Lighting for an Efficient and Sustainable Future

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BENYA LIGHTING DESIGN

Our Goals

This course will teach the principles of, energy efficient lighting design, controls, and how to make basic lighting decisions.

MORE INFORMATION

www.newbuildings.org

The Advanced Lighting Guidelines

Suggested Lighting Principles

- Significantly reduce the use of energy
- Improve resource management: recycle, use renewal materials, eliminate toxins, reduce manufacturing and shipping wastes
- Overcome a century of carelessness and return the night sky
- Improve application decisions – don’t light when not required

Sustainability Begins at Home

- Minimum handout saves paper and energy
- Download this program and other lecture materials at

  www.benyalighting.com
- Follow up Email at

  jbenya@benyalighting.com

First Lighting Concepts

- Ten General Considerations
- Special Considerations for
  - Schools
  - Offices
  - Retail
  - Grocery
  - Big Box
  - Industrial

General Considerations

1. Prepare Well

- Take Classes
- Attend trade shows (LightFair)
- Check with your Utility, Federal Law and Energy Trust to determine the possible incentives and subsidies available to the project

General Considerations

2. Set lighting levels properly

IESNA Categories

A 3 fc Public Spaces
B 5 fc Simple Orientation and Short Visits
C 10 fc Working Spaces with Simple Tasks
D 30 fc Tasks of high contrast and large size
E 50 fc Tasks of low contrast or small size
F 100 fc Tasks of low contrast and small size

General Considerations

3. Evaluate possible task-and-ambient lighting

Task light level	100fc	250 sf
Ambient light level	30fc	750 sf
Average light level	47.5fc	1000 sf

General Considerations

4. Establish an Appropriate Budget

Ordinary lighting-manual switching	$ 3.00/sf
High efficacy lamps	$ .30/sf
High efficiency ballasts	$ .30/sf
Dimming ballasts	$ 1.00/sf
Motion sensing controls	$ .50/sf
Automatic daylighting controls	$ .50/sf
Total costs	$ 4.10-$5.30

General Considerations

5. Evaluate only efficient options

Efficiency Cues

- Low RCR
- Light finishes
- Symmetric lighting
- Direct lighting
- Efficacious light sources
- Efficient luminaires

General Considerations

6. Do careful calculations

- Set sensible minimum and maximum criteria
- Try different layouts
- Run point by point calculations

General Considerations

7. Determine control zones
   - Minimum code required
   - High use/low use
   - Daylighted

General Considerations

8. Apply controls

- Use common sense
- Challenge the amount of energy saved
- Avoid complex and hard-to-commission systems

General Considerations

9. Compare your results to the energy code

- A good design today is 5-10% under

http://www.sbcc.wa.gov/docs/codes/energy04.pdf

General Considerations

10. Restraint-Restraint-Restraint

- The best projects use the minimum to do the job
- More is not always better

Special Considerations for Retrofitting

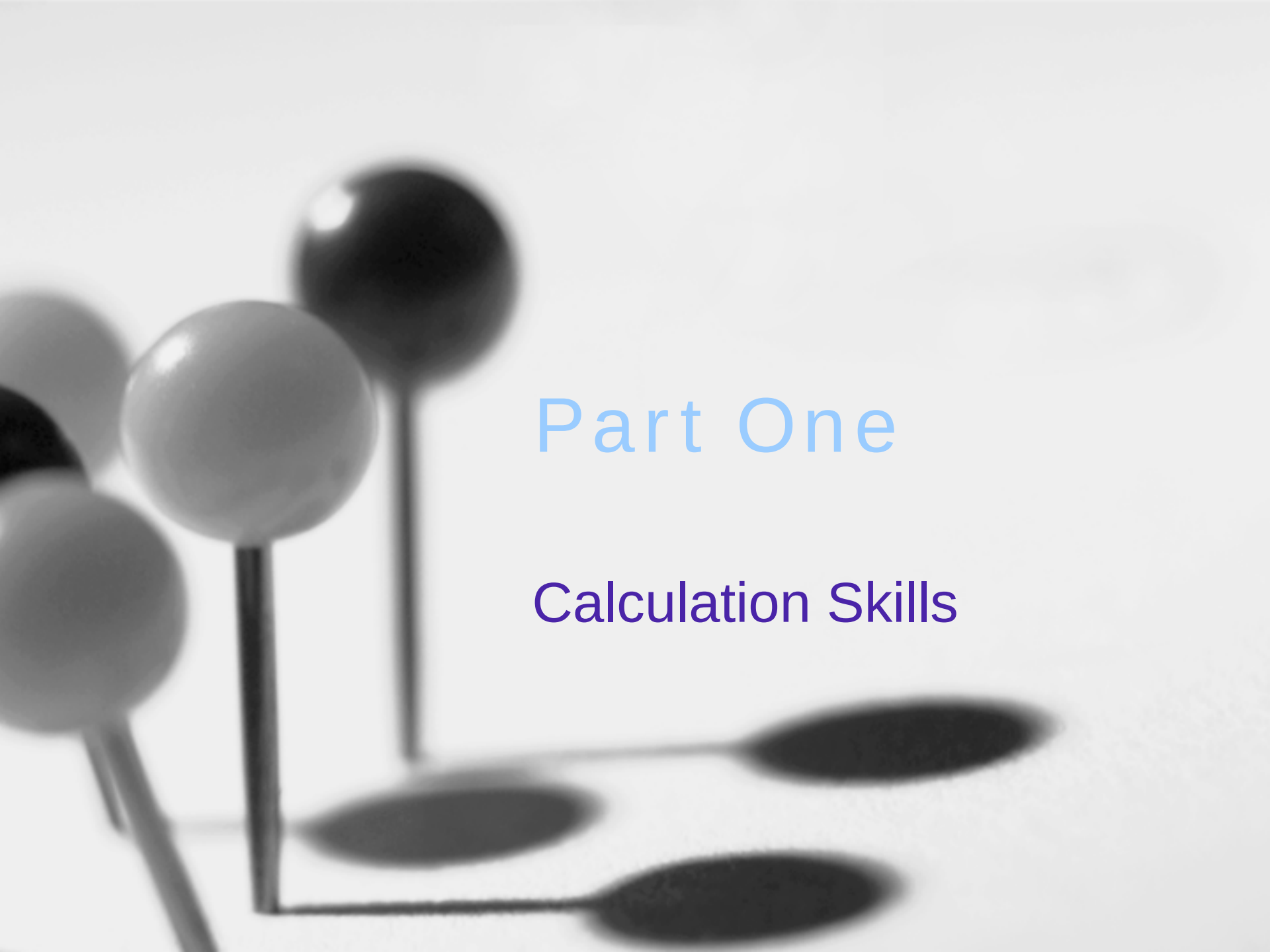
Age of Existing System

- Over 20 years = generally favor relighting
- 10-20 years = consider relighting
- 0-10 years = concentrate on retrofits

