LIGHTING FUNDAMENTAL

For and Behalf of Housing. Building & Planning, USM
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LIGHTING FUNDAMENTAL

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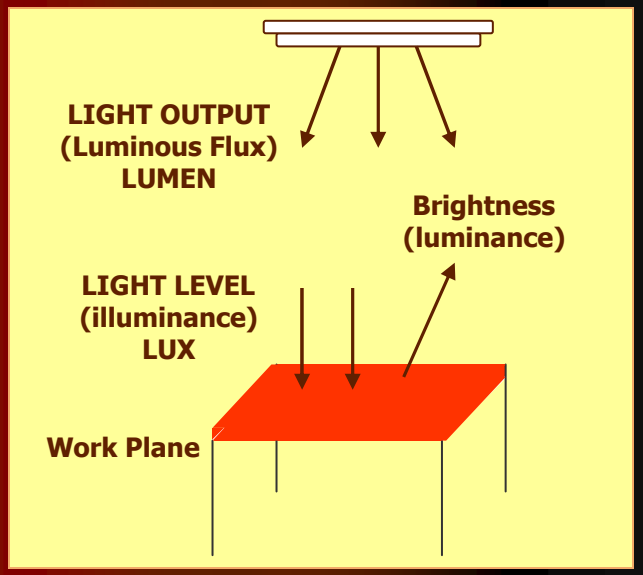
CHAPTER 1
LIGHTING BASICS

LIGHTING BASICS

Introduction

- **Light Output**
  The most common Light output (or *luminous flux*) is the *"Lumen"* Light sources are labeled with an output rating in *lumens*.
- **Light Level**
  Light intensity measured on a plane at a specific location is called illuminance. *Illuminance* is measured in *Lux* (metric), which are the workplane *lumens* per square meter.
- **Brightness**
  Another measurement of light is Luminance, sometimes called brightness. The light "leaving a surface in a particular direction.



LIGHTING BASICS

Light Basics

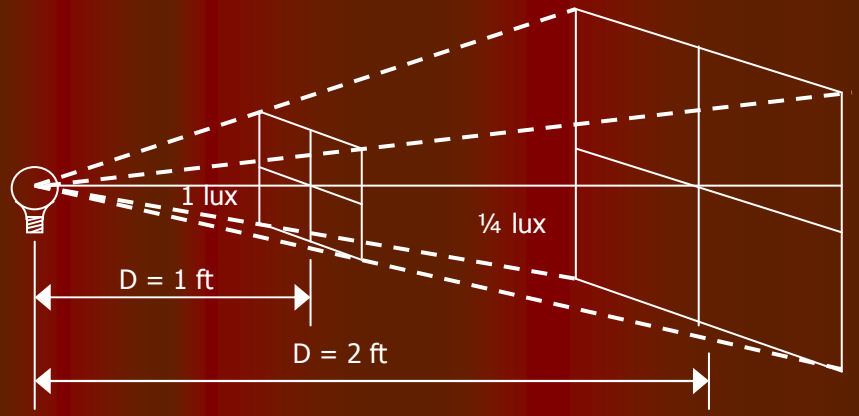
- **Luminous flux**
  Is the time rate of flow of light as measured in lumens. It is a measure of the total light emitted by a source and it most commonly used for measurement of total lamp output.

- **Luminous Intensity (I)**
  Power emitted by a light source in a particular direction. Sometimes is called as Candlepower. The intensity (I) is represent by Candela, ***"cd"***

- **Steradian**
  The unit of solid angle. Figure 1 show that the light travels away from the source, the solid angle covers a larger and larger area but, the angle itself remain the same, as does the amount of light it contains.

Luminous Intensity (I);

$$I = \frac{(\text{lumens})}{(\text{steradians})}$$



LIGHTING BASICS

Light Basics

- **Illuminance (E)**
  Is the quantity of light reaching a unit area of surface and is measured in footcandles or lux. It defines the intensity (I) in candelas directed toward point Pm divided by the square of the distance (D) from the source to the surface.

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

This formula holds only if the receiving surface is perpendicular to the source direction. If the light incident at some other angle. The formula becomes;

$$E = \frac{I \cos \Theta}{D^2}$$

Where E = illuminance in fc or lux
I = Intensity in candelas (cd) toward point P
D = Distance in feet or meters
Θ = angle of incidence

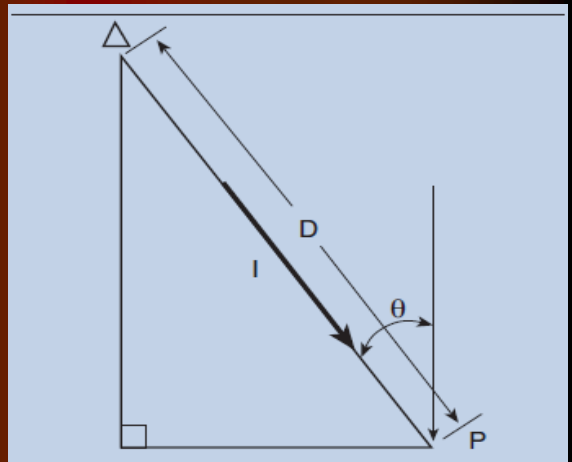


Figure 2

LIGHTING BASICS

Light Basics

- **Exitance (M)**
  Is the total amount of light reflected, regardless of direction, is Exitance.
  Exitance = illuminance x reflection factor.

$$M = E \times \rho$$

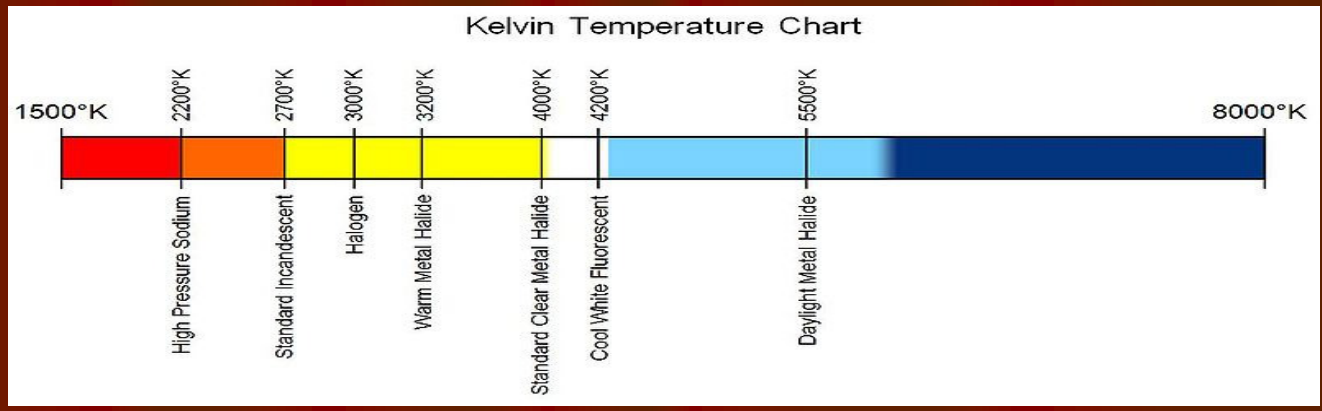
  Where. E = illuminace in footcandles
  p = the reflection factor of the surface expresssed as the percentage of light reflected.
  M = the resulting exitance in lumens per square foot.

LIGHTING BASICS

Color Temperature

Colour temperature is a standard method of describing colours for use in a range of situations and with different equipment. Colour temperatures are normally expressed in units called *kelvins* (K).

