Indoor Lighting Workshop for Municipalities

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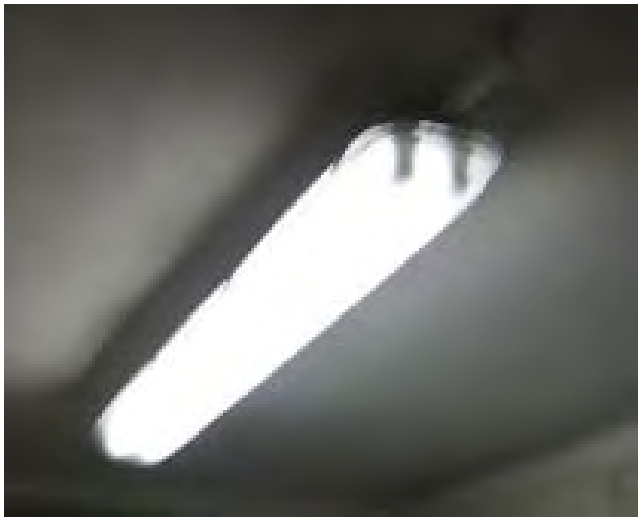
Upper Darby Municipal Building

11/19/13

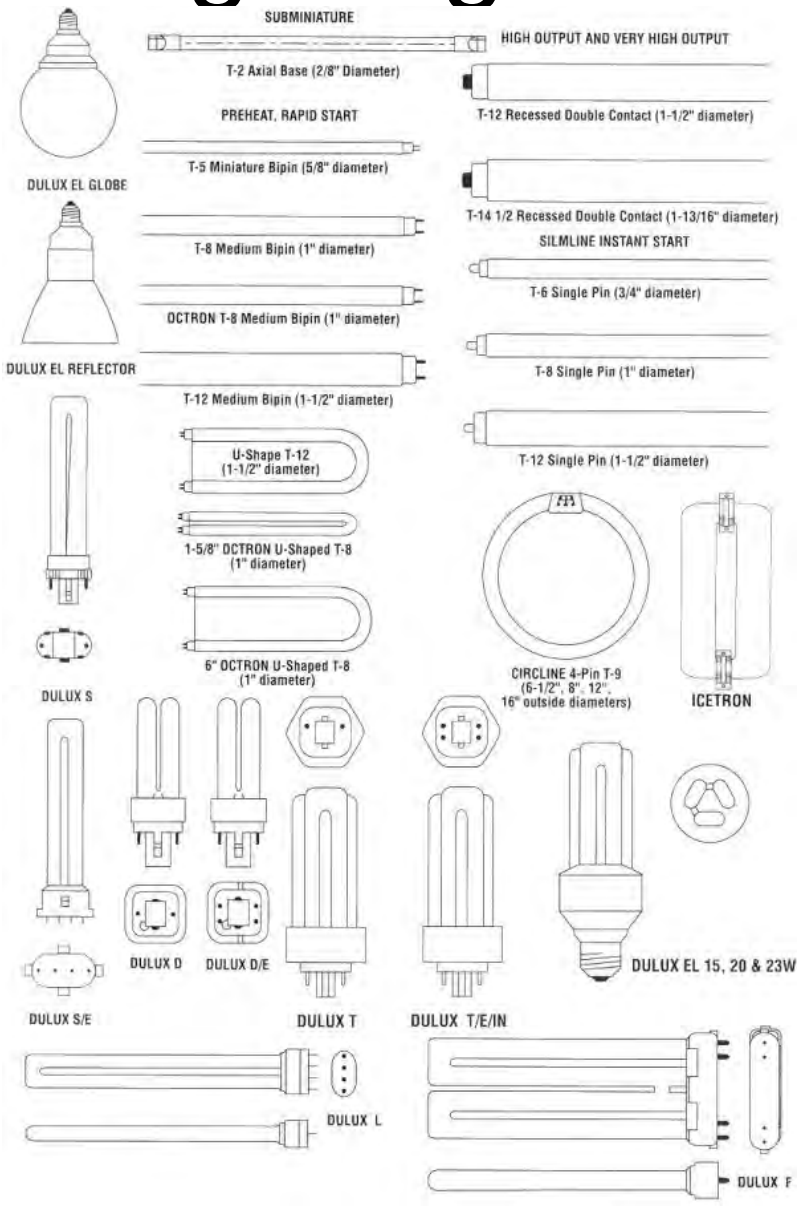
Typical Fixture Types

- Indoor – Incandescent, Fluorescent, Metal Halide, LED, Cold Cathode
- Outdoor and garages – High Pressure Sodium, Low Pressure Sodium, Metal Halide, Fluorescent (Including Induction), Incandescent, Mercury Vapor, LED

Fluorescent Lighting



Fluorescent Lighting



Fluorescent Tube Code

Fluorescent, 32 watt nominal lamp wattage, tube shaped, 8 one-eight inches diameter (1 ½”), 80 CRI, 3500 K temperature

T8 Efficacy (Lumens per watt)

Lamp type	Nominal power (W)	CRI	Efficacy (lm/W)
700 series	32	70s	<85
800 series	32	Low 80s	87–94
Higher lumen (super T8)	32	High 80s	94–100
Energy saver	30	High 80s	94–100
Reduced wattage	28	High 80s	94–100
Reduced wattage	25	High 80s	94–100

Note: CRI = color-rendering index; lm = lumen; W = watt.

