



Lighting 101

Fundamentals of Lighting for Interior Designers and Architects

NeoCon June 15, 2011

Presented by: Ardra Zinkon, Tec Inc, Engineering & Design

This presentation is protected by US and international copyright laws. Reproduction, distribution, display and use of the presentation without written permission of the speaker is prohibited.

© Tec Inc. Engineering & Design
2011



This program is registered with the AIA/CES for continuing professional education. As such, it does not include content that may be deemed or construed to be an approval or endorsement by the AIA of any material of construction or any method or manner of handling, using, distributing, or dealing in any material or product. Questions related to specific materials, methods and services will be addressed at the conclusion of this presentation.

Thank you!



Topics for today

- Sources
- Recommended Practice Footcandles
- Color
- Lighting Quality

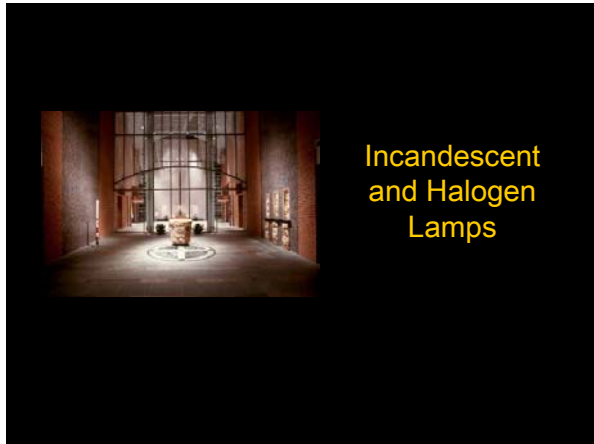
Why start with the source?

- Quality of light emitted (soft, harsh, crisp, punchy, strong, beam pattern)
- Color of Light emitted (white, orange, blue, warm, cool)
- Efficiency (lumens per watt)
- Cost
- Maintenance

Sources

- Incandescent and halogen
- Fluorescent
- HID (High Intensity Discharge)
- LED





How a lamp works

A standard incandescent lamp consists of a tungsten filament inside a sealed glass envelope containing an inert gas. When connected to an electric circuit, the high-resistance filament wire produces heat which causes the filament to “incandesce” or glow.

How a lamp works

A Halogen lamp utilizes halogen gas to create a regenerative cycle within the envelope where the filament material decomposes, then re-deposits back on the filament, extending the lamp life. This is called the Halogen Cycle.

A minimum temperature must be maintained for the cycle to function, therefore these lamps often have sealed capsules around the filament. This also increases the heat and results in higher illumination levels.

How a lamp works

A Halogen Infrared (IR) lamp employs a thin film coating of specialized material deposited on the outer surface of the filament tube. The material directs a portion of the infrared energy emitted by the filament, back onto it.

This redirected IR energy increases the filament temperature resulting in greater lumen output and longer lamp life.





Energy Independence and Security Act of 2007 (EISA)

- EISA 2007 establishes minimum efficiency and lifetime requirements for general service lamps. Manufacturers will be required to improve performance of these lamps over two years, starting in 2012. New requirements by 2014, and even stricter requirements by 2020.
- General Service lamps are medium screw base, type “A” incandescent lamps.

Energy Independence and Security Act of 2007 (EISA)

- Amendments to EISA 2007 were passed last year that will effectively ban all incandescent and halogen Par lamps that do not contain IR technology.

Lamp Comparisons

Incandescent	Halogen	CFL	LED
			
60 Watts	40 Watts	19 Watts	12.5 Watts
840 Lumens	800 Lumens	960 Lumens	800 Lumens
1000 Hours	3000 Hours	8000 Hours	25,000 Hours
100 CRI	100 CRI	82 CRI	80 CRI
Dimmable	Dimmable	Not-Dimmable	Dimmable

Incandescent and Halogen Lamps

- Color is warm and glows warmer when dimmed.
- Line Voltage or Low Voltage options
- Lowest Lumen to Watt Ratio (least energy efficient)
- Lowest Lamp Life (800 to 6000 hours)
- Lamp life can be extended by adding a dimmer.
- Least Expensive first cost.



Energy Saving Halogen Lamps

Comparison of 25 degree Narrow Flood MR-16 Lamps

50 watt	37 Watt IR	20 Watt IR
3050K	3050K	3050 K
6000 hours	5000 hours	5000 hours
2900 *CBCP	4400 *CBCP	2300 *CBCP



*CBCP (Center Beam Candle Power) is the standard measurement for brightness of a point source.