Imagine a piece of tungsten metal being heated. As it is heated the color of the metal will gradually shift from red to orange to yellow to white to bluish white. The color of light is measured along this scale, with the more orange color light being referred to as "warm white" and the whiter color light being referred to as "cool white"



LIGHT SOURCES AND LAMP CHARACTERISTICS

Commercial, industrial, and retail facilities use several different light sources.

Each lamp type has particular advantages; selecting the appropriate source depends on installation requirements, life-cycle cost, color

qualities, dimming capability, and the effect wanted.

- Three main groups:

1. **Incandescent**
2. **Fluorescent & Compact Flourescent**
3. **High Intensity Discharge (HID)**
    i. **High pressure sodium**
    ii. **Low pressure sodium**
    iii. **Metal halide**
    iv. **Mercury vapor**

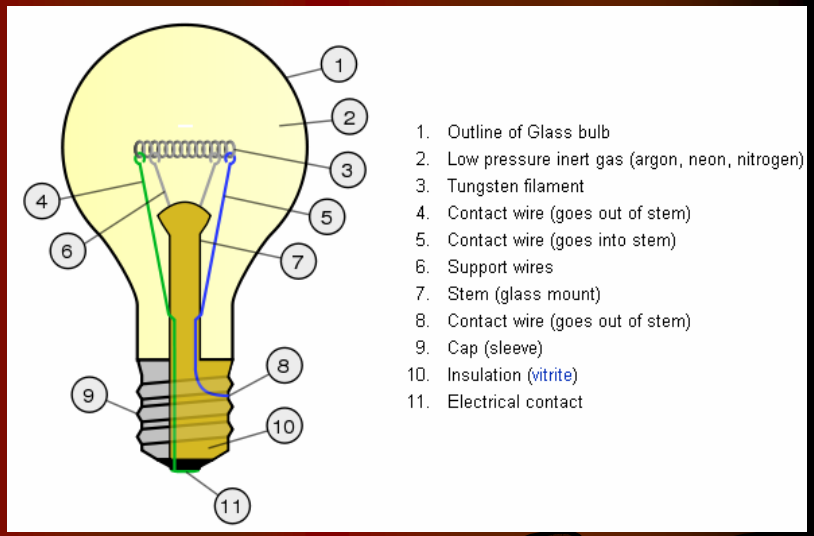
LIGHT SOURCES AND LAMP CHARACTERISTICS

Incandescent Lamp

An incandescent filament lamp is the light source most commonly used in residential lighting.

History
Discover on year 1802 by Sir Humphrey Davy.
1910 Tungsten filament by William David Coolidge

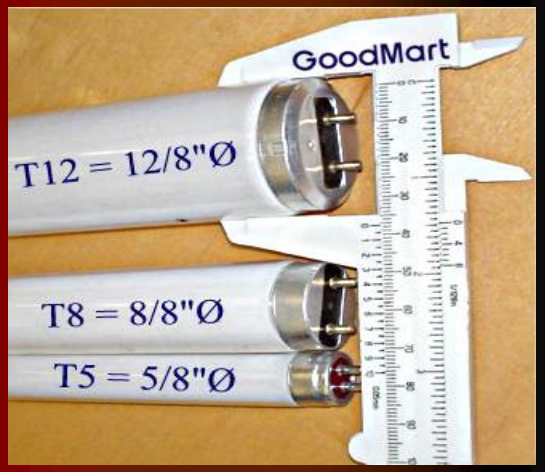
Operation
Light is produced in this source by a wire or filament being heated to incandescence (emitting light) by a flow of current through it.



LIGHT SOURCES AND LAMP CHARACTERISTICS

Fluorescent Lamp

The fluorescent lamp produces light by activating selected phosphors on the inner surface of the bulb with UV energy, which is generated by a mercury arc. A magnetic ballast is needed to start and operate fluorescent lamps. T5, T8 & T12

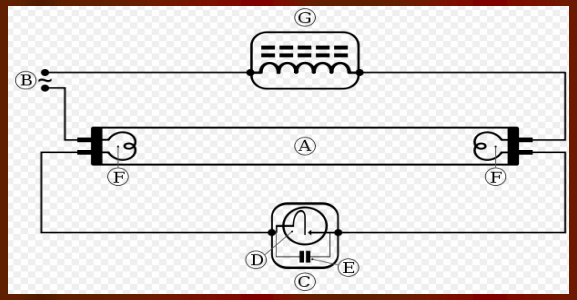


History

Discover on year 1840 by a Scientist and apply electricity by Micheal Faraday & James Clerk Maxwell.
1896 a working fluorescent lamp by Thomas Edison
Commercialize by end of 1920.

Operation

Light is produced by passing electricity through mercury vapor, which in turn produce UV light. The UV light is the absorbed by a phosphor coating inside the lamp, causing it to glow, or fluoresce.



A = Fluorescent Tube
B = 240V
C = Starter
D = Bi Metallic Thermostat
E = Capacitor
F = Filement
G = Ballast

LIGHT SOURCES AND LAMP CHARACTERISTICS

Compact Fluorescent Lamp (CPL)

CPL is a type of fluorescent lamp designed to replaced an incandescent lamp. Many CPLs can fit in existing incandescent light fixtures and are designed for direct replacement.

History

Develop on 1973 During Oil Crisis by Ed Hammer , General Electric.

Operation

Operate as like any other fluorescent tube but, improved phosphor formulation and 8-15 times longer life span than incandescent light bulb.

LIGHT SOURCES AND LAMP CHARACTERISTICS

High Intensity Discharge (HID)

A high intensity discharge (HID) lamp is a type of electrical lamp which produces light by means of an electric arch between tungsten electrodes housed inside a translucent or transparent fused alumina arc tube..

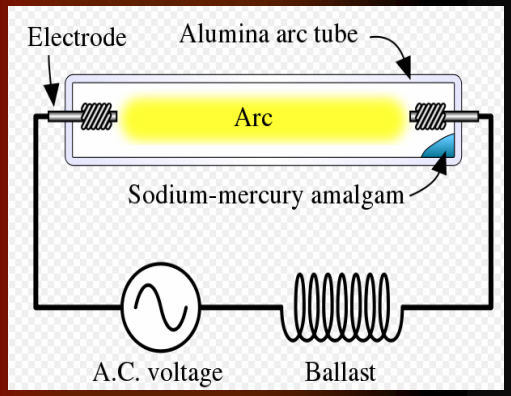
Compare to fluorescent & Incandescent lamps, it has higher luminous efficacy and greater amount of light output per watt of electricity input.

History

Discover on year 1705 by Francis Hauksbee (Gas Discharge lamp).
1802 Vasily V, Petrov on the phenomenon of electric arc

Operation

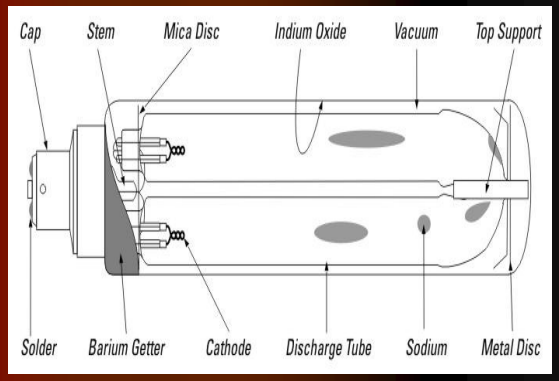
The gas is ionized, and free electrons, accelerated by the electrical field in the tube, collide with gas and metal atoms. The collisions, bring them to higher energy state, it will emit photon which resulting in visible light (UV) radiation. The radiation is converted to visible light by a fluorescent coating inside the lamp glass.



