

What is Glare, When is it Harmful, and How to Control It.....



GLARE MATTERS

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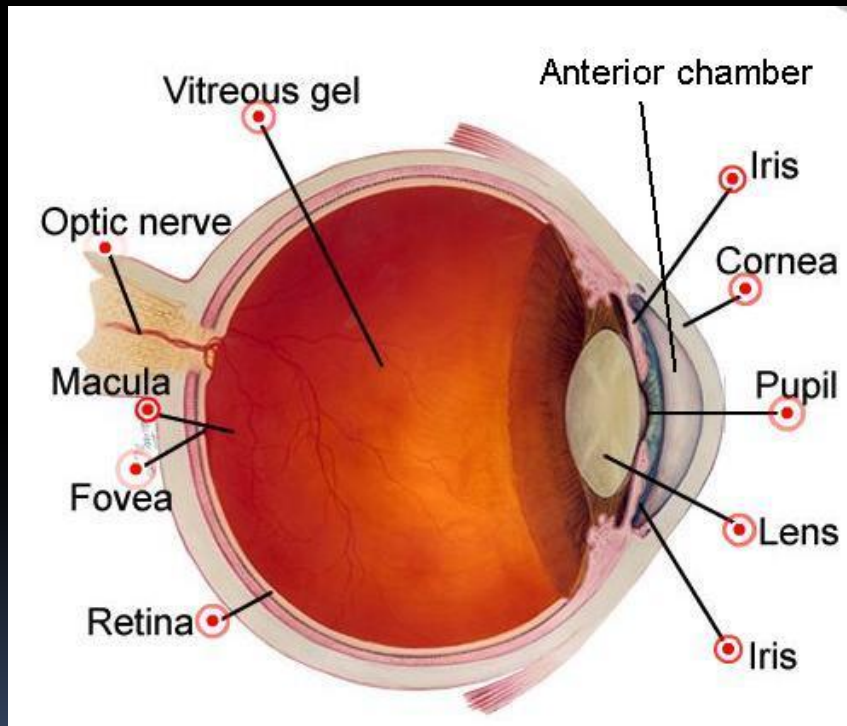
Contents

- What Constitutes Glare?
- How do Ambient Lighting Conditions affect our Glare Perception?
- How do you know if a luminaire or lamp will be perceived as having unacceptable glare?
- Methods for Controlling Glare from Electric Light Sources
- Dimming Light Sources to Reduce Glare

Definition

- Glare, *def. RPI Lighting Research Center*. Glare is a visual sensation caused by excessive and uncontrolled brightness.
- It can be disabling or simply uncomfortable.
- It is subjective, and varies widely
- Characteristics of the Aging Eye give older individuals more problems with glare.

Glare and the Aging Eye



- Changes in the eye as we age (50+) include:
 - Intraocular light scattering
 - Loss of visual contrast
 - Glare sensitivity
 - Blinking or Squinting
 - Fatigue
 - Photostress recovery time
 - Narrowing field of vision

Types of Glare

- Discomfort Glare: The sensation of annoyance and even pain caused by overly bright sources. (Rea, 2000)
- Disability Glare: Reduction in visibility caused by intense light sources in the field of view.



Photo credit- Lighting Research Center, and Lumec

Disability Glare in Night Driving



“Visual skills are pushed to their limit at night by decreased illumination and by disabling glare from oncoming headlights.” British Journal of Ophthalmology

Disability Glare Types

- Dazzle- Intense, small glare source directed toward viewer
 - Poorly Aimed Outdoor flood lights
 - Oncoming vehicle headlights
 - Stage lights
- Scotomatic- photostress
 - Flash photography leaves afterimages

Transient sources of glare are worse than static sources



Disability Glare types

- Veiling – Bright uniform & diffuse light source reduces visual contrast
 - Reading in bright sunlight
 - Seeing an object between two brightly lit windows



Daylighting is a Source of Glare

- Luminance: Range of visual tolerance
 - ▣ Sun on Clear Day Noon
1,600,000,000 cd/m²
 - ▣ 10,000+ fc



Illuminance (fc) of:

- Starlight 0.0002 fc
- Full Moon 0.025 fc
- Overcast Sunrise/set 4 fc
- Clear Sky Sunrise/set 40 fc
- Overcast Noon Sky 200 fc
- Clear Sky in Shade 2000 fc
- Clear Sky Noon 10,000 fc

Discomfort Glare: Annoying but not Disabling

- Too much Light
- Size of the Glare source
- Position of the source in the Field of View
- Excessive Contrast compared to background luminance



Discomfort Glare: Counterproductive and sometimes harmful in the Workplace

- Loss of Productivity
- Headaches
- Loss of Work Time



Too much light- direct or reflected causes eye strain

Discomfort Glare and Visual Contrast

- The eye can adapt to a wide range of Luminance (Brightness), but not at the same time!



Best office lighting has relatively low contrast with good task brightness.

When is Glare Desirable?

- Entertainment Ltg
- Retail and attractions where lighting is part of the act

What is the difference between sparkle and glare?



Difference: Glare vs Light Trespass

- Light trespass is about light projected where it is not wanted
 - Measured in footcandles
- Glare is about the intensity of the light source directed toward an observers eye