Source: Platts; data from Consortium for Energy Efficiency

Source: http://www.reliant.com/en_US/Platts/PDF/P_PA_11.pdf

Table Lamp Application

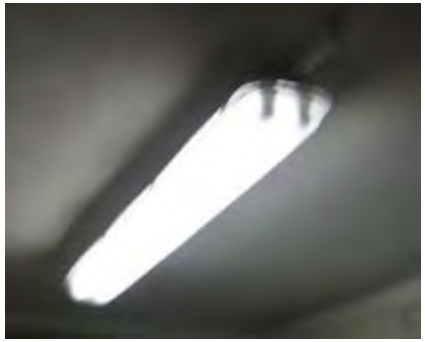
Recessed Fixture Application

- “A” lamp bad
- PAR lamp better
- Heat considerations for compact fluorescent and LED
- Dimming requirements
  - Most CFL are non-dimmable

Metal Halide

High Pressure Sodium

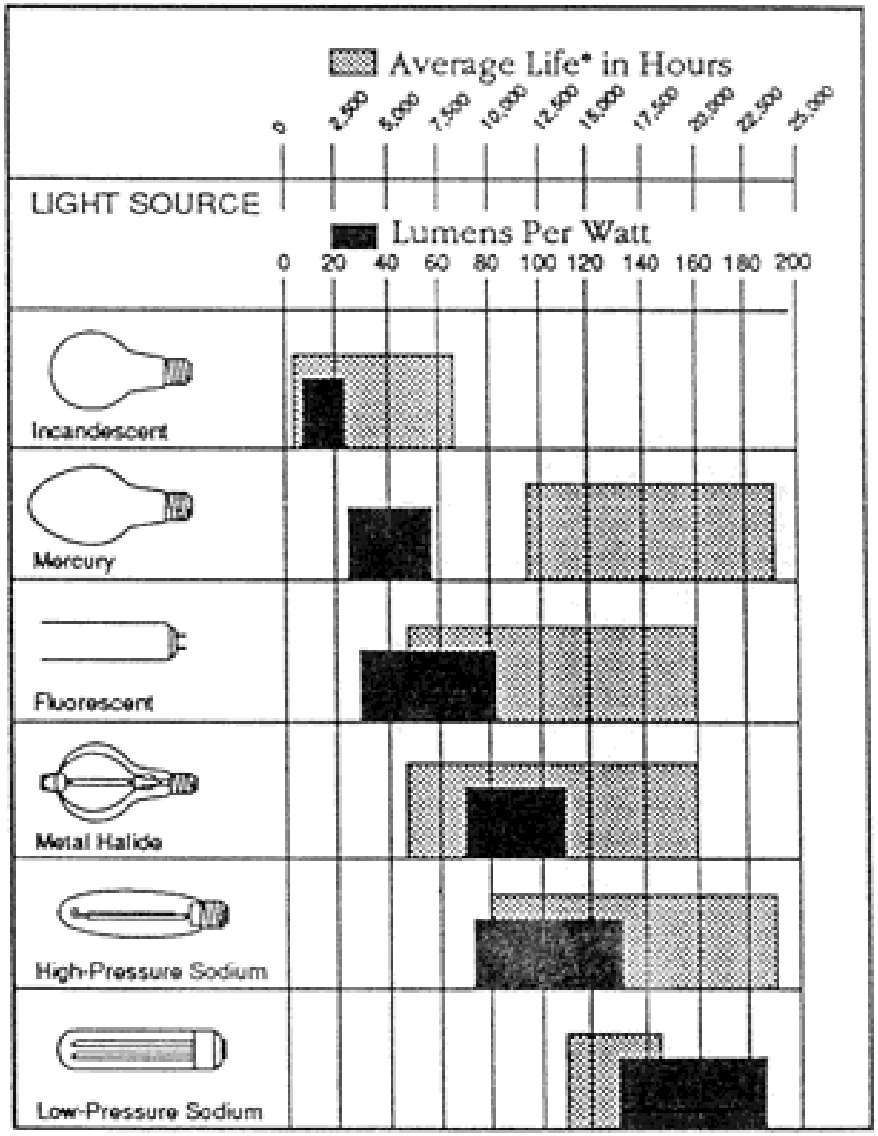
High Bay/Low Bay Application



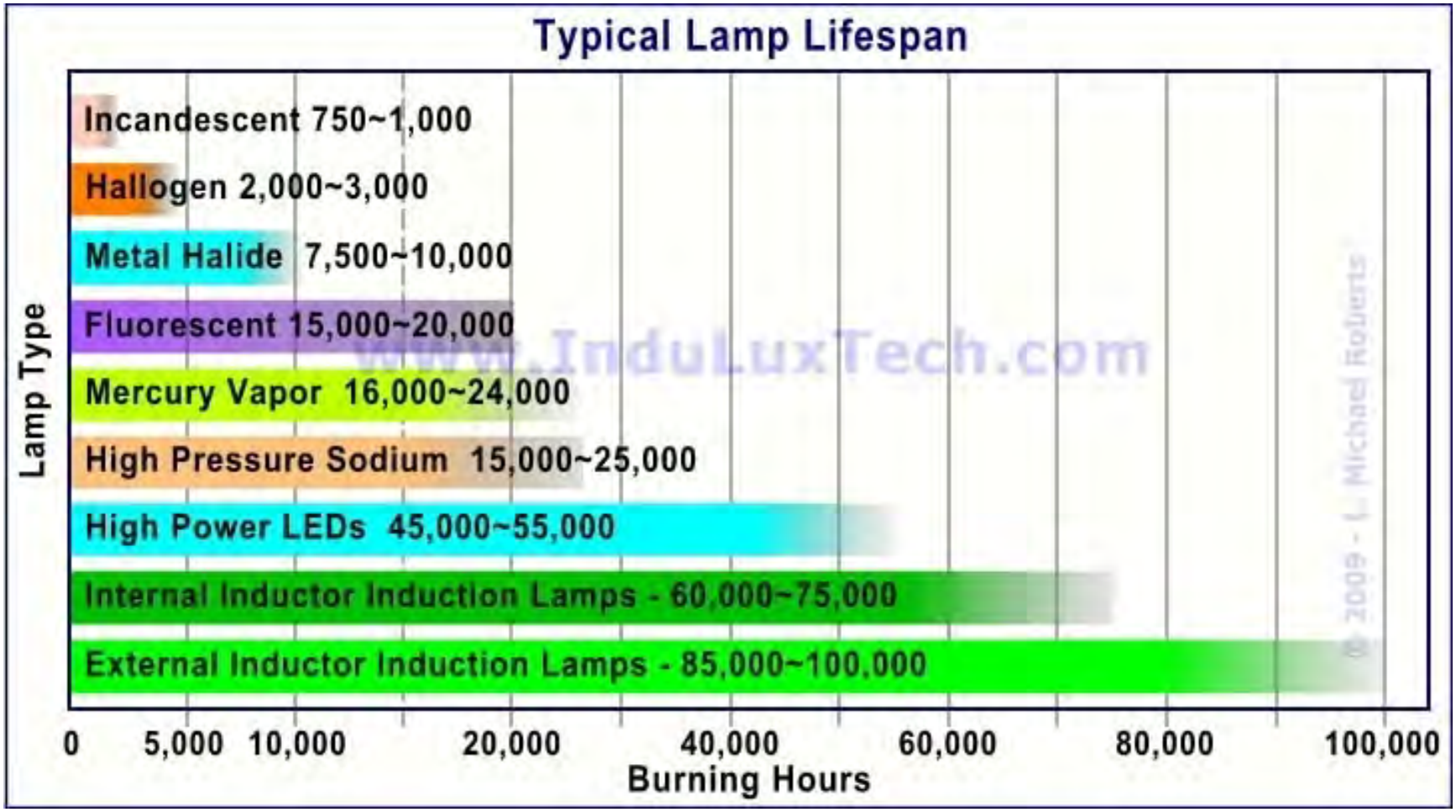
Lighting Terminology

- Footcandles/lumens
  - 1 footcandle = 1 lumen per square foot
- CRI – Color Rendering Index
- Color Temperature (K)
- Phototopic and Scotopic
- Ballast factor