LIGHT SOURCES AND LAMP CHARACTERISTICS

Low Pressure Sodium (LPS)

Also known as Sodium Oxide (SOX) lamps, commercially available on 1932, consist of an outer vacuum envelope of glass coated with an infrared reflecting layer of indium tin oxide a semiconductor material which allows visible light. Outdoor lighting i.e street lighting, security lighting & etc.



High Pressure Sodium (HPS)

HPS lamps are smaller and contain mercury element, and produce dark pin glow and pinkish orange light when light up. Mostly use on Street lighting

Metal Halide Lamps

Commercially available on 1960, these lamps produce almost white light, and attain 100 lumen/watt light output. Application include indoor lighting of high buildings, parking lots, shops, sport terrains.

Mercury Vapor Lamps

Discover during 1901 by Peter Cooper Hewitt. Mercury vapor lamps is a gas discharge lamp which uses mercury in an excited state to produce light. Application farm light, fish pond & etc.

LIGHT SOURCES AND LAMP CHARACTERISTICS

Light Emitting Diodes (LED)

Also known as LED bar or Illuminator is a type of solid state lighting (SSL) that uses light emitting diodes (LEDs) as the source of light.

Design

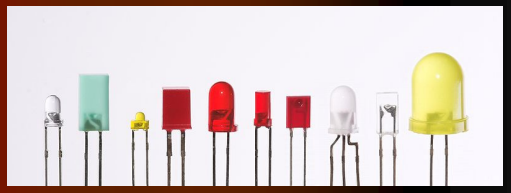
Comprise of clusters of LEDs in a suitable housing, standard light bulb shape, large E27 Edison screw and MR16 shape with bi pin base.

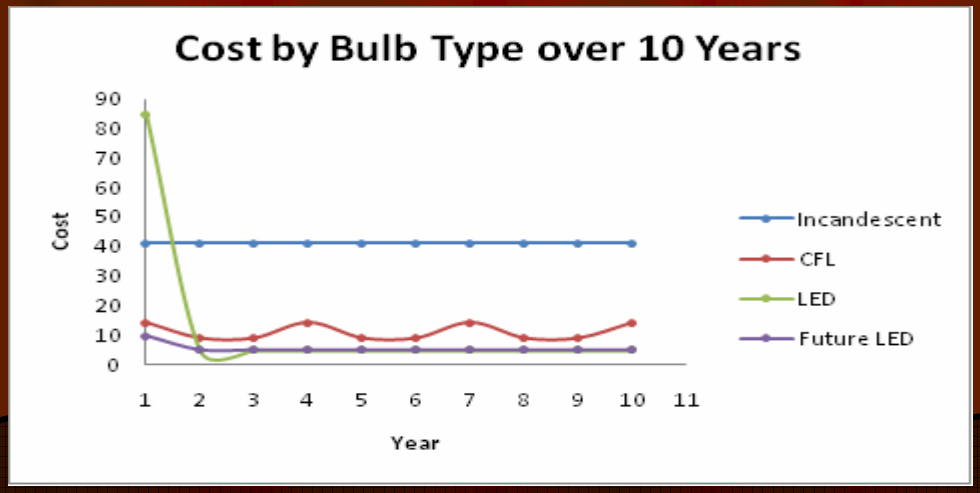
History

LED was discovered during mid 1920s by Oleg losev and commercially available for LED lighting during 1995.

Operation

LED operate like a semiconductor diode, during forward biased it will released a form of light (effect known as electroluminescence).



