CLMC Training

Certified Lighting Management Consultant Training

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CLMC Training

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Module 1: Course Introductions	Module 5: Retrofit + Design
Module 2: Overview of Lamps	Module 6: Lighting Layout
Module 3: Ballasts	Module 7: Legislation
Module 4: LED	Module 8: Sustainability

Module One

Course Introduction

Welcome

Introductions

Logistics

Housekeeping, Breaks
and Technology

WHO is NALMCO?

Mission Statement: NALMCO® is committed to raising the professional level of its members and the performance of lighting systems by providing education, certification and networking opportunities for the lighting industry.

The Standard for Lighting Management since 1953.

NALMCO Value Statements

Quality lighting is the cornerstone of the lighting management profession. NALMCO is committed to promoting quality lighting through the education of members and the business community on the benefits of quality lighting as managed by a professional lighting management company.

NALMCO Value Statements

Education: The speed of technological development in the lighting industry necessitates rapid response by our organization to provide our members with the means to obtain this knowledge. We seek to provide information and training to our industry practitioners expeditiously and in a concise, unbiased manner.

CLMC Training Structure

Module One: Introduction

Module Two: Overview of Lamps

Module Three: Ballasts

Module Four: LED

Module Five: Retrofit + Design

Module Six: Lighting Layout

Module Seven: Legislation

Module Eight Sustainability

CLMC Exam

Module Number	Question Pool	%
Module 1	Characteristics and Proper Usage of Lamps	15%
Module 2	Characteristics and Proper Usage of Ballasts	6%
Module 3a	Characteristics and Proper Usage of Fixtures and Controls: ***Luminaires and Reflectors***	
Module 3b	Characteristics and Proper Usage of Fixtures and Controls: ***Lighting Controls***	14%
Module 4	Lighting Layout Designs and Applications	16 %
Module 5	Energy Conservation Issues as Related to Lighting and Controls	14%
Module 6a	Lighting Maintenance, Recycling, and Disposal Practices: ***OSHA Rules and Regulations***	
Module 6b	Lighting Maintenance, Recycling, and Disposal Practices: ***Recycling and Disposal***	
Module 6c	Lighting Maintenance, Recycling, and Disposal Practices: ***Lighting Maintenance Practices***	18%
Module 7	Sustainable Lighting Practices	17%
	Total	**100.00 %**

Course Registration

- Review the CLMC Candidate Handbook and the Application requirements prior to registering for the exam.
- Register for the exam and pay the application fee online at www.NALMCO.org
- Watch your Inbox for exam information, including a link and unique credentials to access the exam.
  - Only open the exam link when you are prepared to begin the exam
- Prepare for the exam

Test Protocol - In person

1. Know what--and what not--to bring.
   - *Allowed:*
     - Pencils
     - Blank paper
     - Non-programmable calculator
   - *Not Allowed:*
     - Talking
     - Notes
     - Online resources
     - Phone

Test Protocol - In person

2. Be considerate of others; avoid behavior that could be distracting to others:

- Do not chew gum
- Turn off phone
- Please be quiet when entering or exiting
- Not adhering to the rules can lead to dismissal from the exam

Test Protocol - Virtual

Exam requirements:

- Google Chrome - No exceptions
- Name and Photo ID Match
  - The name on your CLMC application and photo ID must match
- Remain in camera view and active
  - Must remain in camera view and engaged with the exam until the exam is complete

Test Protocol - Virtual

Exam requirements:

- No Communication/People
- No electronic devices.
- No Headphones
- No external resources – i.e. browser tabs
- Calculators ARE permitted

Exam details

- 2.5 hour timed exam
- The exam monitors time
- One question is presented at a time
- Indicate your answer choice by a mouse click
- To change your answer click the new option before moving to the next question
- DO NOT click the back button
- Skip feature – moves question(s) to the end of the exam.

Next

Module Two:

Overview of Lamps

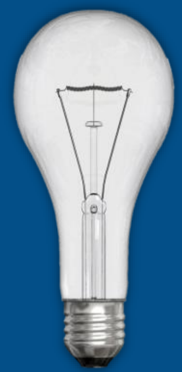
Learning Objectives

- Explain the proper usage of lamps.
- Describe the characteristics of lamps.

Lamps

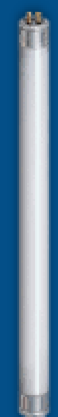
Incandescent, Fluorescent, HID and LED

Lamp Types



Incandescent

- Halogen



Fluorescent

- Compact Fluorescent

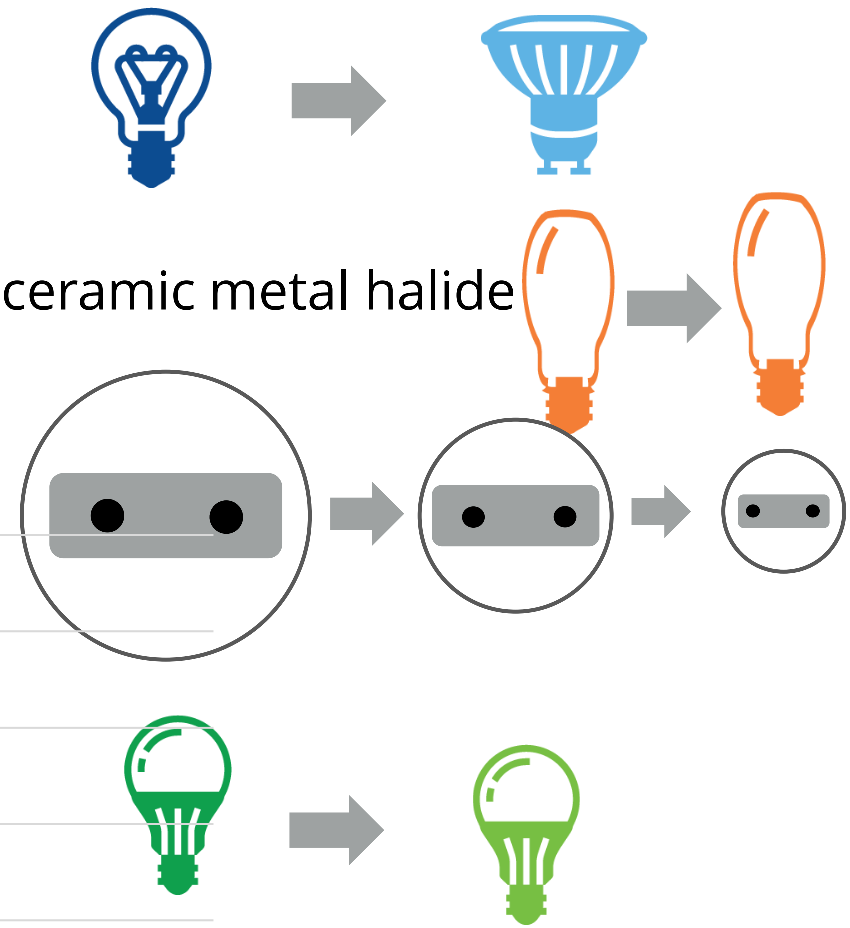
High Intensity Discharge (HID)

- Mercury
- Metal Halide
- Pulse Start Metal Halide
- Low Pressure Sodium
- High Pressure Sodium

Light Emitting Diodes (LED)

Lighting Technology Evolution

- Incandescent to halogen
- Quartz metal halide to (PS) ceramic metal halide
- T12 to T8 to T5
- LED to reLED



Lumens per Watt

Time

Incandescent Lamps

Basics

Incandescent Lamps

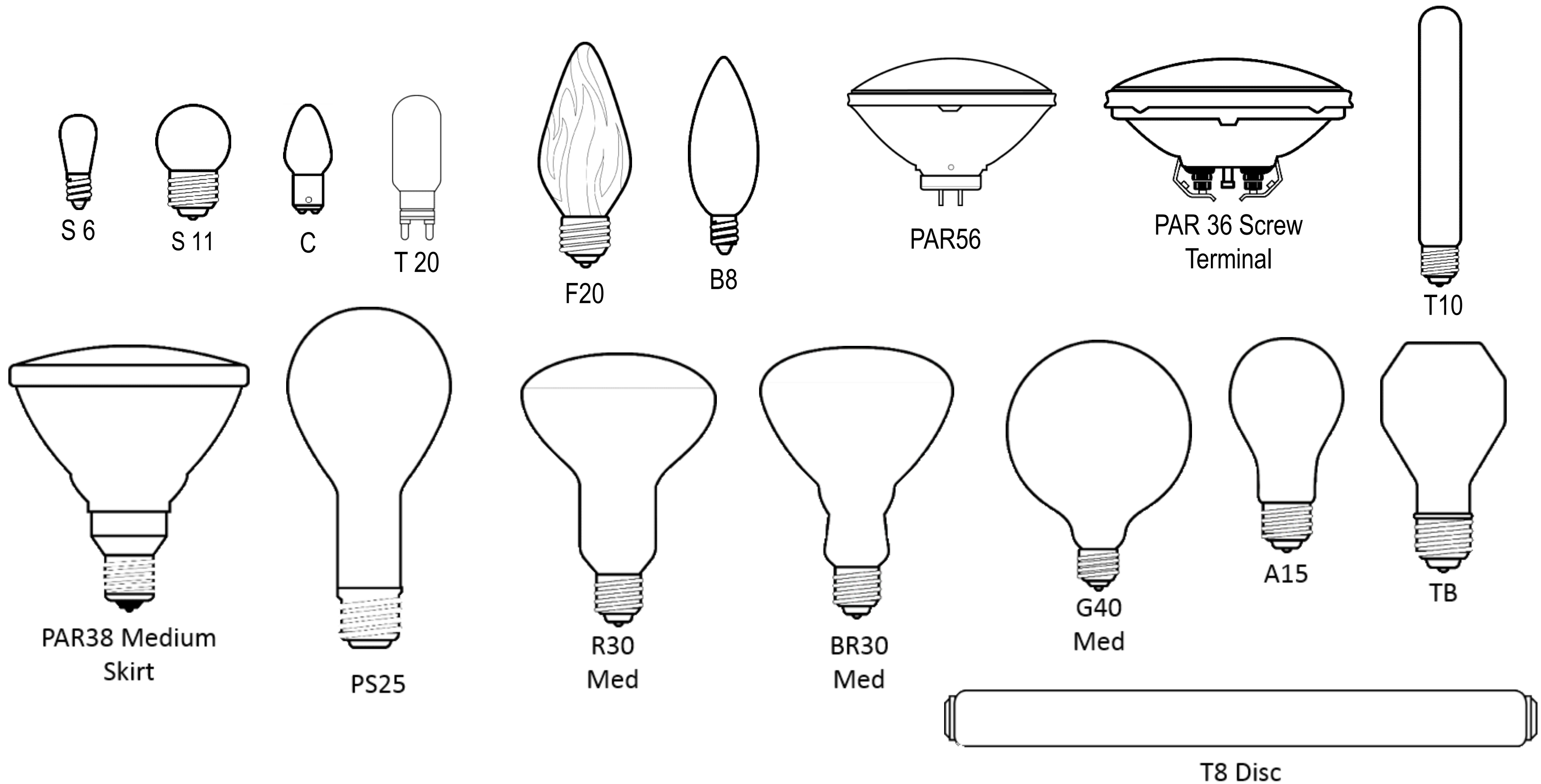
Advantages

- Lowest Initial Cost
- Simple to install
- Excellent CRI - 100
- Instant starting
- Easy to dim

Disadvantages

- Highly inefficient
- Short service life
- Sensitive to vibration

Incandescent Lamp Shapes



Incandescent Lamp Type

A – Arbitrary, Standard

C – Cone

CA – Candle

ER – Ellipsoidal Reflector

F – Flame

G – Globe

GT – Globe, Tubular

MR – Multifaceted Reflector

P – Pear

PS – Pear, Straight

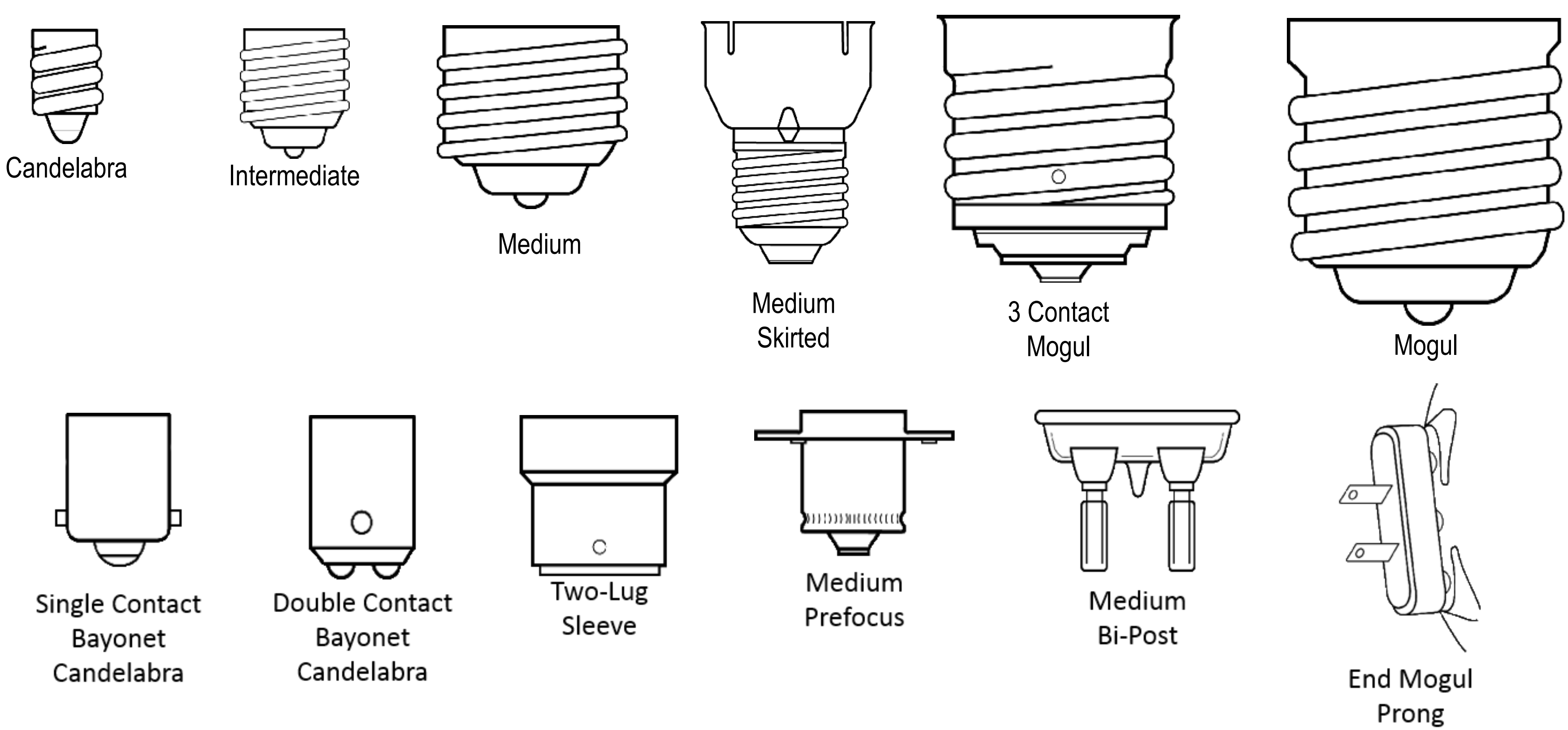
R – Reflector

S – Straight

T – Tubular

PAR – Pressed Aluminized

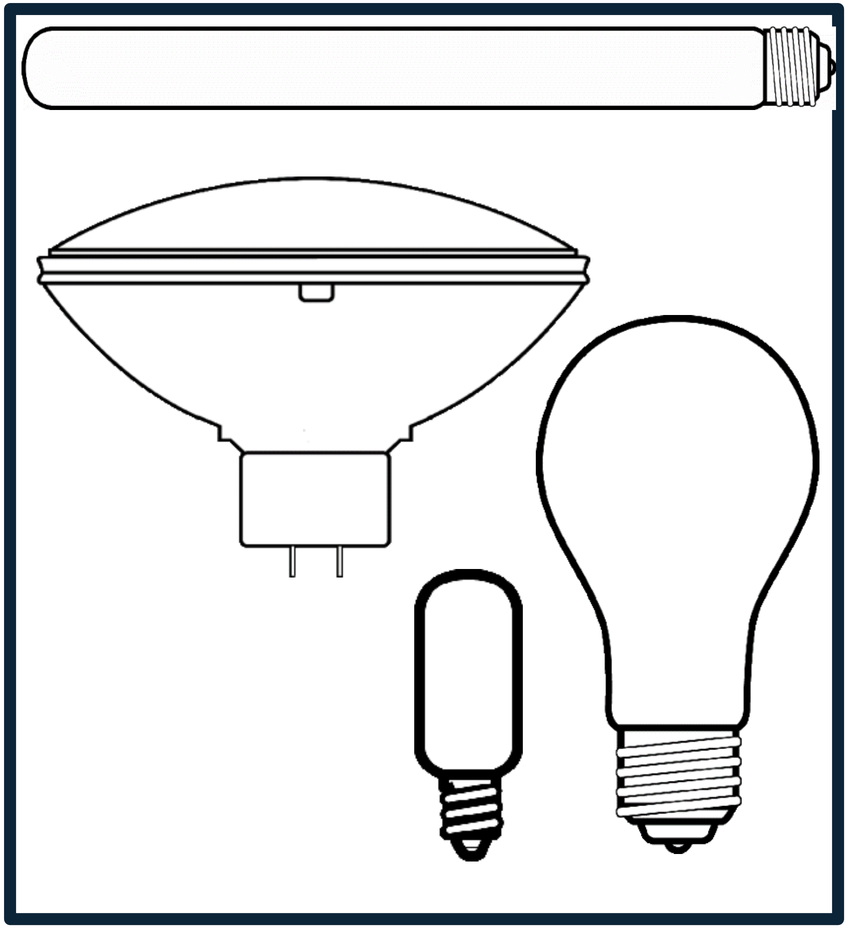
Incandescent Common Bases



Incandescent Fills

Incandescent bulbs have different fills, such as:

- Argon
- Krypton
- Nitrogen
- Vacuum



Incandescent Lamp Life

Incandescent bulb ***lamp life*** has a ***range of 620 to 8,000 hours***. Examples of lamp life for various bulb types:

- 750 hours: 40 watt, 120V T6.5
- 1,000 hours: 50 watt, 120V A21
- 2,000 hours: 50 watt, 120V R20
- 5,000 hours: 250 watt, 120V R40
- 8,000 hours: 165 watt, 120V P25 (traffic signal lamp)

Incandescent Lamp Life + Energy

Example:

If you operate a 130V lamp at just 120V:

Wattage	Light Output	Lamp Life
↓ 10%	↓ 20%	↑ 30%

Halogen Lamps

Advantages	Disadvantages
• Compact size • Excellent lumen maintenance • Longer life • Whiter light	• More costly • Not the most energy efficient

Halogen Types: Line Voltage

Halogen lamps are usually ***line-voltage lamps***, which means they use the voltage coming from the power line. Lamp types include:

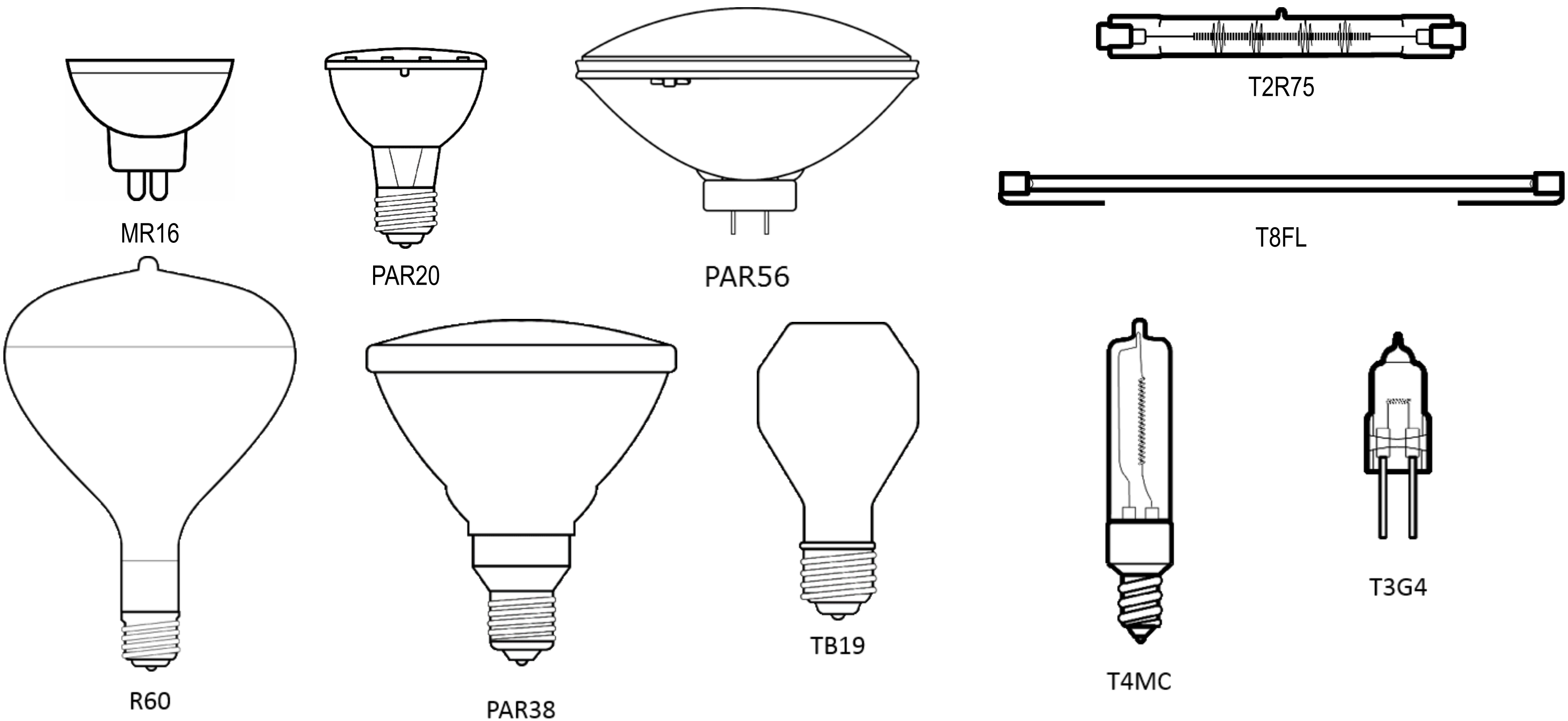
- Quartz
- PAR
- A-lamp
- Tubular

Halogen Types: Low Voltage

Halogen lamps can also be ***low-voltage lamps*** that include a transformer that reduces the voltage to a lower level. Lamp types include:

- Bi-pin
- PAR
- AR
- MR

Halogen Shapes



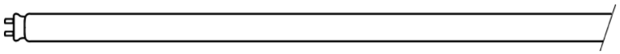
Fluorescent Lamps

Basics

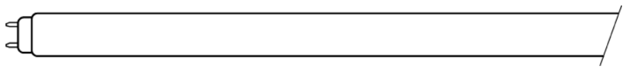
Fluorescent Lamp Types

- Circline
- Cold Cathode
- Compact
- Linear
- Reflector
- Spiral
- U-Shape

Fluorescent Shapes

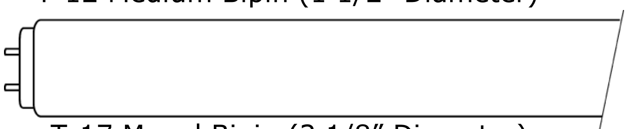


T-5 Miniature Bipin (5/8″ Diameter)

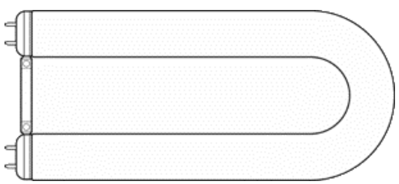


T-8 Medium Bipin (1″ Diameter)

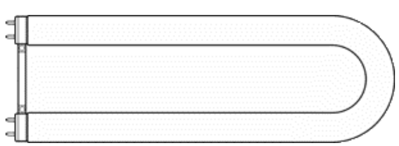
T-12 Medium Bipin (1 1/2″ Diameter)

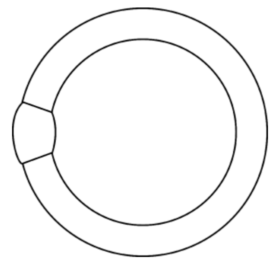


T-17 Mogul Bipin (2 1/8″ Diameter)

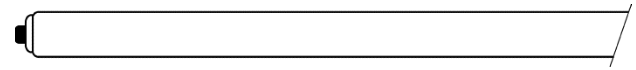


U-Shape T-12 (1 ½″ Diameter) 6″ and 3 ½″ spacing

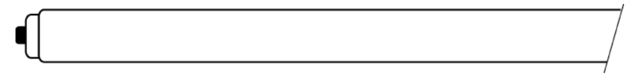




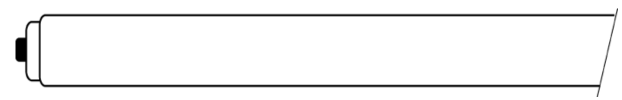
Circline 4-Pin T-9 (6 ½″, 8″ 12″, 16″ outside diameters)



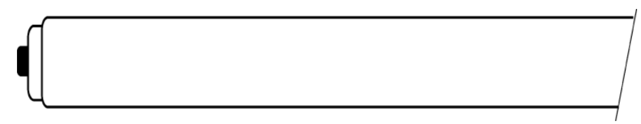
T-8 Recessed Double Contact (1″ Diameter)



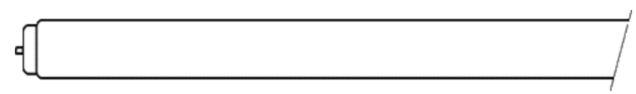
T-10 Recessed Double Contact (1 ¼“ Diameter)



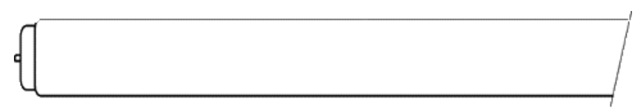
T-12 Recessed Double Contact (1 ½″ Diameter)



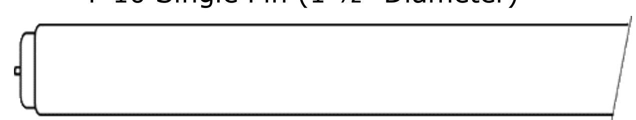
T-17 Recessed Double Contact (2 2/16″ Diameter)



T-8 Single Pin (1″ Diameter)



T-10 Single Pin (1 ½″ Diameter)



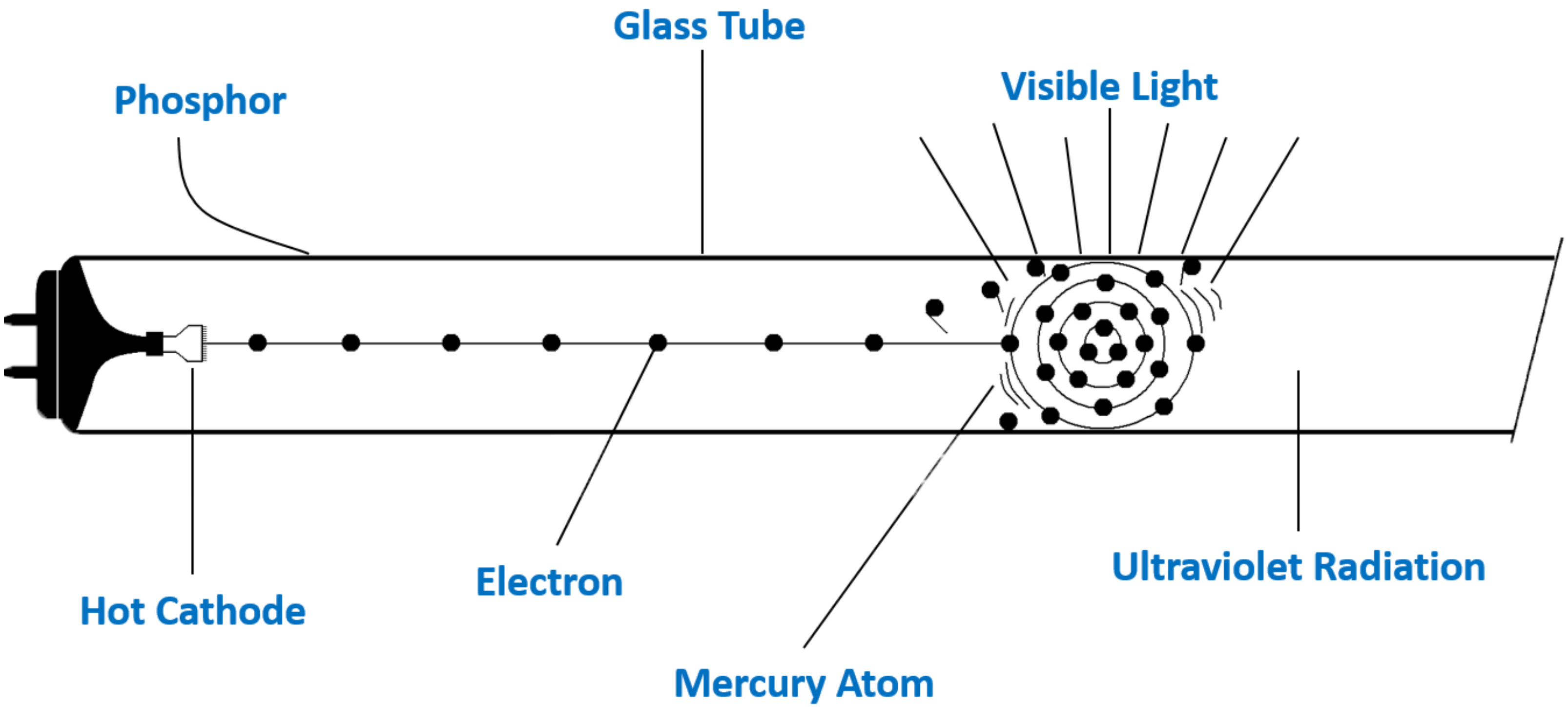
T-14 Single Pin (2 5/8″ Diameter)

Fluorescent Lamp Operation

Four key characteristics of fluorescent lamp operation are:

1. ***Efficacy***, expressed as lumens per watt (LPW)
2. ***Temperature effects***, which include lamp striking and lumen output
3. ***Strobe effect***
4. ***High frequency operation***, which means when operation is at 20kHz or higher, light energy is converted more efficiently

Fluorescent Lamp Diagram



Fluorescent Lamp Families

- Preheat
- Instant Start
- High Output (HO)
- Very High Output (VHO)
- Rapid Start

Fluorescent Lamp Families

Preheat

- External starter heats the lamps electrodes before the electric arc is made

Instant start

- Do not heat lamps
- High voltage discharge strikes the lamp (264 ma)

Fluorescent Lamp Families

Rapid Start

- Ballasts heat the electrodes before lamp starting and during normal operation
- Start quickly with very little flicker
  - Program Rapid Start - Only fluorescent ballast suitable for dimming

Fluorescent Lamp Families

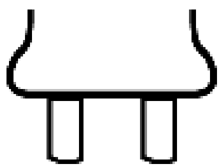
High Output (HO)

- 800 ma

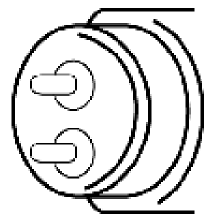
Very High Output (VHO)

- 1500 ma

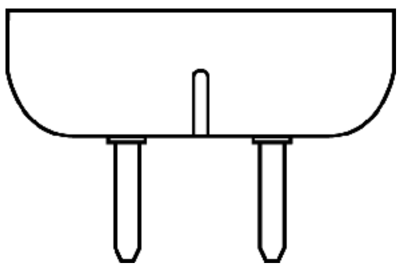
Fluorescent Bases



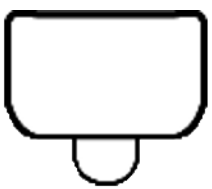
Min Bipin G5



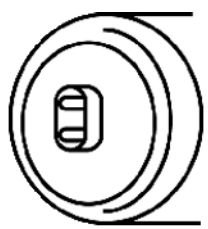
Med Bipin G13



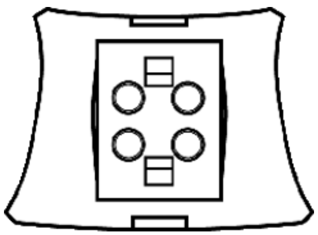
Mog Bipin G20



Single Pin Fa8



Recessed Double
Contact R17d



4-Pin G10q
(Circline)

Fluorescent Lamp Life

- 24,000-60,000 hours
- Lumen depreciation <10%
- T-5 operates more efficiently at higher temperatures (approx. 11% improvement in lumen output)

Fluorescent Lamp Life

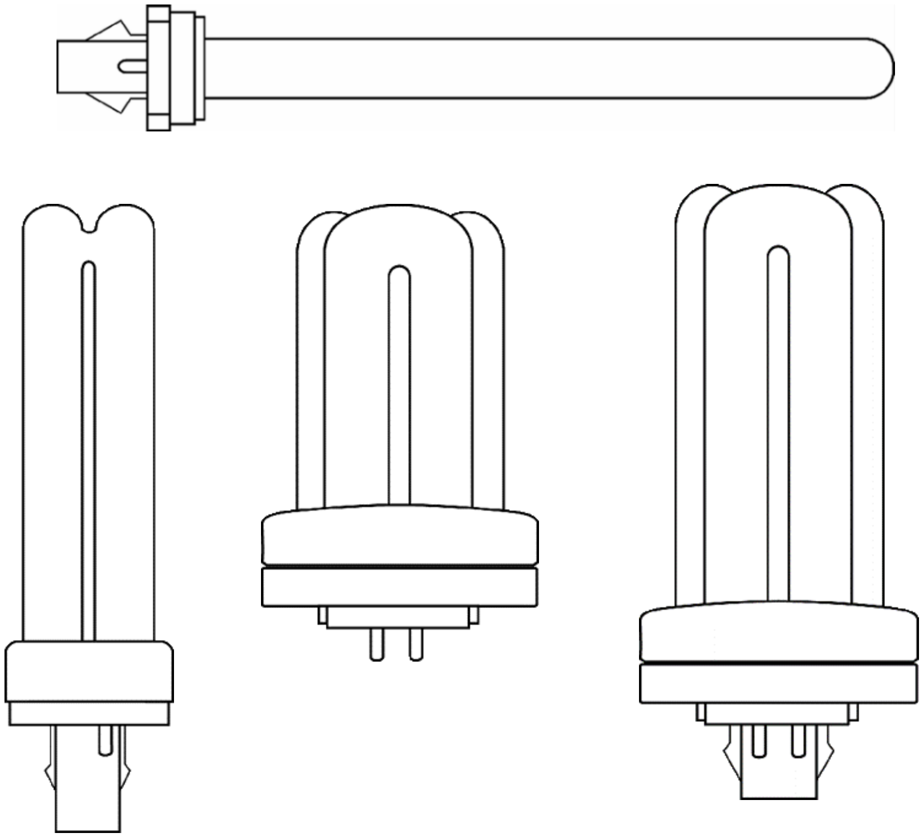
Some ***typical lamp life ranges*** for fluorescent lamps:

Lamp	3-Hour Start	12-Hour Start
T8 32w 800 XP	24,000	40,000
T8 28w XP	24,000	40,000
T8 54w F96	24,000	36,000
T5 28w HO XL	45,000	60,000
T5 54w HO ECO	30,000	40,000

Compact Fluorescent Lights (CFLs)

There are four types of ***compact pin-base lamps***:

- Twin tube
- Triple tube
- Quad tube
- Dimmable = 4pin



Compact Fluorescent Lights (CFLs)

There are eight general configurations ***of medium-base retrofit CFL lamps***:

- Twin Tube
- Triple Tube
- Quad Tube
- Spiral Tube
- Globe
- Reflector
- Adaptor ballasts
- Self-ballasted

Fluorescent Lamps

Advantages	Disadvantages
• Long service life	• Higher initial cost over Incandescent options
• High energy efficiency	• Requires ballast
• Dimmable	• Temperature sensitivity
• CRI options	• Shorter lamp life with low hours per start
• Color temp options	

High Intensity Discharge Lamps

Basics

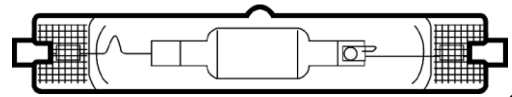
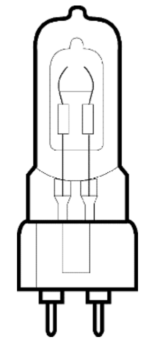
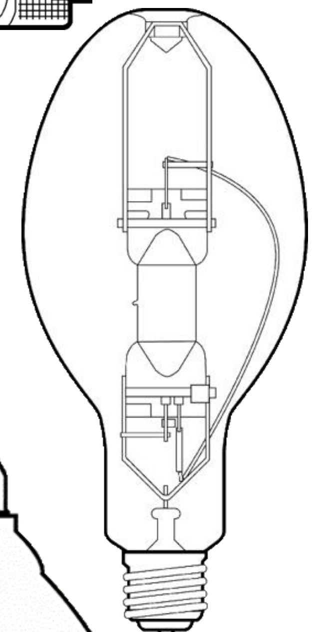
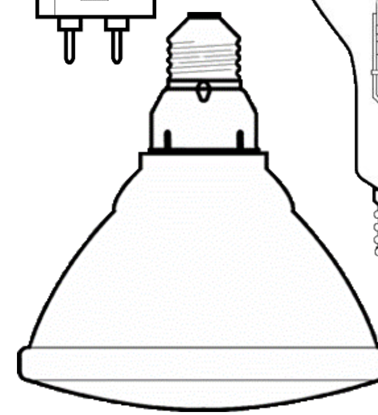
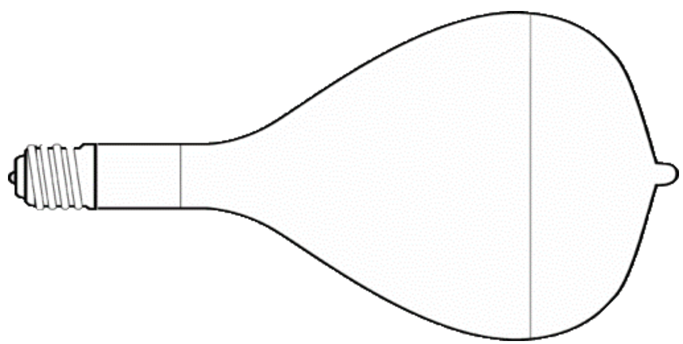
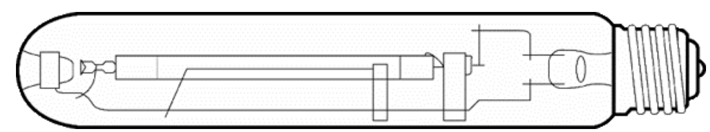
High Intensity Discharge Lighting

The ***four main HID lighting types and families***, are:

1. **High-pressure sodium (HPS):** amber or orange in color
2. **Metal halide (MH):** bright white in color
3. **Mercury vapor (MV):** blue-green in color
4. **Low-pressure sodium (LPS):** dark orange or brown in color

HID Lamp Types

- High Pressure Sodium
- Metal Halide
    - Pulse Start Metal Halide
- Mercury Vapor
- Low Pressure Sodium

Pulse Start Metal Halide

Advantages of ***pulse-start technology*** include:

- Better lumen maintenance
- More lumens per watt (LpW)
- Lower starting temperature
- Longer lamp life
- Faster warmup
- Quicker re-strike
- Superior color rendering
- Not as much tungsten deposited on lamp

High Intensity Discharge Lamps

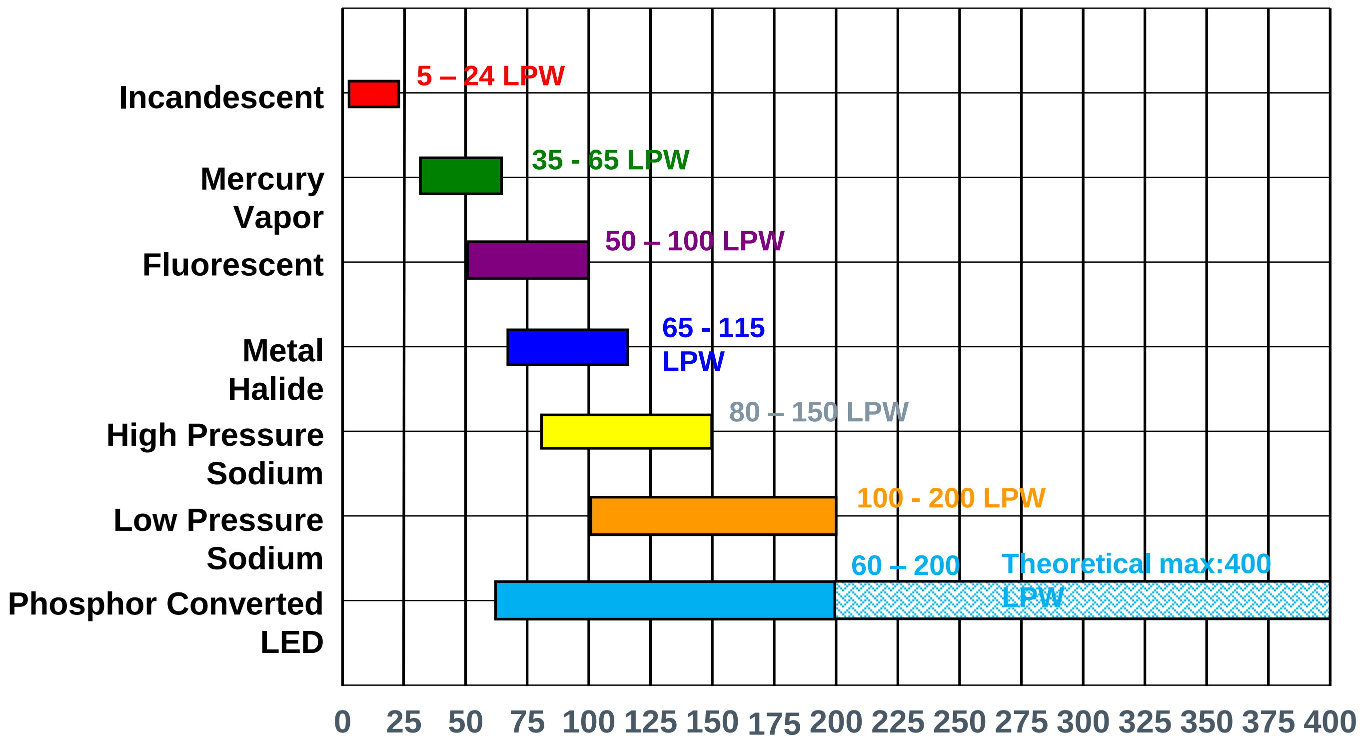
Advantages	Disadvantages
• High lumens per watt • Long lamp life • Multiple wattages available • Multiple shapes and sizes • Resistant to extreme temperatures	• High lumen depreciation • Long restrike time • Poor color rendering