Average Life



Life


Typical Lamp Lifespan
Lamp Type
Incandescent 750~1,000
Hallogen 2,000~3,000
Metal Halide 7,500~10,000
Fluorescent 15,000~20,000
Mercury Vapor 16,000~24,000
High Pressure Sodium 15,000~25,000
High Power LEDs 45,000~55,000
Internal Inductor Induction Lamps - 60,000~75,000
External Inductor Induction Lamps - 85,000~100,000
0
5,000
10,000
20,000
40,000
60,000
80,000
100,000
Burning Hours
www.IduLuxTech.com
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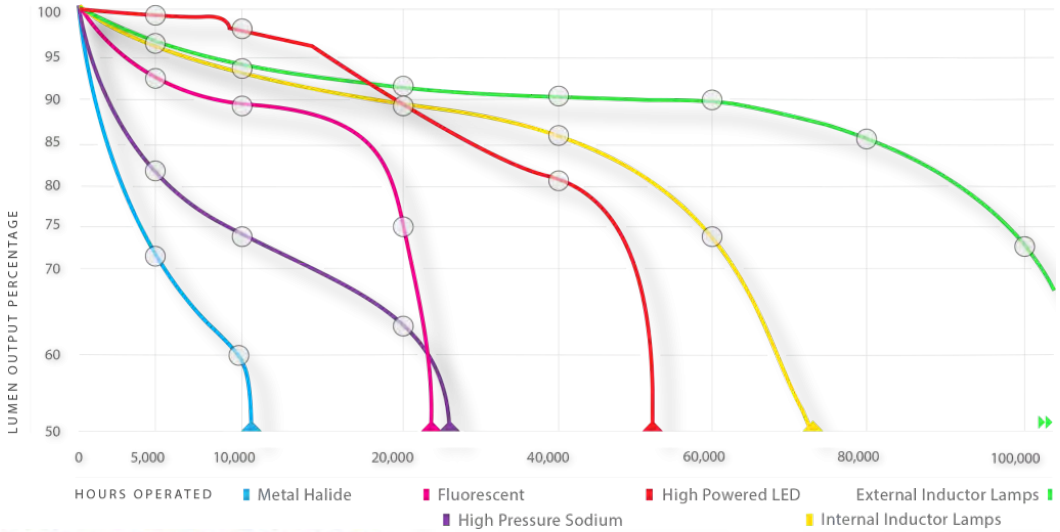
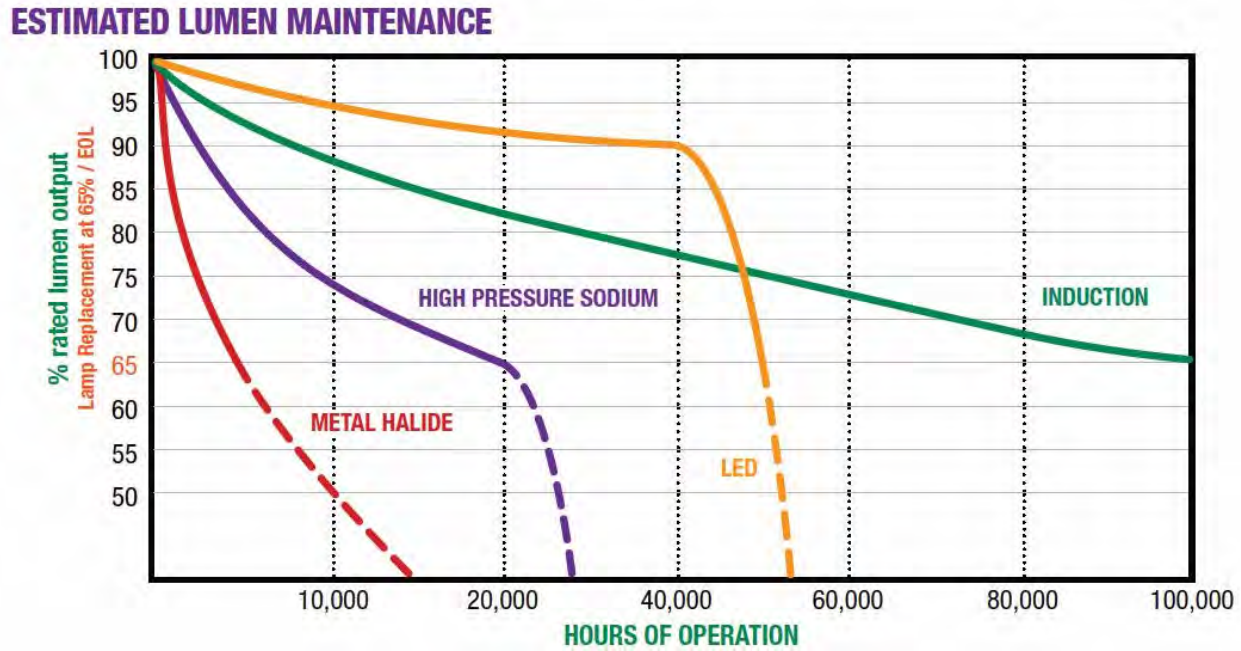
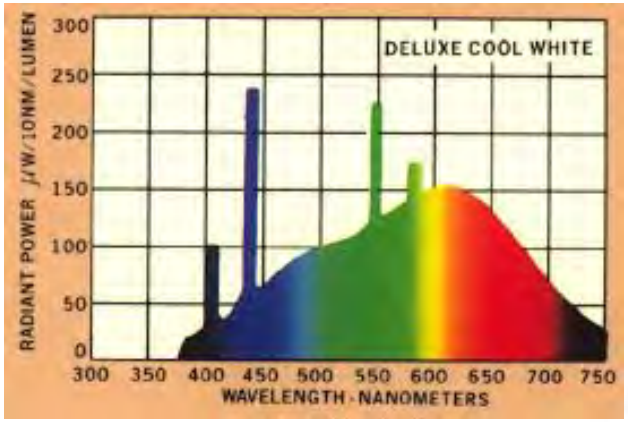
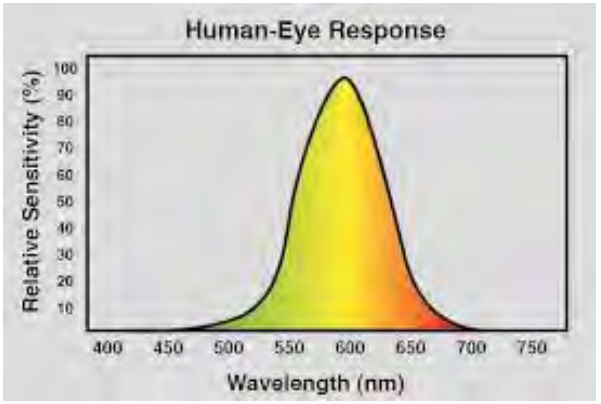
Lumen Depreciation