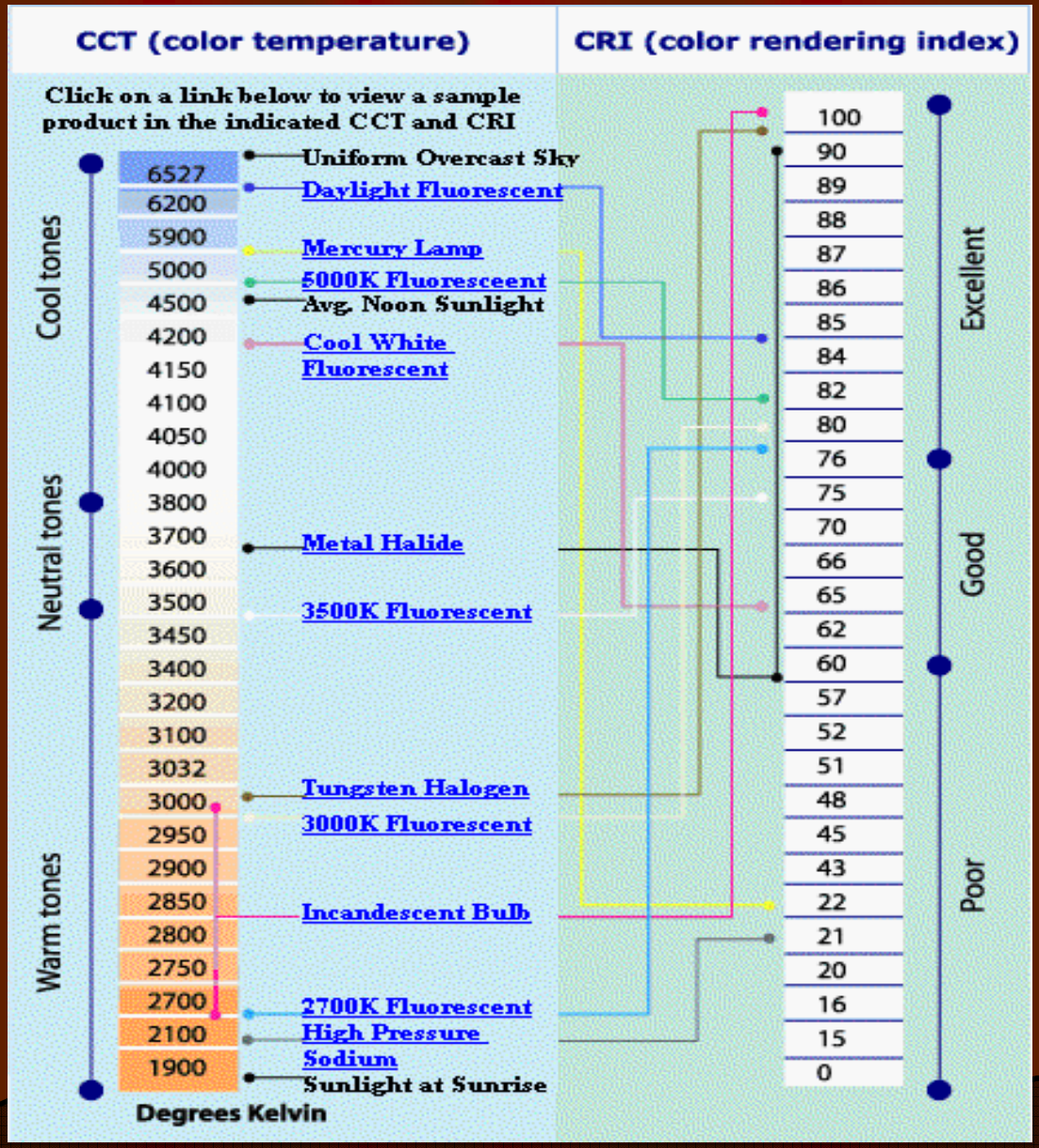


LIGHT SOURCES AND LAMP CHARACTERISTICS

Lighting Comparison Chart

Lighting type	Efficacy (lumens/watt)	Lifetime (hours)	Color rendition index (CRI)	Color temperature (K)	Indoors/outdoors
Incandescent					
Standard "A" bulb	10–17	750–2500	98–100 (excellent)	2700–2800 (warm)	Indoors/outdoors
Tungsten halogen	12–22	2000–4000	98–100 (excellent)	2900–3200 (warm to neutral)	Indoors/outdoors
Reflector	12–19	2000–3000	98–100 (excellent)	2800 (warm)	Indoors/outdoors
Fluorescent					
Straight tube	30–110	7000–24,000	50–90 (fair to good)	2700–6500 (warm to cold)	Indoors/outdoors
Compact fluorescent lamp (CFL)	50–70	10,000	65–88 (good)	2700–6500 (warm to cold)	Indoors/outdoors
Circline	40–50	12,000			Indoors
High-intensity discharge (HID)					
Mercury vapor	25–60	16,000–24,000	50 (poor to fair)	3200–7000 (warm to cold)	Outdoors
Metal halide	70–115	5000–20,000	70 (fair)	3700 (cold)	Indoors/outdoors
High-pressure sodium	50–140	16,000–24,000	25 (poor)	2100 (warm)	Outdoors
Low-pressure sodium	60–150	12,000–18,000	-44 (very poor)		Outdoors

LIGHT SOURCES AND LAMP CHARACTERISTICS



CHAPTER 2
PHOTOMETRY

PHOTOMETRY

Introduction to Photometry

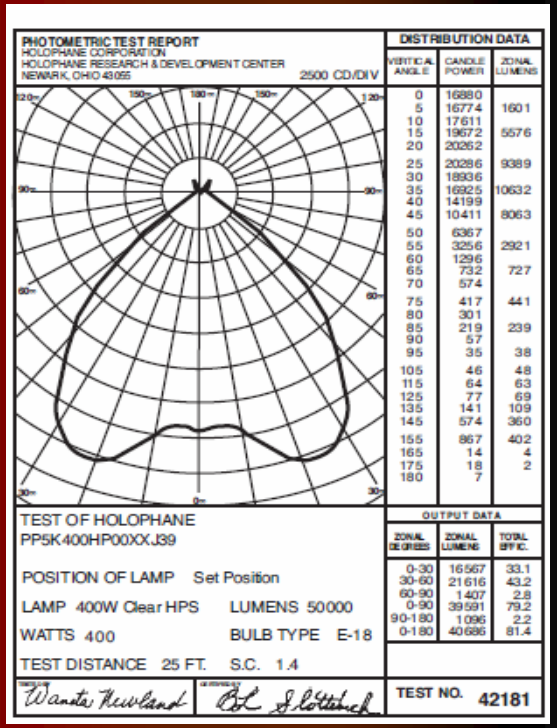
Is “the measurement of light”. The term photometry is refering to define test data which describe the characterictics of a luminaries light output.

Photometry Data

The most common type of photometric data i.e ***candlepower distribution curves***, ***spacing criteria***, ***luminaries efficiency data***, ***coefficients of utilization*** and ***luminance data***.

Purpose of Photometry

Is to accurately describe the performance of a luminaire, to enable the designer to select the lighting equipment and design a fixture layout which best meets the needs of the job.



PHOTOMETRIC TEST REPORT
HOLOPHANE CORPORATION
HOLOPHANE RESEARCH & DEVELOPMENT CENTER
NEWARK, OHIO 43055
2500 CD/DIV

DISTRIBUTION DATA

VERTICAL ANGLE	CANDLE POWER	ZONAL LUMENS
0	16880	
5	16774	1601
10	17611	
15	19672	5576
20	20262	
25	20286	9389
30	18936	
35	16925	10632
40	14199	
45	10411	8063
50	6367	
55	3256	2921
60	1296	
65	732	727
70	574	
75	417	441
80	301	
85	219	239
90	57	
95	35	38
105	46	48
115	64	63
125	77	69
135	141	109
145	574	360
155	867	402
165	14	4
175	18	2
180	7	

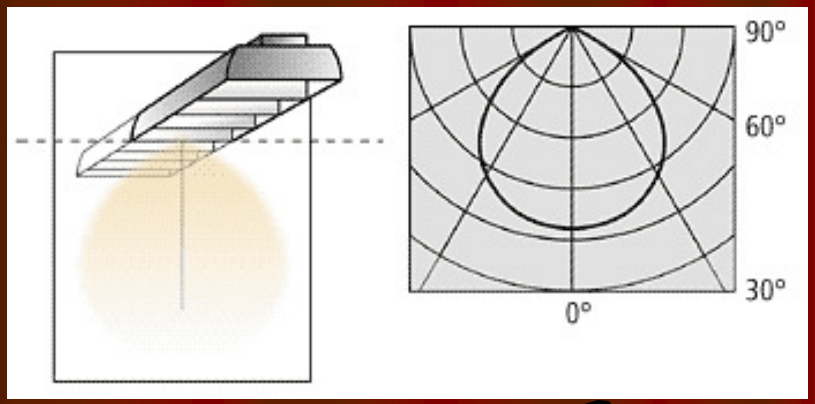
TEST OF HOLOPHANE
PP5K400HP00XXJ39

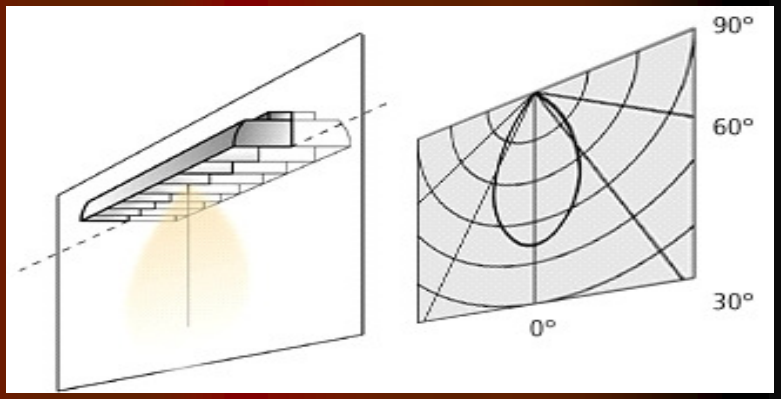
POSITION OF LAMP Set Position
LAMP 400W Clear HPS LUMENS 50000
WATTS 400 BULB TYPE E-18
TEST DISTANCE 25 FT. S.C. 1.4

OUTPUT DATA

ZONAL DEGREES	ZONAL LUMENS	TOTAL EFF'C.
0-30	16567	33.1
30-60	21616	43.2
60-90	1407	2.8
0-90	39591	79.2
90-180	1096	2.2
0-180	40686	81.4

TEST NO. 42181





STANDARD LUX LEVEL

Lux	Area
40 Lux	Corridors
80 Lux	Passageways
80 Lux	Warehouses involving search & retreval tasks
40 Lux	Stairs
160 Lux	Entrance halls
200 Lux	Foyers
80 Lux	Waiting Rooms
300 Lux	Canteens
700 Lux	Machine shop general work bench
240 Lux	Counters
400 Lux	Kitchens (food preparation area)
500 Lux	Offices
400 Lux	Machine shop high tolerance work bench
600 Lux	Electronic assembly work

