Energy Conservation opportunities and Potential for Energy Saving in Illumination/Lighting System

Ar.Prashansha Srivastava
Assistant Professor,Nitte School Of Architecture,Planning & Design

Abstract— The use of natural light to carry out day-to-day activities is known to the mankind for since long. Initially, Sun was the only known source of light for activities during day time. But it was not available on all days. When activities started increasing and the need for light was felt during nights, a man started inventing different sources of lights starting with fire. However, it was not safe. Hence, the use of different natural sources for safer production of light for domestic purposes commenced. The next stage was the burning of different oils available on the earth. Lamps in crude form using available oils were developed and used for many years for domestic and small commercial purposes.

Index Terms— Energy Conservation, Natural Light, Illumination, lamps

1 INTRODUCTION

WHEN, Thomas Alva Edison invented a lamp operating on electricity in the 18th century, it was a great revolution in lighting. However, it was only in the 19th century that the use of electric lamps began increasing in the true sense. In India, electric lamps were introduced on large scale only in the 1950s. These lamps were initially used by and large for domestic illumination and decoration purposes. Hence, the term 'lighting' came into existence. During the last 50-60 years rapid development took place in the lighting field throughout the world and many lamps have been developed. Electric lighting has now become an essential part of man's life.

One often hears the terms 'Lighting' & 'Illumination' these days in connection with lighting; but often wrongly. Lighting is a very commonly used term regarding 'Light' requirements. However, the term 'Lighting' in fact deals with the 'lamp technology' or 'lamp development'. Whereas, the term Illumination deals with the light requirements of various activities/works. When we desire, for a particular activity, adequate light, proper color, no glare, etc. we are referring to the 'Illumination' requirement for the same. When any building or factory premises or office area needs to be provided with proper light, the help of Illumination Engineering becomes necessary

2 Basic Terms in Illumination Engineering

Luminous flux- Light emitted by a light source is called Luminous flux.

Lamp Output-The most common measurement or unit of luminous flux is the lumen. The lumen rating of a lamp is a measure of the total light output of a lamp. The output rating of the light source or lamp is always specified in lumen (lm).

Illuminance-Illuminance is the quotient of luminous flux incident on an element of the surface at a point of surface (containing the point) by area of that element. The lighting level produced by lighting installation is usually qualified by the luminance produced on a specific plane. Most of the time the plane is an interior plane of work and is termed as 'working plane'. The illumination provided by an installation affects both performances of tasks and the appearance of space.

The intensity of Illumination (lumen/sq m)-Light falling on a given area (per sq m or sq feet) is called as Intensity of Illumination. A commonly known unit for measurement of such a parameter is lux, which is defined as one 'Lumen' per square meter. Lux is the illuminance produced by a luminous flux of 'one' lumen uniformly distributed over a surface area of one square meter.

Luminous Efficacy (lumen /W)-Lumen efficacy of a source of light or a lamp is defined as luminous flux emitted by a lamp per watt of electricity consumed by it.

Inverse square law-Inverse square law defines the relationship between illuminance from a point source and distance. It states that the intensity of light per unit area is inversely proportional to the square of the distance from the source.

Illuminance E in lux = Luminous flux I in lm/ distance2 (m2)

Color Rendering-Various colors are seen differently in 'day light' and under different lamps due to the color of light emanating from these lamps. This phenomenon is known as 'Color Rendering'. An attempt is usually made to match the color of 'day light' so that colors are seen as if in 'day light'. It is a measure of the degree to which colors of surface illuminated by a given light source conform to those of the same surface under a reference illuminant (Daylight), suitable allowance having been made for the state of 'chromatic adaptation'.

This variance is expressed as 'Color Rendering Index and is expressed in %. Lower value means poor color quality.

Installed Load Efficacy-Average maintained illuminance provided on a horizontal working plane per watt and is expressed in lumen/watt/m2

Installed Power Density-Installed power density per 100 lux is the power needed per square m of floor area to achieve 100 lux average maintained illuminance on a horizontal working plane with general lighting of an interior. The unit of measurement is W/m2/100 lux.

Glare-Pointed or linear sources of light usually cause 'glare' in our eyes. This is a negative aspect of illumination design. Hence, lamps are to be selected that 'glare' is either absent or low.

3 Characteristics of various types of lamps

Type of lamp	*Normal Wattage W*	*Luminous Efficacy lm/W*	*CRI %*	*Life Hours*
Incandescent (TF)	*15–1000`*	*8 – 18*	*100*	*1000*
Tungsten Halogen	*1000*	*18–24*	*100*	*2000/4000*
Fluorescent Tubes	*20-40-65*	*45 – 60*	*75 – 77*	*5000*
(FTL)	*18 -/36*	*60 – 75*	*75 – 77*	*5000*
New	*28 / Phosphor*	*75 – 90 /110*	*75 –77*	*5000*
Blended lamp	*160-250*	*18 – 22*	*50*	*5000*
PL lamp	*5–7-9*	*65*	*85*	*7500*
HPMV	*80-1000*	*45 – 60*	*45*	*5000*
HPSV (SON)		*150-250-400*	*25*	*70-120*
LPSV (SOX)	*35-70*	*100-175*	*NA*	*6000/12000*
Metal Halide	*250-2000*	*70-95*	*70*	*8000*
CFL	*5-7-9-11-13-14-15-16-18*	*40-70*	*75*	*8000/10000*

4 Lamps Accessories & Fixtures

Lamp Accessories and Lamp Fixtures have a large bearing on Illumination system design, operation, and performance.