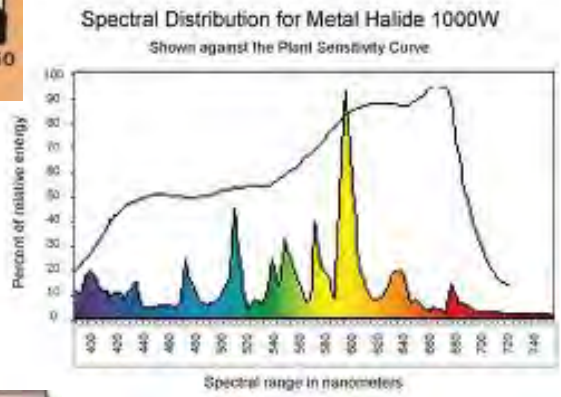


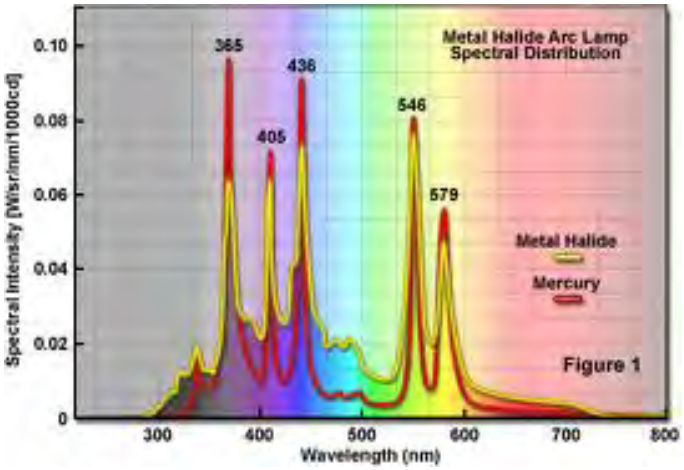


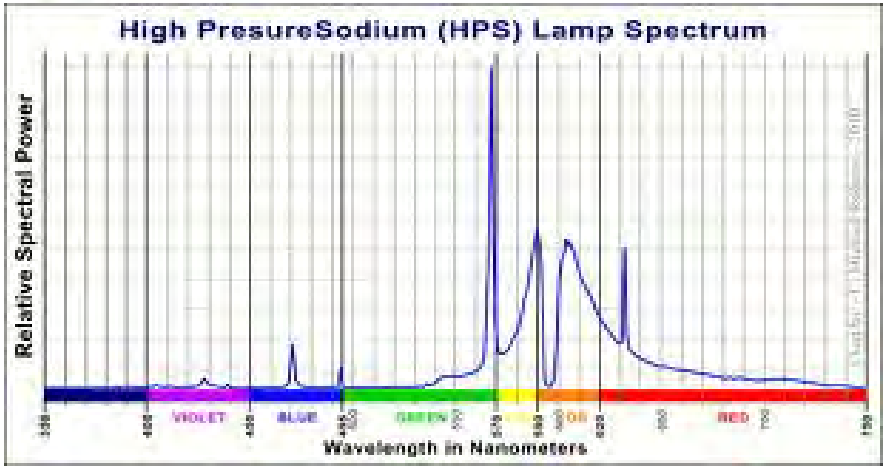
Optics


DELUXE COOL WHITE
RADIANT POWER µW/10NM/LUMEN
300
250
200
150
100
50
0
300 350 400 450 500 550 600 650 700 750
WAVELENGTH - NANOMETERS