LIGHT FIXTURES TESTING METHOD

Optical Test

Water Spray Test

Visual Performance

Mechanical Test

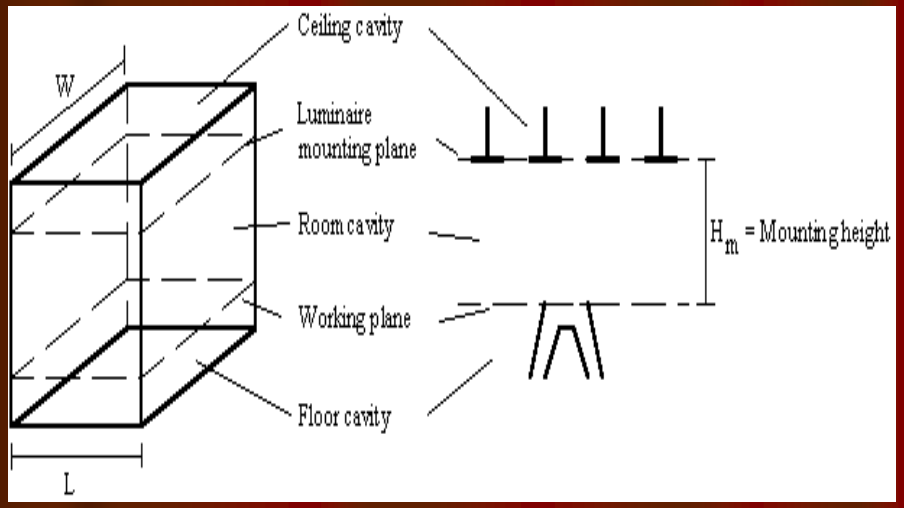
CHAPTER 3
LIGHTING CALCULATION

LIGHTING CALCULATIONS

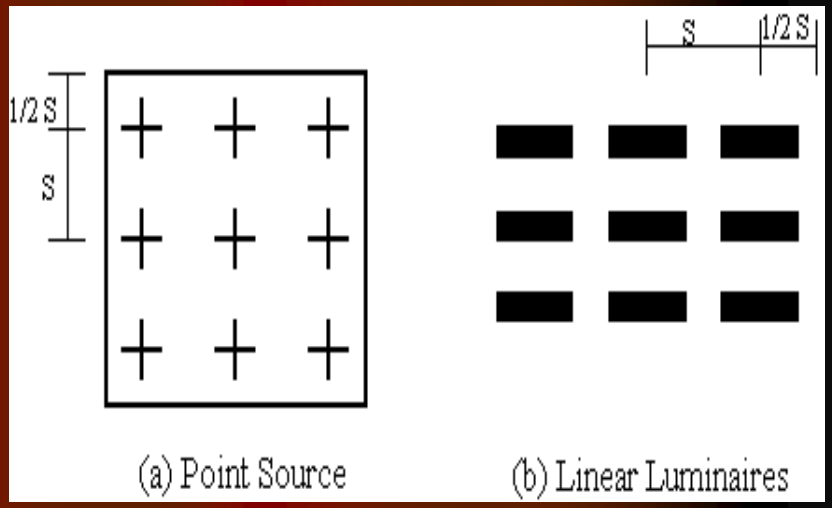
Introduction to Lumen Method Calculation

The lumen method is applicable to design of a uniform (general lighting scheme in a space where flexibility of working locations or other activities is required.

This method is applied only to square or rectangular rooms with a regular array of luminaires as shown below



Working Plane



Spacing if luminaries in lumen design method

LIGHTING CALCULATIONS

Lumen Method Calculation

The lumen method is based on fundamental lighting calculations.
The lumen method formula is easiest to appreciate in the following form.

$$\Phi = (E \times A / \mu \times \rho)$$

$$N = (E \times A / \mu \times \rho \times \phi) \quad (1)$$

Where,
E = Lux level
μ = Light loss factor
N = number of light
ρ = Lamp lumen maintenance factor
ϕ = lighting flux
A = area of the horizontal working plane

Lamp Lumen Maintenance Factor (ρ)

Is the ratio of illuminance produced by the lighting installation at some specified time to the illuminance produced by the same installation when new.
It allows for effects such as decrease in light output caused by:-

1) The fall in lamp luminous flux with hours of use.
2) The deposition of dirt on luminaire.
3) Reflectances of room surface overtime.

LIGHTING CALCULATIONS

Utilization Factor (μ)

Is the propotion of the luminous flux emitted by the lamps which reaches the working plane. It is a measure of the effectiveness of the lighting scheme.
Factors that affect the values if μ are as follows:-

1) Light output ratio of luminaire
2) Flux distribution of luminaire
3) Room portions
4) Room reflectances
5) Spacing/mountng height ratio

Example no.1

A room with dimension 18 m x 15 m, required luminance at workplane of 330 lux. The ceiling height from the work plane is 3 m. The light fixtures being proposed for this room

1) Fluorescent Tube with 80 watt, 4800 lumen when new.
2) Incandescent lamp with 150 watt, 1950 lumen when new.

Determine the number of light fixture for each type of lighting proposed. Confirm the distance between each type of lighting fitting. The utilization factor (μ) and the lamp lumen maintenance factor (ρ).

LIGHTING CALCULATIONS

Example no.1 (Solution)

Step 1

1. Find the number of fitting for Fluorescent fitting 80 watt, 4800 lumen.

$$N = (E \times A / \mu \times \rho \times \phi)$$

Formula

N = (330 x 18 x 15 / 4800 x 0.6 x 0.5)

= 36.3 or 36 nos

LIGHTING CALCULATIONS

Example no.1 (Solution)

Step 1

1. Determine the light fitting arrangement on the room

Distance of Ratio Height = (Distance between the light) / Light Fitting height)

**** Note: the distance between light is from 0.9 to 1.5, we selected 1.0.**

Distance between light = Height of light x distance of ratio height
= 3 x 1
= 3 m

(a) Fluorescent Lamp

Row of light = room width / distance between light.
= 15 / 3
= 5

Nos of Fluorescent light in a row = total nos of light / number of row
= 36 / 5
= 6.12 or 6 numbers

Total number of light = number of row x number of light in a row
= 5 x 6
= 30 numbers.

LIGHTING CALCULATIONS

Example no.1 (Solution)

Step 2

We need to put 36 number of light fitting, the room is perfect with 6 x 6 row of light arrangement (= 36 number of light).

The lighting perpendicular arrangement need to be decided for making the 36 number of light, J_L = 3 m (need to be factor in).

Perpendicular row = Room width / crossing of perpendicular light fitting
= 15 / 6
= 2.5 m

Perpendicular distance of lighting between the wall (J ⊥d)

= Perpendicular row / 2
= 2.5 / 2
= 1.25 m

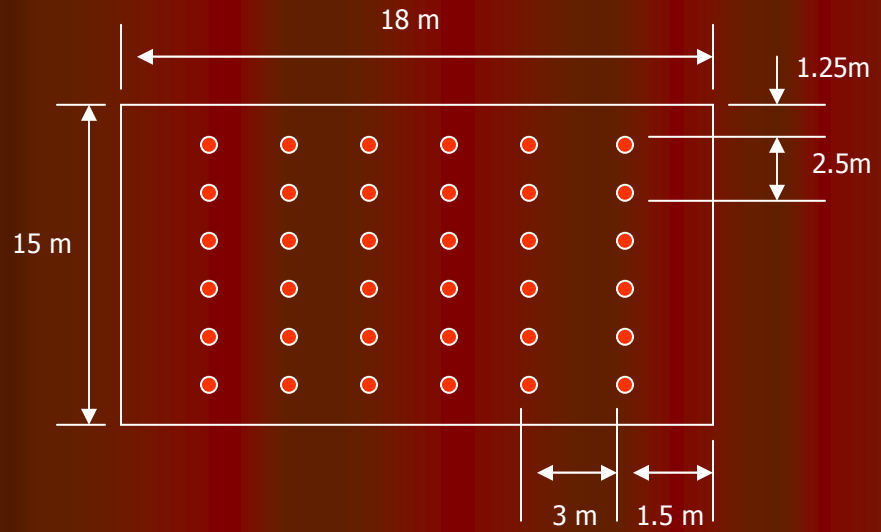
The length between lighting (J_m)