Special Considerations for Retrofitting

Core Technology

- Mercury vapor or incandescent suggest relighting or major retrofits
- T12 fluorescent suggests the option of retrofitting
- T8 can be retrofitted



Part One

Calculation Skills

Principal Lighting Terms

Lumens light emitted by a source

Candela the intensity of a source in a specific direction

Illuminance the amount of light falling on a plane, measured in footcandles (lumens/sf) or lux (lumens/m^2)

Luminance the brightness of an object in candelas per m^2

Predicting Daylighting

You can do:

- Scale Modeling
- Computer Modeling

Scale Model Daylighting

Requires:

- A scale model of the daylighted space and relevant fenestration and shading elements
- A means of measuring light levels inside the model
- A method to simulate direct sunlight
- A method to simulate diffuse (cloudy) light

Scale Model Daylighting

Modeling without lab resources

- Can provide useable information if properly corrected for all conditions
- It's harder than it looks!

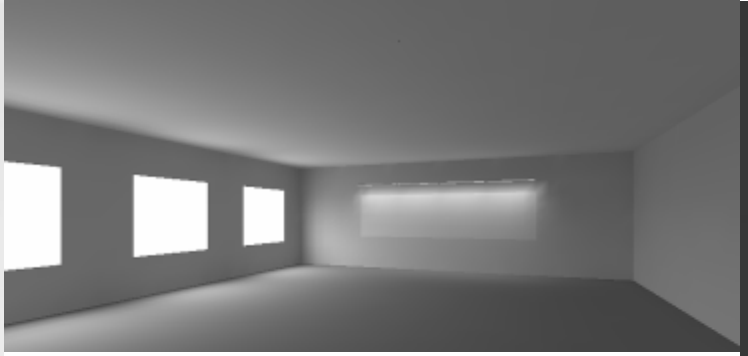
Modeling in a Daylighting Lab

- Use the Heliodon to evaluate direct solar effects
- Use the artificial sky to evaluate diffuse sky effects
- Computer instrumentation makes it easier than it looks

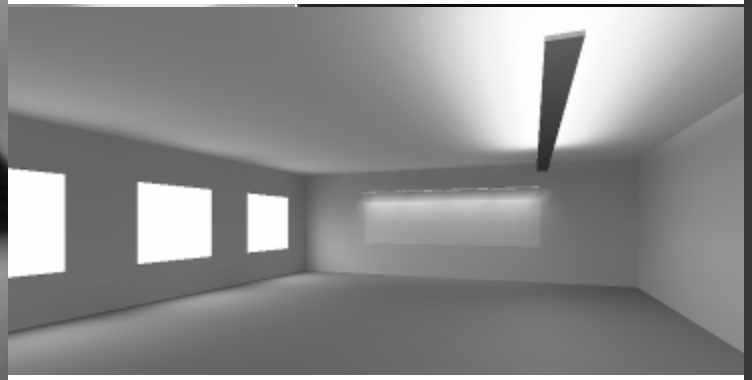
Computer Modeling

Requires:

- Some basic information about each space such as basic geometry, window type and location, shading, etc.
- Photometric information about lighting systems and complex skylights
- Relatively low cost computer software



Cloudy 6/21 12:00 board light only
Avg 10 fc – max 150fc min 3 fc



Cloudy 6/21 12:00 board and 1 row
Avg 55 fc – max 150fc min 30 fc

Night 6/21 board light and 2 rows
Avg 55 fc – max 80fc min 27 fc

Computer Modeling

- *Permits rapid assessment and change of all conditions (weather, time, date, etc.)*
- *Can be corrected for site location and orientation*
- *Allows combinations of electric and natural light*

Basic Hand Calculations

The average illuminance E is:

$$E = \frac{\text{Lumens} * \text{CU} * \text{LLF}}{\text{Area}}$$

Basic Hand Calculations

Where

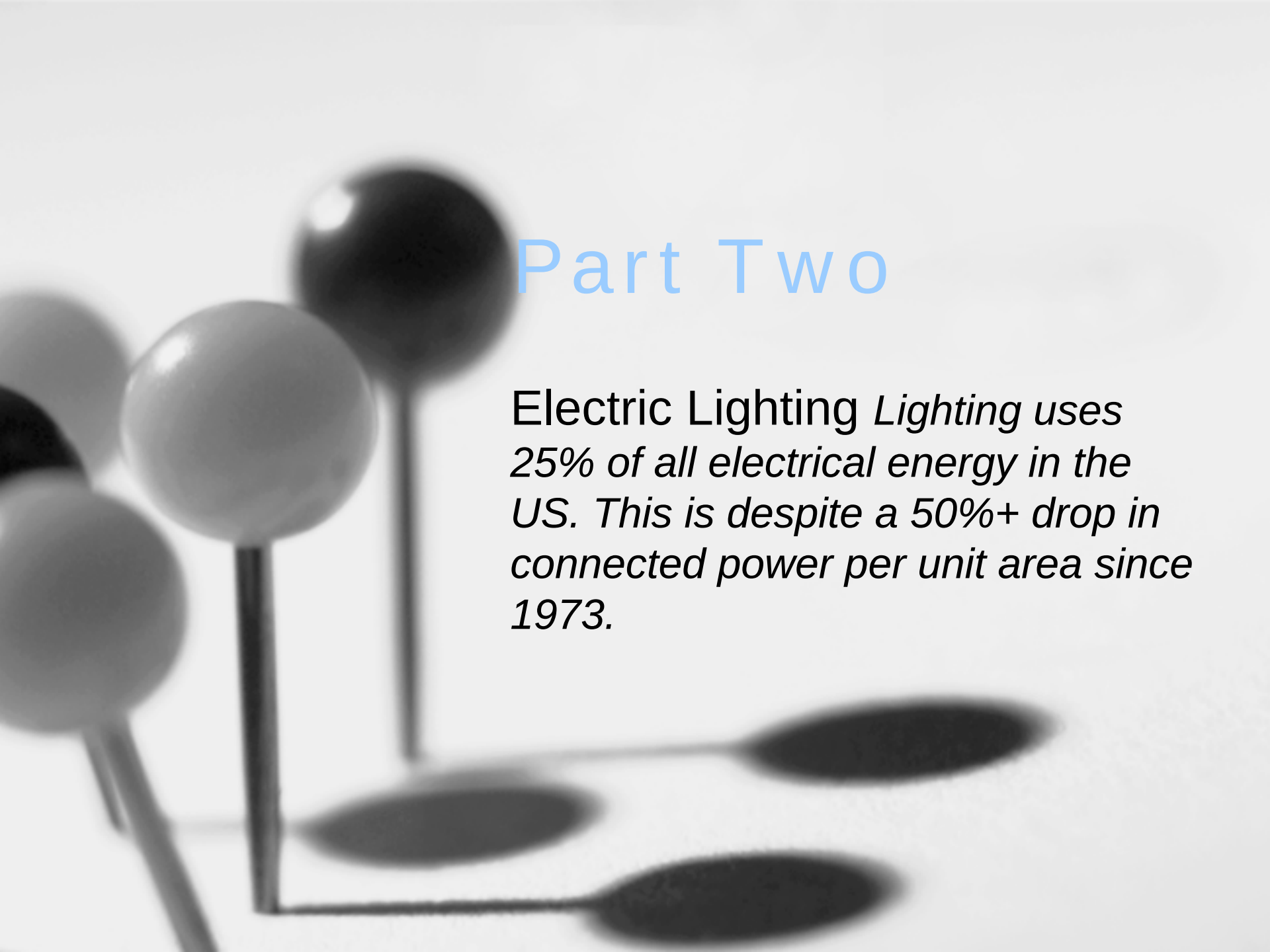
Lumens are the total emitted lumens in the space from a lighting system