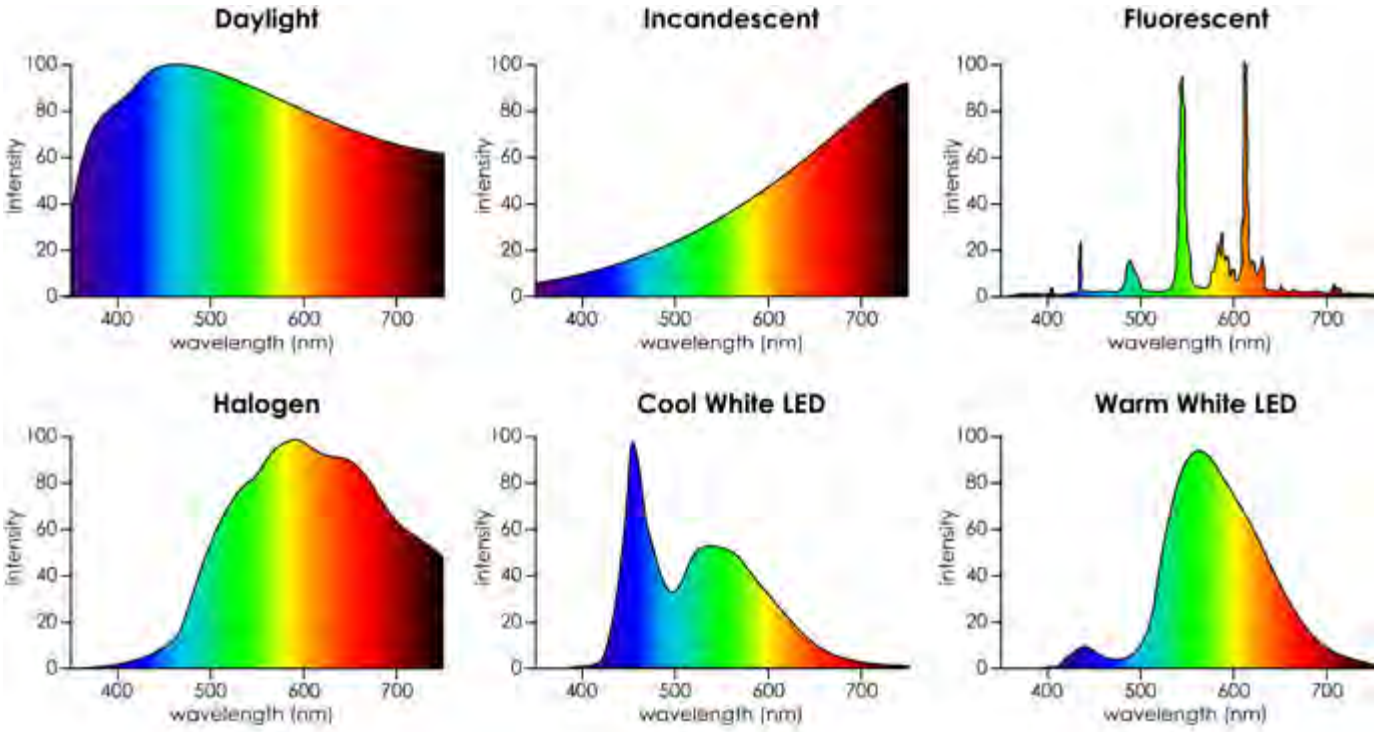

Human-Eye Response
Relative Sensitivity (%)
100
90
80
70
60
50
40
30
20
10
400 450 500 550 600 650 700 750
Wavelength (nm)

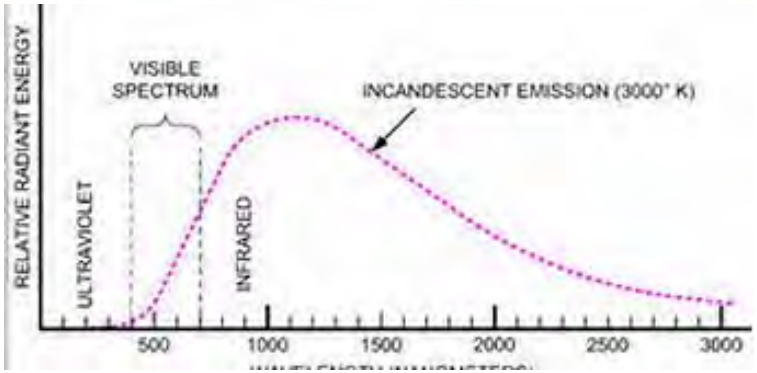

Spectral Distribution for Metal Halide 1000W
Shown against the Plant Sensitivity Curve
Percent of relative energy
Spectral range in nanometers