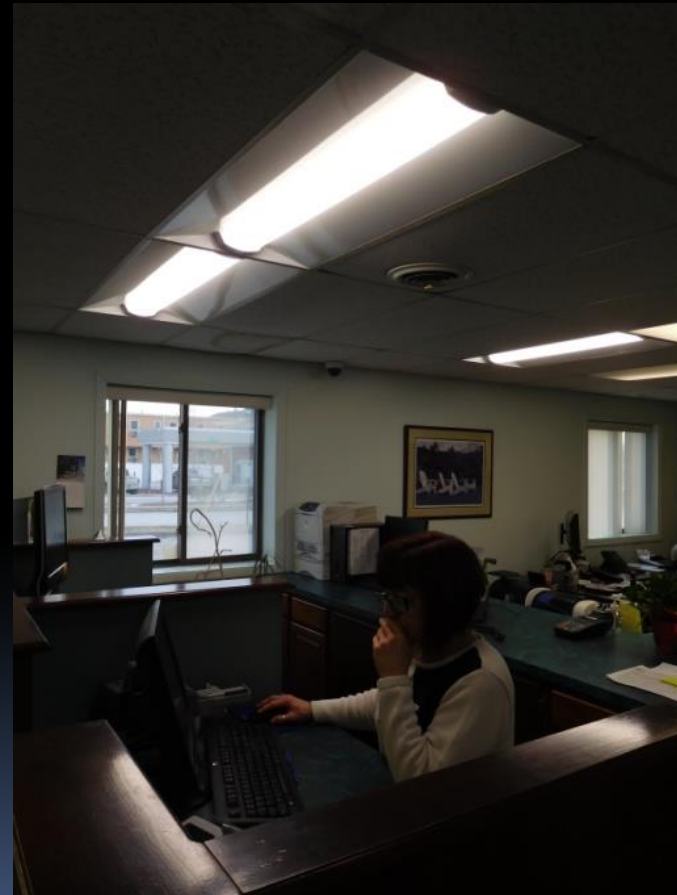


Glare Control and Prevention is Good Lighting Practice

- Adaptation to Average Scene Luminance composed of:
 - Task Luminance
 - Self Illuminated Tasks
 - Task Reflectance
 - Background Luminance
 - Light Source Luminance
 - Light Patterns
 - Light Gradients
- Ranges from
 - 0.001 fc – starlight
 - 10,000 fc- sunny day
- The eye can only adapt to part of this range at a time.
 - Abrupt changes cause temporary glare until eye adapts.

Practical guideline

- Glare is typical when unshielded light is >1000 times brighter than average visual field.
 - Night conditions
 - Office
 - Retail
- Candela meter to measure candelas/m²
- Digital camera auto adjusts to average Lum.



Practical Measurement of Glare

- In retrofit- compare with existing sources



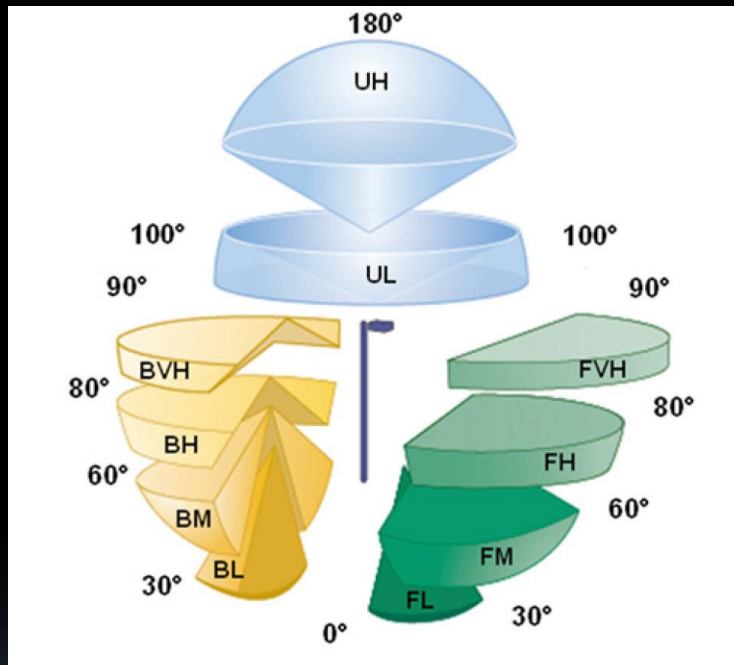
- Looking at a luminaire on a table is not the same as viewing it in place.

Why Exterior Glare is a Problem

- Can't Balance Outdoor Luminance
- Light Emitting Diodes are point sources
 - Very high lumen output from a small source
 - Continued gains in efficacy (lumens/watt)
 - Mfrs cutting fixture costs by using fewer, higher output LEDs



Understanding Glare from Data



International Dark Sky Association
and Illuminating Engineering
Society of North America

- IESNA TM-15-07
Rating of Outdoor
Luminaires
- B-U-G Rating
 - Backlight – relates to
light trespass
 - Uplight- relates to sky
glow, unusable light
 - Glare- in the 60-90°
range of lumen output

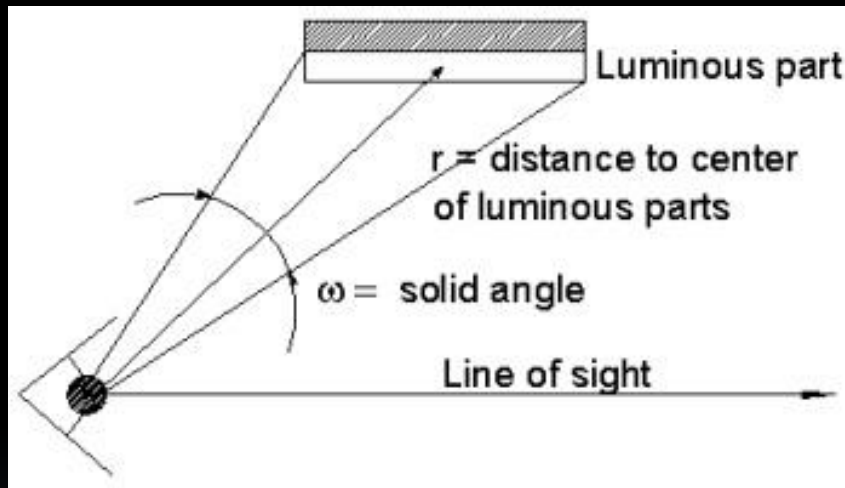
Outdoor Glare Measurements

- CIE doc#112-1994, Glare Rating (GR)- calculated for outdoor lighting from one observer position
 - Based on Veiling luminance summed across luminaires, and the angle of sight vs direction of lighting.
 - Resulting scale 10 to 90
 - 90+ is unbearable
 - Function in lighting software
- LRC, Discomfort Glare (DG)- empirical model rated by subjects on a DeBoer scale
 - Glare strongly related to illuminance for smaller outdoor light sources.
 - Based on source illuminance, source luminance, and surrounding and ambient illuminance.
 - 1 is unbearable, 9 is best.

