

BEYOND

SMART CITIES



LIGHTING SYSTEMS - CEM REFRESHER

ONLINE TRAINING COURSE

KRISHNAJI PAWAR, LEED AP BD+C, GSAS CGP, ISO 14001:2015, GCP

ENERGY SPECIALIST CURRICULUM





BEYOND

SMART CITIES



EFFICIENT LIGHTING DESIGN AND BASICS

FOR ENERGY PROFESSIONALS

KRISHNAJI PAWAR, LEED AP BD+C, GSAS CGP, ISO 14001:2015, GCP

ENERGY SPECIALIST CURRICULUM





WHAT SHOULD YOU LEARN



Lighting Retrofits: Evaluate and Identify Opportunities for High Energy Saving Potential

Lighting Design Basics and Terminology





LIGHTING BASICS

- ✓ Efficient Lighting Design
- ✓ Effective Lighting Maintenance



PRINCIPLES OF EFFICIENT LIGHTING DESIGN

- ✓ Meet target light levels
- ✓ Efficiently produce light
- ✓ Efficiently deliver light
 - Balance efficiency with aesthetics, lighting quality, visual comfort
- ✓ Automatically control lighting operation

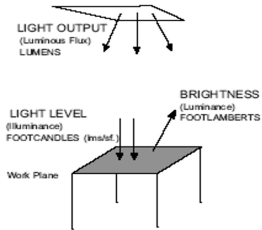


FACTORS IN SUCCESSFUL LIGHTING APPLICATIONS

- ✓ Amount of light required in Lux
- ✓ Efficacy in Lumens/watt
- ✓ Lumen output of lamps and fixtures
- ✓ Color rendition, Color Rendering Index - CRI
- ✓ Color temperature in Kelvins
- ✓ Types of light sources
- ✓ Lighting quality



QUANTITY OF ILLUMINATION



Inverse Square Law

$$E = \frac{I}{d^2}$$

where d = distance from light source to surface of interest

COLOUR

Color Rendering Index (CRI)

Indicates the effect of a light source on the color appearance of objects.

75 – 100 CRI = Excellent color rendition

65 – 75 CRI = Good color rendition

55 – 65 CRI = Fair color rendition

0 – 55 CRI = Poor color rendition

Color Temperature

A measure of the “warmth” or “coolness” of a light source.

< 3200K = “warm” or red side of spectrum

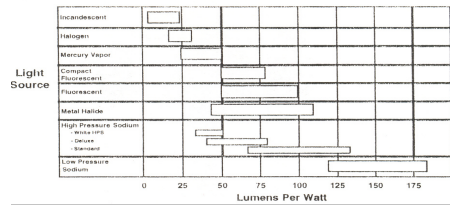
> 4000K = “cool” or blue side of spectrum

TYPES OF LIGHT SOURCES

Incandescent
Tungsten Halogen
Mercury Vapor
Fluorescent
Metal Halide
High Pressure Sodium

Low Pressure Sodium
Induction
Laser
LED

LIGHT SOURCE EFFICACY



COLOR RENDERING INDEX (CRI)

EXHIBIT 3
TYPICAL CRI VALUES FOR SELECTED LIGHT SOURCES

Source	Typical CRI Value
Incandescent/Halogen	100
Fluorescent	
Cool White T12	62
Warm White T12	53
High Lumen T12	73-85
T8	75-85
T10	80-85
Compact	80-85
Mercury Vapor (clear/coated)	15/50
Metal Halide (clear/coated)	65/70
High-Pressure Sodium	
Standard	22
Deluxe	65
White HPS	85
Low-Pressure Sodium	0

COLOR TEMPERATURE

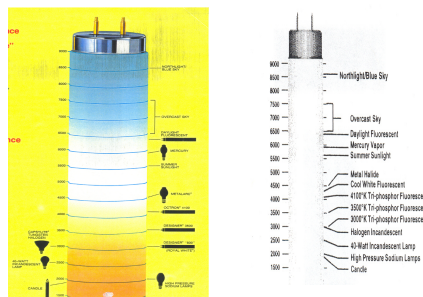
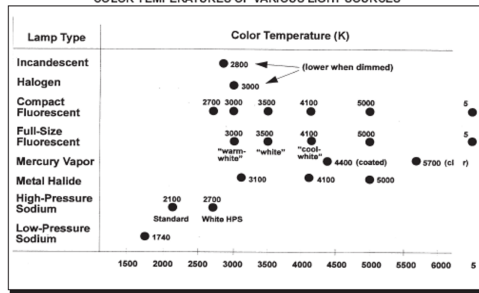
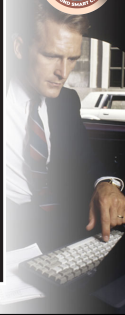


EXHIBIT 5
COLOR TEMPERATURES OF VARIOUS LIGHT SOURCES



AMOUNT OF LIGHT REQUIRED FOR SPECIFIC APPLICATION

- ☑ We often use more light than is needed for many applications and tasks.
- ➡ Light levels are measured in Lux (or Footcandles, in IP units) using an illuminance meter.
- ➡ Lux = lumens / m²
- ➡ FC = lumens / ft²
- ➡ Consensus standards for light levels are set by the Illuminating Engineering Society of North America (IESNA.org).



SOME TYPICAL LIGHT LEVELS NEEDED ARE

Parking lot	20 Lux
Hallways	100 Lux
Factory floor	300 Lux
Offices	500 Lux
Inspection	1000 Lux
Operating room	10000 Lux



AVERAGE RATED LIFE

- ✓ Average rated life of a lamp is median value of life expectancy of a group of lamps
 - ⇒ Time at which 50% have failed, 50% are surviving
 - ⇒ Fluorescent lamps rated at 3 hours on, 20 minutes off per operating cycle
 - ⇒ HID lamps rated at 10 hours on, one hour off per operating cycle
- ✓ Increased frequency of switching will decrease lamp life in hours, but typically increase useful calendar life
 - ⇒ Energy savings more significant than lamp costs



LIGHTING MAINTENANCE PRINCIPLES

- ✓ Light output of all lighting systems decreases over time
- ✓ Lighting systems are over-designed to compensate for future light loss
- ✓ Improving maintenance practices can reduce light loss (depreciation) and can either:
 - ⇒ allow reductions in energy consumption (redesign), or
 - ⇒ improve light levels
- ✓ Group maintenance practices save money



LAMP LUMEN DEPRECIATION (LLD)