Energy Saving Halogen Lamps

Comparison of 25 degree Narrow Flood Par-38

100 watt	70 watt IR	55 watt IR Silver
2000 hours	3000 hours	4000 hours
5000 *CBCP	4700 *CBCP	4400 *CBCP



*CBCP (Center Beam Candle Power) is the standard measurement for brightness of a point source.

Low Voltage Incandescent



Fluorescent Lamps



How a lamp works

A Fluorescent lamp is a gas discharge lamp where illumination is provided predominantly by the phosphors activated by UV energy generated by Mercury vapor inside the tube. Mercury also acts to stabilize the color.

The inside surface of the tube is coated with fluorescent phosphors. When the proper voltage is applied, an arc is created. The UV radiation from that arc excites the phosphors and they become illuminated.



How a lamp works

A ballast is required for fluorescent lamps. The starting mode is called rapid start (programmed) or instant start.

Rapid start types give "immediate" starting with full brightness and tend to have longer life. Instant start provides instant brightness, but may shorten lamp life with frequent starts and short running cycles. That is why Rapid start is often used employed in toilet room applications.



How a lamp works

Compact fluorescent lamps are available in multiple shapes and sizes. Originally the 2-pin, single and double tube sizes and now the 4-pin double twin and triple tubes.

2-pin lamps were originally only available with magnetic ballasts, although now electronic ballasts do exist for them. 4-pin is the current standard with electronic ballasts. Only 4-pin ballasts can be dimmed.



Fluorescent Lamps

- Fluorescent lamps provide a softer quality of light.
- Higher lumen to watt ratio
- Color varies
- Lamp life is 10,000 to 60,000 hours
- Sources can be dimmed based on ballast selected.
- Dimmed source maintains color



Color

DESCRIBING LIGHT-SOURCE COLOR

The pictures are intended, within the limits of modern high-speed printing, to give a good indication of the differences between SP and SPX colors, at various color temperatures.

Note: Color Rendering Index (CRI) is approximately 90 for all lamps shown.

STANDARD COLOR AND HIGH EFFICIENCY	WARM WHITE (2700K)	COOL WHITE (4000K)	LITE WHITE (5000K)
	SP20 (T8)	SP25 (T8)	SP41 (T8)
GOOD COLOR AND HIGH EFFICIENCY	SP30 (T8)	SP41 (T8)	SP50 (T8)
VERY GOOD COLOR AND HIGH EFFICIENCY	SP47 (T8)	SP48 (T8)	SP50 (T8)
	3000K "WARM"	3500K	4000K "COOL"

Fluorescent Lamps



Fluorescent Lamps



Fluorescent Lamps and Ballasts

- Requires require a ballast to power the lamp.
- Magnetic Ballasts have been phased out and with that, so has the buzzing sound and flicker that has been associated with Fluorescent lighting.

Energy Independence and Security Act of 2007 (EISA)

- Amendments to EISA 2007 were passed last year that will effectively ban all 700 series T8 lamps and all T12's.



High Intensity Discharge (HID) Lamps

How a lamp works

High Intensity Discharge (HID) encompasses metal halide, high pressure sodium and mercury vapor.

They are the most efficacious source (highest lumen/watt ratio).

Normally designed with inner arc tube that is at a higher pressure than fluorescent.

Start-up time to full brightness is 2-15 minutes. Require a cool down time prior to restarting.

Many of these lamps have very specific operating positions and will be designated: Horizontal (HOR), Vertical (V) or Universal (U).



High Intensity Discharge

- Mercury Vapor, Metal Halide and High Pressure Sodium are the most commonly used HID lamp types.
- All three require a ballast to supply power to the lamp. Ballasts are available in both magnetic and electronic.
- HID lamps require a warm-up prior to reaching full output.



High Intensity Discharge

- Metal Halide- White Light with good color (used in interior and exterior)
- High Pressure Sodium- Orange light with high lumen/watt (used in roadway)
- Mercury Vapor- blue/green color most widely used to simulate moonlight in landscape lighting applications. Being phased out.

HID Lamps and Ballasts

Ballast Specifications

The difference in energy efficiency in a metal halide lamp ballast may be as great as a 30% difference between Magnetic and Electronic ballasts.