Measuring Interior Glare

- UCR- Uniform Glare Rating (CIE Publication #117-1995) an index ranked on a scale 5 to 40.
- UCR is included in major lgtg software
- Includes:
 - Background luminance
 - Luminaire luminance (sum of all)
 - Angle of the source from viewer's position
 - Viewer's Position Index

Uniform Glare Rating



$$UGR = 8 \log \left[\frac{0.25}{L_b} * \sum \frac{L^2 \omega}{\rho^2} \right]$$

UGR	Discomfort Glare Criterion
10	Imperceptible
13	Just perceptible
16	Perceptible
19	Just acceptable
22	Just uncomfortable
25	Uncomfortable
28	Unacceptable

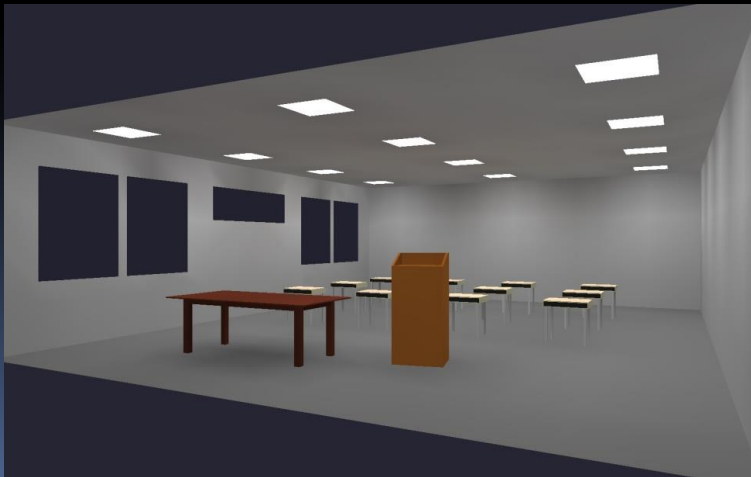
Room Simulation of UGR



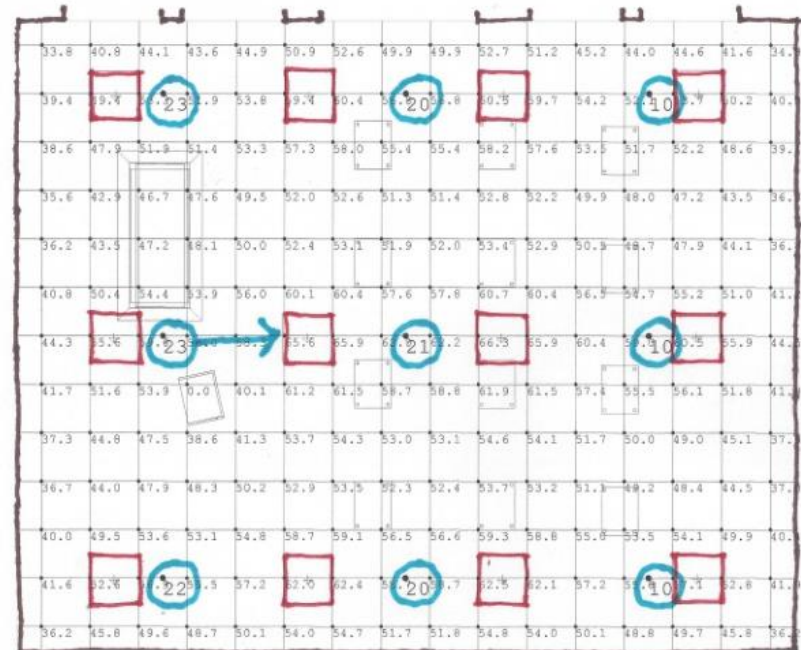
Simulation:

1. 85/40/20 reflectance and full output 4688 lumen LED direct/indirect at 49w, Avg fc = 52

UGR Range 23 to 10, Avg 18



Area = 832.00 Sq.ft
Total Watts = 590.4001
Lighting Power Density = 0.710 Watts/Sq.ft



Hallway Simulation of UGR



Simulation:

1. 80/50/20 reflectance at 675 lumens, LED surface direct at 13w, Avg fc= 11

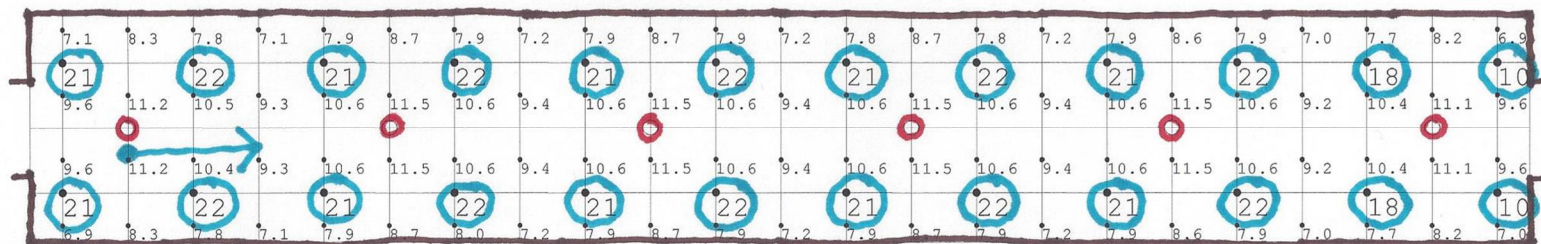


UGR Range 22 to 18

Area = 322.00 Sq.ft

Total Watts = 79.2

Lighting Power Density = 0.246 Watts/Sq.ft



3 Methods of Controlling Glare

1. Shield the light source from view
2. Enlarge and Diffuse the light source to reduce luminance
3. Balance room luminance
 - Dim the lamp/luminaire
 - Add daylight
 - Lighten walls, floors, ceilings



1. Shielding the Light Source

- Light “spillage” is a property of a luminaire design.
 - ▣ Shades, reflectors, louvers, or refractive lensing project light in a controlled direction
 - ▣ Reduces glare when viewed outside projected area



Where Shielding is Most Needed

- Retail lighting
 - Glare distracts from product display
- Work environments
 - Long hours under glarey lights can cause eye strain and headaches
- Health Care
 - Healing space requires lighting designed for comfort