Metal Halide Arc Lamp
Spectral Distribution
365
436
405
546
579
Metal Halide
Mercury
Figure 1
Spectral Intensity [W/sr/nm/1000cd]
0.10
0.08
0.06
0.04
0.02
0
300 400 500 600 700 800
Wavelength (nm)


High PresureSodium (HPS) Lamp Spectrum
Relative Spectral Power
VIOLET
BLUE
RED
Wavelength in Nanometers

Optics


Daylight
Incandescent
Fluorescent
Halogen
Cool White LED
Warm White LED
intensity
wavelength (nm)
0
20
40
60
80
100
400
500
600
700


RELATIVE RADIANT ENERGY
VISIBLE SPECTRUM
INCANDESCENT EMISSION (3000° K)
ULTRAVIOLET
INFRARED
500
1000
1500
2000
2500
3000

CRI and Color Temperature

- Candle: 1700k 100 CRI
- High Pressure Sodium: 2100k 25 CRI
- Incandescent: 2700k 100 CRI
- Tungsten Halogen: 3200k 95 CRI
- Cool White: 4200k 62 CRI
- Clear Metal Halide: 5500k 60 CRI
- Natural Sunlight: 5000-6000k 100 CRI
- Daylight Bulb: 6400k 80 CRI

Myths and Facts

- Does a higher ballast factor mean higher efficiency?
- Is full spectrum or daylighting better than cool white or warm white?
- Is metal halide lighting always more efficient than fluorescent lighting?
- Are higher lumens always better?
- Why do people not like compact fluorescent for reading lamps?
- If T8 is better than T12, is T5 even better?
- Can T5 be used everywhere?
- Are long life lamps less efficient?
- Is a higher CRI and Color Temperature always better?
- For every dollar spent on lighting, what is cost of lamp?

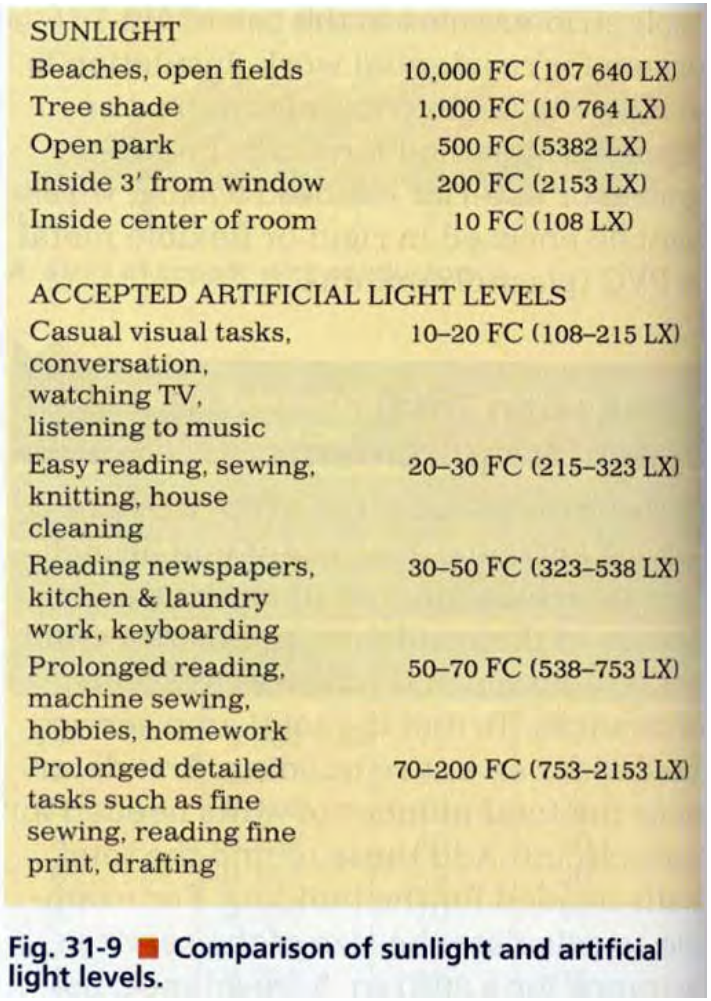
Ballast Choices

- External or self-ballasted lamp
- Fluorescent tube
  - High output, energy efficient, high/low ballast factor
  - Program start, instant start, rapid start
  - Electronic and magnetic
- Metal Halide
  - Probe start, pulse start
- PCBs
- **** Lamp must match ballast – type and manufacturer (sometimes)
- Lamp/ballast system
- High efficiency