CU is the Coefficient of Utilization taking into account fixture efficiency, room geometry and inter-reflectance

LLF is the light loss factor, the *product* of ballast factor (BF), lamp lumen depreciation factor (LLD), luminaire dirt depreciation factor (LDD), application thermal factor (ATF) and other things that reduce lamp output

Exercise

What is a footcandle anyway?

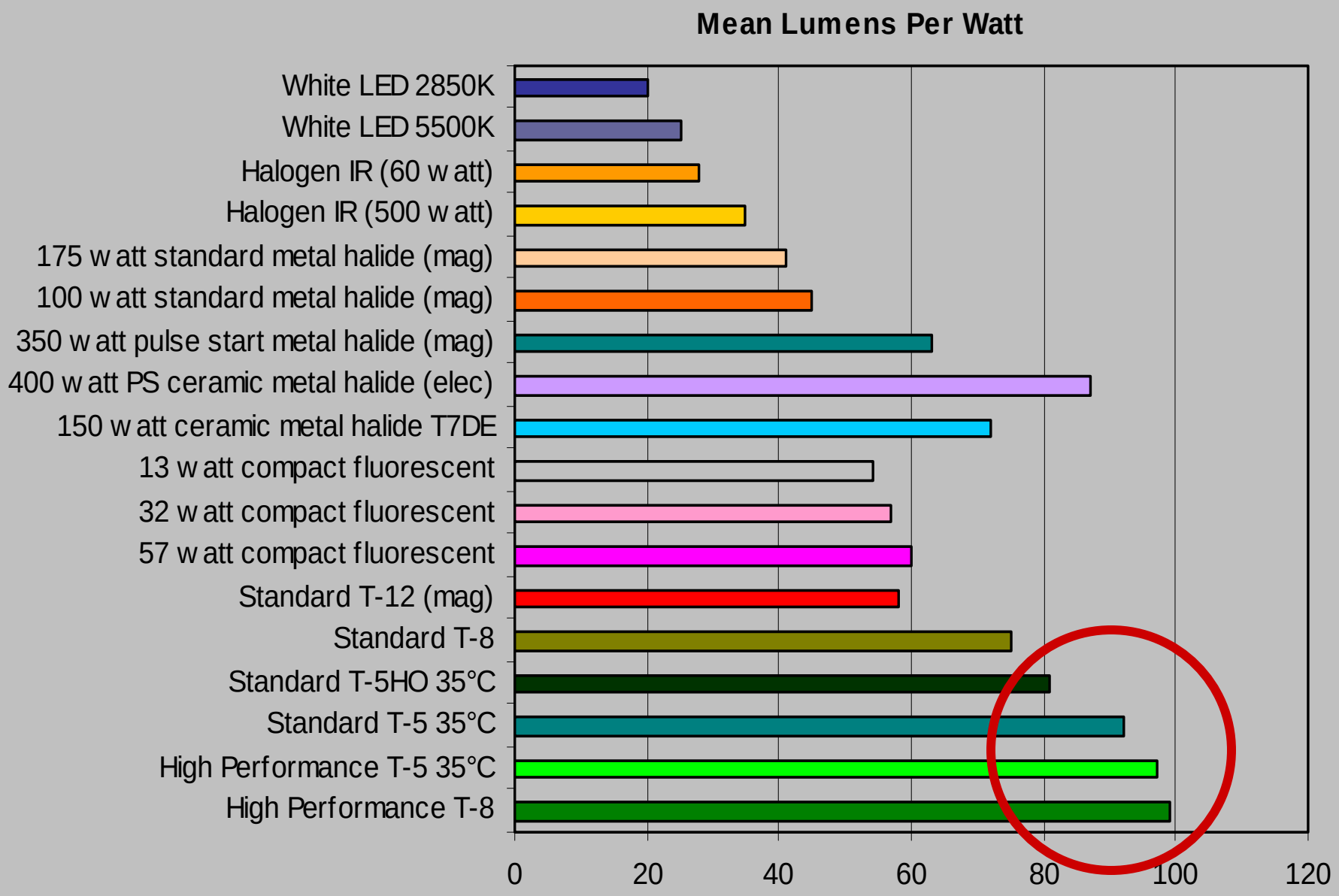


Part Two

Electric Lighting *Lighting uses 25% of all electrical energy in the US. This is despite a 50%+ drop in connected power per unit area since 1973.*

Select Proper Electric Light Sources

- Efficacy (lumens per watt)
  - Determines the efficiency of converting electricity to light.
  - The higher the efficacy the better.
- Color Temperature
  - We tend to prefer “white” light sources between 3000K (“warm”) and 4100K (“cool”). We might consider 5000K (cold) for studios.
- Color Rendering Index
  - Measures light source quality.
  - Sources with CRI < 70 are noticeably distorted. CRI<60 unacceptable.
  - Whenever possible choose light sources with CRI > 80.
- Lamp Life
  - Choose lamps with maximum life possible to minimize maintenance.
- System Costs
  - Choose systems that employ low cost lamps and ballasts.