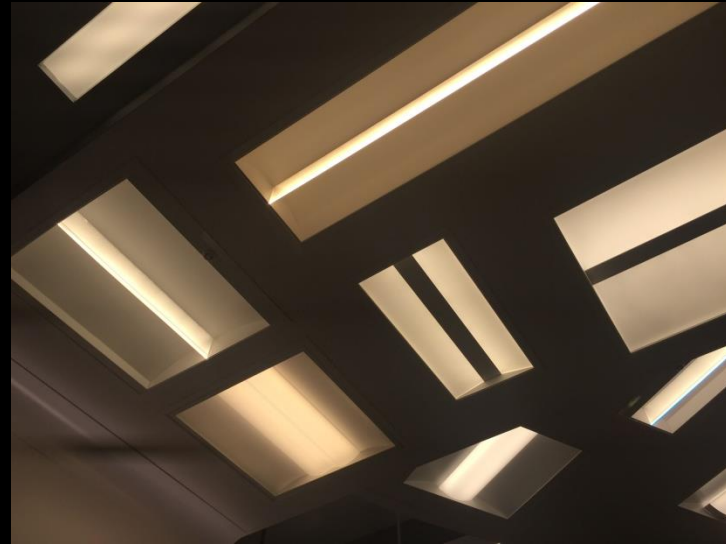
Shielding of Outdoor Light Sources

“Cutoff” Shielding and High angle brightness control are critical for outdoor luminaires. Parking garage lgt should also illuminate ceiling surface.



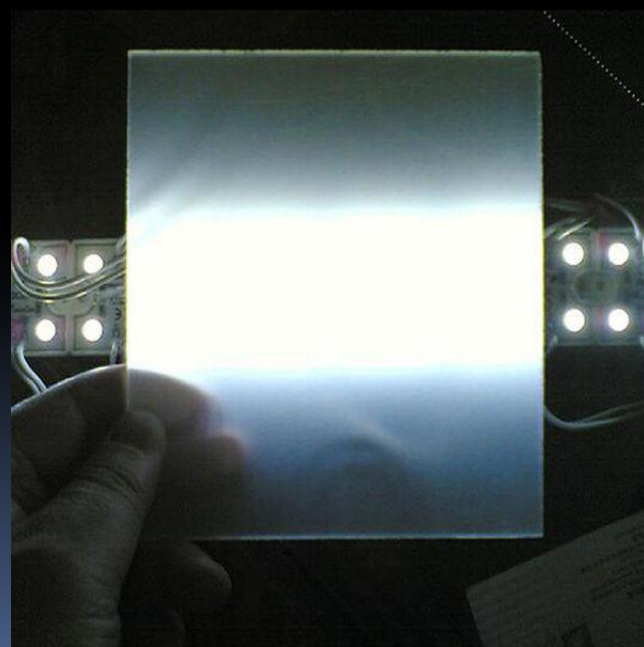
2. Diffuse the Light Source

- Particularly important with directional LED light source
- Improved lens options diffuse appearance of individual diodes
- Size and brightness of luminous area in contrast to adjacent room surfaces (UGR)



Back Light and Edge Light Diffusion

- Lenses mounted to individual LED package
- Acrylic laminate sheet diffusers typical of LED backlight applications
- Proprietary materials refract LED edge light



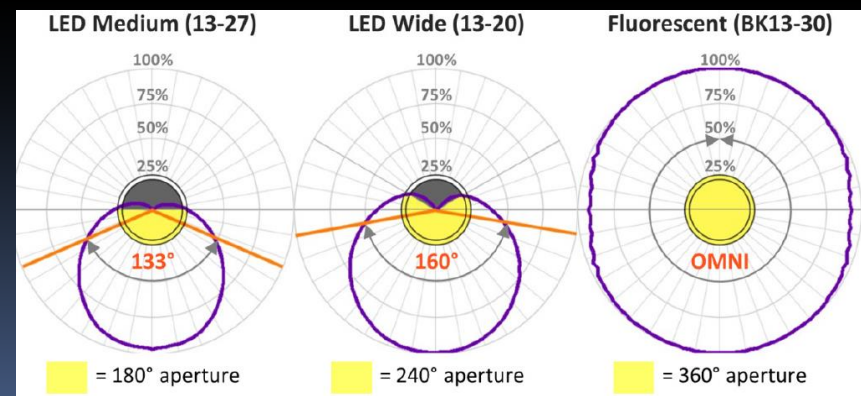
When Choosing LED Troffer Options

- LED Luminaires (HiE)