Controls

- Occupancy sensors
  - Ultrasonic
  - Infrared
  - Combined
- Timers
  - Indoor and outdoor
  - Astronomic and time clock
- Advanced control components and systems in new energy and building codes
- Dual or variable lighting levels (stairwells)
- Dimmers

Footcandle Levels



SUNLIGHT	
Beaches, open fields	10,000 FC (107 640 LX)
Tree shade	1,000 FC (10 764 LX)
Open park	500 FC (5382 LX)
Inside 3' from window	200 FC (2153 LX)
Inside center of room	10 FC (108 LX)
ACCEPTED ARTIFICIAL LIGHT LEVELS	
Casual visual tasks, conversation, watching TV, listening to music	10–20 FC (108–215 LX)
Easy reading, sewing, knitting, house cleaning	20–30 FC (215–323 LX)
Reading newspapers, kitchen & laundry work, keyboarding	30–50 FC (323–538 LX)
Prolonged reading, machine sewing, hobbies, homework	50–70 FC (538–753 LX)
Prolonged detailed tasks such as fine sewing, reading fine print, drafting	70–200 FC (753–2153 LX)

Fig. 31-9 ■ Comparison of sunlight and artificial light levels.

Table 6-1—Typical Footcandle Levels

	Footcandles
Nature's Levels	
June sunlight	10,000
Shady porch	500
Moonlight	0.02
Starlight	0.0001
Artificial Lighting Levels (IES Recommendations)	
Fine assembly—industrial	500
Regular office work	100
Ordinary classroom	70
Corridors, stairways, etc.	20
Street Lighting Levels (ASA-IES Recommendations)	
Downtown areas	0.9 to 2.0
Intermediate areas	0.6 to 1.2
Outlying and rural areas	0.2 to 0.9

Footcandle Levels

Space Type	LEED Baseline LPD (W/sq-ft)	Estimated Footcandles
Enclosed Office	1.1	45
Open Office	1.1	45
Classroom	1.4	58
Lobby	1.3	54
Corridor	0.5	21
Restroom	0.9	37
Food Preparation	1.2	50
Dining	0.9	37

*Assuming a lamp with 90 mean lumens per watt in an 85% efficient fixture, 60% coefficient of utilization and a 90% maintenance factor

Source: http://www.michaelsenergy.com/PDFs/Briefs/Lighting%20the%20Way%20to%20LEED%20Energy%20Credits-L.pdf

Good Lighting Design

- Fixtures fit the application
- Lighting levels meet the task requirements
- Leading edge vs. bleeding edge
- First Cost – Fixture and Labor
- Energy Savings
- Light Distribution
- CRI and Color Temperature
- Maintenance Considerations
- Retrofit versus New
  - Environmental (asbestos and PCB)
  - Age and condition of fixtures
  - Fit to application

Design Concepts/Concerns

- Direct vs. indirect vs. direct/indirect
- Ambient/task lighting
- Is existing space under lit or over lit
- Has application changed
- Meet energy and building codes
- Increased ballast factor options for T-8 enable more design options
- Rebates and Direct Install Programs
- Glare
- Low bid vs. optimum design
- Safety and security lighting
- Lumens produced vs. surface footcandles
  - How much gets out of the fixture
  - How much is reflected/absorbed by the walls, ceiling, floor, and furniture
- Integration with other equipment such as heating and cooling

Maintenance Concepts

- Future costs of labor and materials
- Ease of use and repair
- Ability to reorder parts
- Lamp and ballast life
- Reduce inventory (standardize lamp and ballasts)
- Power factor and harmonics
- Group relamping
- Reduce number of ballasts (4 lamp vs. 2 lamp ballast and tandem wiring)
- Disposal and environment
- Phase out of T-12 and incandescent lamps

Historic Lighting Issues

- Early T-8 had high harmonics that causes issues on the neutral
- Early low wattage T-8 lamps only worked with specific type and manufacturer's ballasts
- T-5 misapplied to direct lighting applications
- HID lamps left in too long – lumen depreciation
- Early LED lamps underperformed and color variations
- Dimming causes premature lamp failure and strobe effect
- Strobe or failure to come on in cold temperatures or near cooling vents
- Cool white and warm white lamps used in same room or same fixture
- Reflectors misapplied and lamps halved
- Lamp failure in enclosed fixtures
- Metal Halide lamps take 20 minutes to start back up
- Clouding over of lenses
- My distributor or Home Depot don't have the energy efficient lamp and ballast I want and/or do not know what the hell I am talking about

Advantages of Working with a Lighting Consultant

- Ensure optimum design for the next 20 - 50+ years
- Lowest first cost, lowest energy costs and lowest future costs all simultaneously possible
- Fixtures fit the application vs. limitations of 1 for 1 retrofit
- Quality, quantity, and usefulness of lighting
- All factors integrated into the design
- Leading edge vs. bleeding edge vs. no edge
- Get it right the first time

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