Lamp Comparisons

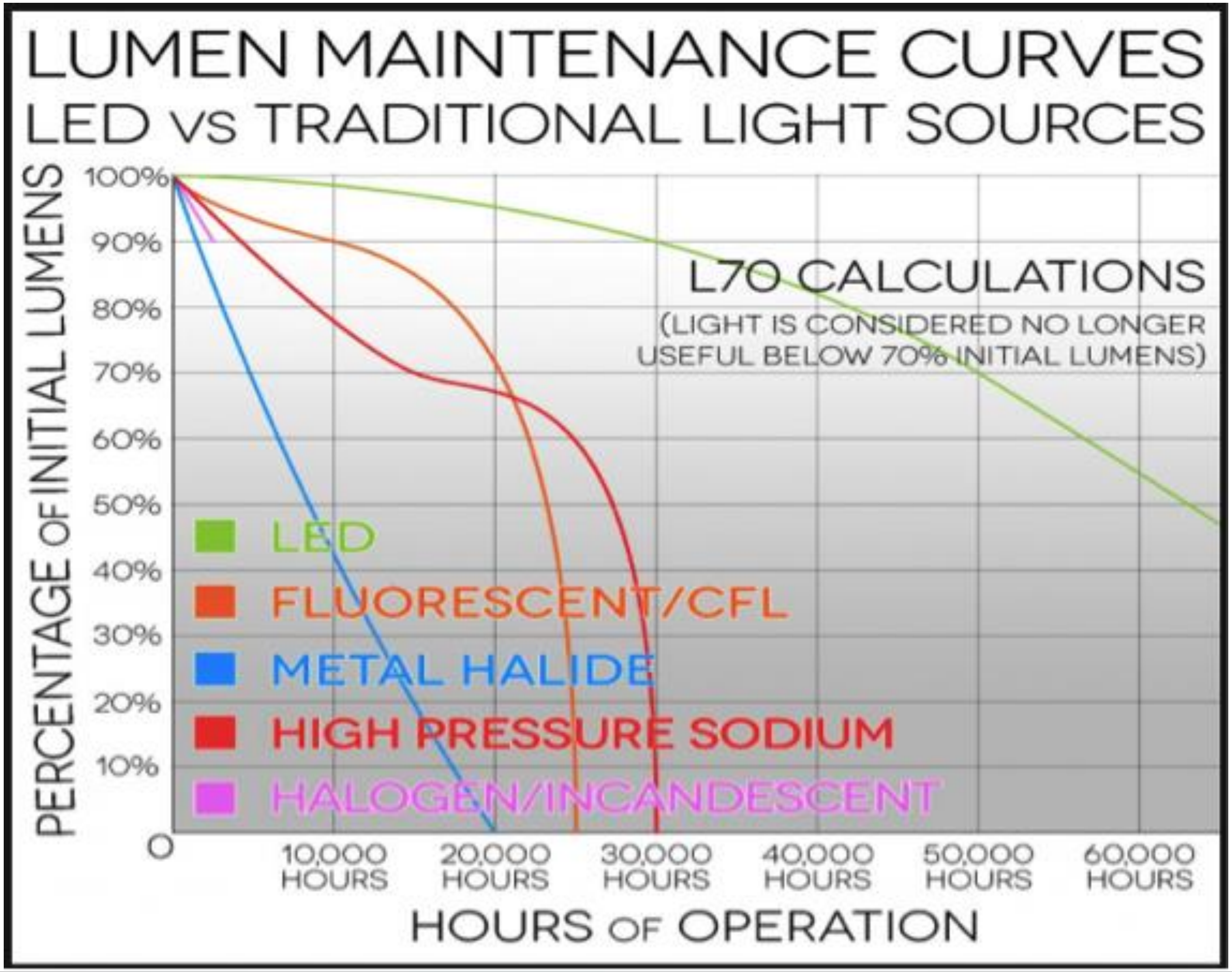
Efficacy, Depreciation and Lamp Life

Lamp Efficacies

LPW Comparisons:



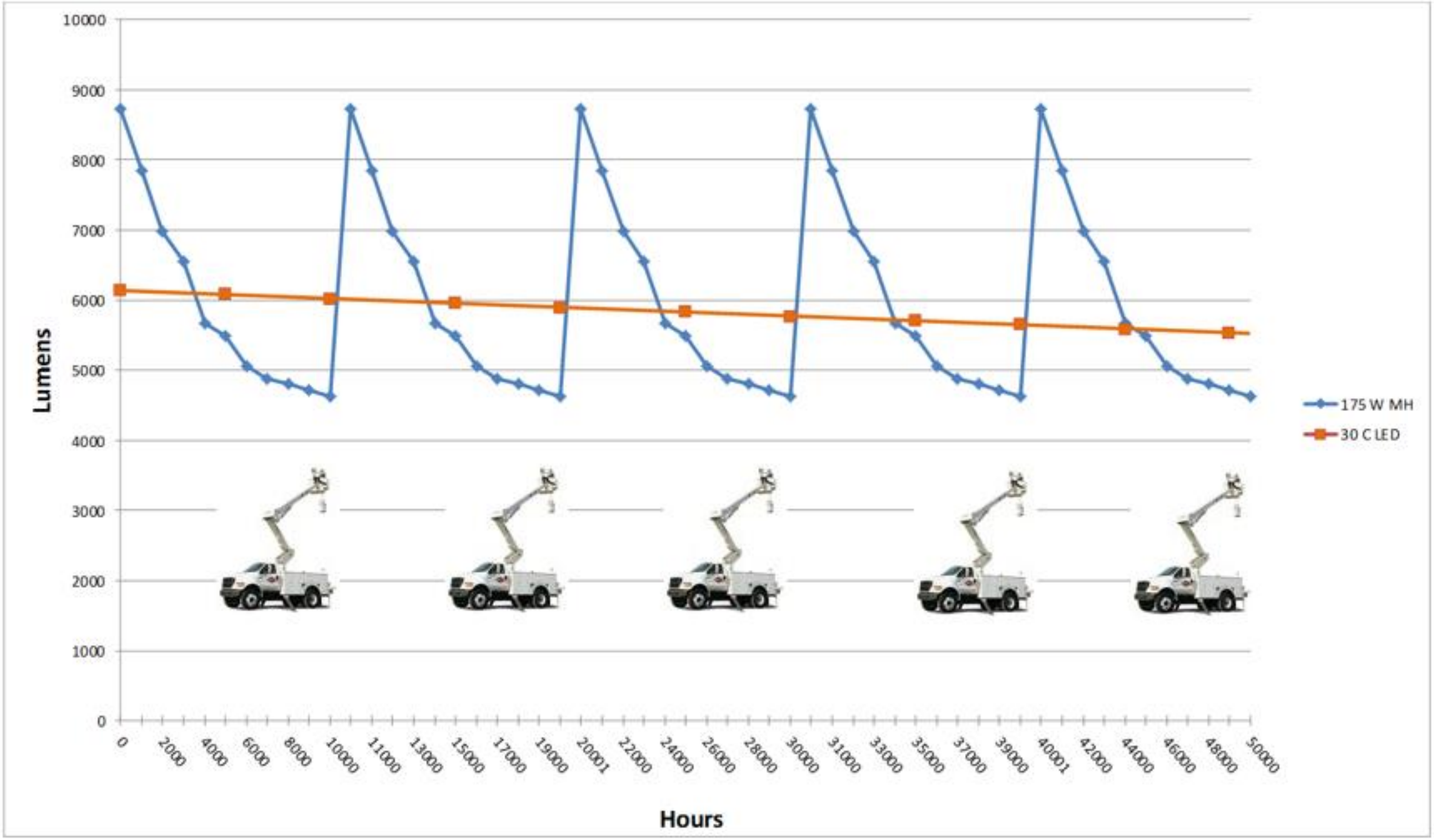
Lumen Depreciation Comparison



Comparative Lamp Life

Lamp Type	Lamp Life
Incandescent	600 to 2,000 hours
Halogen	2,000 to 3,000 hours
Fluorescent	12,000 to 60,000 hours
Sodium	12,000 to 24,000+ hours
Probe Start Metal Halide	8,000 to 20,000 hours
Pulse Start Metal Halide	8,000 to 26,000 hours
Mercury	20,000 to 24,000 hours
LED	100,000 hours

Lamp Depreciation: HID



Review

Knowledge Review:

Questions

Question: Light Measurement

What is the unit of measure for the amount of light on a surface?

Next

Module Three:

Ballasts

Module Three

Ballasts

Learning Objectives

- Describe the characteristics of ballasts.
- Explain the proper usage of ballasts.

Definition: Ballasts

Ballast

A *ballast* is "an auxiliary piece of equipment required to start and properly control the flow of current to gas discharge light sources such as fluorescent and high-intensity discharge (HID) lamps."

Acronyms: Ballasts

When discussing ballasts, you should be familiar with the many related acronyms, including:

- **CBM** (*Certified Ballast Manufacturers)*
- **UL** (*Underwriters Laboratories*)
- **ETL** (*Electrical Testing Laboratories*)
- **CSA** (Canadian Standards Association)

Key Factors

There are ***two key factors*** associated with ballasts:

1. The Ballast Factor (BF)
2. The Power Factor (PF)

The Ballast Factor (BF)

The ***BF*** measures how well a ballast can produce light from the lamp(s) it powers.

It is calculated by ***dividing*** *the lumen output of a particular lamp/ballast combination by the lumen output of the same lamp(s) on a reference ballast*.

Example:

2x4 4L T8 **32w** NPF Electronic Ballast Fixture

BF = **4 lamps** x **32w** x .88 (ballast factor) = ***112 watts***

The Power Factor (PF)

The ***PF*** measures the effectiveness with which an electrical device converts volt-amperes to watts. It determines the current drawn by the ballast.

Example:

A high power factor decreases the “current draw” allowing more fixtures per circuit.

The Power Factor (PF)

The ***PF*** can range from 0 to 1.0; here are various categories of ***PFs***:

- **High Power Factor** (*HPF*): PF ≥ 0.90
- **Power Factor Corrected** (*PFC*): 0.80 to 0.89
- **Normal Power Factor** (*NPF*): PF < 0.87
- **Low Power Factor** (*LPF*): PF < 0.78

Fluorescent Ballasts

Basics

Fluorescent Ballasts: Magnetic

The ***four*** main starting methods using ***magnetic*** ballasts are:

- Hybrid or cathode cut out ballasts
- Instant start ballasts
- Preheat ballasts
- Rapid start ballasts

Fluorescent Ballasts: Electronic

Advantages:

- Higher lamp efficiency – 10%
- Lower connected wattage
- Energy savings 25-85%
- Produces less heat
- Produces less noise – sound rated 'A'
  - A,B,C,D scale
    - "A" being the lowest or best sound rating
- Life span up to 25 years

Fluorescent Ballasts: Specialty

Cold Weather Ballasts

- Provide higher open circuit voltage to the lamp to aid in starting and maintaining design lumens
- Examples:
  - 0 degrees for Slimline and 34/40 watt rapid start lamps
  - -20 degrees for HO & VHO lamps

Dimming Ballasts

- Manufactured in both ***electronic*** and ***magnetic*** version
- Controlled by a manual dimmer or automatic controls such as a photo cell or daylight sensor
- Typically operate by varying the VOLTAGE to the ballast or via 0 – 10V signal that control lights output internally

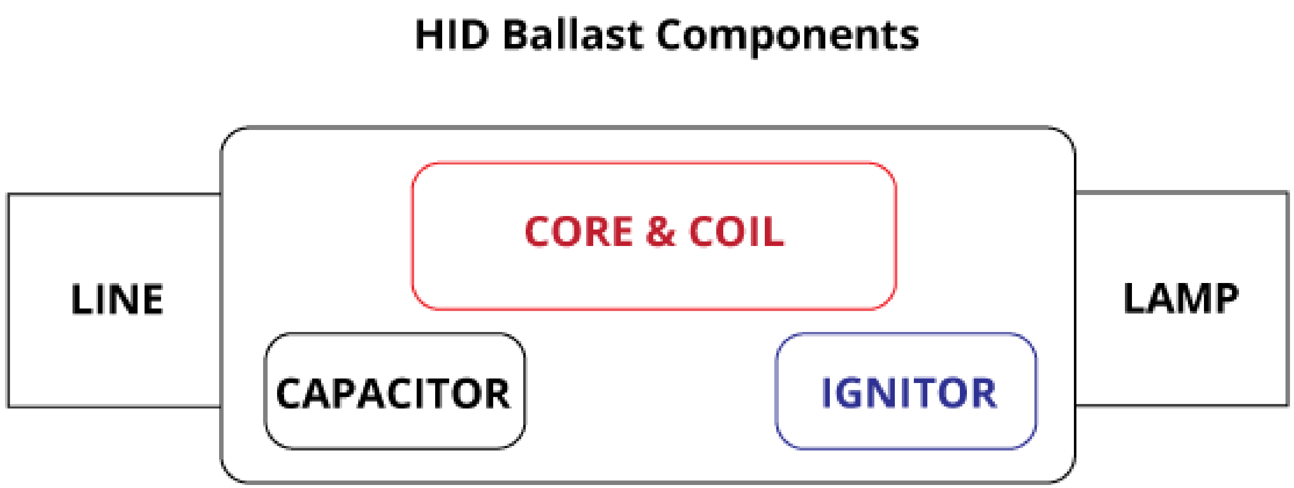
HID Ballasts

Basics

HID Ballasts

HID Ballasts are needed to:

- Start the lamp
- Control the current flow to the lamp



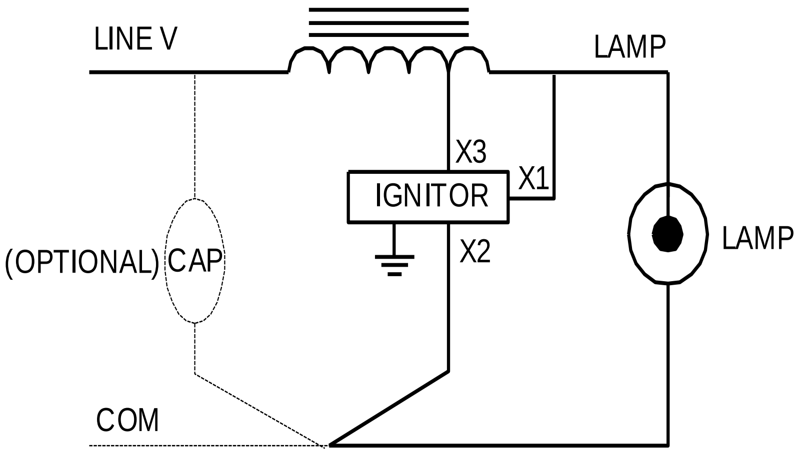
Ballast Circuits

There are ***four*** main types of ***ballast circuits***:

- Reactor (R)
- High Reactance Autotransformer (HX)
- Constant Wattage Autotransformer (CWA)
- Constant Wattage Isolated Transformer (CW)

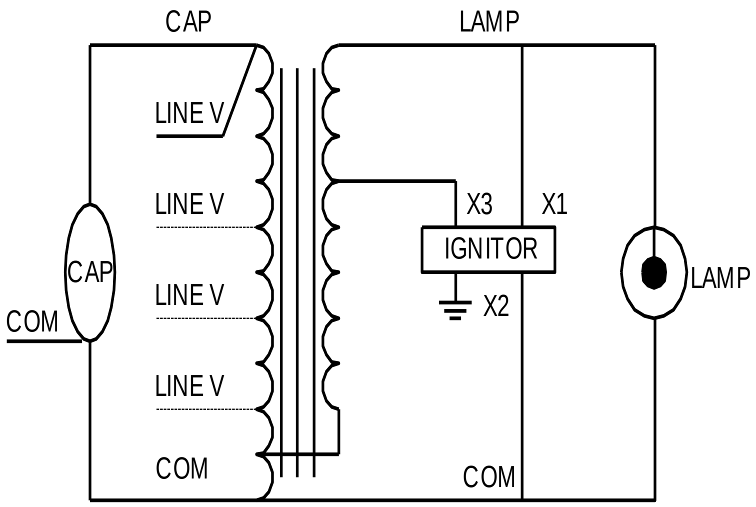
Ballast Circuits: Reactor (R)

A ***reactor*** is used when the supply voltage is sufficient to start the lamp on its own. Once the lamp starts, a choke controls the current.



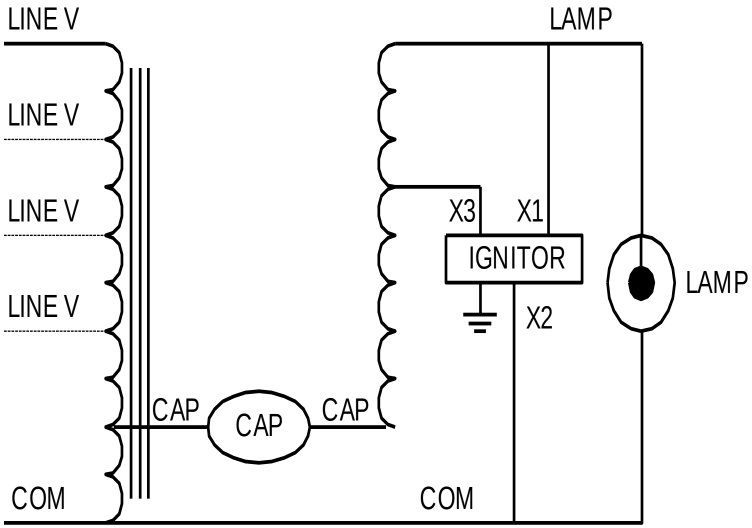
Ballast Circuits: HX

A ***high reactance autotransformer (HX)*** provides the voltage needed to start the lamp and limits the current through a choke once the lamp starts. It is a combination of the reactor and the autotransformer.



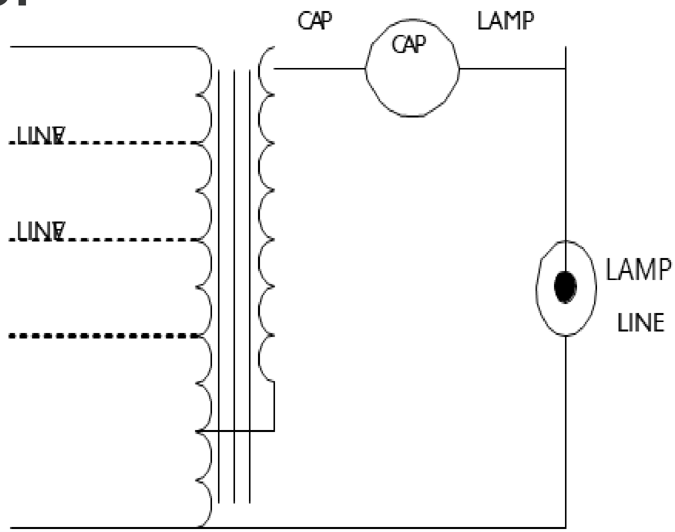
Ballast Circuits: CWA

A ***constant wattage autotransformer (CWA)*** uses a capacitor and a high reactance autotransformer in series with the lamp. A cap assists in controlling the current once the lamp is started. It continues to operate the lamp at a constant wattage regardless of supply voltage variations. It is the most commonly used ballast.



Ballast Circuits: CW

A ***constant wattage isolated transformer (CW)*** is similar to the constant wattage autotransformer except the secondary coil is isolated from the primary coil. This type is only used with 400W mercury lamps.



HID Ballast Configurations

HID ballasts are ***categorized*** in many ways:

- **Core-and-Coil**
- **Electronic**
- **Potted Or Encapsulated**
- **Encased And Potted (Also Called F-can)**
- **Indoor Enclosed**
- **Outdoor Weatherproof**
- **Post-line**

Potted Or Encapsulated

Potted or Encapsulated

- Sealed or potted in a high temperature resin to minimize ballast noise
- Used for remote indoor applications

Encased and Potted (F-can)

- Similar to the “potted or encapsulated” but packaged similar to fluorescent ballasts

Potted Or Encapsulated

Indoor Enclosed

- Used indoors where the ballast must be mounted remotely from the luminaire

Outdoor Weatherproof

- Designed to operate in all weather conditions separately from the luminaire
- Mounted to the base and sometimes filled with resin

Potted Or Encapsulated

Post-Line

- Core-and-coil ballasts that are elongated
- Potted and encased in high temperature resin
- Designed for mounting inside round poles

Ballast Components

Ballast Components

Capacitor

- Two types:
  - Dry Film
  - Oil Filled
- Corrects power factor
- Controls lamp wattage

Ignitor

- Provides high voltage pulse to ignite lamp arc
- Ballast Specific
- Mount near, but not on
- MH: 35-150w
- PSMH: 175-1000w
- HPS: 35 – 1000w
- Requires pulse rated sockets

HID Voltages

HID voltages

- 120V
- 208V
- 240V
- 277V
- 480V

Dual-tap

- Operates at two common voltages

Multi-tap

- 120V
- 208V
- 240V
- 277V

5-tap

- 120V
- 208V
- 240V
- 277V
- 480V

Review

Knowledge Review:

Questions

Question: Ballast

The measured ability of a particular ballast to produce light from the lamp(s) it powers is?