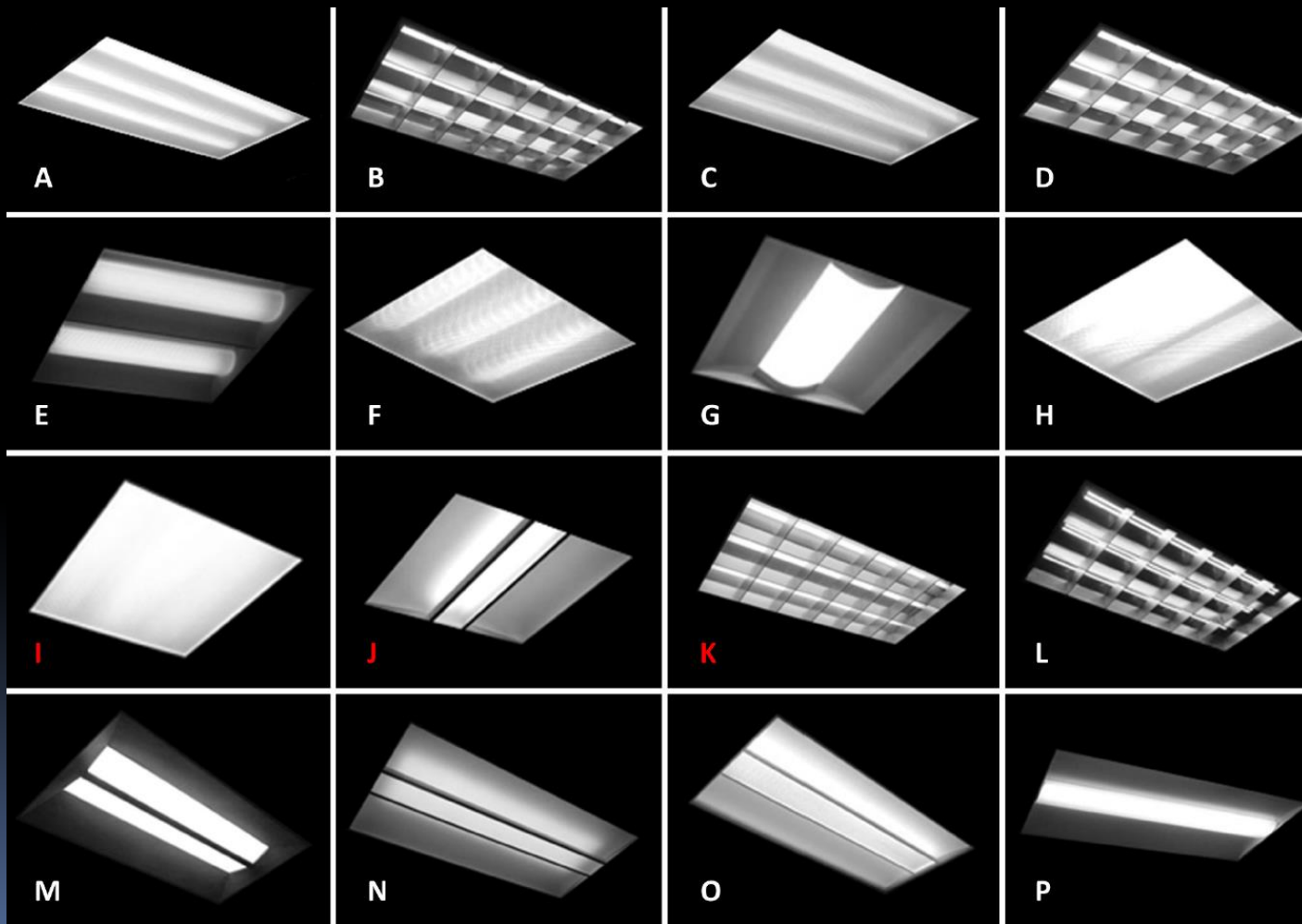
- Indirect Relationship of Cost and Glare
- Avoid pixelation
- A Larger illuminated surface area is better
- Lower surface luminance is better
- Reduce contrast with ceiling for best results

- LEDT8 Lamps

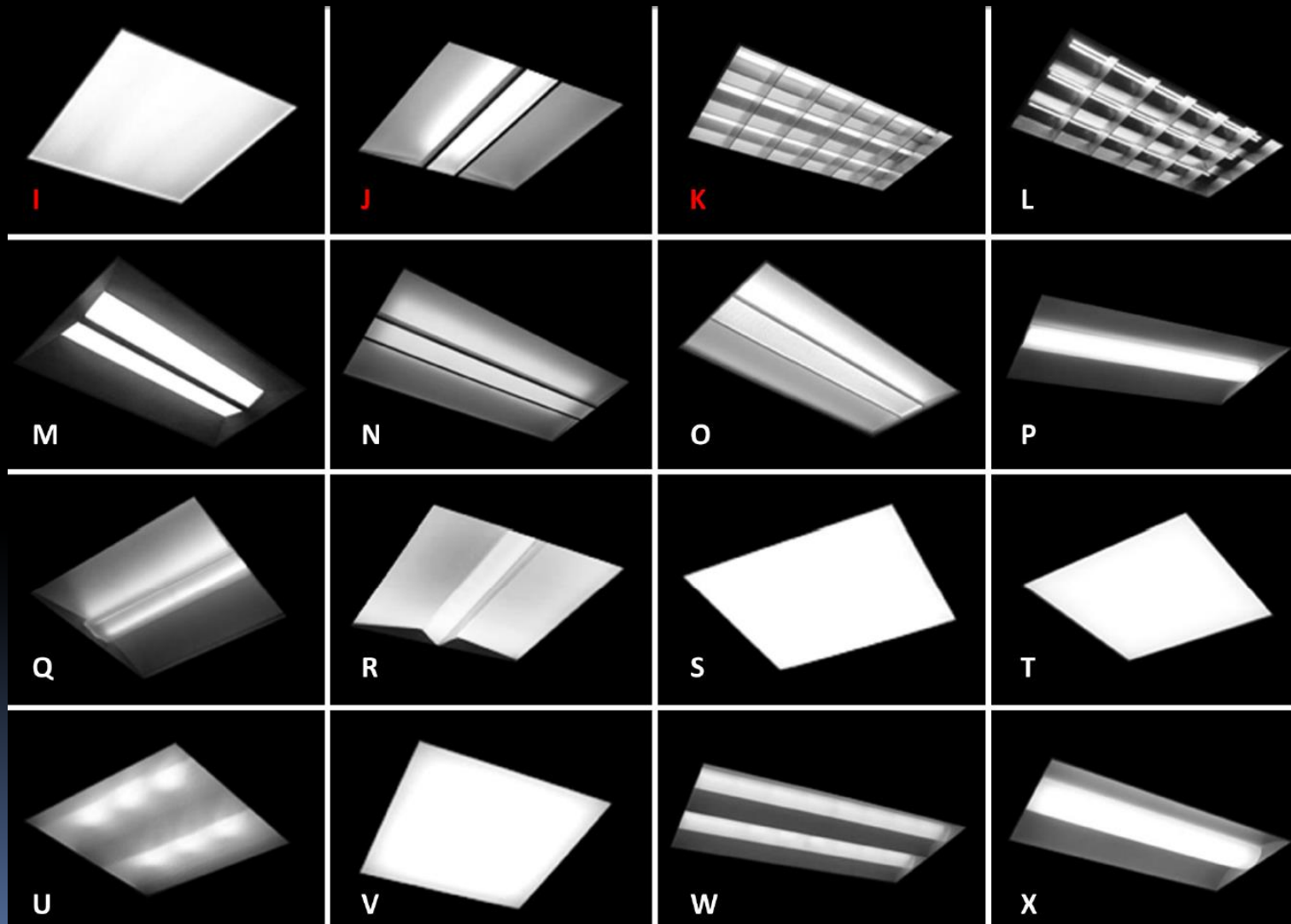
- Best with open luminaires
- Always test luminaire application with existing ballasts (UL approval)



