.0	Horizontal

REFERENCES

- Deshmukh, D. J. (2008); "Elements of Mining Technology, Vol. – II"; Denett& Co., Nagpur, India.
- Trotter, D. A. (1982); "Lighting of Underground Mines"; Trans Tech Publication.
- Vutukuri, V. S. & Lama, R. D. (1986); "Environmental Engineering in Mines"; Cambridge University Press, Cambridge.