Mean Lumens Per Watt
White LED 2850K
White LED 5500K
Halogen IR (60 watt)
Halogen IR (500 watt)
175 watt standard metal halide (mag)
100 watt standard metal halide (mag)
350 watt pulse start metal halide (mag)
400 watt PS ceramic metal halide (elec)
150 watt ceramic metal halide T7DE
13 watt compact fluorescent
32 watt compact fluorescent
57 watt compact fluorescent
Standard T-12 (mag)
Standard T-8
Standard T-5HO 35°C
Standard T-5 35°C
High Performance T-5 35°C
High Performance T-8
0
20
40
60
80
100
120

Efficient Sources

- Full size fluorescent lamps
- Compact fluorescent lamps
- Induction Lamps
- HID Lamps
- LED lamps
- Low wattage halogen

Full Size Fluorescent Lamps

- Highest lumens per watt you can get (80-100)
- Dimmable
- Best applications: everywhere where linear lighting works
- Drawbacks
  - Long lamps need long fixtures
  - Too much light for some spaces

“Real” Compact Fluorescent Lamps

- High lumens per watt (40-70)
- Some are dimmable
- Best applications: cans, sconces, pendants
- Drawbacks
  - Dedicated CFL fixtures hard to find
  - Slight color shift

“Screw-in” Compact Fluorescent Lamps

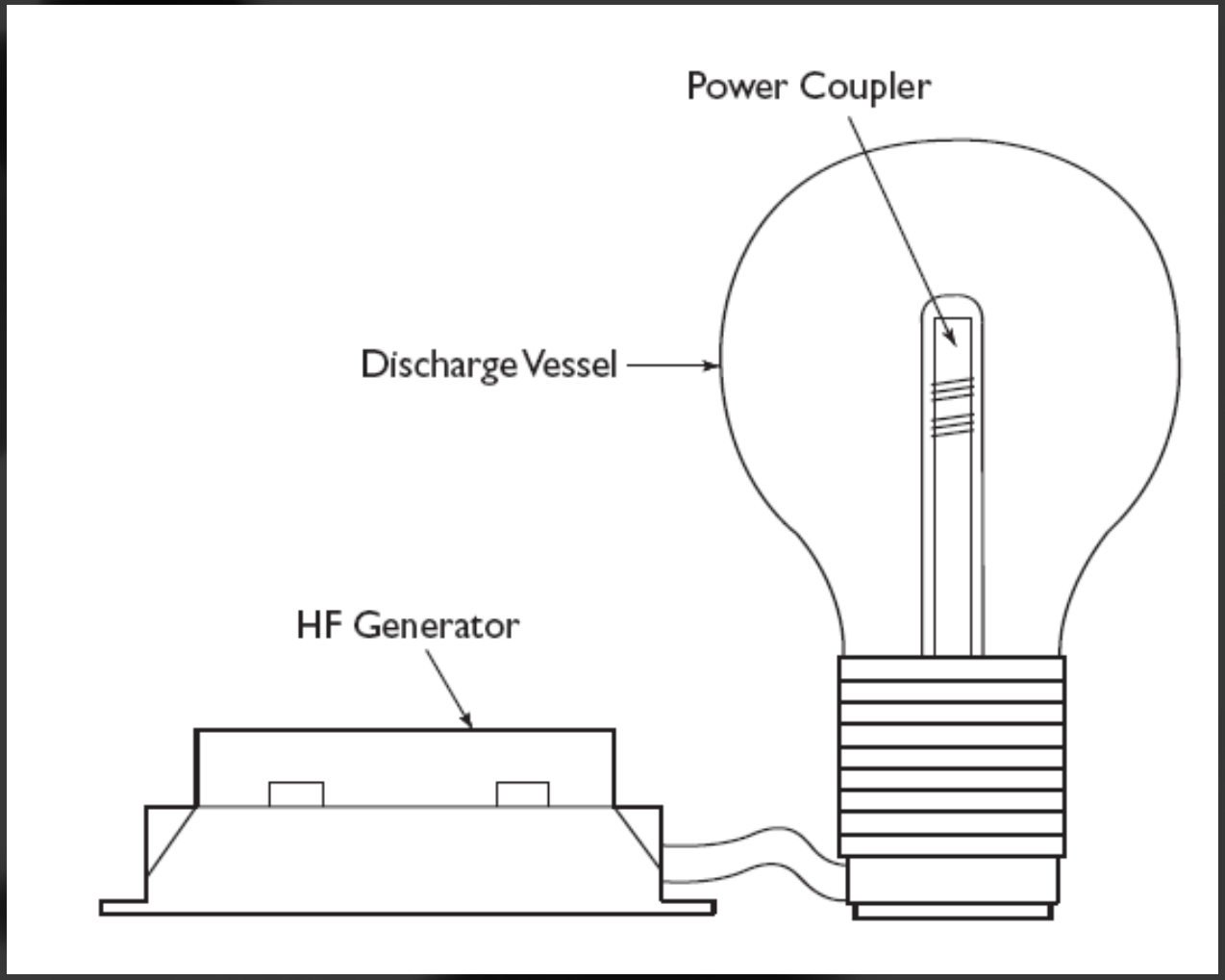
- High lumens per watt (40-60)
- Some are dimmable
- Best applications: any existing socket!
- Drawbacks
  - What can screw in can screw out
  - Warm up time
  - Color ranges from good to horrid

Bare Products		Covered Products			Reflector Products
Mini-Spiral or Twist	Tube or Universal	Incandescent/ A-line	Globe G25, G30, G40	Candelabra, Post or Bullet Shape	Indoor and Outdoor R20, R30, R40, PAR38
					