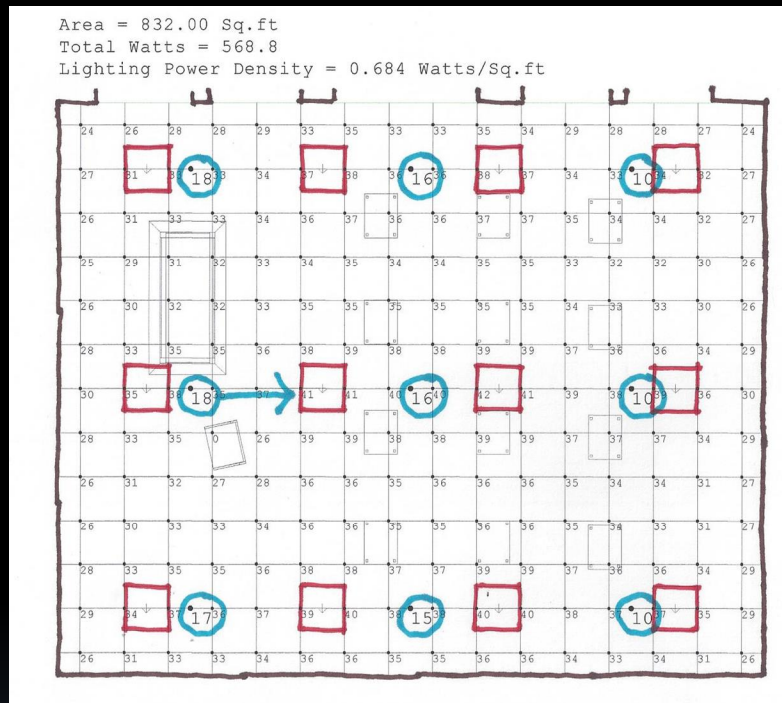
Comparing Shielding and Diffusion in Fluorescent & LED Luminaires



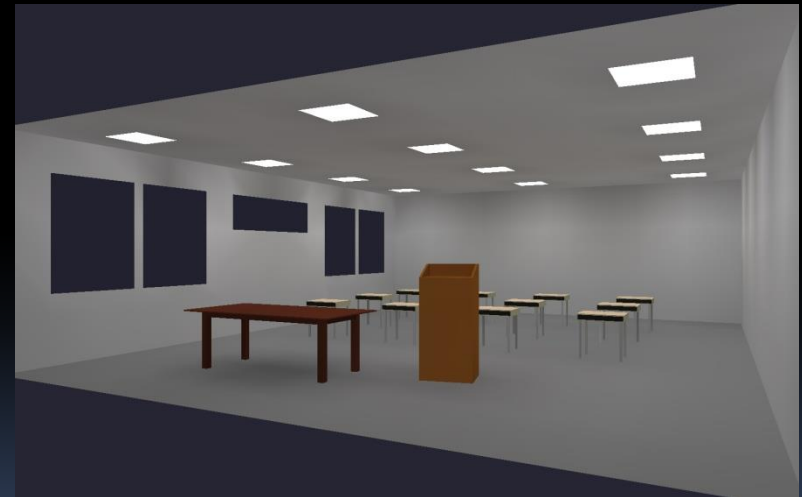
Comparing Fluorescent and LED Fixtures



Control Luminaire Brightness



- Edge Light LED Troffer reduces surface brightness and UGR



Simulation:

2. 90/60/30 reflectance and full output 4452 lumen LED surface edgelit luminaire at 47w, Avg fc = 34
UGR Range 18 to 10, Avg 14 (just perceptible)

3. Balance Room Luminance

- High reflectance, matt finish walls, ceiling, floors
- Control light source surface luminance
- Reduce contrast with additional light source
- Controlled use of daylight



Controlling Luminance

- For office work in particular- Balance Room Surface Luminance with Task Luminance.
- If computer screen luminance is 100 cd/m^2 then the brightest surface should be $< 1000 \text{ cd/m}^2$ and the darkest $> 10 \text{ cd/m}^2$.



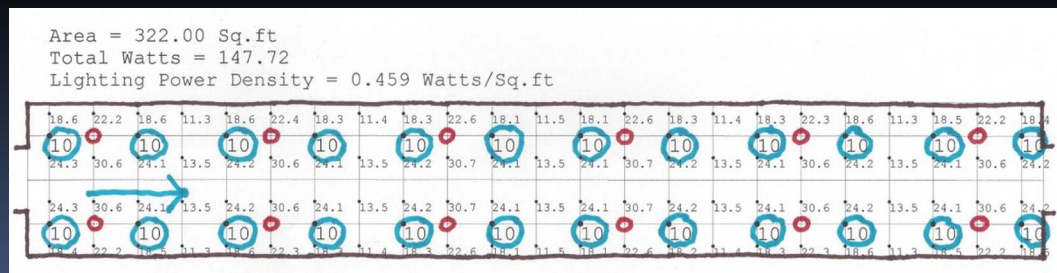
Control Luminaire Brightness and Increase Wall Luminance



- True recessed LED downlight conceals light source, uses low glare reflector
- Moving fixtures closer to wall increases wall luminance

Simulation:

80/50/20 reflectance with 685 lumens @ 12w each, UGR of 10 (imperceptible glare)



3c. Controlling Luminance by Dimming

- Besides controlling glare, why dim?
 - Maximize energy saved
 - Extend system life
 - Enhance flexibility
 - Increase productivity
 - Enhance ambience
 - Provide comfort



Dimming: LED lamps or LED fixtures?

- Lamp Dimming
 - If options are limited to LED lamps, control options will also be limited.
 - Screw Base Lamp base contains an integral driver
 - Size of components and costs pose limits
 - Most designed for typical incandescent dimmers
 - Most work better on dimmers designed for LED



What type of Control or Control System can be used with LED Lamps?