Since the ballast regulates the power to the lamp, performance is key! You can decrease your lumen output by selecting the wrong ballast. This can be critical in site lighting applications where safety may be an issue.

Energy Independence and Security Act of 2007 (EISA)

- Older style magnetic ballasts will effectively be banned. All ballasts will now be required to be Pulse start technology.

High Intensity Discharge



Before image illuminated with Mercury Vapor Downlights

Incandescent



After image illuminated with Halogen Incandescent

High Intensity Discharge



Ceramic Metal Halide

High Intensity Discharge



Ceramic Metal Halide

High Intensity Discharge



Metal Halide

High Intensity Discharge



Ceramic Metal Halide
on Façade with High
Pressure Sodium
Streetlights

Solid State Lighting LED



LED

LED's are a completely different type of source.

- They are solid state and contain no gases within the bulb.
- Color is based on the type of conducting materials used.
- Very high Lumen to Watt Ratio of bare LED sources
- Very Long Lamp life.
- Generate very little heat from the front.
- They operate on DC Voltages



LED

Basic questions to ask when considering LED's

1. Is the product UL listed?
2. Has the product been tested using LM79 or LM80 standards?
3. What is the color temperature?
4. What is the binning?
5. What is the CRI?
6. What is the life?
7. What is the replacement method?
8. Is the Driver integral?
9. Is it Dimmable (and how)?



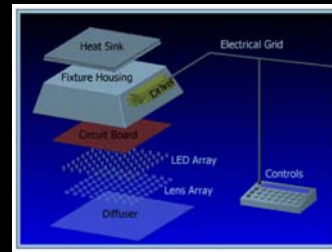
LED

Retro-fit lamps don't always FIT!



LED

Anatomy of a complete LED luminaire



LED



LED in Application

The Pentagon is installing 4200 recessed LED 2x2 luminaires. States it is a 22% Energy Savings.



Parabolic Troffer



LED Troffer

LED in Application

An additional concern with LED is the color. The "bluer" the color appears (higher color temp), the higher lumen package can be claimed.



Photo shows 5700K.

Recommended Practices and Footcandle Levels

What is a footcandle and why do we care?

Footcandle is a term that references the illuminance measured in lumens per square foot. Illuminance is the light falling onto the surface taking into account throw distance and surface reflectances.



What is a footcandle and why do we care?

The IESNA has published recommended footcandle levels for almost every space and task- inside and outside.

Levels are measured both horizontally and vertically.

Typical Footcandle levels

Lobbies	30 fc
Conference Rooms and Classrooms	50 fc
Corridors and Hallways	5-20 fc
Food Service Prep	50 fc
Parking Lots	1-5 fc
Building Façade	5-10 fc

Color

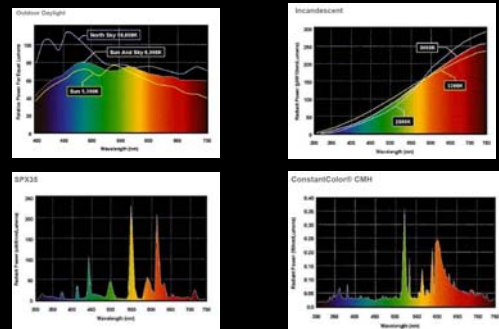
Color

The Visible Spectrum is made up of different colors of light with specific wavelengths.

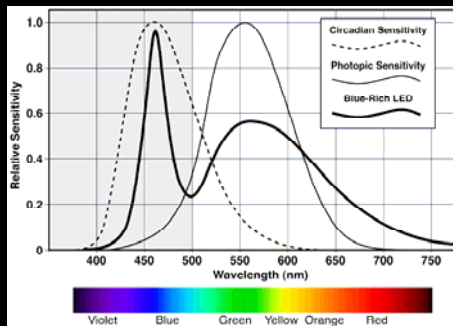
Our eyes respond differently to the wavelengths under different lighting conditions.

The Visible Light Spectrum					
Red	Orange	Yellow	Green	Blue	Violet
780 nm- 620 nm	620 nm- 597 nm	597 nm- 577 nm	577 nm- 492 nm	492 nm- 455 nm	455 nm- 390 nm
Long λ Low f			Short λ High f		

Color



Color



Color

- Our eyes are made up of a system of Rods and Cones which are stimulated differently by different levels of light and colors.
- When it is dark, our sensitivity shifts to the rods (scotopic vision) which pick up the shorter blue/green wavelengths better.
- When there is an abundance of light, our rods and cones work together to pick up all the colors of the visible spectrum.