Induction Fluorescent

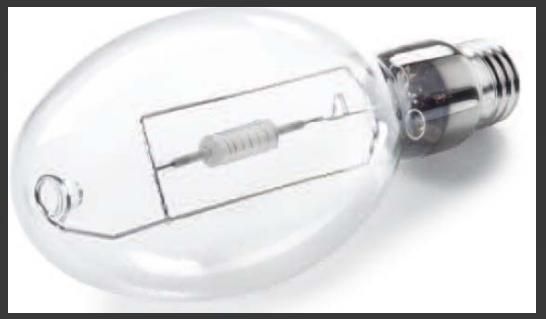
- No electrodes – extremely long life
- Use RF excitation
- About the same as standard T-8 efficacy
- Optically mediocre

Induction Fluorescent



HID Lamps

- High efficacy lamps with good to excellent color
- Long warm up time
- Even longer restrike time
- Poorly dimmable



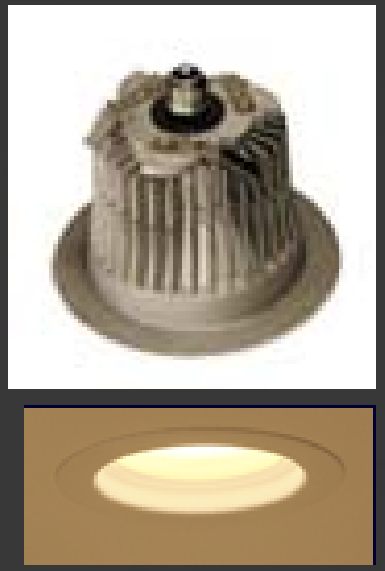
HID Lamps

Self ballasted HID

- The HID alternative to the screw in CFL

LED Lighting

- Promising future
- Current products 30-50 lumens per watt
- Significant underperformance concerns with many current products
- Dimmable



Some of the first LED downlight products that actually perform as advertised (we think)

LED Accents

- Products now becoming available
- Good products are costly, cheap products have issues

Halogen

- A relatively inefficient source
- But the quality is superior for certain applications
- Keep the watts low and it’s still viable
- Uses
  - Accent lighting in living spaces, especially art
  - Downlighting in hallways
  - Reading lights in bedrooms
  - Spot lighting tables and displays

Use 20 watt IR lamps for general lighting and 37 watt IR lamps for art accents and table lighting

Halogen

Fluorescent can't do this. LED can't do this (yet).

The King of the Hill: Super T8 is a SYSTEM

- Standard 32 watt T-8 lamps with high initial lumens, high lumen maintenance, and long life construction
  - GE “HL” series
  - Sylvania “XPS” series
  - Phillips “Advantage” series
- New High Efficiency “Super” Electronic Ballasts
  - Standard 2-lamp T8 ballast is 59 watts – super ballast is 53 watts
- Optional instant start ballasts give 99 mean lumens per watt and should be used where lights are turned on and left on
- Optional program start ballasts give 92 mean lumens per watt and provide extended lamp life, especially when frequently switched.

For Primary Lighting Systems: Linear Fluorescent Lamps

- T-8 “Super” Lamps
  - 101 MLPW vs. 75 MLPW for ordinary T-8.
  - 85+ CRI.
  - 30,000 hour lamp life on program start electronic ballasts.
- T-5 Standard Lamps
  - 91 MLPW.
  - 83+CRI.
  - 20,000 hours + life.
- T-5 HO
  - 80 MLPW.
  - 83+CRI.
  - 20,000 hours life.

T-5 vs. T-8

The T-5 System

- Choice of both standard and high output lamps
- 5/8” diameter
- Smaller, more efficient luminaires
- More costly and harder to get lamps

The T-8 System

- Yes there are HO lamps but not really
- 1” diameter
- Low cost readily available
- Variable ballast factor

Secondary and Special Lighting Systems

- Compact fluorescent lamps
  - 10,000 hour lamp life.
  - 50-65 MLPW varies with wattage.
  - High CRI >80.
  - Color temperature 3000K, 3500K, 4100K, and others.
  - NOW – use 57 watt and 70 watt compact fluorescent INSTEAD of low wattage metal halide!
- Pulse start metal halide lamps
  - 50-79 MLPW varies with wattage.
  - 7,500 to 20,000 hour lamp life.
  - Standard lamps CRI 65-70.
  - Ceramic high color lamps CRI>80.
  - Long warm up and restrike times.
  - PREFER THE CERAMIC METAL HALIDE LAMPS FOR SUPERIOR COLOR

Light Sources for Limited Use

- Halogen IR lamps
  - Excellent CRI ~100.
  - Color temperature warm 2850-3000K.
  - Highly directional.
  - Inexpensively dimmable.
  - Life 3000-4000 hours.
  - Efficacy 20-30 MLPW.

Why Not Mercury Vapor, High Pressure Sodium or Low Pressure Sodium Lamps?

- High pressure sodium lamps produce a pinkish yellow light.
  - CRI <20.
  - Color temperature <2200K.
  - Provides poor visibility for indoor tasks, including problems with focusing on small work.
  - Provides decreased peripheral vision and response time in outdoor lighting.
- Low pressure sodium lamps produce monochromatic yellow light.
  - CRI = 0.
  - Worse than high pressure sodium in all respects.
- Mercury Vapor
  - Low efficacy
  - Poor color

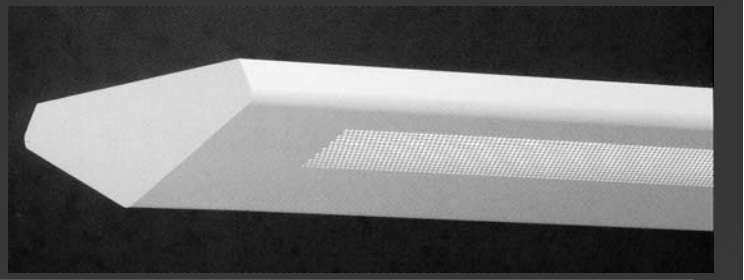
Light Source Applications

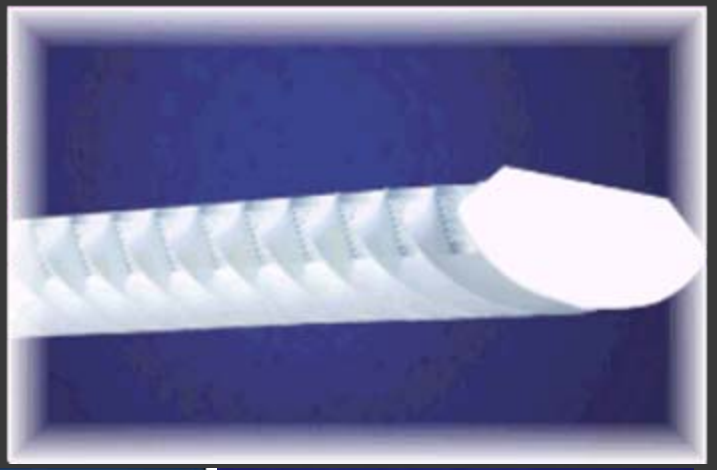
	General (Indoor)	Special & Utility (Indoors)	Display & Mood (Indoors)	Outdoor Lighting
Linear Fluorescent	+ +	+		
Compact Fluorescent		++	+	+
Metal Halide		+	+	++
HIR Tungsten Halogen			+	
LED		+	+	+