Next

Module Four:

LED’s

Module Four

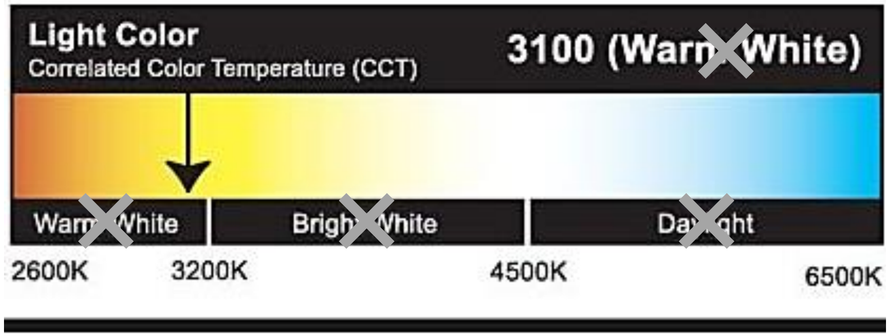
LED’s

LED Myth #1

LEDs give off blue light

LEDs are offered in a variety of correlated color temperatures (CCT)

When selecting or comparing LED light sources, do not rely on the "names" of colors – these names are for marketing purposes only and may vary widely between manufacturers



LED Myth #2

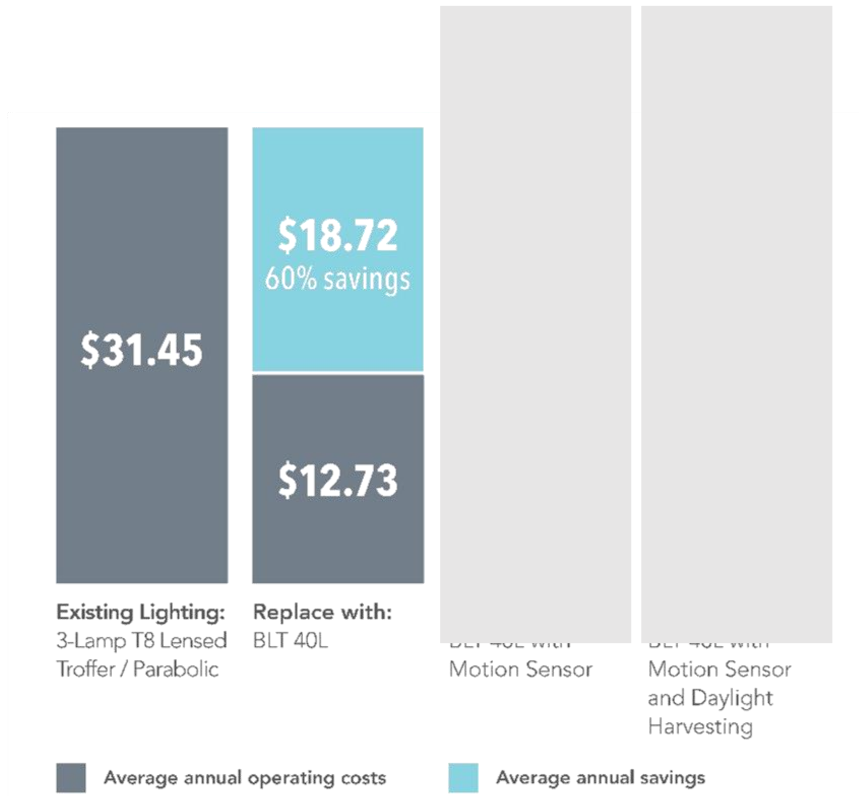
LED is too expensive

LED equipment has a higher initial cost

Total Cost of Ownership is less

- Add motion sensing = +15%
- Add daylight harvesting = +8%

83% energy savings



LED Myth #3

LED is not as bright as traditional sources

LEDs can be much brighter than traditional sources

Evaluate ***LUMEN OUTPUT***, not ***WATTS***

Brightness in Lumens	200+	400+	700+	900+	1300+
Incandescent	25w	40w	60w	75w	100w
CFL	6w	9w	12w	15w	20w
LED	4w	6w	10w	13w	18w

LED is the preferred light source

for most applications today

Lumens per watt (LPW) = greater efficacy = energy savings

Excellent selection of color temperatures and color rendering

Exponentially longer expected life = reduced maintenance

Instant-on, instant-off

Controllable/Dimmable

Next

Module Five:

Retrofits

Module Five

Retrofits

Learning Objectives

- Describe the characteristics and proper usage of luminaires and reflectors.
- Explain the characteristics and proper usage of lighting controls.

Definition: Retrofit

Retrofit

Exchanging older lighting systems for newer ones is called *retrofitting*.

Retrofit Components

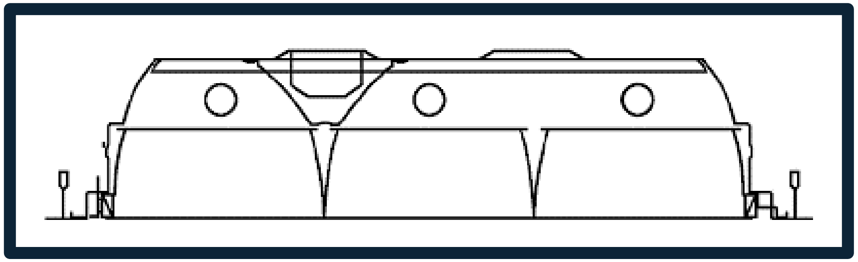
- Lenses and Louvers
- Reflectors
- Motion Sensors
- Codes and Regulations
- Lighting Audits
- Formulas
- Lamp and ballast disposal

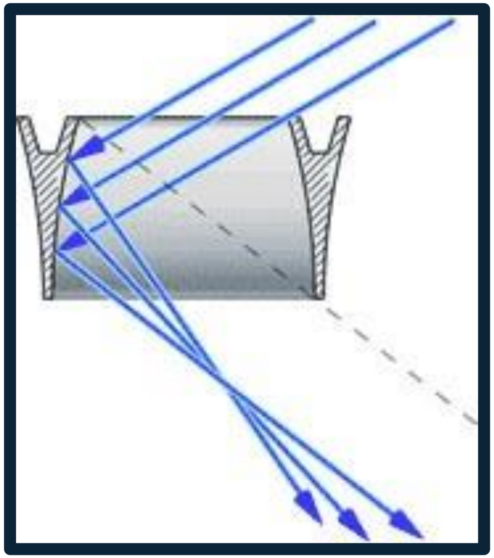
Louvers

- Variety of sizes and cell configurations
  - ½" by ½"
  - ¾" by ¾"
- Made of various plastics with silver, gold and white finishes
- Parabolic in design to provide reduced glare

Louvers

- Typical shielding angle of 25%
- Deep cell parabolic louvers typically 2-3 and 4” deep cells are generally anodized aluminized finish





Retrofit Components

- Lenses and Louvers
- Reflectors
- Motion Sensors
- Codes and Regulations
- Lighting Audits
- Formulas
- Lamp and ballast disposal

Reflectors

Reflector finishes consist of:

- White paint/powder coated
- Polished Aluminum
- Anodized Aluminum
- Silver Film
- All of which can have a reflectivity of over 85%
- Some produce different clarity of lamp image

Reflectors

- Change the angle of light leaving the fixture to 25 degrees
- Fixtures retrofitted with a reflector that replaces the original ballast cover must carry a UL label for the application

Retrofit Components

- Lenses and Louvers
- Reflectors
- Motion Sensors
- Codes and Regulations
- Lighting Audits
- Formulas
- Lamp and ballast disposal

Motion Sensors: Basic Types

Passive Infrared (PIR):

Detects changes in heat

Ultrasonic:

Detects high frequency sound

Dual Technology:

Detects changes in heat and sound

Microphonic:

Sends out a pulse much like sonar

Motion Sensors

- All available in wall, ceiling or fixture mount configuration
- Proper application is **key to success!**

Retrofit Components

- Lenses and Louvers
- Reflectors
- Motion Sensors
- Codes and Regulations
- Lighting Audits
- Formulas
- Lamp and ballast disposal

Codes and Regulations

- ***EPA toxic leachate procedures*** for a standard 4 T-12 fluorescent lamp must be less than 10mg or proper disposal must be performed

- ***Federal EPA*** takes precedent over any state that has not already adopted the federal guidelines regarding the disposal of hazardous waste

Codes and Regulations

- Section 410-15(a) of the ***National Electric Code*** states that fixtures weighing more than 6 lbs. and exceeding 16” in any dimension shall not be supported by the screw shell of the lamp holder

- The ***National Energy Conservation Amendments of 1988*** states that a 2-lamp, 4', 120 volt ballast must have a (BEF) Ballast Efficacy Factor of 0.90

Question: Ballast Factor

What is the equation for ballast efficacy factor?

$$BEF = \frac{\text{Ballast Factor} * 100}{\text{Input Watts}}$$

*.88 * 100/ 50 = 1.76*

Codes and Regulations

- Section 410-130 (g) of the **NEC** states that, “all new and existing non-residential fluorescent lighting fixtures must have power disconnects installed to safeguard electricians from shock when replacing ballasts.”

Retrofit Components

- Lenses and Louvers
- Reflectors
- Motion Sensors
- Codes and Regulations
- Lighting Audits
- Formulas
- Lamp and ballast disposal

Lighting Audits and Summaries

Prior to your retrofit, you should conduct an ***onsite lighting audit*** and collect the following information:

1. Determine the annual burn hours of the system.

- Offices – 3,000 +
- Schools – 1,800 -2,400
- Exit Signs – 8,760

2. Identify the electric rate for kilowatt hour (KWH).

- Demand Charges
- Scale Sliding
- $0.04 to $0.22 depending upon location

Lighting Audits and Summaries

3. Determine the total system wattage.

- Total System Wattage = Lamp Wattage * Number of Lamps

4. Make note of the lighting system installation date.

- PCB Ballast disposal issues

5. Record the foot-candle levels by area.

- Record existing by area
- Targeted (as recommended by IES for the task)
  - Classrooms – 50+
  - Halls – 20+

Lighting Audits and Summaries

6. Collect information about the fixture, ballast, lamp types, and how many of each are present.

- ***Example:***
  - ***Fixture:*** *Ceiling*
  - ***Ballast:*** *Electronic Normal Power Factor*
  - ***Lamp Types:*** *Fluorescent*
  - ***Number:*** *100*

7. Take the room measurements.

- For redesign purposes
- ***Example:*** *Gym refixture of Metal Halide to LED*

Retrofit Components

- Lenses and Louvers
- Reflectors
- Motion Sensors
- Codes and Regulations
- Lighting Audits
- Formulas
- Lamp and ballast disposal

Input Wattage Guide

A typical Input Wattage Guide includes the following data fields:

- ***Fluorescent lamp description*** (e.g., F15T12 1.5’ 15W)
- ***Number of lamps*** (e.g., 2)
- ***Three types of ballasts*** (standard magnetic, energy-saving magnetic, and electronic)

Input Wattage Guide

T12 FLUORESCENT LAMPS

Fluorescent Lamp Description	Number of Lamps	Fixture Input Watts (for normal power ballasts): *Standard Magnetic Ballast	Energy Saving Magnetic Ballast	Electronic Ballast	Fluorescent Lamp Description
F15T12 1.5' 15W	1	–	21	–	F48T12 4' 116W HO

F21T12 3' 21W	1	–	–	25
F21T12 3' 21W	2	–	–	49
F24T12 3' 24W	1	–	45	
F24T12 3' 24W	2	–	65	
F25T12 3' 25W	1	–	–	35
F25T12 3' 25W	2	–	–	71
F25T12 3' 25W	3	–	–	70
F25T12 3' 25W	4	–	–	88
F30T12 3' 25W	1	–	40	28
F30T12 3' 25W	2	–	64	50
F30T12 3' 25W	3	–	103	80
F30T12 3' 25W	4	–	125	
F30T12 3' 30W	1	–	40	30
F30T12 3' 30W	2	–	75	60
F30T12 3' 30W	3	–	113	90
F30T12 3' 30W	4	–	138	–
F36T12 3' 30W SLIM	1	–	57	–
F36T12 3' 30W SLIM	2	–	83	–

F64T12 64" 80W HO	3	–	246	–
F64T12 64" 80W HO	4	–	312	–
F72T12 6' 168W HO	1	–	169	–
F72T12 6' 168W HO	2	–	314	–
F72T12 6' 168W HO	3	–	424	–
F72T12 6' 57W	1	–	80	67
F72T12 6' 57W	2	–	122	106
F72T12 6' 85W HO	1	–	106	–
F72T12 6' 85W HO	2	–	190	164
F72T12 6' 85W HO	3	–	291	225
F72T12 6' 85W HO	4	–	323	–
F84T12 7' 65W	1	–	89	75
F84T12 7' 65W	2	–	143	120
F84T12 7' 100W HO	1	–	113	–
F84T12 7' 100W HO	2	–	209	190
F84T12 7' 100W HO	3	–	278	–
F96T12 8' 60W	1	–	74	67
F96T12 8' 60W	2	–	113	105

Input Wattage Guide

T12 U-BEND FLUORESCENT LAMPS

Fluorescent Lamp Description	Number of Lamps	Fixture Input Watts (for normal power ballasts)		
		Standard Efficiency, Electronic Ballast	Standard Efficiency, Energy Saving Magnetic Ballast	Standard Efficiency, Energy Saving Magnetic Ballast
FT12 4' 34W	2	60	67	84

T8 FLUORESCENT LAMPS

Fluorescent Lamp Description	Number of Lamps	Fixture Input Watts						
		Standard Ballast Type				High Efficiency Ballast		
		Energy Saving Magnetic	Low Ballast Factor Electronic	Normal Ballast Factor Electronic	High Ballast Factor Electronic	Low Ballast Factor Electronic	Normal Ballast Factor Electronic	High Ballast Factor Electronic
F13T8 1' 13W	1	17	–	–	–	–	–	–
F13T8 1' 13W	2	36	–	–	–	–	–	–
F15T8 1.5' 15W	1	20	–	–	–	–	–	–
F28T8 4' 28W	4	–	–	[illegible]	–	[illegible]	[illegible]	[illegible]
F30T8 4' 30W ES	1	40	–	31	–	–	–	–
F30T8 4' 30W ES	2	82	–	54	–	–	–	–
F30T8 4' 30W ES	3	–	–	77	–	–	–	–
F30T8 4' 30W ES	4	–	–	104	–	–	–	–
F32T8 4' 32W	1	35	–	32	–	25	28	37
F32T8 4' 32W	2	68	52	59	77	50	56	74
F32T8 4' 32W	3	100	78	88	115	75	84	110
F32T8 4' 32W	4	131	104	117	153	100	113	147
F32T8 4' 32W	6	–	–	–	–	150	169	221
F32T8 4' 32W	8	–	–	–	–	200	225	294
F32T8 4' 32W	12	–	–	–	–	300	338	442
F32T8 4' 32W	14	–	–	–	–	349	394	515
F32T8 4' 32W	16	–	–	–	–	399	451	589
F32T8 4' 32W	18	–	–	–	–	449	507	662
F32T8 4' 32W	20	–	–	–	–	499	563	736
F32T8 4' 32W VHLO	3	–	–	–	–	–	279	–
F32T8 4' 32W VHLO	5	–	–	–	–	–	465	–
F32T8 4' 32W VHLO	6	–	–	–	–	–	555	–
F32T8 4' 32W VHLO	8	–	–		–	–	793	–
F36T8 4' 36W	2	–	–	74	–	–	–	–
F48T8 HO 4' 44W	1	–	–	59	–	–	–	–
F48T8 HO 4' 44W	2	120	–	98	–	–	–	–
F40T8 5' 40W	1	50	–	39	–	–	–	–
F40T8 5' 40W	2	86	–	75	–	–	–	–

SUPER T8 SYSTEM INPUT WATTAGE

	Instant Start Ballast			Rapid Start Ballast		
	Low Ballast factor (0.77)	Normal Ballast factor (0.87)	High Ballast factor (1.15)	Low Ballast factor (0.71)	Low Ballast factor (0.77)	Normal Ballast factor (0.88)
1 Lamp	25	28	38	25	–	31
2 Lamps	48	55	74	47	48	60

Input Wattage Guide

T5 FLUORESCENT LAMPS

LIGHTING EFFICIENCY INPUT WATTAGE GUIDE

T5 FLUORESCENT LAMPS

		Fixture Input Watts (for normal power ballasts)	
Fluorescent Lamp Description	Number of Lamps	Energy Saving Magnetic Ballast	Electronic Ballast
F4T5 6'' 4W	1	9	–

		Fixture Input Watts (for normal power ballasts)	
Fluorescent Lamp Description	Number of Lamps	Energy Saving Magnetic Ballast	Electronic Ballast
F28T5 4' 28W	1	–	32

F13T5 2' 13W	2	26	27
F14T5 2' 14W	1	–	14
F14T5 2' 14W	2	–	28
F24T5 HO 2' 24W	1	–	27
F24T5 HO 2' 24W	2	–	54
F21T5 3' 21W	1	–	25
F21T5 3' 21W	2	–	49
F39T5HO 3' 39W	1	–	42
F39T5HO 3' 39W	2	–	85

F54T5HO 4' 54W	2	–	117
F54T5HO 4' 54W	3	–	179
F54T5HO 4' 54W	4	–	234
F54T5HO 4' 54W	5	–	295
F54T5HO 4' 54W	6	–	358
F54T5HO 4' 54W	8	–	468
F54T5HO 4' 54W	10	–	468
F39T5HO 3' 39W	1	–	40
F39T5HO 3' 39W	2	–	77
F80T5HO 5' 80W	1	–	89

Energy Calculations

The following table shows energy calculations for the ***original*** classroom and halls of a building:

Energy Calculations

Location	Quantity	Fixture Type	Watts	Total
Classroom	10	2 x 4 4-lamp (std. ballasts and F40 lamps)	175	1,750
Halls	6	1 x 4 2 lamps	97	582
Note: Input watts for rebate purposes may vary by specific utilities.			**Total**	**2,332**

Energy Calculations

This table shows the energy calculations for a ***proposed*** lighting system for the space described:

Energy Calculations

Location	Quantity	Fixture Type	Watts	Total
Classroom	10	2 x 4 4-lamp (T8 electronic ballast and F32 lamps)	110	1,100
Halls	6	1x4 2 lamps T8	58	348
Note: Input watts for rebate purposes may vary by specific utilities			**Total**	**1,448**

Energy Calculations

Based on the ***two*** previous tables:

Energy Calculations

Existing System →	2332 Watts
Proposed System →	1448 Watts
Watts Saved	**884 Watts**
	For this exercise assume
	$.105 per kWh
	2000 annual hours

Energy Calculations

Based on the previous tables:

$$\text{Annual Dollars Saved} = \frac{\text{Watts Saved} \times \text{Annual Burn Hours} \times \text{Electric Rate}}{1{,}000}$$

$$\frac{884 \times 2000 \times \$0.105}{1{,}000} = \$185.64$$

Energy Calculations

Based on the ***two*** tables:

System Cost

Description	Quantity	Cost	Total
4 lamp ballasts & lamps	10	$50.00	$500.00
2 lamp ballasts & lamps	6	$40.00	$240.00
	Total System Cost		**$740.00**

Energy Calculations

Based on the previous tables:

ROI (Return on Investment)

Annual Savings / System Cost= ROI

$185.64 / $740 = 25.1%

Simple **Payback** (Yrs.) –**without** Utility Rebates

System Cost / Annual Savings = Payback

$740 / $185.64 = 3.99 yrs.

**without utility rebates*

Energy Calculations

Based on the previous tables:

Simple **Payback** (Yrs.) –**with** Utility Rebates

System Cost / Annual Savings = Payback

($740-$250) $490 / $185.64 = 2.64 yrs.

**with $250 utility rebates*

CLMC® Retrofit Key Formulas

Watts Saved

Wattage Existing System – Wattage of Proposed System = Watts Saved

Return on Investment (ROI):

$$\frac{\textit{Annual Savings}}{\textit{System Cost}} = \textit{ROI}$$

Simple Payback (yrs) *without* Utility Rebate:

$$\frac{\textit{System Cost}}{\textit{Annual Savings}} = \textit{Payback (yrs.)}$$

CLMC® Retrofit Key Formulas

Simple Payback (yrs) *with* Utility Rebate:

$$\frac{\textit{System Cost - Rebate}}{\textit{Annual Savings}} = \textit{Payback (yrs.)}$$

Annual Dollars Saved

$$\frac{\textit{Watts Saved x Annual Burn Hours x kWh rate}}{1{,}000} = \textit{Total \$ Saved}$$

EPA Ballast and Lamp Disposal

Who is paying? *Customer*

Who is handling? *Installer*

Who is liable? *Both!!!*

Review

Knowledge Review:

Questions

Next

Module Six:

Lighting Layout

Module Six

Lighting Layout

Learning Objectives

- Explain the calculations involved in lighting layout.
- Describe what photometric data is involved with lighting layout.

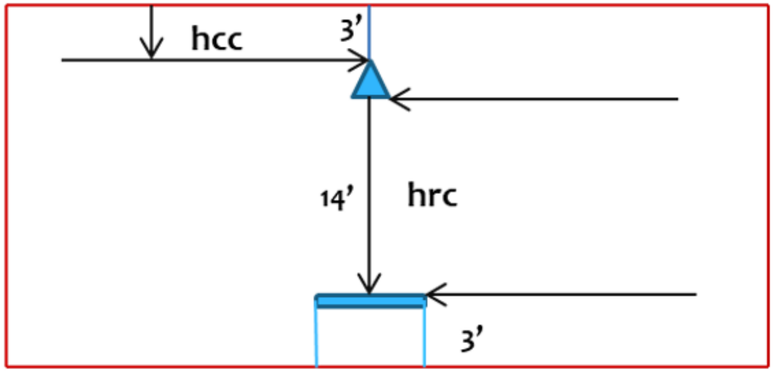
Area Calculations

Dimensions

Area Calculations: hcc and hrc

When considering lighting layout, one of the first things you must obtain are the ***dimensions of the area***:

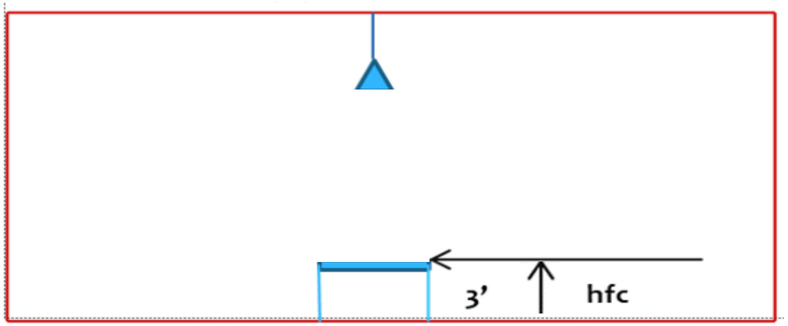
- Ceiling cavity height (hcc)
- Room cavity height (hrc)



Area Calculation : hFC

Floor Cavity Height (Hfc)

Hfc = Distance from Floor to the work plane



Example:

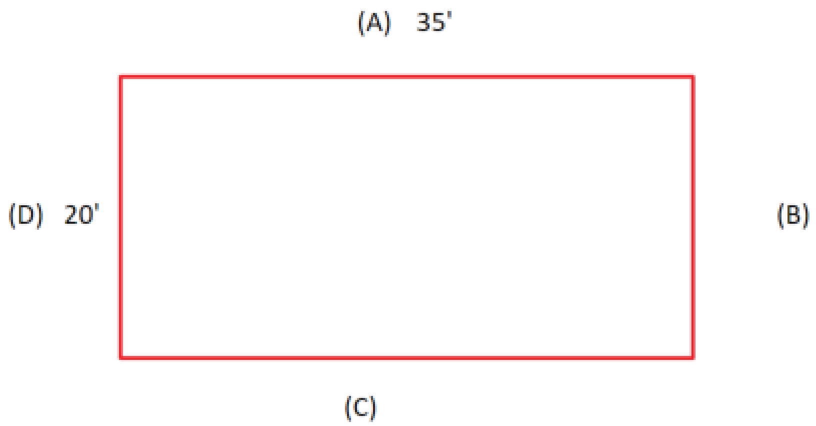
hFC is the distance from the floor to a desktop.