- For Single Room and Retrofit Applications
 - Reverse Phase PWM
 - Forward Phase PWM
 - 0-10v Wired or Wireless
- Wifi Controls
 - Control of individual lamps



What is the Dimming Range?

- Dimming range is based on the driver



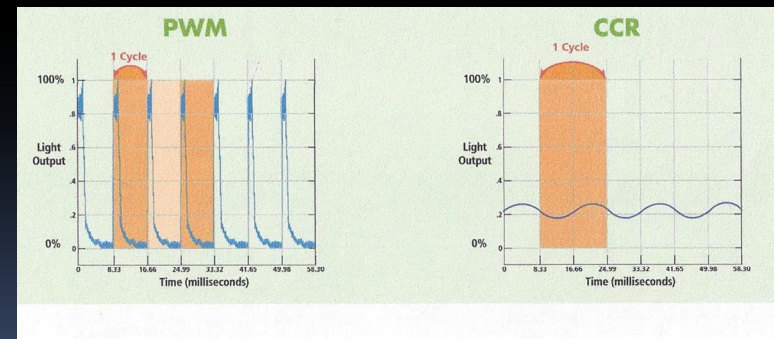
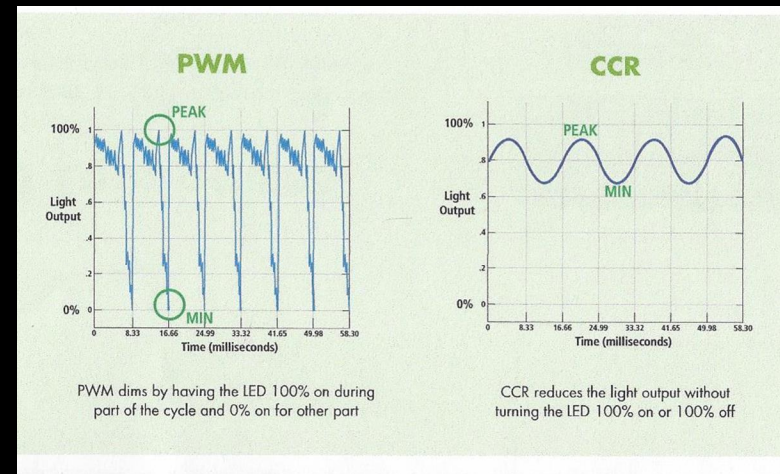
- Example: For a conference room, 5% dimming or lower may be required.
- Solution: Specify fixtures with drivers that dim to 5% (1% available), and a compatible dimmer with low end setpoint.

What is the Dimming Performance?

- Dimming performance is mainly a function of the driver, although a compatible controller is needed to realize flicker-free, smooth and continuous dimming.
- Driver Types
 - Pulse Width Modulation
 - Rapid on/off switching of the current to the LED's
 - Flicker can be an issue when dimmed to low level
 - Constant Current Reduction
 - Reduces the amount of current delivered without turning it on/off.
 - Best dimming

Factors Determining Flicker in Dimming

1. Peak light output vs minimum light output in a cycle
2. Difference between Peak and Minimum light output
3. Shape of the light output in a cycle
4. Frequency



How many LED Lamps can be Connected to One Dimmer?

- LED lamps often have a high startup inrush current
 - A 15w rated LED lamp may have the inrush current equivalent to a 60w incandescent lamp.
 - (1) 600w dimmer can dim only (10) 15w lamps.
 - (1) 600w dimmer per (30) 5w candelabra base.



How would you dim this when using LED candelabra lamps?

Is there a Minimum Load Required by a LV Transformer or Dimmer?



- If a dimmer requires 25w minimum load, you may need 4 or 5 LED lamps to meet it
- Low voltage halogen track heads often not compatible w/ LED

Better Options for LED Fixture Dimming

- Dimming luminaires with LED drivers
 - Dimming is a function of the type of power supply
 - Not all LED drivers are dimmable
 - Dimming Power supplies
 - Pulse Width Modulation (Phase Cut Dimming)
 - Constant Current Reduction
 - Control Method is separate and distinct from dimming type



Dimmer or Control System Options for Dimming LED Driver

LED drivers

- Low voltage dimming controls operated by
 - LV Dimming switch
 - LV Dimming Panel
 - LV Control network
- Digital drivers dim with digital addressable network controls