= Length of room / number of lighting
= 18 / 6
= 3 m

The length between lighting and wall (Jmd)

= Length of room between lighting / 2
= 3 / 2
= 1.5 m

LIGHTING CALCULATIONS



Fluo. 80 watt Light Arrangement

Perpendicular Row	= 2.5 m
Perpendicular Distance	= 1.25 m
Length between lighting	= 3 m
Length between lighting & wall	= 1.5 m

LIGHTING CALCULATIONS

Example no.2

A room with dimension 20 m x 18 m, required luminance at workplane of 430 lux. The ceiling height from the work plane is 3.3 m. The light fixtures being proposed for this room

1) Fluorescent Tube with 28 watt, 2800 lumen when new.
2) Incandescent lamp with 50 watt, 950 lumen when new.

Determine the number of light fixture for each type of lighting proposed. Confirm the distance between each type of lighting fitting. The utilization factor (μ) and the lamp lumen maintenance factor (ρ).

Example no.3

A room with dimension 20 m x 18 m, required luminance at workplane of 430 lux. The ceiling height from the work plane is 3.3 m. The light fixtures being proposed for this room

1) Incandescent lamp with 50 watt, 950 lumen when new.

Determine the number of light fixture for each type of lighting proposed. Confirm the distance between each type of lighting fitting. The utilization factor (μ) and the lamp lumen maintenance factor (ρ).

CHAPTER 4
LIGHTING COMPUTER SOFTWARE

LIGHTING COMPUTER SOFTWARE

Lighting Design Software

A special computer program to help Architects, interior designer, electrical engineer, energy engineer to carry out basic lighting design or advance lighting design.

Features:

- Determines the overall reflectance in the room
- Finds the proper footcandle/Lux level for General Task & etc
- Adjust footcandle/Lux level for dark to light rooms.
- Determines the proper spacing needed.
- Uses both Lumen methods and Inverse Square Law.
- Art Lighting – see the light right on artwork.

LightCal Software

Calculux 7.0.1.1

DIALux

LIGHTING COMPUTER SOFTWARE

April-29-09 Rev.1

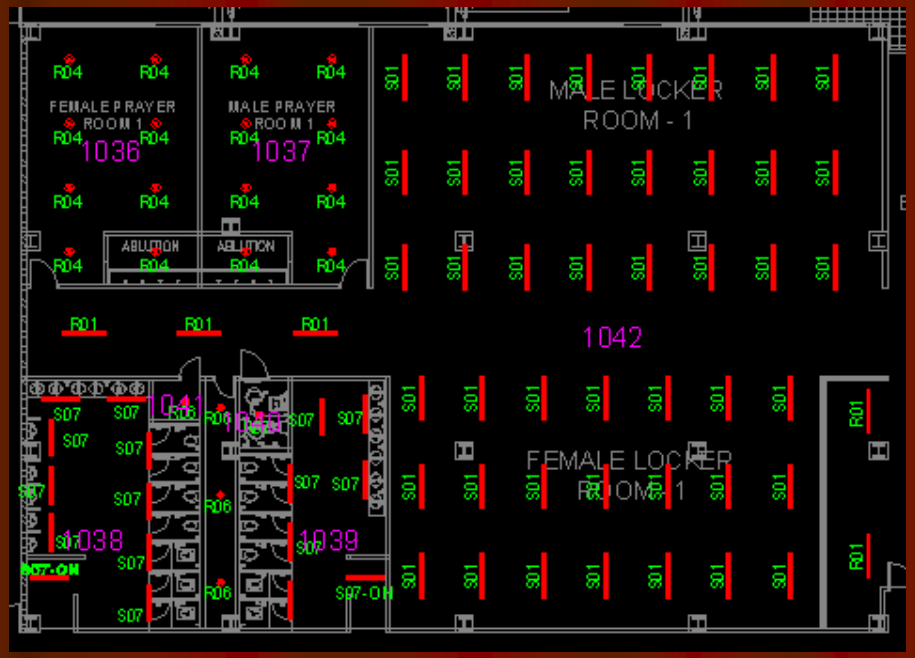
Lighting Design Basis for Critical Areas

A	B		D				
Item No.	Location	Initial Lumen Output (lumens/lamp)	Fab 3 Target Illuminance, J (lux) (as per 60% Design Review Drawings by MEI)	Reference Design from Other MNC's spec Input by MEI - 12-Dec-08	Reference Design from IES lighting levels Input by MEI - 12-Dec-08	TELCS Target Illuminance (Lux) face of machinery	TELCS Target Illuminance (Lux) at 85cm workplane
1	Manufacturing - Cleanroom	2850	700	700	1076	150 - 200	400 – 500
2	Manufacturing -Non-Cleanroom	2850	700	500	500	150 - 200	400 – 500
3	Manufacturing -Area with FFU	2850	700	700	1076		
4	Change Room	2850	500	500	500		200 – 300
5	Vertex Room	2850	350	350	300		400 – 500
6	Manufacturing -Plating Area	2850	700	700	500		400 – 500
7	Office Area	2850	500	500	750		400 – 500
8	Cell Test Area						
	8.1 Overall Cell Test Room			500	500		450 – 600
	8.2 Visual Inspection Table (dropdown luminaire)			1800	1076		700-1000
9	Screen Making Area			500	500		500

Note: This table is only for critical areas. For common areas, please refer to codes/standards as such for hallways, etc.

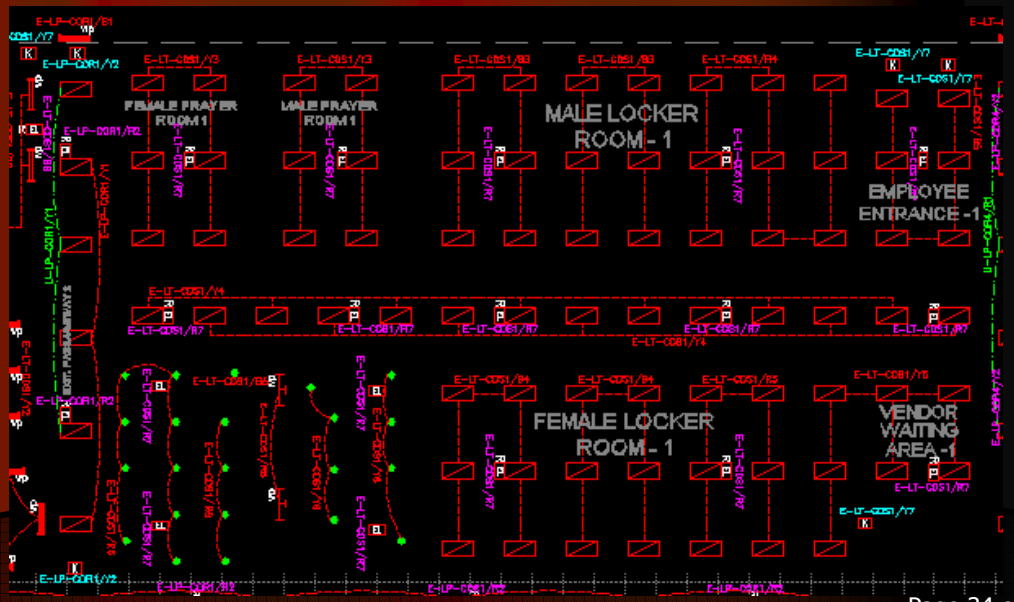
Ceiling elevation to floor is 3.65 meters