Area Calculation: Perimeter

Perimeter (P) = Total distance around a given space

$$P = A + B + C + D$$

The ***perimeter (P)*** is the total distance around the space in which the system will go.

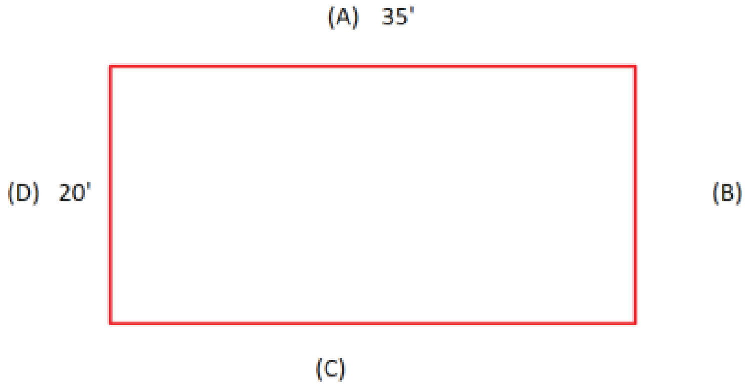


Area Calculation: Area

Area (A) = Length (L) * Width (W) of a given space

$$A = L \times W$$

Next, calculate the ***area (A)***, which is the length of the room times the width of the room.



Light Loss Factors: LLF

Light Loss Factor (LLF)

LLF = LLD x LDD

LLD = Lamp Lumen Depreciation (provided by Mfg)
LDD = Luminaire Dirt Depreciation

Another key factor is the ***coefficient of utilization (CU)****.*

Lumen output: Lamp Lumens

Initial Lamp Lumens

Lumen output for a new lamp

Example:

A space containing F32T841K (32W energy-saving) 4100K color temp, the lumen level is: *2,700 Initial Lumens x 4 Lamps Per Luminaire =* ***10,800 lumens***

Delivered light: FC and AIL

Foot candles (FC) per Luminaire

FC per Luminaire = (Fixture lamp lumens)(CU)(LLF) ÷ Area of space

Foot candles (FC) *are produced by each fixture.*

Average Illuminance Level (AIL)

AIL = FC per Luminaire x # of Luminaires

Ratios

There are ***<u>three cavity ratios</u>***:

- Ceiling cavity ratio (CCR)
- Room cavity ratio (RCR)
- Floor cavity ratio (FCR)

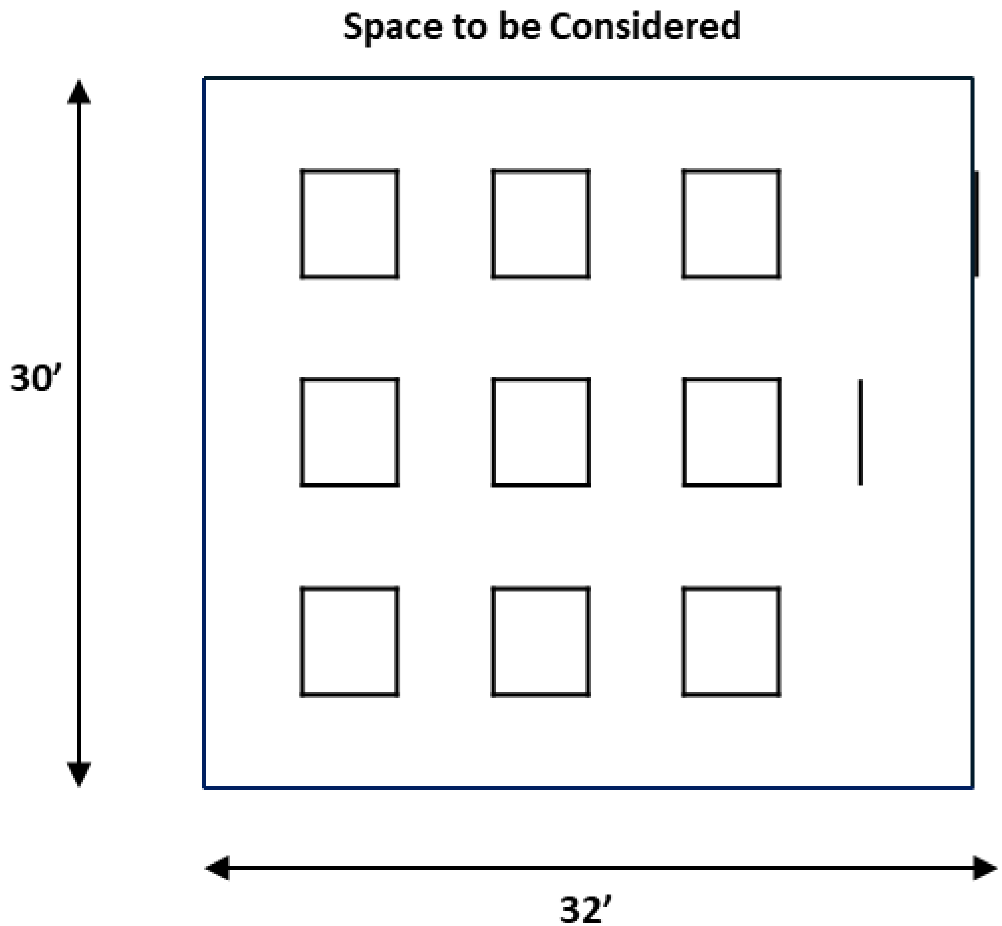
Cavity Ratio Formula

$$\textit{Cavity Ratio Formula} = \frac{5h(L + W)}{L \times W}$$

Lighting Layout

Average Illuminations

Average Illuminance: Example 1



Average Illuminance: Example 1

Atmosphere:

- Med

Clean/Relamp:

- Every 24 months

Reflectance:

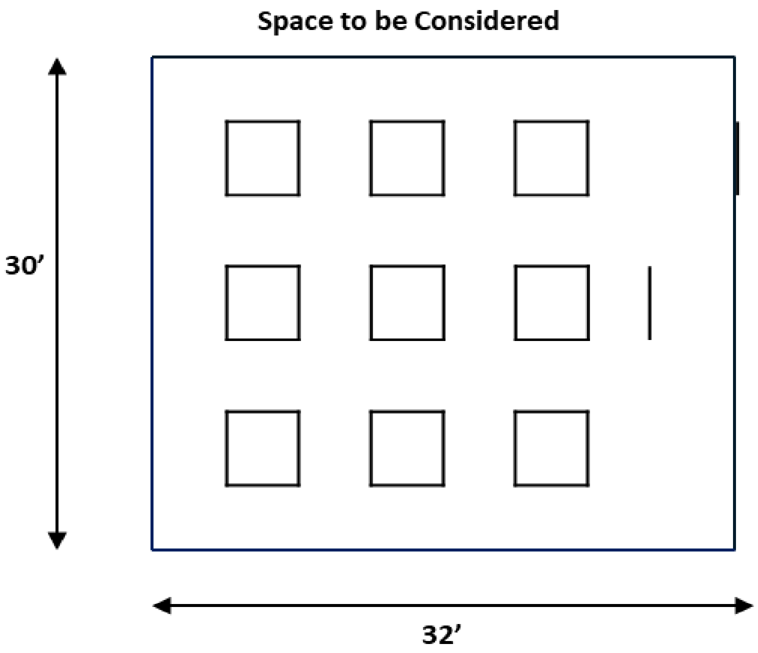
- Ceiling - 80
- Wall - 50
- Floor - 20

Dimensions:

- Area - 30' x 32'
- Ceiling Height - 10'
- Work plane Height - 2 ½'

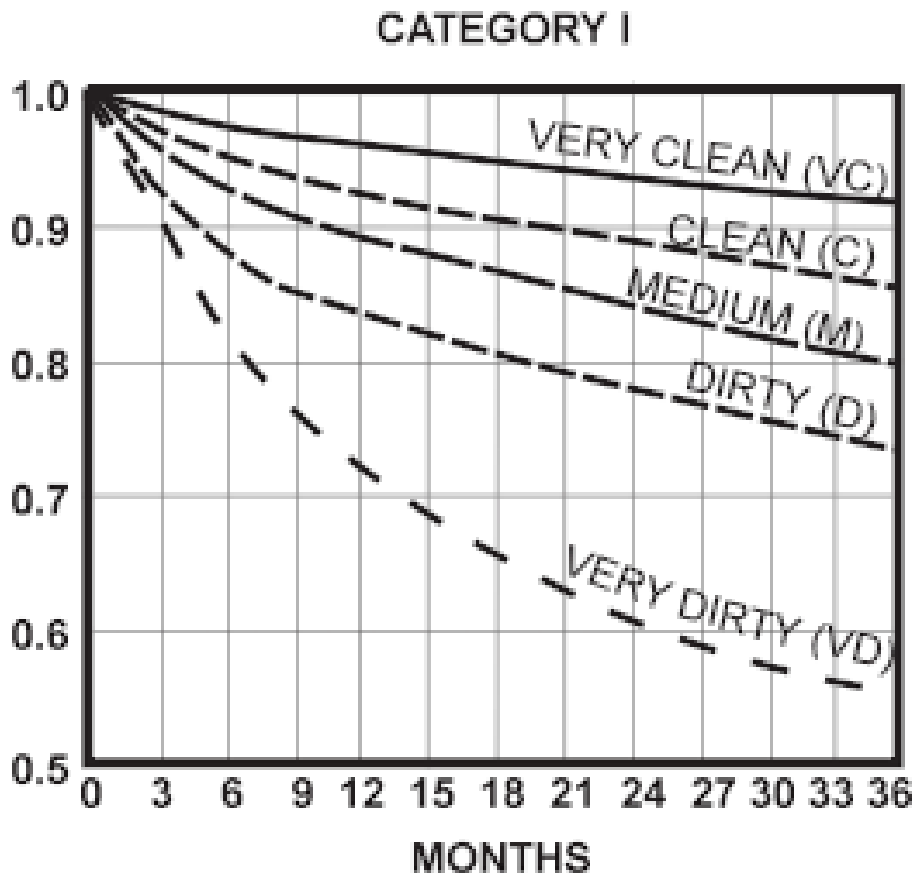
Lighting Equipment:

- 2' x 4'- 4 lamp Lay-in Luminaire/Flat Prismatic Lens
- 4 - 20 Watt/2700 Lumen 4100K color temp LED tubes
- Lamp Lumen Depreciation (LLD) = 1.0 (per manufacturer)



Calculations – Environmental Chart

Dirt Depreciation Chart



Calculations

	Coefficients of Utilization - Zonal Cavity Method											
RCC	80				70				50			0
RW	70	50	30	10	70	50	30	10	50	30	10	0
RCR 1	0.90	0.86	0.83	0.80	0.88	0.85	0.82	0.79	0.81	0.79	0.76	0.70
2	0.83	0.76	0.71	0.67	0.81	0.75	0.70	0.66	0.72	0.68	0.64	0.60
3	0.76	0.68	0.61	0.56	0.74	0.66	0.61	0.56	0.64	0.59	0.55	0.51
4	0.70	0.61	0.54	0.49	0.68	0.60	0.53	0.48	0.57	0.52	0.48	0.45
5	0.65	0.55	0.48	0.42	0.63	0.54	0.47	0.42	0.52	0.46	0.42	0.39
6	0.60	0.49	0.42	0.37	0.58	0.49	0.42	0.37	0.47	0.41	0.37	0.35
7	0.56	0.45	0.38	0.33	0.54	0.44	0.38	0.33	0.43	0.37	0.33	0.31
8	0.52	0.41	0.34	0.30	0.51	0.41	0.34	0.30	0.40	0.34	0.30	28.00
9	0.49	0.38	0.31	0.27	0.47	0.37	0.31	0.27	0.36	0.31	0.27	0.25
10	0.46	0.35	0.29	0.25	0.44	0.35	0.29	0.24	0.34	0.28	0.24	0.23

Calculations: Example 1

- Reference printed slides & practice calc answer pages
- Have on your desk for review and note taking during the calculations

Average Illuminance: Example 1

Atmosphere:

- Med

Clean/Relamp:

- Every 24 months

Reflectance:

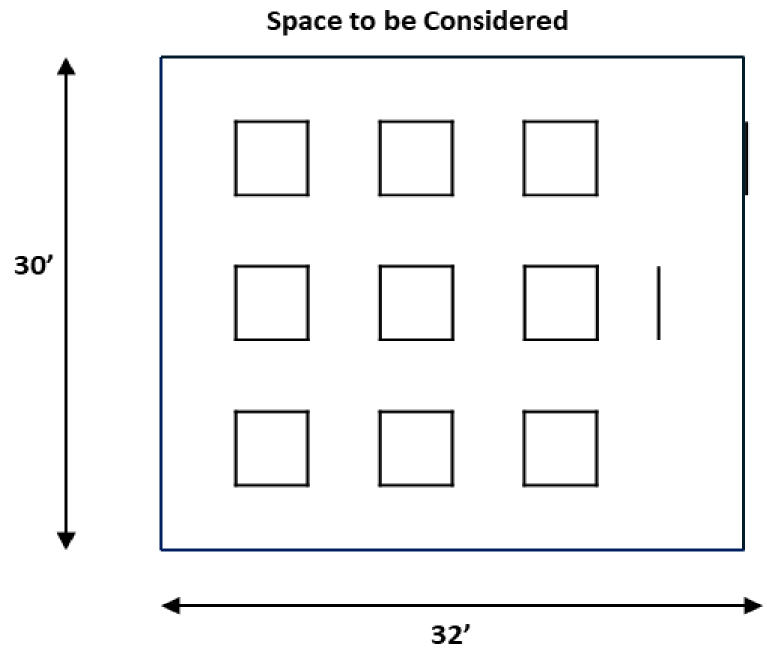
- Ceiling - 80
- Wall - 50
- Floor - 20

Dimensions:

- Area - 30’ x 32’
- Ceiling Height - 10’
- Work plane Height - 2 ½’

Lighting Equipment:

- 2’ x 4’- 4 lamp Lay-in Luminaire/Flat Prismatic Lens
- 4 - 20 Watt/2700 Lumen 4100K color temp LED tubes
- Lamp Lumen Depreciation (LLD) = 1.0 (per manufacturer)



Practice Calculations: Example 1

Dimensions

Ceiling Cavity Height (hcc)	___________
Room Cavity Height (hrc)	___________
Floor Cavity Height (hfc)	___________
Perimeter (p)	___________
Area (A)	___________
Ceiling Cavity Ratio (CCR)	___________
Room Cavity Ratio (RCR)	___________
Floor Cavity Ratio (FCR)	___________
Initial Lumens @ LED Tube	___________
Total Lumens @ Luminaire	___________

Cavity Ratios:

$$\frac{5h(L + W)}{L \times W}$$

Average Illuminance: Example 1

Atmosphere:

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Clean/Relamp:

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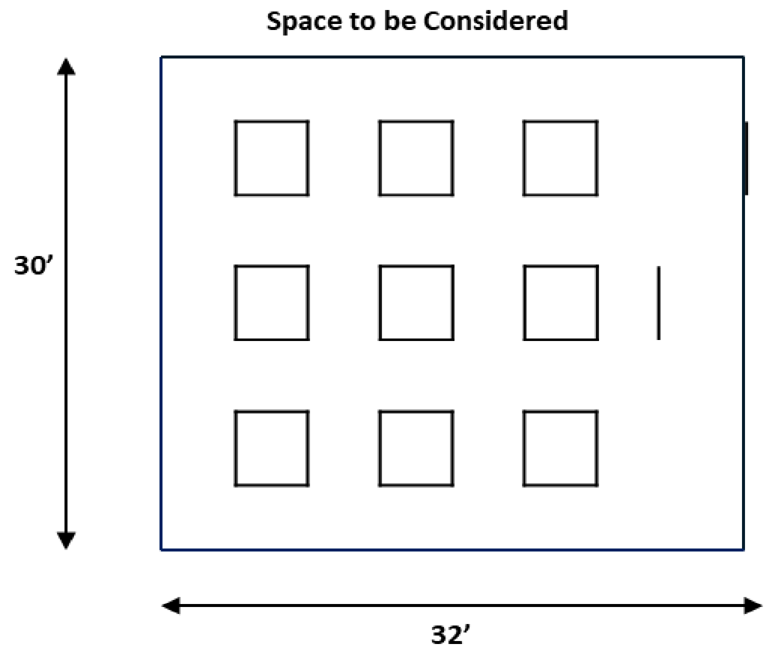
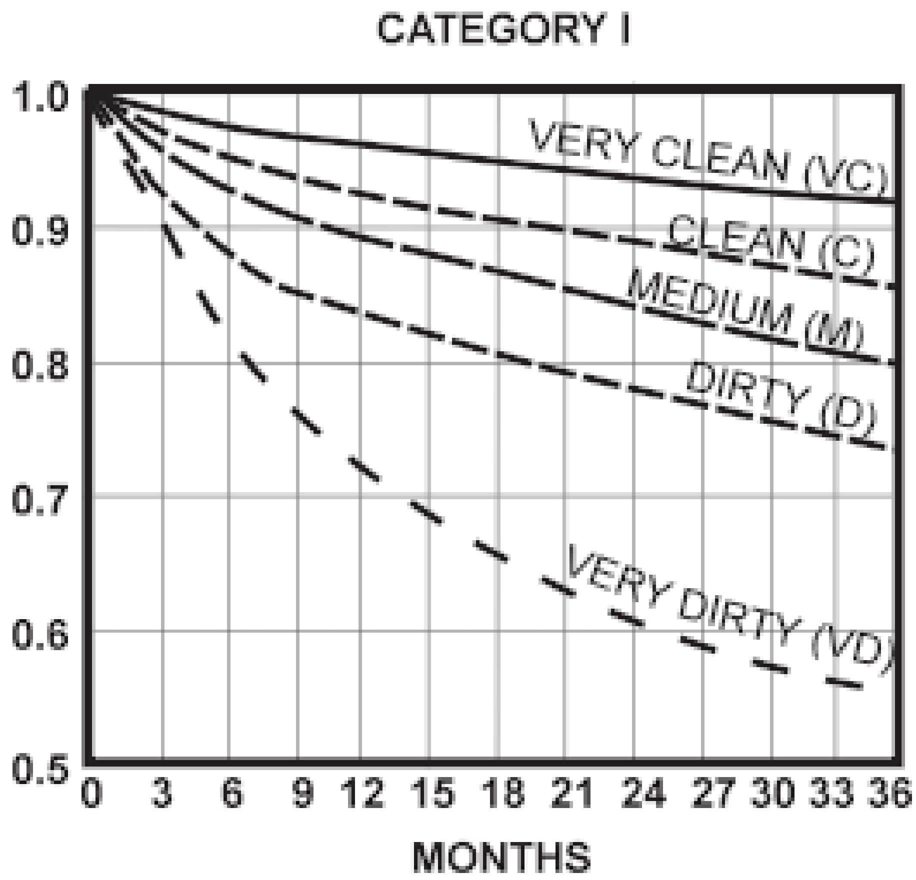


Calculations – Environmental Chart

Dirt Depreciation Chart



Calculations

	Coefficients of Utilization - Zonal Cavity Method											
RCC		80				70				50			0
RW		70	50	30	10	70	50	30	10	50	30	10	0
RCR	1	0.90	0.86	0.83	0.80	0.88	0.85	0.82	0.79	0.81	0.79	0.76	0.70
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	5	0.65	0.55	0.48	0.42	0.63	0.54	0.47	0.42	0.52	0.46	0.42	0.39
	6	0.60	0.49	0.42	0.37	0.58	0.49	0.42	0.37	0.47	0.41	0.37	0.35
	7	0.56	0.45	0.38	0.33	0.54	0.44	0.38	0.33	0.43	0.37	0.33	0.31
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Practice Calculations: Example 1

Calculations

Lamp Lumen Depreciation (LLD) ____________

Luminaire Dirt Depreciation (LDD) ____________

Light Loss Factor (LLF) ____________

Coefficient of Utilization (CU) ____________

Foot Candle (FC) @ Luminaire ____________

Average Illuminance Level (AIL) ____________

Foot candle Formulas

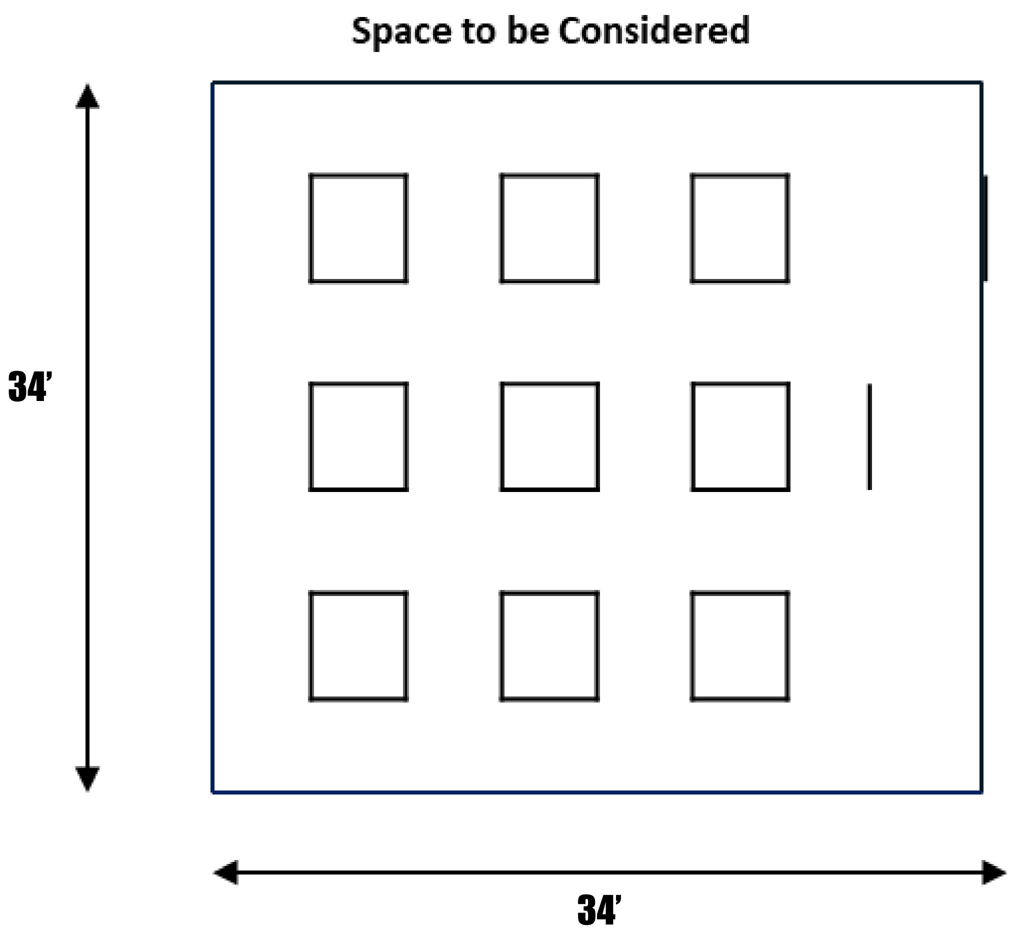
FC per Luminaire = $\frac{\text{(Fixture lamp lumens)(CU)(LLF)}}{\text{area of space}}$