Dimming Driver



Low voltage dimmer switch

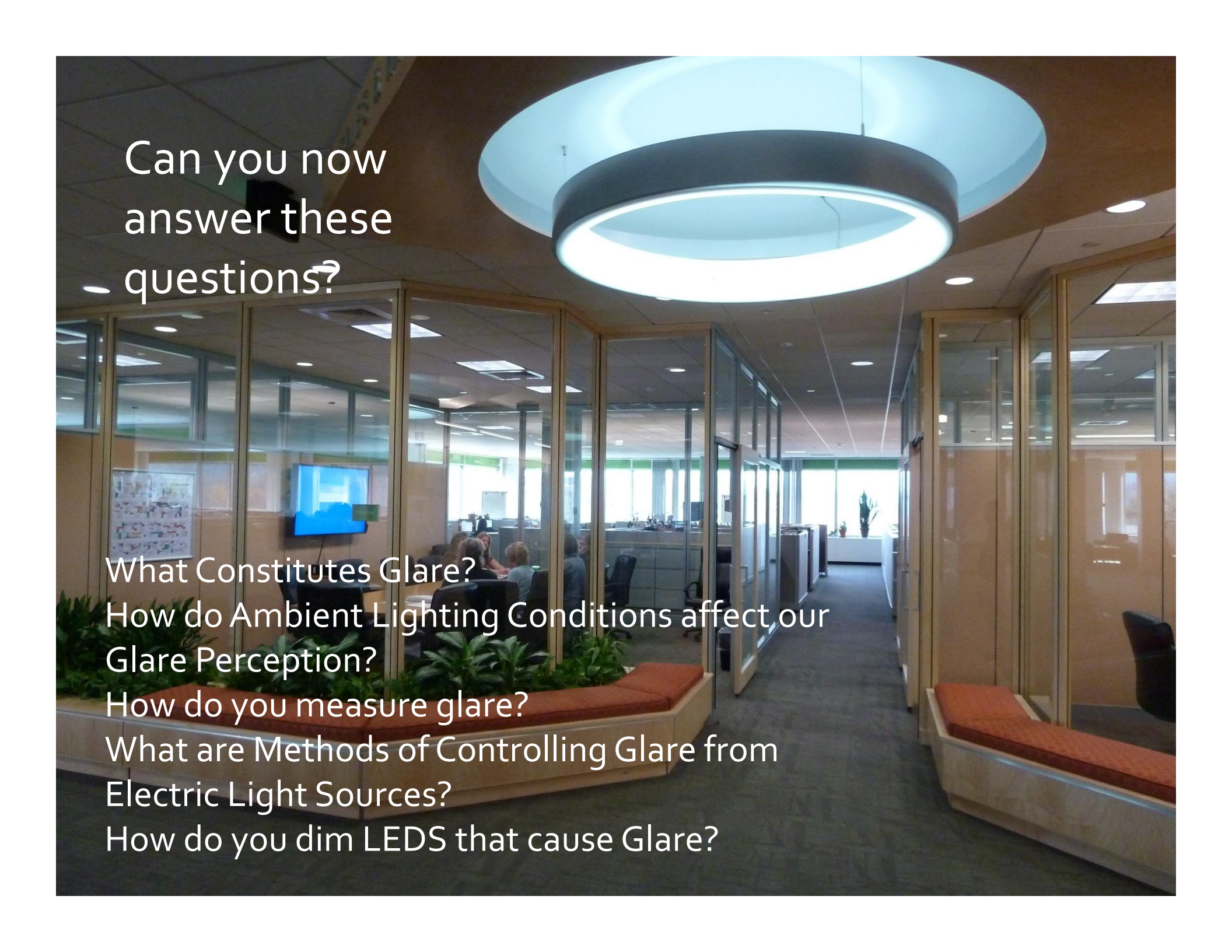


Wireless low-voltage controller

Recap: 3 Methods for Controlling Glare

1. Shield the light source from view
2. Enlarge and Diffuse the light source to reduce luminance
3. Balance room luminance
 - Dim the lamp/luminaire
 - Lighten walls, floors, ceilings



A photograph of a modern office interior. The space features glass-walled meeting rooms and open-plan areas. A large, circular, recessed ceiling light fixture with a glowing white ring is the central focus. In the foreground, there are low, curved wooden planters with orange cushions and green plants. In the background, people are visible working at desks. The overall atmosphere is bright and professional.

Can you now
answer these
questions?

What Constitutes Glare?

How do Ambient Lighting Conditions affect our
Glare Perception?

How do you measure glare?

What are Methods of Controlling Glare from
Electric Light Sources?

How do you dim LEDS that cause Glare?

Caliper ID	Tag	Product Type	Description	Size	Aperture Type
12-115	A	T8 LED Lamps ¹	Three Clean Light Green Light 342-SMD	2x4	K12 Lens
12-112	B	T8 LED Lamps ¹	Three Philips EnduraLED GA 22W	2x4	18 Cell Parabolic Louver
12-113	C	T8 LED Lamps ¹	Three Redbird L4-22W	2x4	K12 Lens
12-136	D	T8 LED Lamps ¹	Three Lumenor 17 W T8 LED lamps	2x4	18 Cell Parabolic Louver
12-107	E	LED Retrofit Kit	Acuity LE 2RTLEDRT	2x2	Partial Aperture Diffuser
12-106	F	LED Retrofit Kit	Albeo Technologies RK-V3D5-1U1	2x2	K12 Lens
12-109	G	LED Retrofit Kit	Envirobrite Dailite LED Restyle	2x2	Partial Aperture Diffuser
12-108	H	LED Retrofit Kit	LED Living Technology Claris CLA-34	2x2	K12 Lens
BK12-132	I	T8 Fluorescent	Two F32T8/SPX41/U6/WM/ECO lamps in Acuity Lithonia SP8 2x2 luminaire	2x2	K12 Lens
BK12-133	J	T8 Fluorescent	Two F17T8XL/SPX41WMEC lamps in Finelite HPR-A2x2DCO-3T8 luminaire	2x2	Diffuser with Linear Details
BK12-138	K	T8 Fluorescent	Three F28T8/XL/SPX41ECO lamps in Acuity Lithonia 2PM3N2x4-332-18LD luminaire	2x4	18 Cell Parabolic Louver
12-131	L	T8 LED Lamps ¹	Three prototype lamps with separate LED drivers	2x4	18 Cell Parabolic Louver
12-119	M	LED Troffer	Cree CR24-40L-40K 2x4	2x4	Partial Aperture Diffuser
12-120	N	LED Troffer	Finelite HPR-A-2x4-DCO-LED SO	2x4	Diffuser with Linear Details
12-117	O	LED Troffer	Philips Lightolier Skyway SKS24-PK	2x4	Diffuser with Linear Details
12-118	P	LED Troffer	Cooper Corelite R2WL1L40	2x4	Partial Aperture Diffuser
12-123	Q	LED Troffer	Columbia Serrano LSER22-40-HL-G-C	2x2	Partial Aperture Diffuser
12-124	R	LED Troffer	Philips Ledalite Pique 9122-1-ST-L	2x2	Diffuser with Linear Details
12-125	S	LED Troffer	GE Lumination LED 2x2 edge-lit	2x2	Uniform Diffuser Panel
12-126	T	LED Troffer	MaxLite Direct Lit MLFP-22-D-45	2x2	Uniform Diffuser Panel
12-127	U	LED Troffer	Ringdale ActiveLED OL2-5538-C	2x2	K12 Lens
12-128	V	LED Troffer	Lunera 22-G3	2x2	Uniform Diffuser Panel
12-116	W	LED Troffer	Columbia e-Poc LEPC 24-40-44-G-LL	2x4	Partial Aperture Diffuser
12-122	X	LED Troffer	Acuity Lithonia VT-LED 2VTL4-48L-ADP-D47	2x4	Partial Aperture Diffuser

1. Lamps installed in 3L troffer having aperture as shown.