LIGHTING COMPUTER SOFTWARE

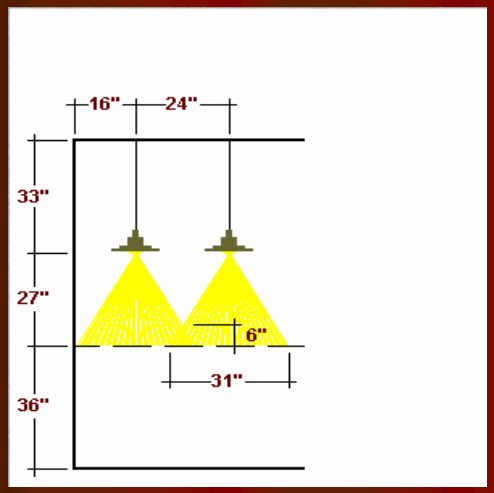


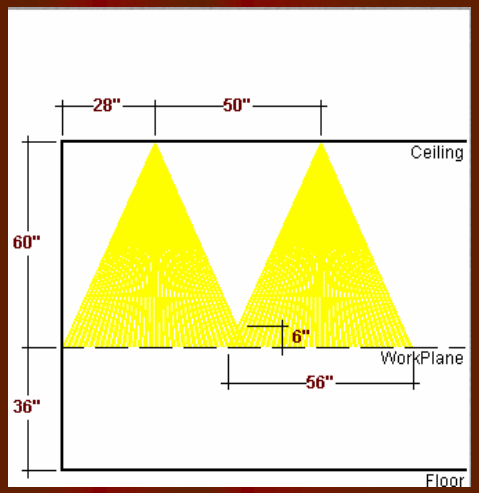
- **Lighting design with the help of software**
  - **~ Less fixtures is being used**
  - **~ 1 x 4 x 35W fixtures design**

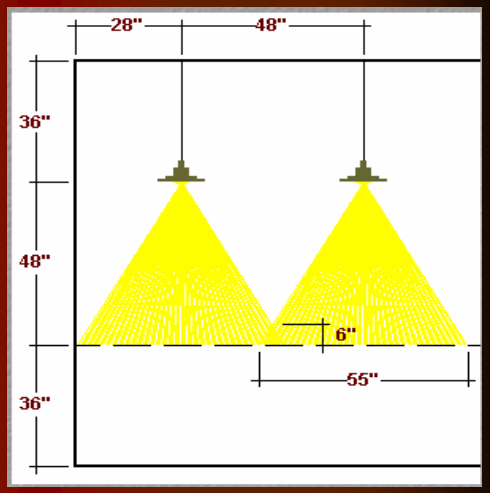
- **Lighting with lumen method without software.**
  - **~ More fixtures is being used**
  - **~ 2 x 4 x 36W fixtures design**