AIL = FC per Luminaire x # of Luminaires

Light Loss Factor (LLF)

LLD x LDD = LLF

Average Illuminance : Example 2



Average Illuminance : Example 2

Atmosphere:

- Med

Clean/Relamp:

- Every 24 months

Reflectance:

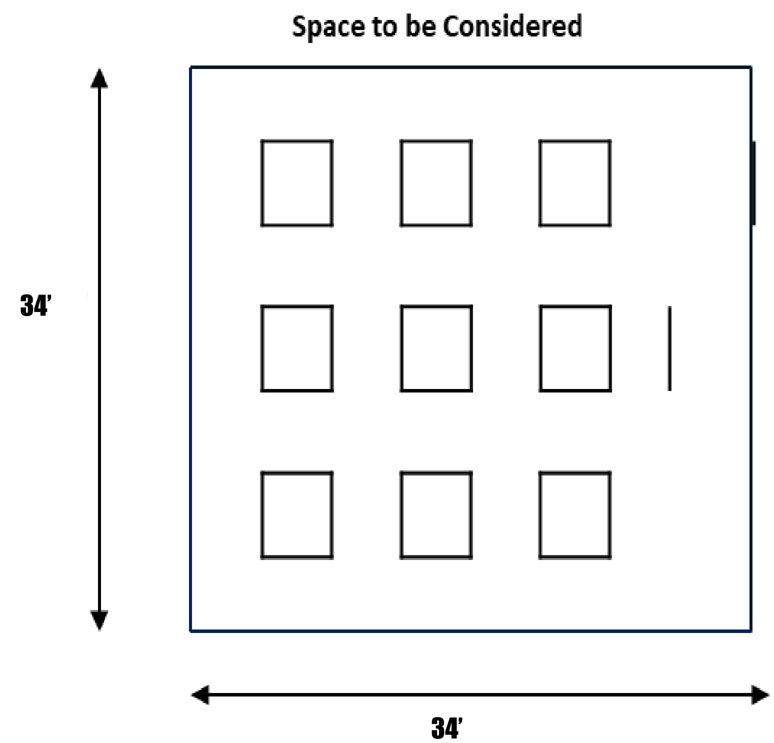
- Ceiling - 80
- Wall - 50
- Floor - 20

Dimensions:

- Area - 34’ x 34’
- Ceiling Height - 12’
- Work plane Height - 3’

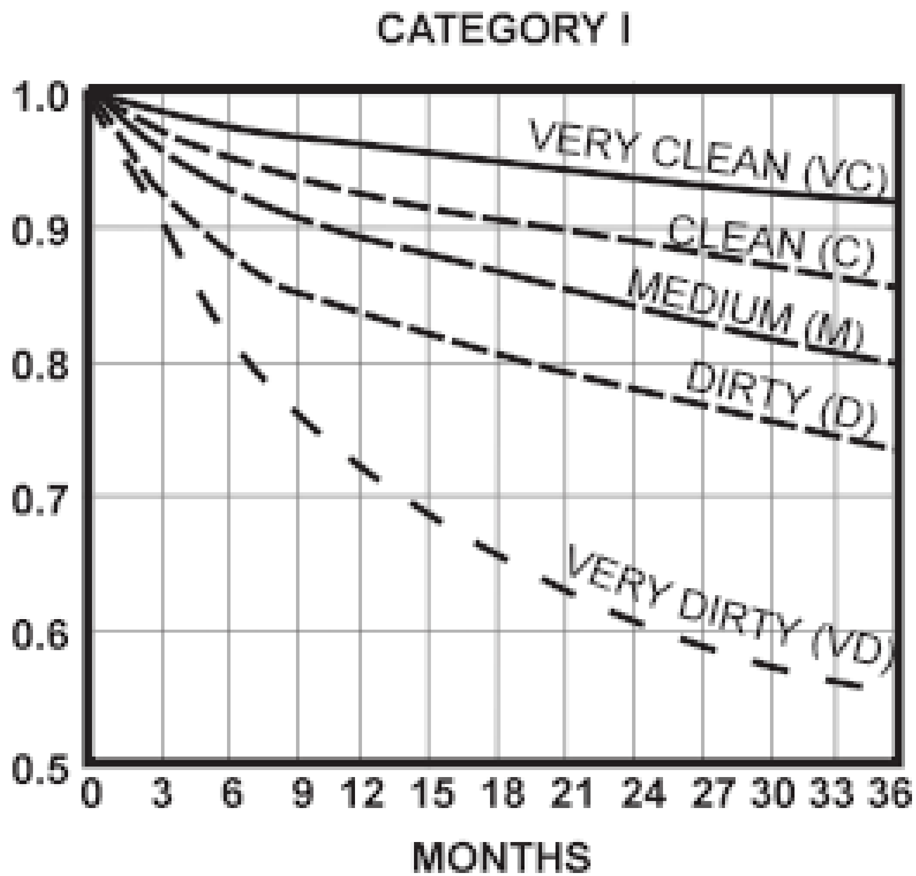
Lighting Equipment:

- 2’ x 4’- 3 lamp Lay-in Luminaire/Flat Prismatic Lens
- 3 - 20 Watt/2700 Lumen 4100K color temp LED tubes
- Lamp Lumen Depreciation (LLD) = 1.0 (per manufacturer)



Calculations – Environmental Chart

Dirt Depreciation Chart



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2	0.83	0.76	0.71	0.67	0.81	0.75	0.70	0.66	0.72	0.68	0.64	0.60
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5	0.65	0.55	0.48	0.42	0.63	0.54	0.47	0.42	0.52	0.46	0.42	0.39
6	0.60	0.49	0.42	0.37	0.58	0.49	0.42	0.37	0.47	0.41	0.37	0.35
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10	0.46	0.35	0.29	0.25	0.44	0.35	0.29	0.24	0.34	0.28	0.24	0.23

Calculation: Example 2

- Reference printed slides & practice calc answer pages
- Have on your desk for review and note taking during the calculations

Practice Calculations: Example 2

Dimensions

Ceiling Cavity Height (hcc)	____________
Room Cavity Height (hrc)	____________
Floor Cavity Height (hfc)	____________
Perimeter (p)	____________
Area (A)	____________
Ceiling Cavity Ratio (CCR	____________
Room Cavity Ratio (RCR)	____________
Floor Cavity Ratio (FCR)	____________
Initial Lumens @ LED Tube	____________
Total Lumens @ Luminaire	____________

Cavity Ratios:

$$\frac{5h(L + W)}{L \times W}$$

Average Illuminance : Example 2

Atmosphere:

- Med

Clean/Relamp:

- Every 24 months

Reflectance:

- Ceiling - 80
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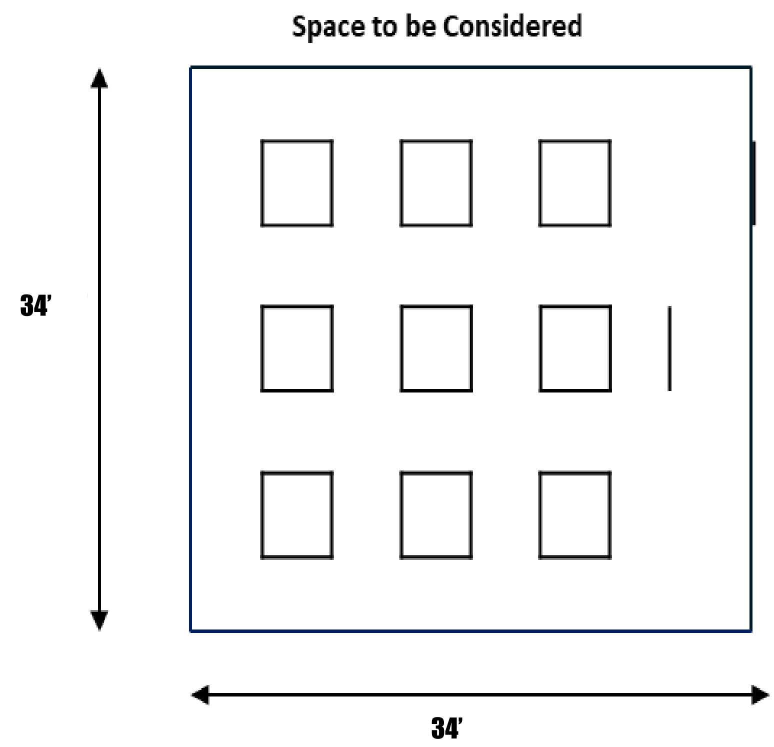
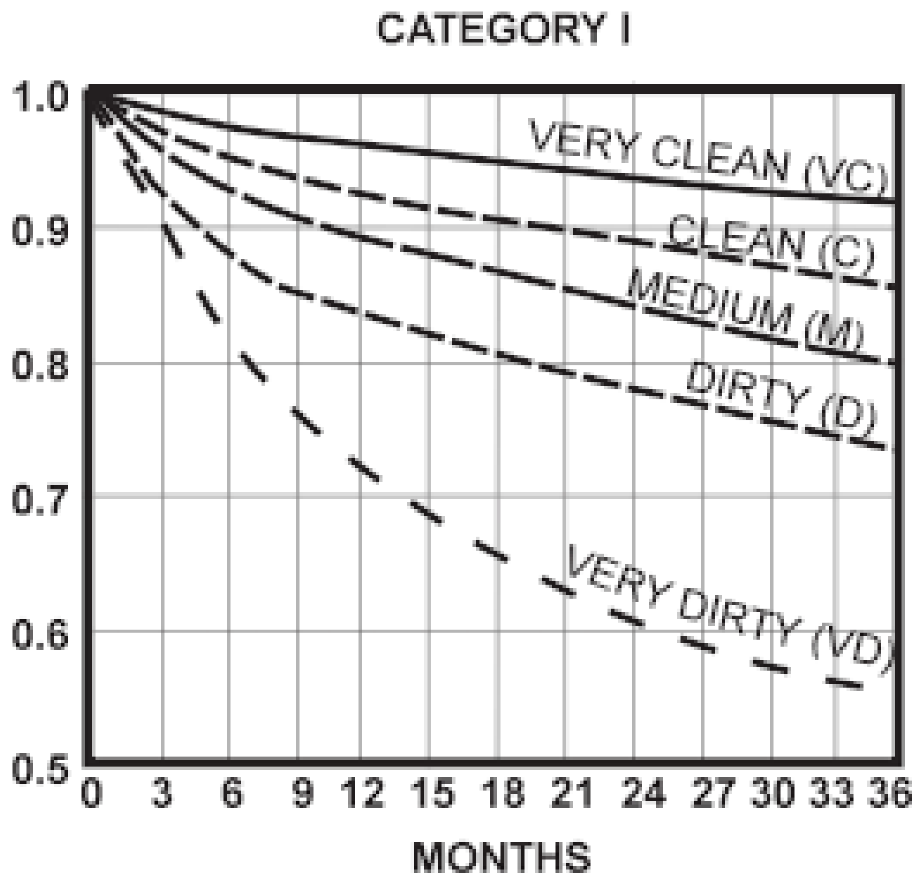


Calculations – Environmental Chart

Dirt Depreciation Chart



Calculations

	Coefficients of Utilization - Zonal Cavity Method												
RCC		80				70				50			0
RW		70	50	30	10	70	50	30	10	50	30	10	0
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	6	0.60	0.49	0.42	0.37	0.58	0.49	0.42	0.37	0.47	0.41	0.37	0.35
	7	0.56	0.45	0.38	0.33	0.54	0.44	0.38	0.33	0.43	0.37	0.33	0.31
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	9	0.49	0.38	0.31	0.27	0.47	0.37	0.31	0.27	0.36	0.31	0.27	0.25
	10	0.46	0.35	0.29	0.25	0.44	0.35	0.29	0.24	0.34	0.28	0.24	0.23

Practice Calculations: Example 2

Calculations

Lamp Lumen Depreciation (LLD) ____________

Luminaire Dirt Depreciation (LDD) ____________

Light Loss Factor (LLF) ____________

Coefficient of Utilization (CU) ____________

Foot Candle (FC) @ Luminaire ____________

Average Illuminance Level (AIL) ____________

Foot candle Formulas

FC per Luminaire = $\frac{\text{(Fixture lamp lumens)(CU)(LLF)}}{\text{area of space}}$

AIL = FC per Luminaire x # of Luminaires

Light Loss Factor (LLF)

LLD x LDD = LLF

Lighting Layout

Footcandles

Area Calculation: FC

Foot candles (FC) are produced by each fixture and are calculated like this:

(Fixture lamp lumens)(CU)(LLF) ÷ Area of space = FC per luminaire

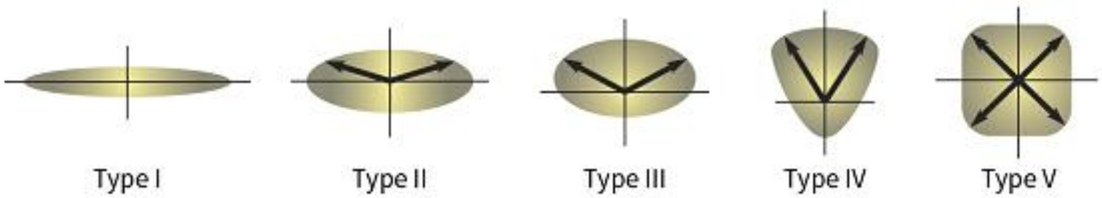
Coefficient of Utilization

Before – 250w MH, 295w

After – 144w LED

50% energy savings
More even illumination

Exterior Lighting Distribution Types



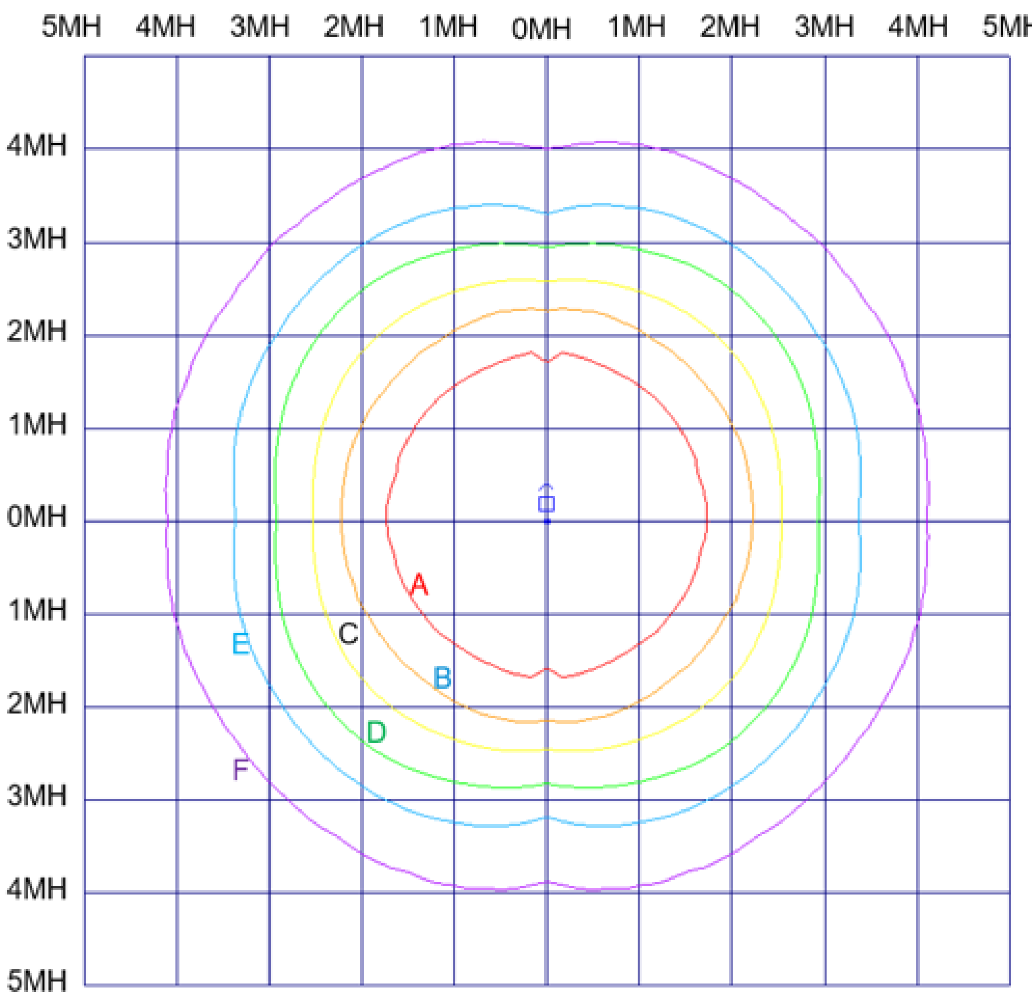
Above are the five main distribution types for exterior area lighting. Each type has certain applications that it is best suited for.

Type I – Used for pathways, narrow roadways and at the front row of car dealerships
Type II - Also often used on roadways, when you need light distributed very far to the sides, but not very far forward
Type III – Provides not as much distribution to the sides, but more forward distribution
Type IV - Sometimes just called “Forward Throw.” It does just that, it distributes light forward from the pole. Most suitable along the perimeter of sites
Type V – Can be round or square. It distributes light relatively evenly in all direction from the poles. Most suitable in the center of larger sites

Practice Calculations: Footcandles

In a nearby parking lot, there are **9 poles**, each having one **22,317 lumen post top luminaire with Type 5 distribution** mounted at 30’. The manufacturers specifications for the post top luminaires are provided in the following table

Practice Calculations: Footcandles

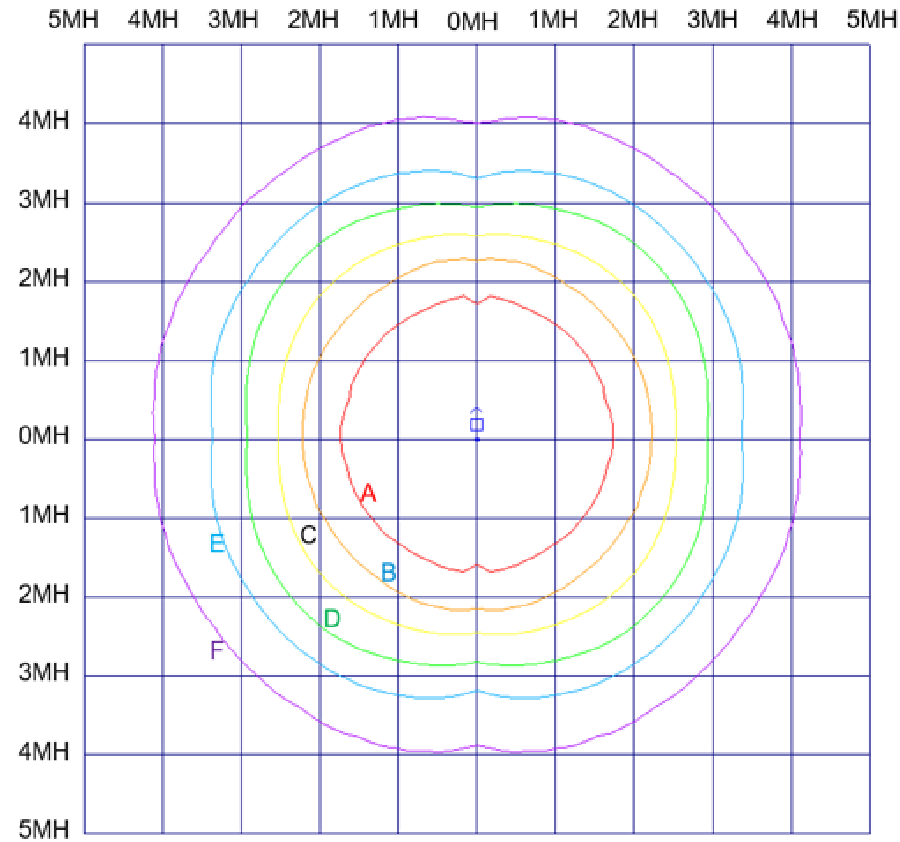


Practice Calculations: Footcandles

Luminaire Used:

- RSX2 LED P3 40K R5 (22,317 lumens)
- Scale: 1 Square = 1 Mount Height

Mounting Height	Foot-candle Values for Following Curves					
	A	B	C	D	E	F
10'	10.3	7.4	5.7	3.7	2.2	1.4
15'	4.6	3.3	2.5	1.6	1.0	0.6
20'	2.6	1.8	1.4	0.9	0.6	0.4
25'	1.6	1.2	0.9	0.6	0.4	0.2
30'	1.1	0.8	0.6	0.4	0.3	0.2