- **Lamp Accessories / Control gear**

Ignitor and Ballast are the most important Accessories used with Discharge lamps. These can be integral with the lamp or external. Ignitor with suitable can only ignite the lamps and sustain the arc produced in the discharge of the lamp. The ballast also does the same function for Fluorescent Tubes. Traditionally 'Electro-magnetic' type of Electronic ballasts was in use. These consumed lot of energy. Subsequent developments of this device were 'Low loss Electrical Ballast' having 5-7 watt loss. Countries like Australia used these. Not popular in India. Whereas, recently developed ' 'Electronic Ballast' have become very popular due to large saving potential (25-30%) long life, high power factor, instant switching of the tube, high frequency, low electromagnetic interference with other electronic equipment (hum), etc.

- **Luminaires**

A lot depends on the shape of a fixture in Illumination design. Luminaires are made as per desired objectives. They contribute a lot to the proper distribution of light on the working plane. The polar curve of light distribution depends on the size and shape of Fixtures. The shape of the luminaire, internal painting/enamel. Mirror optics significantly decide illumination spread and intensity. A lot of changes are being made in luminaires to improve light efficiency.

- **Reflectors**

Mirror Optics is now a common type of reflectors used. However, for Old fixtures installed in the factories, polished mirror quality Aluminium Reflectors are now available in the country. These increase luminous efficacy by nearly 30-40 %.

- **Control Switches / Automation**

Various types of Control can be provided for achieving energy savings and energy efficiency. The auto cut of switches is often used to switch off lights in unwanted areas or recesses times. Motion sensors, occupancy sensors are finding increasing use in Office cabins, office floors, Toilets, Hotel rooms, etc. Various types of 'Timers' are in use to control lighting use by timers. Photocontrol is conventionally employed in 'Street lighting', 'Yard lighting' etc However; these may be replaced by 'Astronomic calendar' for better accuracy and control.

5 Recommended Intensity of Illumination (Lux Levels)

Every activity requires certain 'Intensity of Illumination (Lux levels). Indian Standards (IS 3356-1972), as well as Factory Laws, specify the MINIMUM intensity of Illumination depending a to be maintained as per activity carried out.

Typical Examples are (As per BIS 6665-1972)–

- General Factory Areas –

i) Machine Shop - 250 - 3000 lux
ii) Assembly shop - 150 - 1500 lux
iii) Entrance/corridors - 100 lux
iv) Canteen - 150 lux
v) Outdoor areas - 20 lux
vi) Inspection - 150 – 3000 lux

- Forging / Foundry-

i) General - 150 lux
ii) Fine Moulding / Core making – 300 lux

- Iron & Steel

i) General - 100 lux
ii) Melting / Rods / Wires – 300 lux
iii) Inspection - 300 and above

Machine Shop & Fitting - 150-700 lux
Paint shops/Spraying - 150-700 lux
Paper Works - 200–300 lux
Pharmaceutical /Fine Chemicals factory - 200–300 lux
Yard lighting / Corridors - 50-300 lux

6 Methodology for Illumination System Study

1. Survey the area for types of lamps used, fixtures, control gear used, controls provided, if any.
2. Measurement of 'lux' in different areas
3. Measure load in kW, energy consumption in each area

4. Compare 'measured' lux with 'Standard' lux and analyze.
5. Analyze the above data and work out possible Measures for energy saving.
6. Consider replacement of existing lamps by 'Energy efficient lamps, provided economics is favorable.

7 Conclusion

Energy Saving Opportunities in Illumination Systems
Following 'Good Practices' are recommended for achieving 'Energy efficiency' are –

a) Ensure Maximum use of Daylight by following methods
- Providing North light Roof Truss
- Installing Translucent strips (Glass) in Roof
- Installing Translucent Fibreglass Sheets on Walls or Roof
- Use of Atrium with FRP Dome
- Proper design of Windows to provide adequate Natural light
- Installing light shelves

b) Replacing existing Lamps with Energy-efficient Lamps
- Installing Fluorescent Tube lights in place of incandescent lamps
- Replacing 40 W Fluorescent Tube lights by 36 W or 28 W Fluorescent Tube lights or 'Tri-phosphor Tube lights

c) Reducing Number of Lamps or De-lamping
- De-lamping to reduce excess lighting – In empty spaces where active work is not being performed
- Reducing the Mounting height of lamps and reducing the number of lamps
- Providing efficient luminaires and reducing the number of lamps
- Providing a false ceiling will reduce lamp height and fewer lamps will give the same illumination level

d) Providing Task Lighting

Providing low wattage lamps for good illuminance in small areas where a specific task is being performed instead of providing General lighting throughout, e.g Testing areas, Inspection areas, Machine lamps, etc. The number of General lighting fixtures, reduction in wattage of lamps can save a lot of energy.

e) Installation of Electronic Ballasts & Regulators
- Replace Electromagnetic ballasts with Electronic ballasts (25-30 % saving)
- Replace Resistor type Fan regulators with Electronic Fan Regulators (5-10 % saving)

f) Installing Energy Efficient & Labeled Lamps & Fans
- Replace old fans with 'Energy Efficient' Fans.
- Use BEE 'Energy labeled' Tube lights – with 4 or 5 Star rated ones
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g) Installing Energy Efficient Reflectors
- Install 'Energy Efficient Aluminium 'Reflectors' in Fixtures
- Avoid the use of diffusers on decorative office lighting

h) Installation of Energy Saving Devices
- Install Energy Saver for Lighting Circuits (Saving of 5 –15 %)
- Installation of Light Pipes in interior locations

i) Voltage Control

Reduction in lighting feeder voltage
- Providing Voltage Regulator
- Installation of 'Servo-stabilizer' for Lighting

j) Installation of Sensors & Lighting Controls

k) Install separate 'Lighting Transformer

l) Proper Layout of Lighting

m) Maintenance
- Periodic cleaning of lamps, luminaires, and Room surfaces will improve illumination level considerably.

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