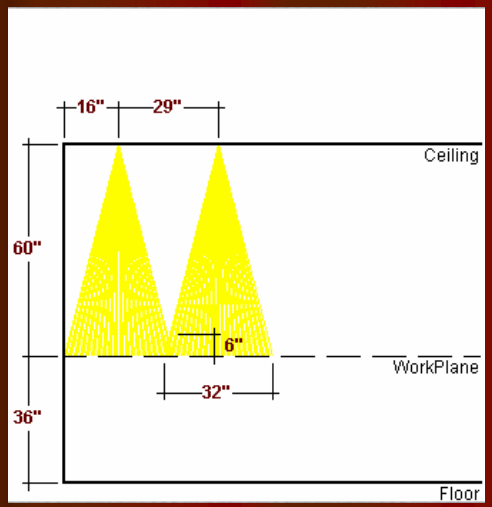


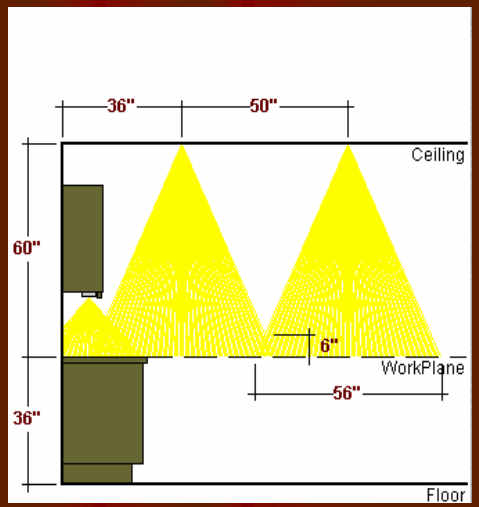
LIGHTING COMPUTER SOFTWARE





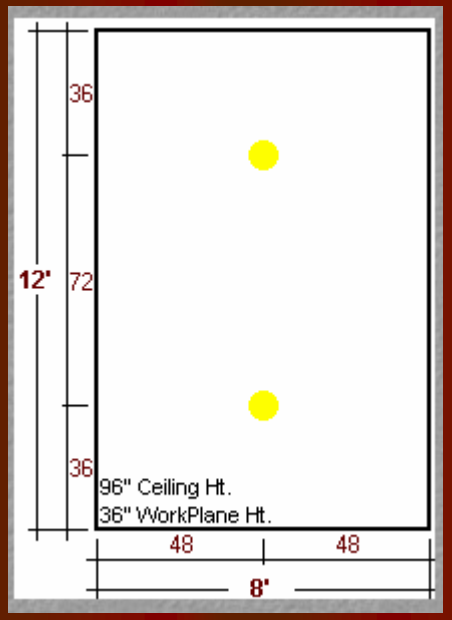


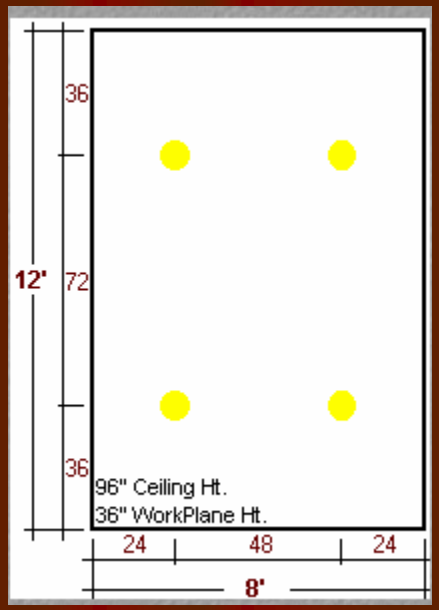


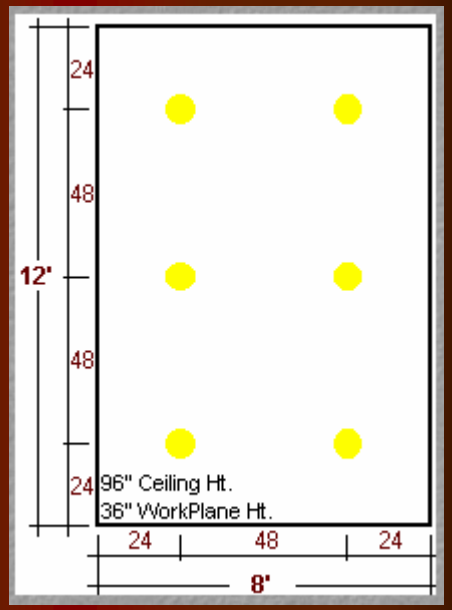


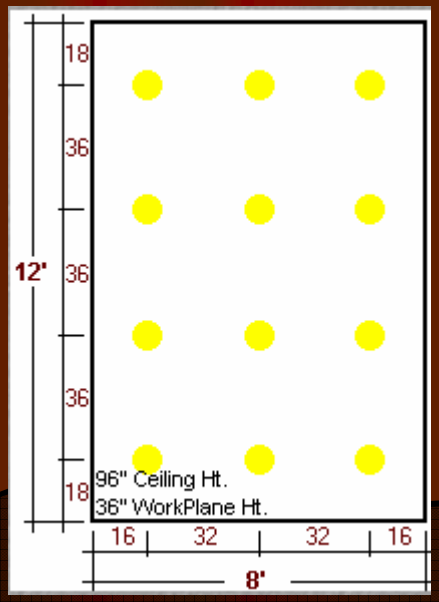
- **Clearly indicating the light output coverage, distance of ceiling height, working plane, degree of angle**

LIGHTING COMPUTER SOFTWARE





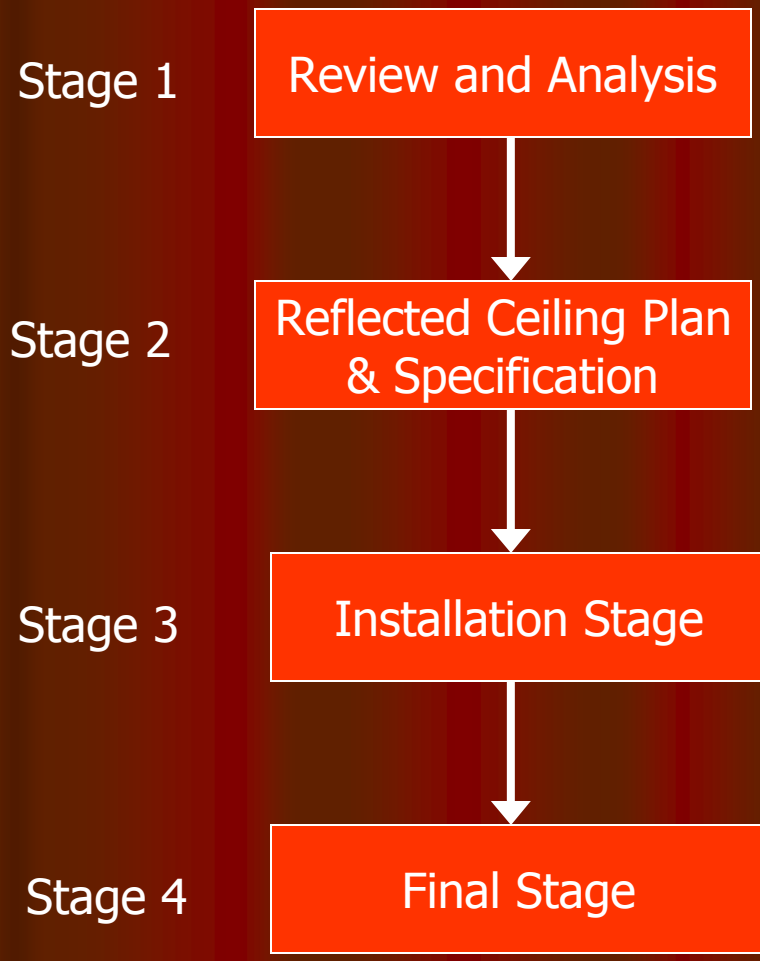




- **Auto arrange the light fixtures, indicating the light location, distance of ceiling height, working plane, distance of light fixtures.**

CHAPTER 5
LIGHTING DESIGN PROCESS

LIGHTING DESIGN PROCESS



Review and analyzes the Architectural plan

- High light important architectural features.
- Visual acuties, usage of each space.
- Impression that are desired or "feeling" area evoke.
- Review colors, finishes and furniture plans.
- Understand the Interior design detail & coordination.

Final reflected ceiling plans and specifications

- Tailored the lighting design on the reflected ceiling layout
- Thorough documentation of all lighting & control systems.
- Custom design control systems and desired capabilities.
- Accommodate the decorative lighting requirements.

Implementation

- Site visits to understand the site requirements.
- Reflected ceiling coordination with other trades/services
- Proper implementation in accordance to project master schedule.
- Use appropriate lighting installation method statement.

Final Stage

- Finishing touches on the lighting fixtures
- Proper adjustment for maximum lighting effect.

LIGHTING FITTING DATA

FITTING INFORMATION SHEET

PROJECT	: SUNPOWER, MALAYSIA	**REF NO**	: R23
DATE	: May 8, 2009	**PAGE**	: 1 of 1

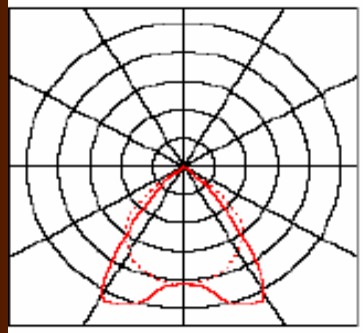
Revision :
Date

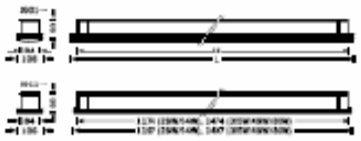
Luminaire data

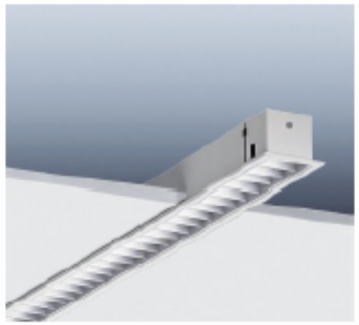
Luminaires efficiency	:	82.99
Control gear	:	electronic ballast, dimmable 0-10V analogous
System power	:	30 W
Length	:	1247 mm
Width	:	106 mm
Height	:	90 mm

Equipped with

Number of	:	1
Designation	:	T5 28 W
Power	:	28 W
Colour	:	nw
Luminous flux	:	2600 lm







DESCRIPTION	:	**1X28W RECESSED LOUVERED FLUORESCENT FITTING IP20**
SIZE OF FIXTURE	:	**L = 1247mm W = 106mm H = 90mm**
MANUFACTURER/S	:	**PHILIPS, SITECO, TRILUX, ... Or equivalent provided with documented specifications, photometric data and plug-in (.ies or .ldt) for approval**
REFLECTOR	:	**Micro-segmented, highly-specular parabolic louvre made of reflection intensifying aluminum with surface purity of 99.99% for especially high light output. Suitable for DSE applications in accordance with EN 12464-1 due to limited luminance L ≤ 1000 cd/ m2 at reference angle above 65° all-round**
LAMP	:	**T5 HE 28W, 4000K (cool white), >90lm/w, OSRAM, GE, PHILLIPS or equivalent provided with documented specification for approval**
CONTROL GEAR	:	**electronic ballast, OSRAM, BAG, NOBILE Or equivalent provided with documented specification for approval**

IMPORTANT INFORMATION

- Designation = T5 28W
- Control gear = Elec. ballast
- Luminous flux = 2600 Im
- Wattage = 28W
- Efficiency = 82.99%
- Color = nw (cool white)

END