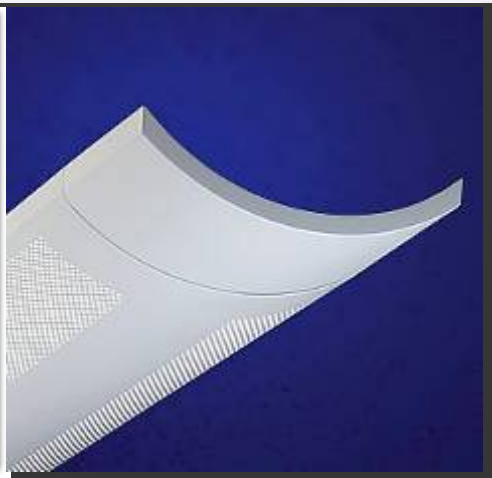
Know Your Ballasts

- Use electronic ballasts exclusively for fluorescent and compact fluorescent lamps.
  - For T-8 lamps, investigate “low light output” and “high light output” ballasts to fine tune fixture watts to the minimum needed for a space.
  - Dimming ballast prices are still high – carefully evaluate the need for dimming.
  - Low temperature ballasts permit compact fluorescent lamp starting and operation at <0º ºF.
- Use electronic ballasts for metal halide lamps up to 150 watts (and maybe higher).

Choose Suspended Luminaires for Efficiency and Comfort

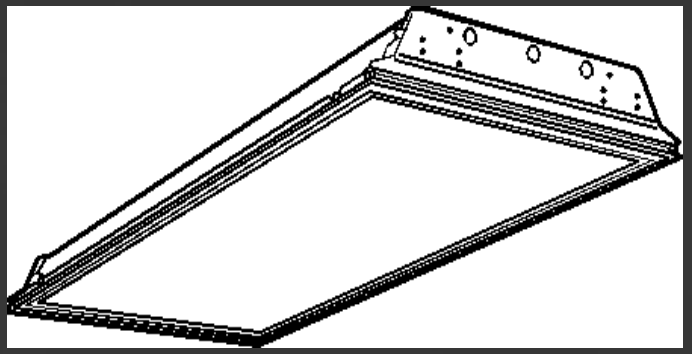


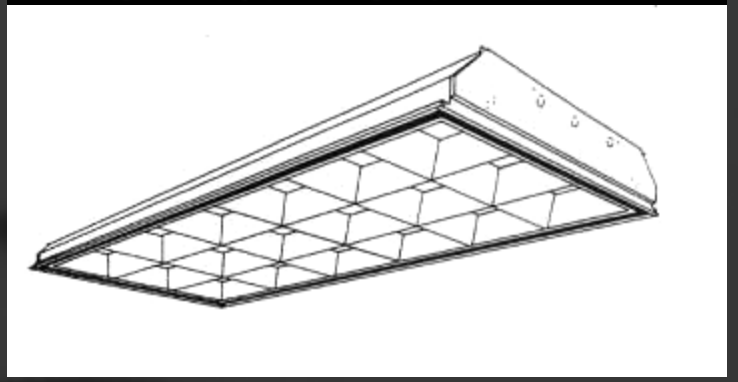




If You Must...Recessed Luminaires

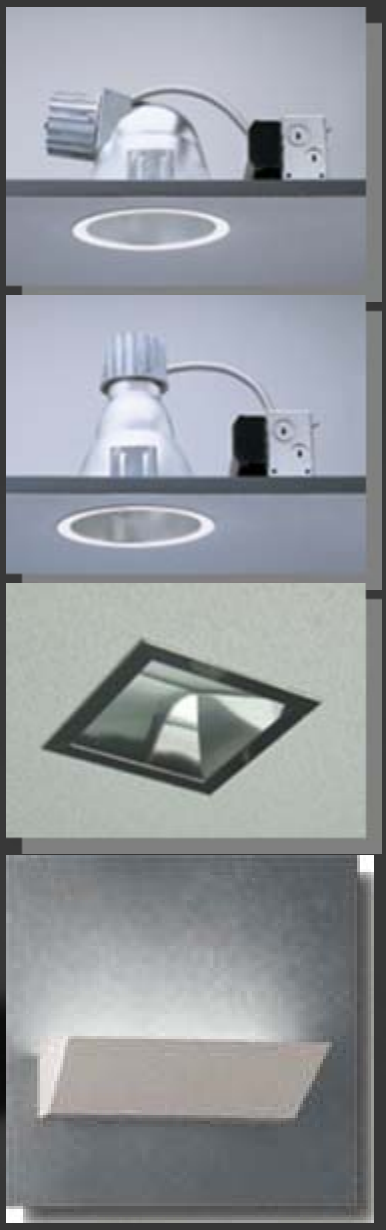
- Use recessed luminaires in conjunction with t-bar grid ceilings in low ceiling applications.
  - Lens troffers are very low cost and efficient solutions.
  - Basket style troffers offer similar performance but are more appealing.
  - Parabolic troffers are very commonly used in a number of space types.