Practice Calculations: Footcandles

Mounting Height	Foot-candle Values for Following Curves					
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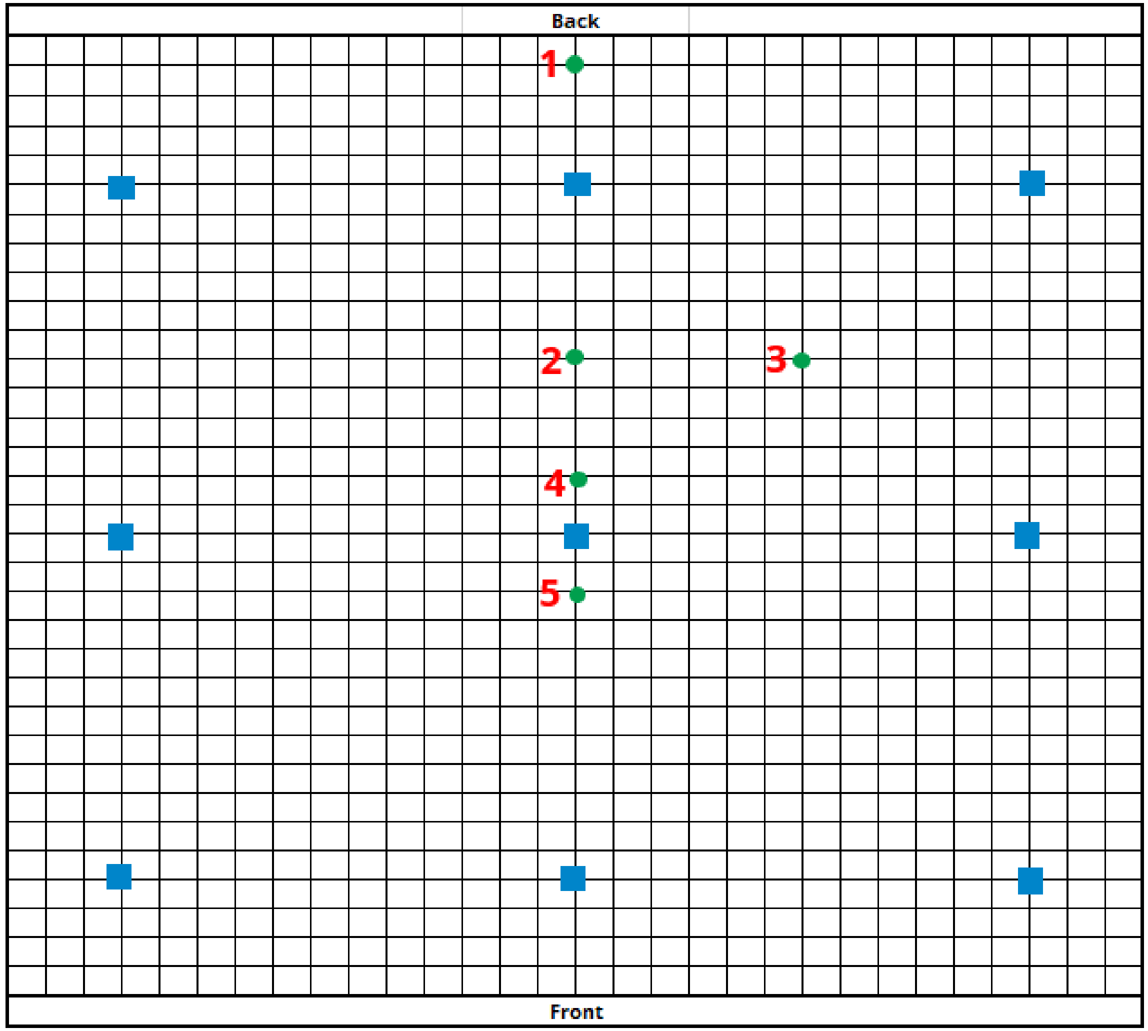
25'	1.6	1.2	0.9	0.6	0.4	0.2
30'	1.1	0.8	0.6	0.4	0.3	0.2

Scale: 1 square = 10'

Fixture mount height = 30'

= 22,317 lumen post top luminaire
Type 5 optics

= Foot Candle Level Point

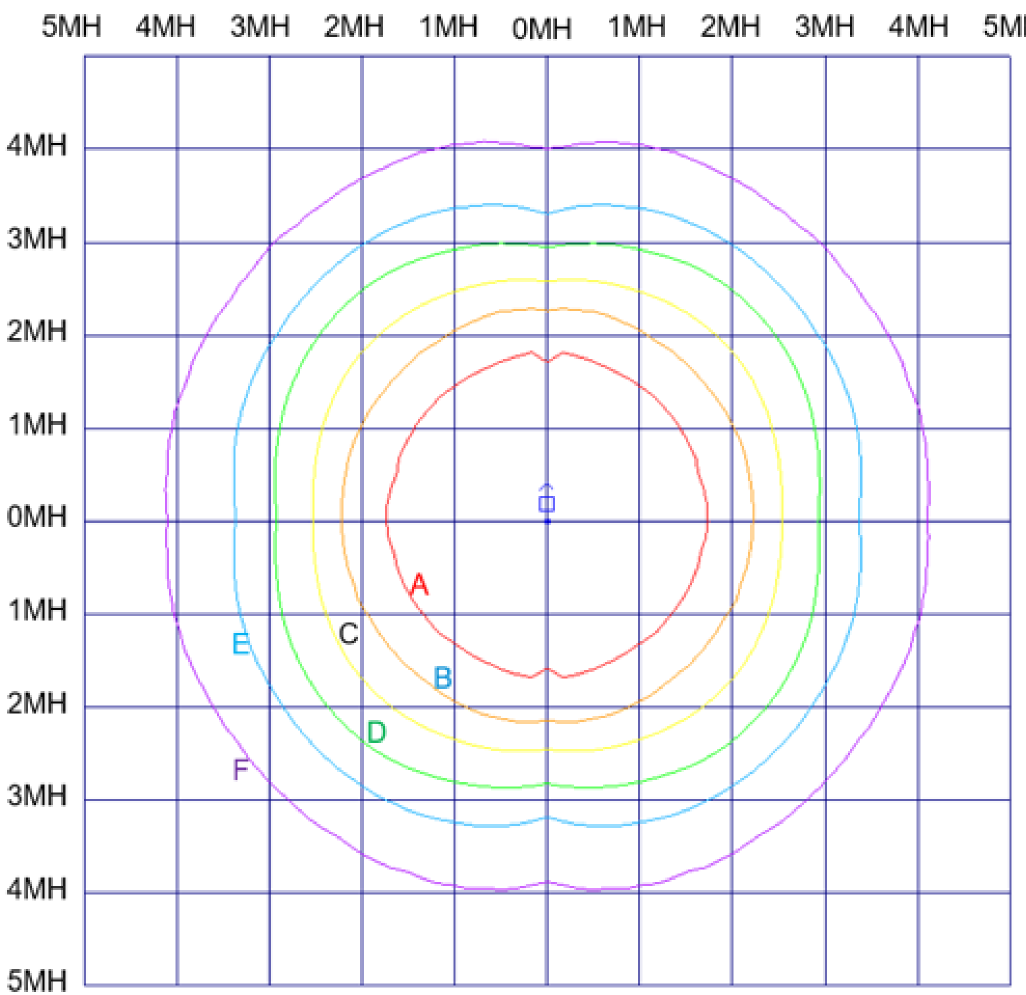


Practice Calculations

Footcandle Values

Point	*Answer*
Point 1	____________
Point 2	____________
Point 3	____________
Point 4	____________
Point 5	____________

Practice Calculations: Footcandles



Practice Calculations: Footcandles

Mounting Height	Foot-candle Values for Following Curves					
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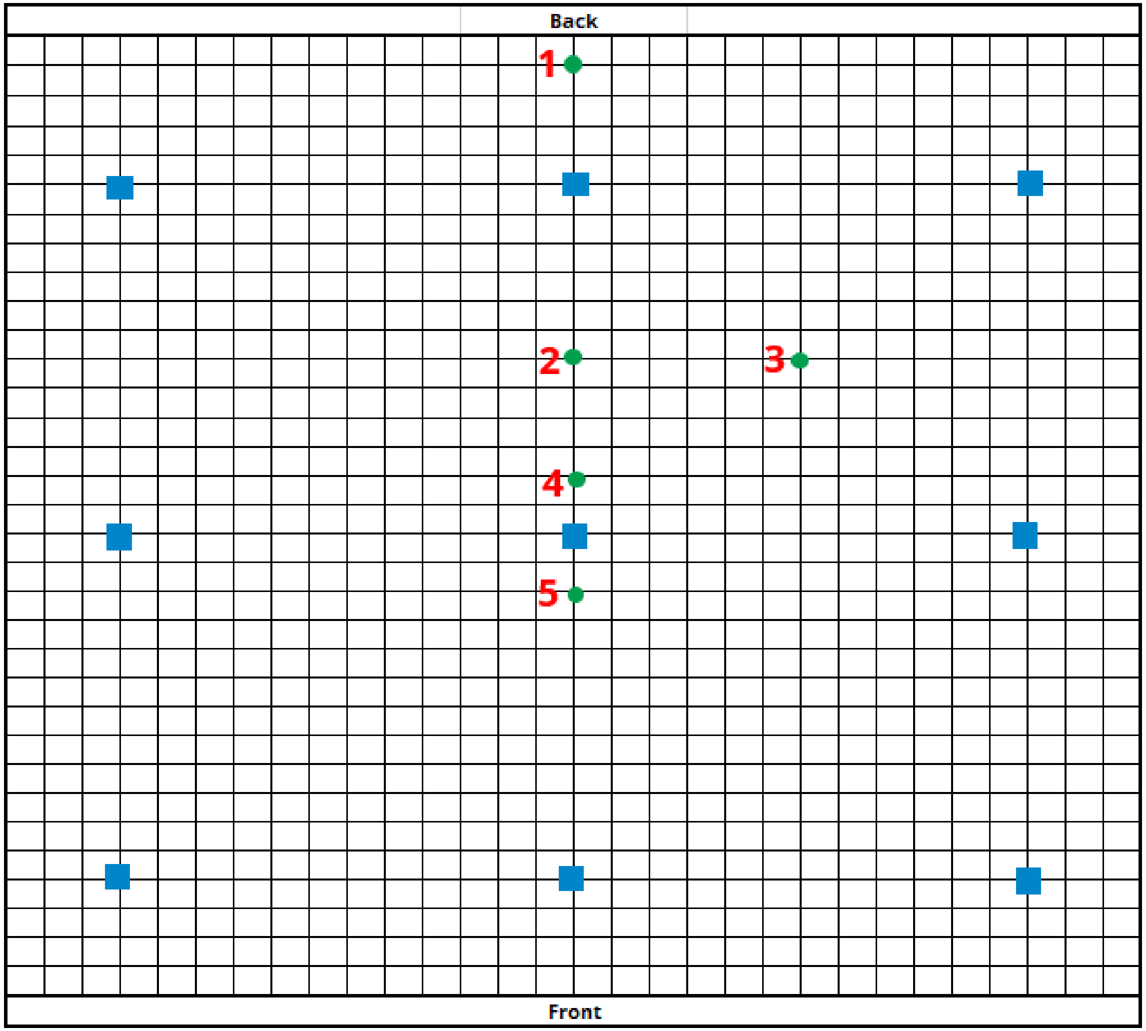

Scale: 1 square = 10'

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= 22,317 lumen post top luminaire
Type 5 optics

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Practice Calculations

Footcandle Values

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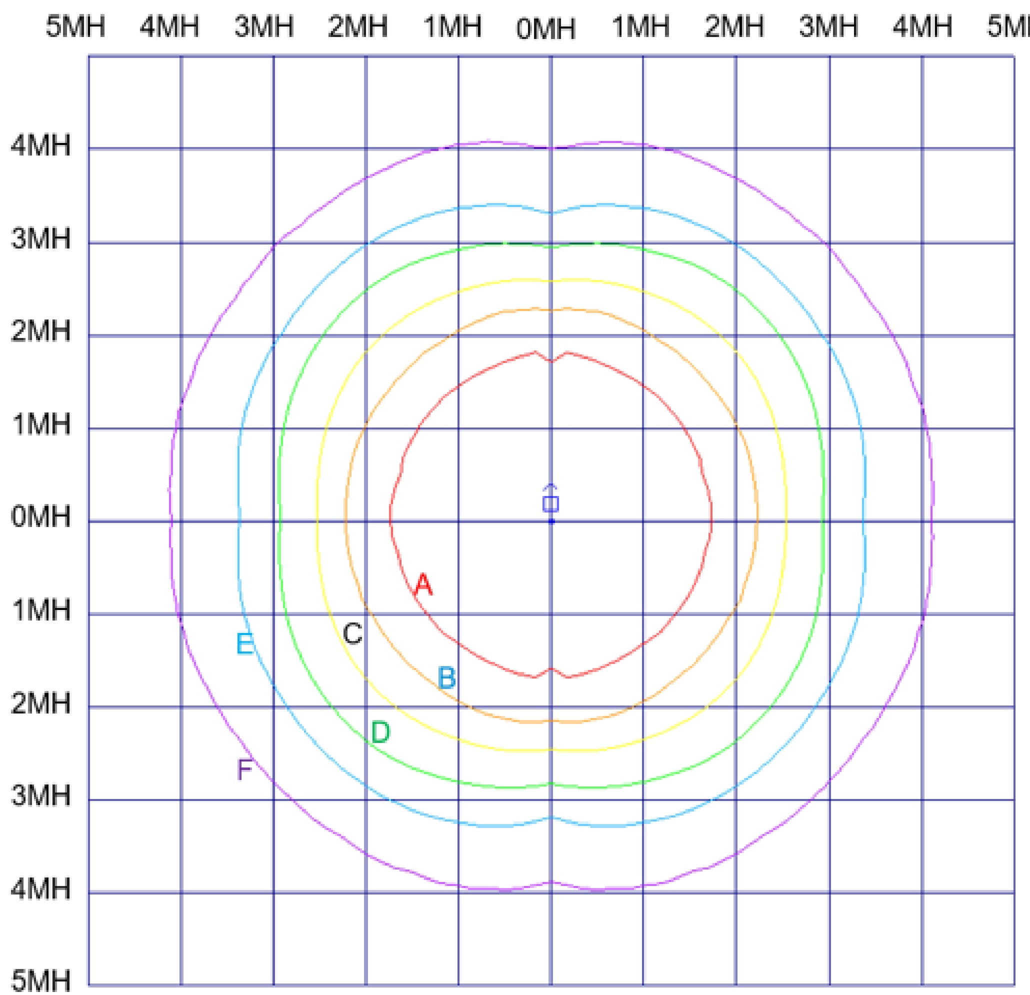
Practice Calculations: Footcandles



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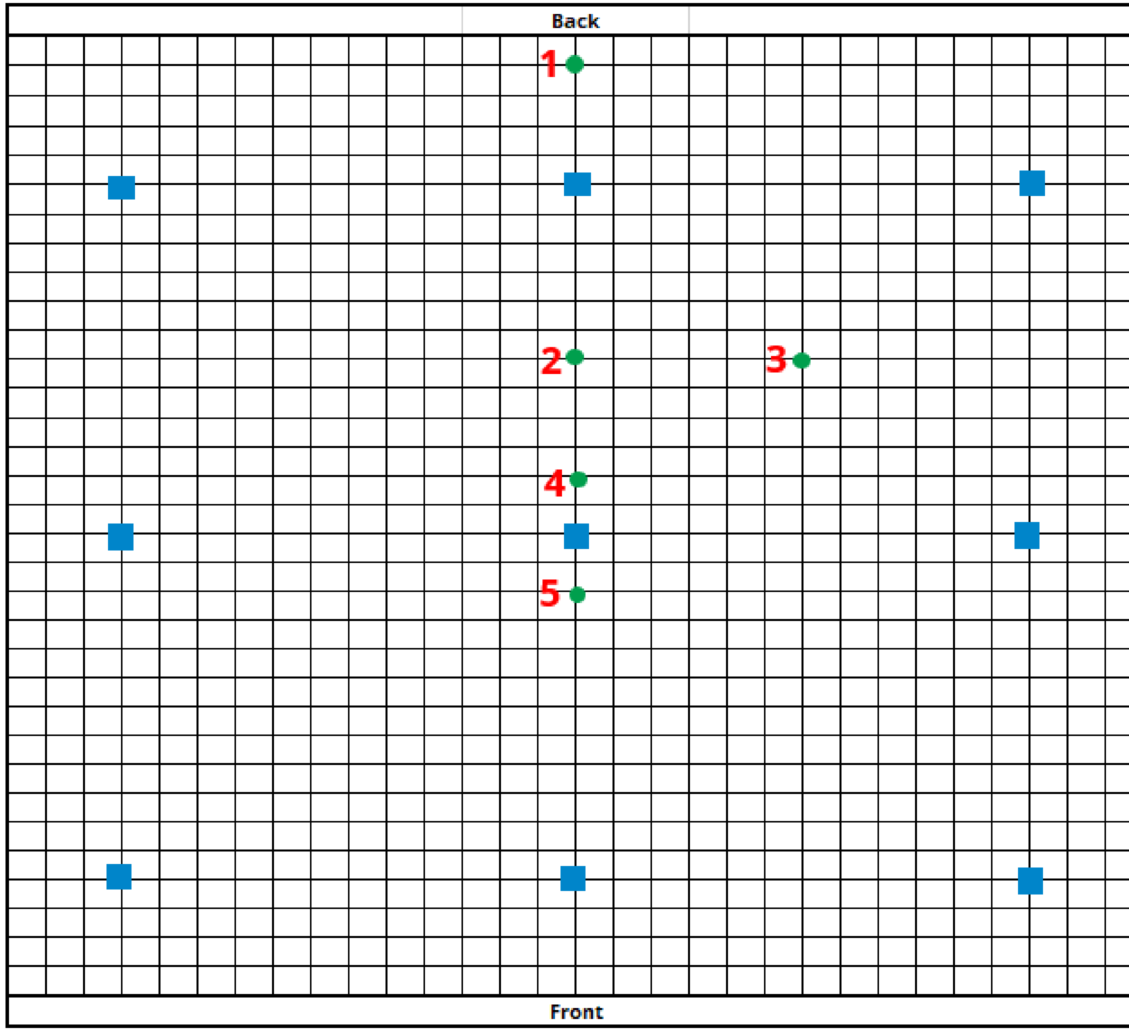
Scale: 1 square = 10'

Fixture mount height = 30'

■ = 22,317 lumen post top luminaire
Type 5 optics

● = Foot Candle Level Point



Practice Calculations

Footcandle Values

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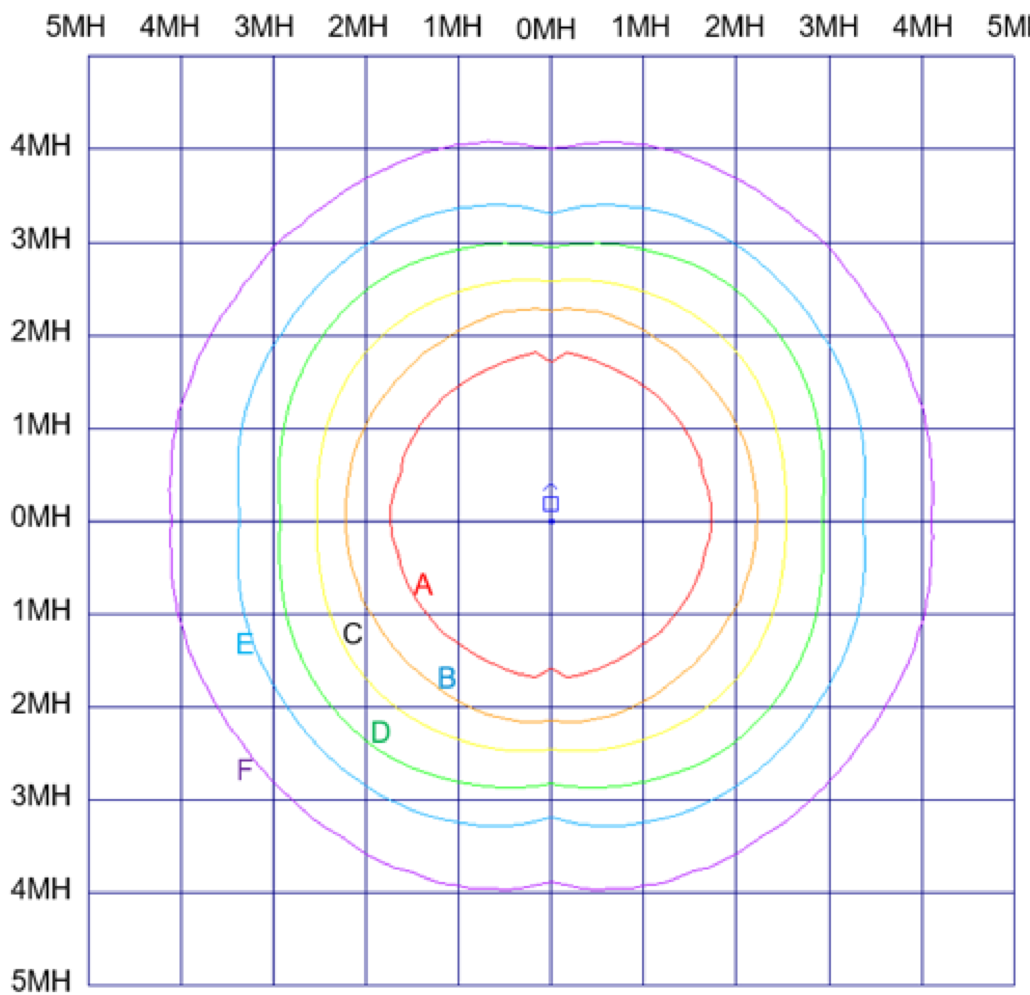
Practice Calculations: Footcandles