Color

- Spectrally Enhanced Lighting
 - New photoreceptors have been recognized in the peripheral part of the eye.
 - They are more sensitive to blue light in the spectrum.
 - When they encounter blue light, the pupil gets smaller and visual acuity increases

Spectrally Enhanced Lighting

- Research has been documented on several projects that changing from a 3500k to a 5000k lamp can result in a 24% energy savings by reducing wattage.
- Studies showed no occupant discomfort with lower light levels with higher blue tones.
- Companies that participated in the study now exclusively using SEL are:
 - PG&E, Cities of San Diego and Oakland, Counties of Napa and San Mateo

Color

Research has demonstrated that the eye perceives white light as brighter than orange light



High Pressure Sodium vs. Fluorescent

Color

Why and where do we still use High Pressure Sodium?

1. In Roadway lighting. It has the longest lamp life of the metal halides.
2. In site lighting applications. It creates less light trespass and is often used near observatories



Color

- Why do Surgeons prefer green light in surgical suites?



Lighting Quality

What is Lighting Quality?

The ability of the visual environment to meet human needs.

Why is Lighting Quality Important?

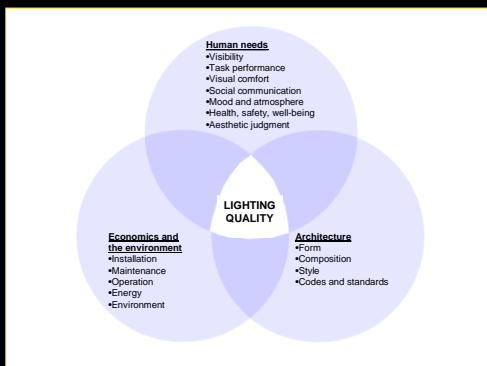
GOOD LIGHTING

- Supports visual performance
- Enhances interpersonal communication
- Improves comfort

POOR LIGHTING

- Inhibits visual performance
- Can create a confusing visual environment
- Can be uncomfortable

How do we define Lighting Quality



IESNA Lighting Design Guide 21 Design Issues

- Appearance of Space & Luminaires
- Color Appearance
- Daylighting Integration & Control
- Direct Glare
- Flicker (& Strobe)
- Illuminance (Horizontal & Vertical)
- Intrinsic Material Characteristics
- Light Distribution on Room Surfaces
- Light Distribution on Task Plane
- Light Pollution/Trespass
- Luminaire Noise
- Luminances of Room Surfaces
- Modeling of Faces or Objects
- Peripheral Detection
- Points of Interest
- Reflected Glare
- Shadows
- Source/Task/ Eye/Geometry
- Sparkle
- Surface Characteristics
- System Control & Flexibility

IESNA *Lighting Handbook*, 9th Edition, © 2000
Chapter 10 – Lighting Design Guide
Chapter 18 – Residential Lighting

Case Studies

Lighting for Architecture



Lighting for Architecture

Integration with the Architecture conveys meaning and contributes to the observers overall understanding of the space.



Accent Lighting



Accent Lighting



Accent Lighting



Accent Lighting



Accent Lighting



Lighting Control



Lighting Control



Lighting Control



Zoning



Source and Color Mixing



Color Temperature



Color Temperature



Color Temperature



Reflectance



Photo courtesy of GE Lighting

Lighting for Architecture Points to consider

- Color of space and reflectance levels
- Varied use of space for zoning and lighting control design
- How does the light integrate with the architecture, millwork and furniture. Turn on the millwork layers and review the interior elevations.
- How can the lighting add or alter the space, for the better. Always remember- everyone can spot BAD LIGHTING. Good Lighting is rarely commented on, the architecture is instead.

Topics covered

Sources- Understand when to use what type and why.

Recommended Practice Footcandle Levels- Understand what you need to provide as a base minimum and build on that.

Color- Understand the use of color and consider it.

Lighting Quality-How can we improve the quality, light for the space, and the occupants

Thank you for your time!

This concludes the AIA portion of the presentation.

Any questions?



Lighting 101

Fundamentals of Lighting for Interior Designers and Architects

NeoCon June 15, 2011

Presented by: Ardra Zinkon, Tec Inc, Engineering & Design