Occasional Luminaires

- Use recessed downlights both in t-bar grid ceilings and hard lid ceilings.
  - Compact fluorescent downlights for most interior and many exterior applications.
  - Metal halide downlights in high bay applications and outdoors.
  - Halogen downlights and accent lights in special “social” spaces and A/V environments.
- Compact fluorescent and HID wallwashers
- Durable wall sconces
  - Incandescent in theaters and AV spaces
  - Compact fluorescent in corridors, offices, other low abuse settings
  - HID in pools and some large spaces



Evolutionary lighting

Drop Diffuser Downlight

- Efficiency over 80% versus 60% for a good downlight
- No scallops on corridor walls

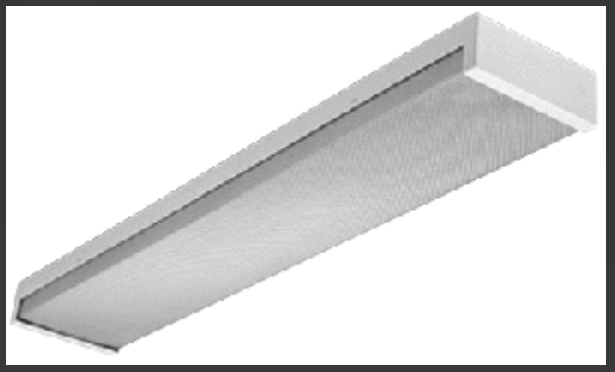
Decorative and Stylish Luminaires

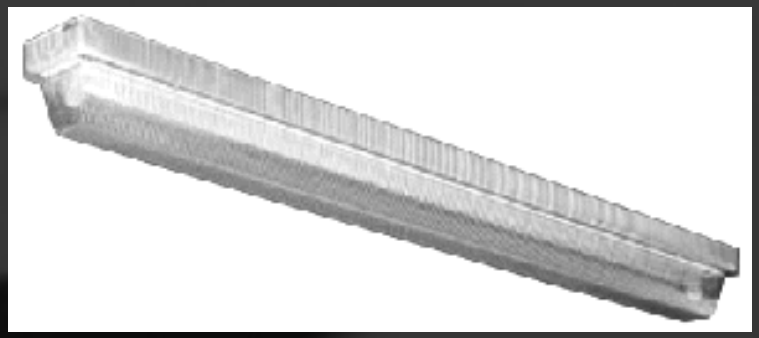
- Add a touch of style
- Use in low abuse “special” locations
  - Major entries and lobbies
  - Commons areas
  - Cafeterias
  - Libraries
- All of these are compact fluorescent

Surface-mounted High Abuse Luminaires

Choose T-8, T-5, HID or compact fluorescent luminaires for a number of occasional and utility applications such as:

- Stairwells.
- Exterior doors.
- Locker and toilet rooms.
- Showers.





High Bay High Performance

High bay fluorescent is an energy efficient choice for large spaces like gyms. The 6-lamp T5HO fixture at 360 watts exceeds the maintained performance of a 400 watt metal halide operating at 458 watts. Optional uses include 1/3, 2/3 and 3/3 light level operation for energy savings.

High performance metal halide downlights with electronic ballasts are a good choice when lights must be left on for many hours a day. A 350 watt ceramic metal halide operating at 370 watts exceeds the maintained performance of a 400 watt pulse start metal halide operating on a magnetic ballast at 458 watts. Dimming is a practical option.

Exit Signs

- Unless otherwise required by code us exit signs.
- Red or green depending on local authorities.
- Use very low power making them especially easy to equip with their own backup battery.
- Remember, LED exit signs don’t have a downlight egress light - you will need to provide that.

The Top 5 Biggest Equipment Trends

1. T5 Lighting
2. Ceramic Metal Halide Track and Display Lighting
3. Pendant Mounted Lighting for Offices, Schools and other Commercial and Institutional Lighting
4. Light Emitting Diodes (LED’s)
5. High Wattage Ceramic HID with Electronic Ballasts

Trend: T-5 Luminaire Systems

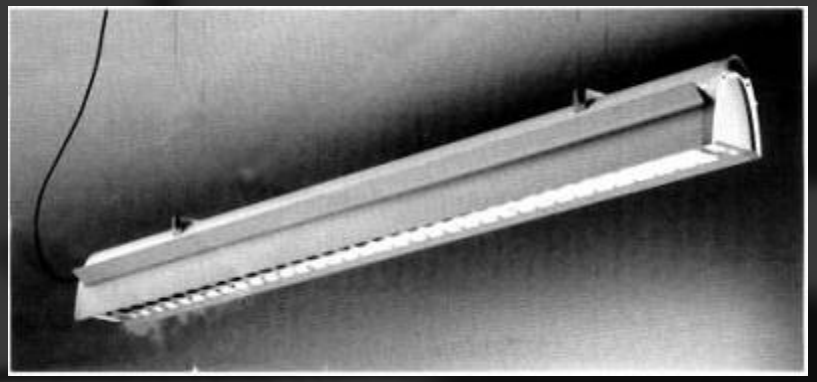
- New Generation T5 troffers
- Direct small aperture
- Asymmetric (wallwash)
- Asymmetric (aimable)
- Asymmetric (cove)
- Direct/indirect
- Indirect and semi-indirect
- Specialty

New Generation T5 troffers

- 90% efficient
- 3” tall
- Two level electronic ballast
- Standard or overdrive ballasts

Direct Small Aperture

- Theoretically requires 40% of the dimensions of a T-12 luminaire to achieve the same efficiency
- A new product family?