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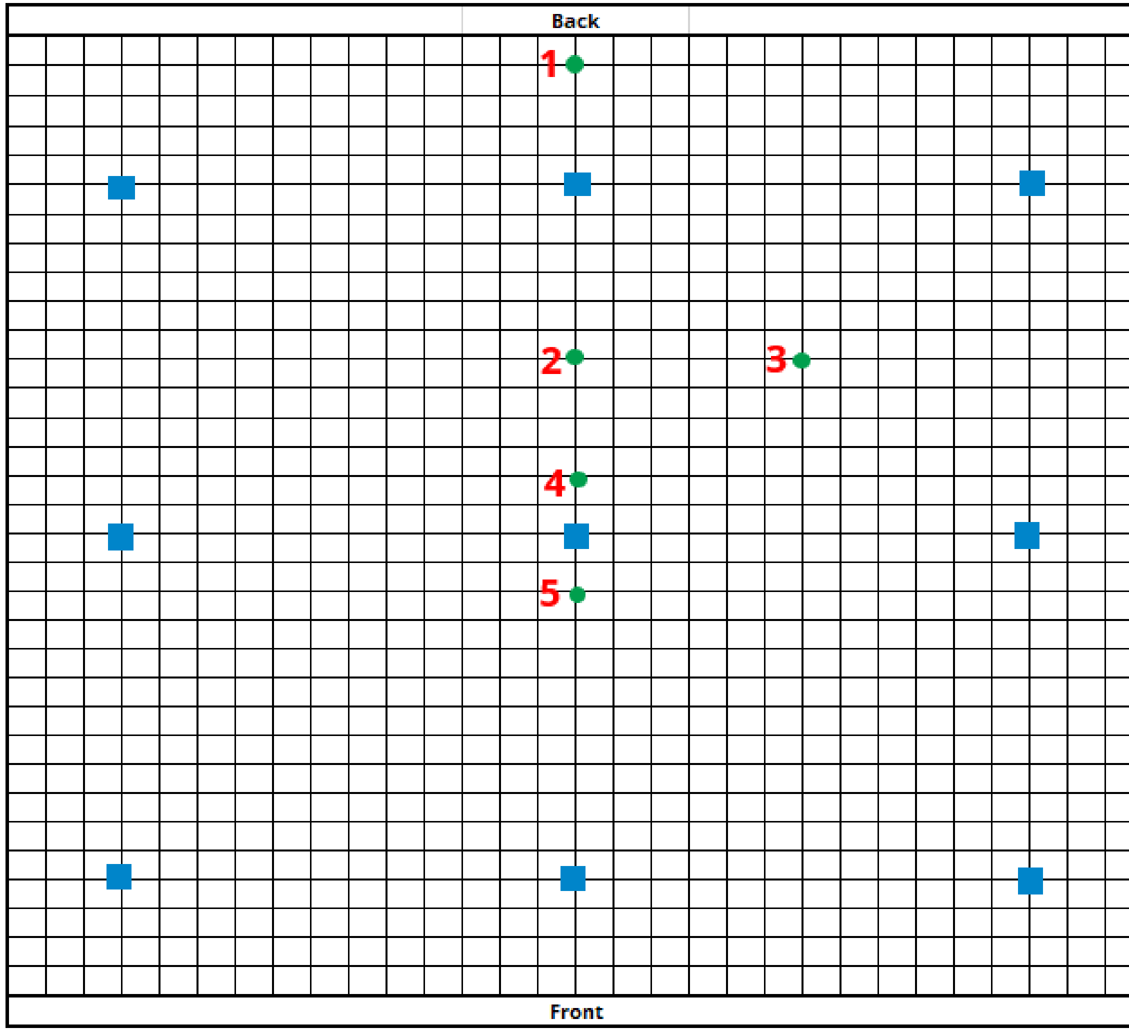

Practice Calculations

Footcandle Values

Point	*Answer*
Point 1	____________
Point 2	____________
Point 3	____________
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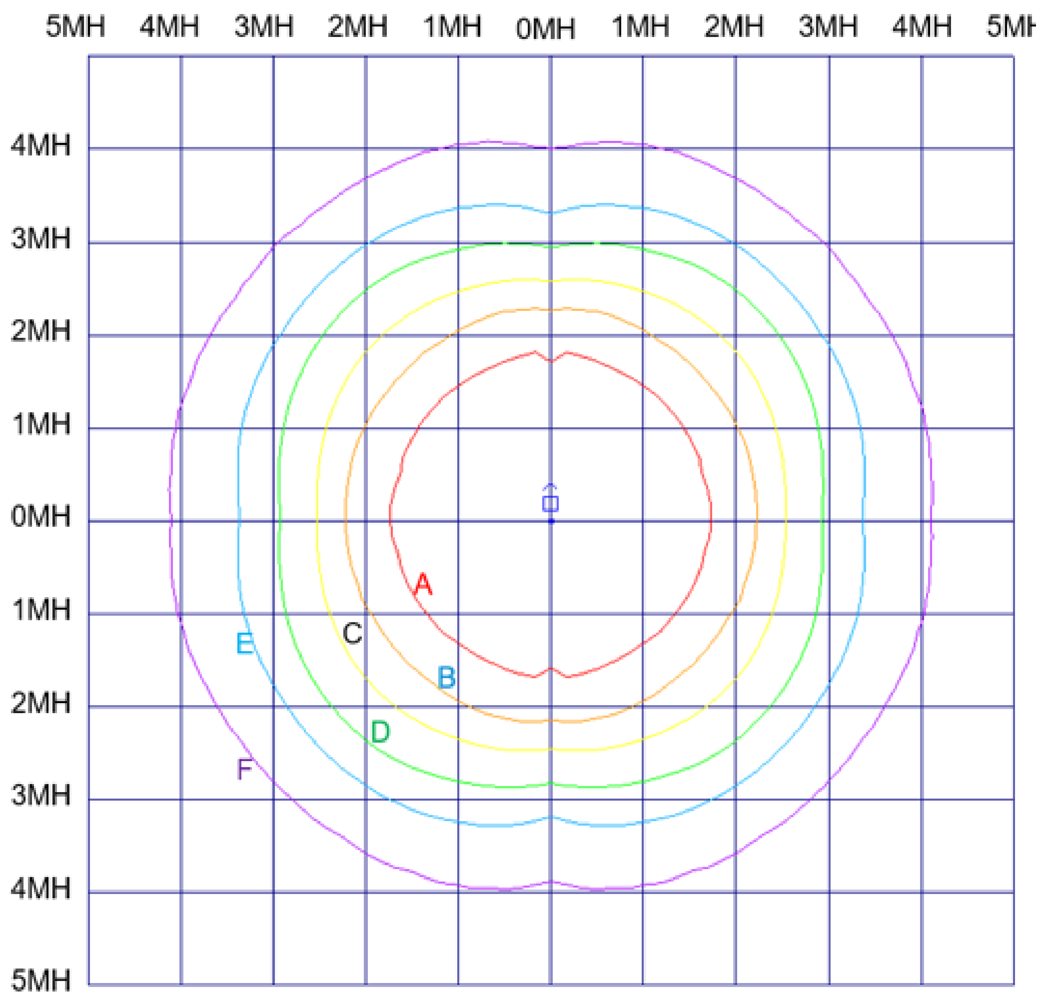
Point 5	____________

Practice Calculations: Footcandles



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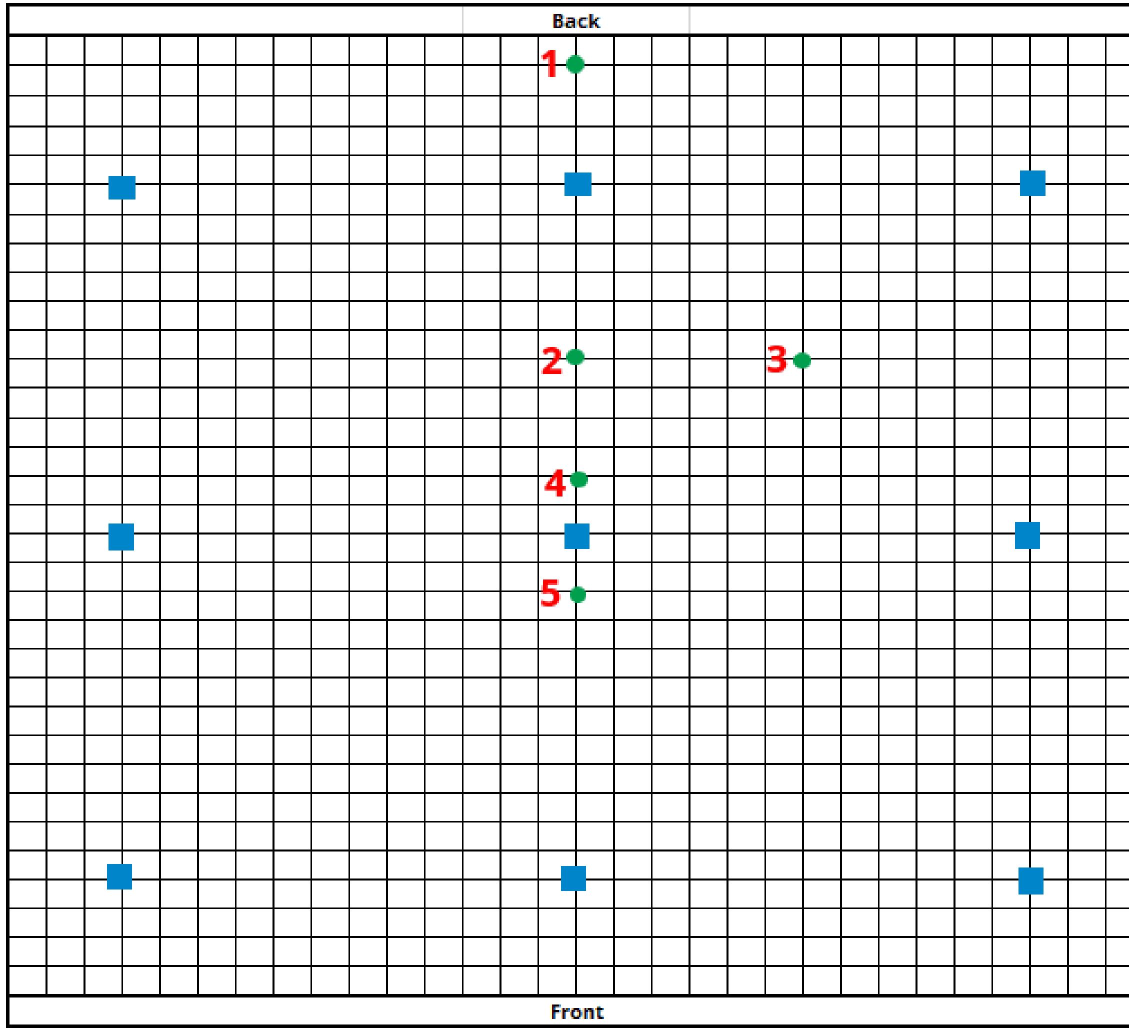


Practice Calculations

Footcandle Values

Point	*Answer*
Point 1	____________
Point 2	____________
Point 3	____________
Point 4	____________
Point 5	____________

Knowledge Review:

Questions

Next

Module Seven:

Legislation

Module Seven

Legislation

Learning Objectives

- Describe legislation pertaining to lighting systems, including energy conservation credits and disposal regulations.

Legislation

Lighting Systems

Energy Policy Act 2005

- Up to $1.80/sq. ft. ***Tax Credit to Owners*** for installation of energy efficient systems
- Up to $0.60/sq. ft. ***Tax Benefit to Lighting Contractors*** for installation of energy savings lighting systems in new or existing public buildings owned by federal, state or local government

Glossary

Arc (Arc Tube)

Intense luminous discharge formed by the passage of electrical current across a space between two electrodes.

Auto-Restrike

Circuitry used to restart the lamps without resetting the power to the ballast.

Ballast Efficacy Factor (BEF)

Measure used to compare various lighting systems based upon light output and input power. BEF= Ballast Factor x 100 / Input Watts

Ballast Factor (BF)

Measure of light output from lamp operated by commercial ballast, as compared to laboratory standard reference ballast specified by ANSI

Ballast Losses

Power that is supplied to the ballast but is not converted into light energy.

Capacitor

Device in ballast that stores electrical energy.

*****See handout for complete glossary***

Question: Legislation

Section 410-15(a) of the National Electric Code states that a fixtures weighing:

Next

Module Eight:

Sustainability

Module Eight

Sustainability

Learning Objectives

- Describe sustainability with regard to manufacturing, packaging, and transporting
- Explain financial impacts of lighting systems including life cycle costs and energy calculations
- Describe lumen delivery and control systems and how they impact tenants
- Explain the societal and environmental impacts of lighting systems

What is "Sustainability" ?

Meets the needs of the present without compromising the ability of future generations to meet their own needs.

Definitions & Terminology

Terms and concepts you should be familiar with include:

- Productivity
- Recycler
- Recycling
- Renewable Materials
- Renewable Resources
- Scotopic
- Supply Chain
- Sustainability
- TCLP
- Toxicity
- Transporter
- USGBC
- Waste Management
- Waste Stream
- Watts

MPT Sustainability

Manufacturing, Packaging and Transporting

MPT Sustainability

Processes and strategies used to make and to bring a particular product to its intended use.

Which product and/or manufacturer effectively performs these functions while minimizing environmental impact and energy usage?

- Manufacturing Materials Used
- Packaging Methods
- Transportation Choices

Manufacturing Considerations

Where and how is the product manufactured?

What are the practices within the manufacturer's facility?

Does the manufacturer recycle products in the process?

Packaging Considerations

How is the product packaged?

Is packaging made of recycled materials?

Are there local options for product procurement?

Photo credit: animaster via VisualHunt / CC

Transporting Considerations

How is the product transported?

How far is it transported?

Are we unnecessarily disposing of products that could be re-used or retrofitted?

Life Cycle Costs and Energy Usage

The Impact of Design

Sustainable Life Cycle Costs

Ensuring that long life products and intelligent maintenance practices are **uncompromised by lower initial costs**

- Weighed and analyzed in the design stage

Sustainable Life Cycle Costs

CLMCs must be familiar with:

- General life expectancies of various lighting systems
- Effect(s) of external factors on expected life

Example:

- Control systems
- Occupancy patterns
- Space conditioning
- Environmental conditions

Sustainable Life Cycle Costs

Convey the impact of design choices on Life Cycle Costs

- Financial Impacts
- Environmental Impacts
- Societal Impacts

Energy Considerations

Identify and quantify all factors which allow for:

- The most accurate representation of an existing lighting system
- Potential improvements to that system

Utility Rate Structures	Lighting Control Systems	Energy Usage	Climate Technology Choices

Energy Calculations

A CLMC **must**:

- Know the difference between demand and energy charges
- Know the effect of the ballast factor on the energy consumption in a lighting system
- Be able to analyze different systems for the most effective solution that meets the customer's needs

Energy: Modifying Lighting Systems

Modifications will have impacts on other building systems, such as the HVAC system.

- Calculate the impact by converting **watts to BTU/Hr**

1 watt = 3.412 BTU/Hr

1 BTU/Hr = 0.293 watts

Lumen Delivery Systems

Comprehensive Content Area of the Exam

Lumen Delivery Systems

A CLMC uses the knowledge accumulated over the course of their career to design the most sustainable lighting system that meets the needs of the system's users.

Lumen Delivery Systems

CLMC candidates must have an understanding of the following:

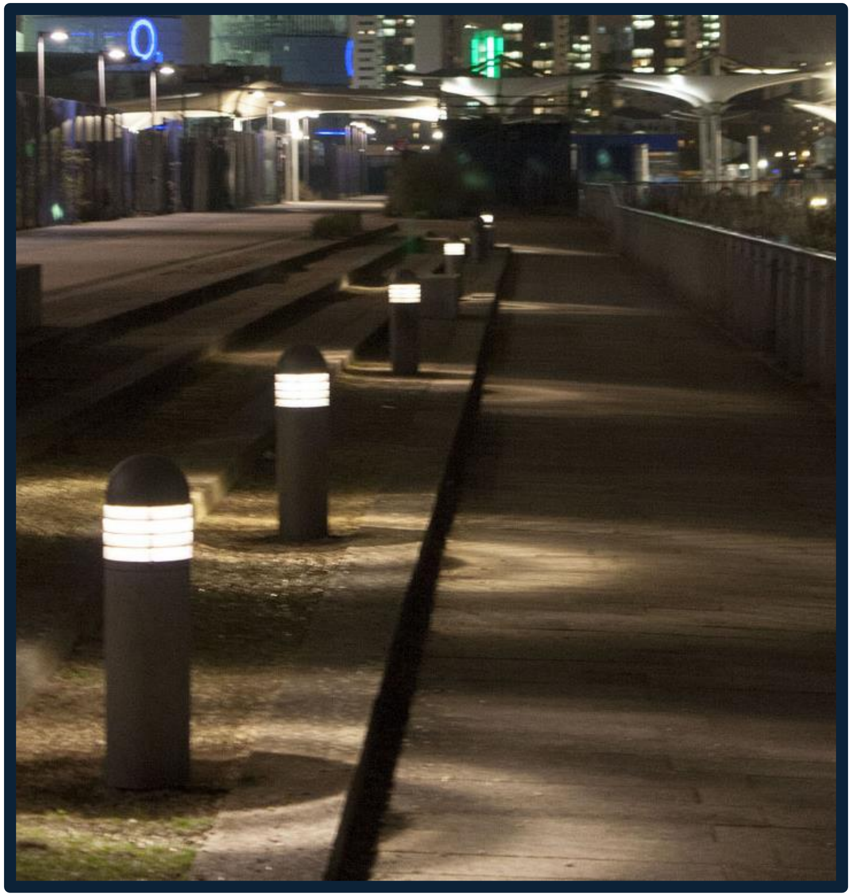
All associated costs of a lighting system in every phase of operation

How each system component affects the overall performance of the system

Creating a usable lighting system for all its users

Lumen Delivery Systems

The CLMC must consider a variety of issues when it comes to designing or upgrading exterior lighting systems.



Exterior Lighting Considerations

Whether designing or upgrading exterior lighting systems, consider the following:

ASHRAE Standards and Terminology for Design and Analysis

Usability of Different Light Sources

Maintenance Practices and Future Upgrades or Enhancements

Control Systems

Fast Growing and Complex Lighting Design Component

Sustainable Control Systems

Design considerations:

- Whether the controls are an enhancement rather than just a cost-saving measure
- Effectiveness of various technologies in the overall lighting strategy
- Functionality as it relates to tenant comfort and productivity

Sustainable Control Systems

Lighting Controls	*Lighting Control Systems*
Stand-alone control of a space's lighting	Networked, intelligent systems that facilitate lighting controls
Includes: • Timeclocks • Photocells • Occupancy sensors	Devices such as: • Relays • Light control switches • Signals from other entities *(i.e. fire alarm or BMS)*

Question

ASHRAE/IES Standard (90.1-2010 and -2013) requires automatic shut off if _______ or more of the connected lighting load is replaced as part of a lamp-plus-ballast retrofit.

Question

ASHRAE/IES Standard (90.1-2016) and (IECC 2018) require that when occupancy sensors are used, they must turn controlled interior general lighting OFF within ___ minutes of the space being vacated.

Question

ASHRAE/IES Standard (90.1-2019) specifies a maximum lighting power density (LPD) of 0.70 W/sq. ft. for an open office application. The current system used a T8 fluorescent system with electronic ballasts that yields a lighting power density of 1.0 W/sq. ft. Which of the following solutions gives the BEST opportunity to meet or exceed the LPD target?

Control Technologies

CLMCs need to recognize control opportunities and the requirements involved:

- Integrate lighting controls with other systems' controls to maximize lighting performance

Example:

- Passive infrared (PIR)
- Ultrasonic & microphonic
- Time-based controls
- Ambient light sensing
- Dimming/step dim systems

Sustainable Usability of Space

Lumen Delivery System

+

Lighting Controls

=

Direct Effect on Employee Productivity and Comfort Levels

Sustainable Usability of Space

Weigh all considerations when analyzing a lighting system, including:

- Will the lighting affect the tenant's productivity?
- Does the lighting support the tasks, work, culture and intended use of the space?

Productivity and Tenant Comfort

According to the ***National Lighting Bureau***, lighting affects performance both directly and indirectly, which in turn influences overall productivity:

- How much light?
- What type of light?

Sustainable Usability of Space

Effective System with the Latest Technologies

+

Inappropriate Lighting Environment

=

Useless and Ineffective Lighting System

Environmental and Societal Impacts

Environmental Impacts

CLMC should have knowledge of:

- Raw material content in equipment
- Energy consumption’s effect on carbon footprint, pollutants, safety

Major Factor:

Use of electricity during peak demand times causes the generation of electricity with the use of **less efficient** and **more polluting** methods.

Environmental Impacts

Four key areas of lighting generate carbon footprints:

- Extracting the raw materials needed to make the lighting components
- Manufacturing the product
- Transporting the product through the supply chain
- The energy consumed while the product is in use

Disposal and Recycling

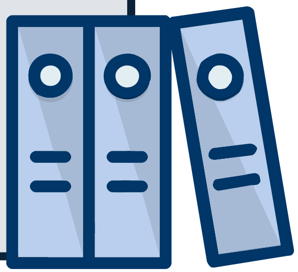
- Know disposal and recycling techniques and how they affect the environment
- Existing systems must be reviewed for reusable components before specifying a new product

Disposal/Recycling Key Term

Hazardous Waste Generator

Per the EPA, a *hazardous waste generator* is any person or site whose processes and actions create hazardous waste *(see 40 CFR 260.10)*.

- Generators are divided into three categories based upon the quantity of waste they produce.



Hazardous Waste Generators

LQGs

Large Quantity

- 1,000 kg or more per month, *or*
- 1 kg per month of acutely hazardous waste, *or*
- > 100 kg per month acute spill residue or soil

SQGs

Small Quantity

- > 100 kg per month, but < 1,000 kg per month of hazardous waste

CESQGs

Conditionally Exempt Small Quantity

- 100 kg or less per month, *or*
- 1 kg or less/month acutely hazardous waste, *or*
- < 100 kg per month acute spill residue

Societal Impacts: Light Pollution

Dark sky issues are a main concern, causing light pollution. Adverse effects include:

- Glare
- Skyglow
- Light trespass
  - CLMCs should know accepted strategies for resolving light trespass concerns

Knowledge Review: Questions

thank you

And Good Luck!

*Images from Free Vector