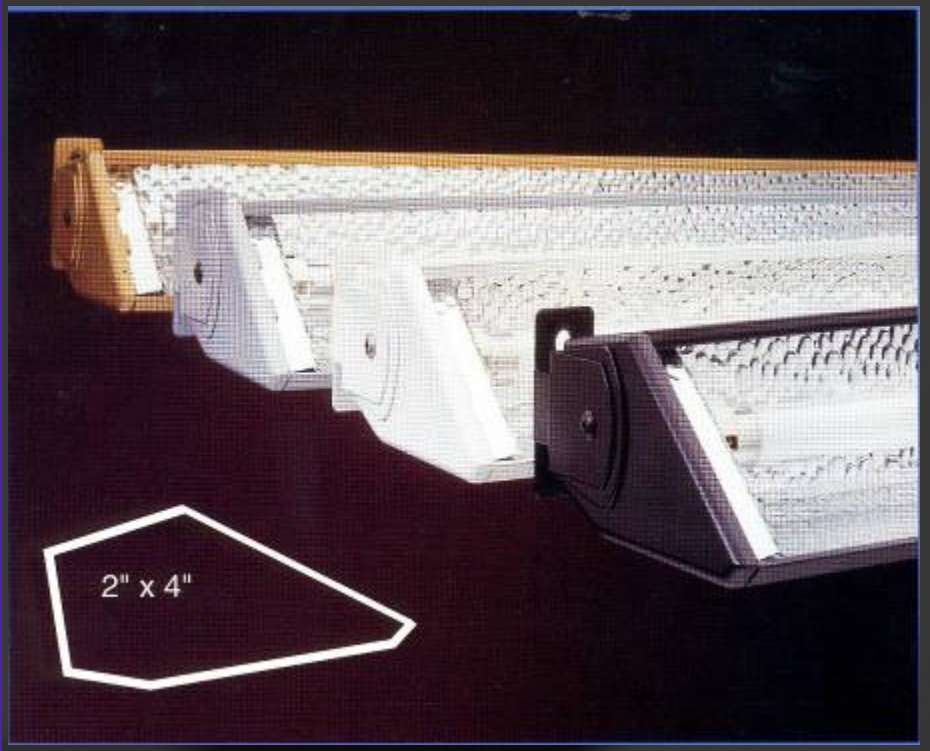


Direct HID Replacement

- Use 4 T5HO instead of 250 watt HID
- Use 6 T5HO instead of 400 watt HID
- Narrow distribution
- Immediate “on” and “off”
- Fully dimmable
- High CRI 86+
- High lumen maintenance LLD=90+

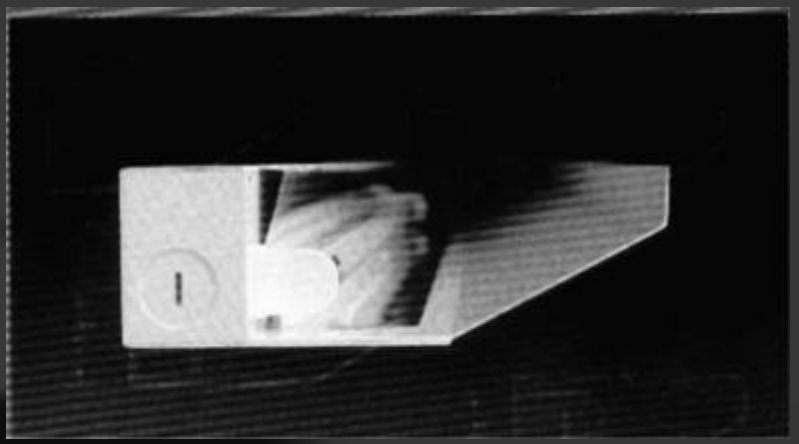
Asymmetric Wallwash

- Requires only 20% of the volume of a T-12 luminaire
- Makes linear luminaire cross-section similar to a quartz luminaire



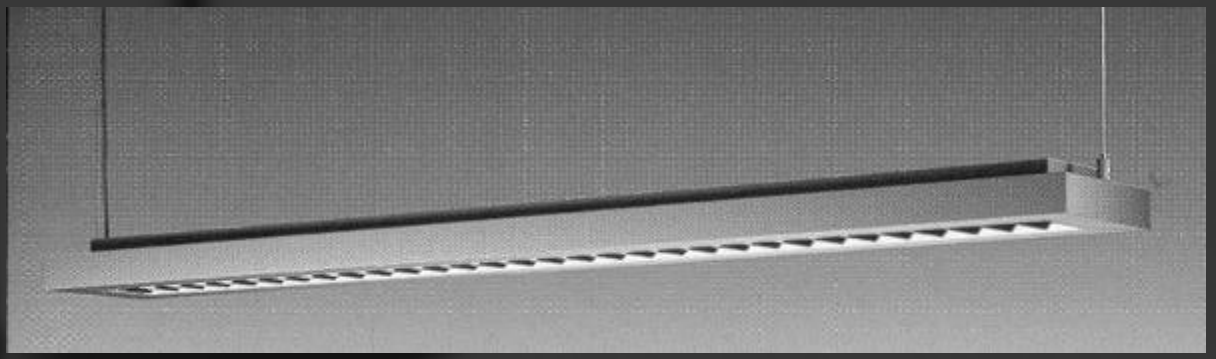
Asymmetric Cove

- Reduced overall dimensions now 2” x 6” include ballast
- Small profile can include adjustability



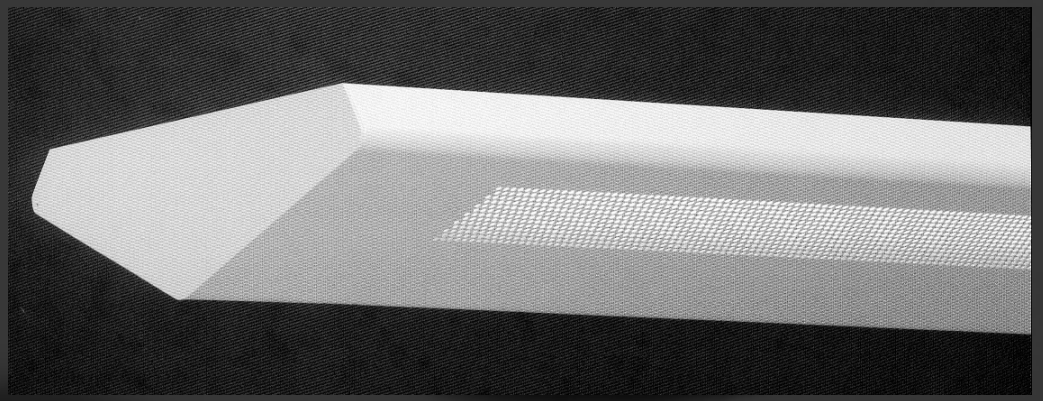
Direct/Indirect

- Smaller profile, less material, lighter weight
- Potential for high efficiency
- Conventional and advanced designs



Indirect

- Smaller profile
- Potentially optimum use of the T-5 HO lamp
- Minimum downlight %



Targets for Design

- 10-25% better than 90.1-2004
- 20-40% better than 90.1-2001
- Daylighting equal to LEED
- Controls better than 90.1

The Total

- Code Compliant
- Save Client energy costs
- Access to tax deductions
- Access to utility rebates

Effective Controls

- Motion sensors
- Dimmers
- Daylight sensors
  - Non dimming
  - Dimming
- Time of day switching
  - Clock time
  - Solar time
  - Calendar time

Options

- Simple controls (analog)
- Complex controls (analog)
- Integrated controls (analog power with digital features)
- Digital all the way

Exercise

Making Lighting Decisions