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Trade Show and Conference

Designers Lighting Forum

The Challenges of Assessing Glare

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Learning Objectives

At the end of this course, participants will be able to:

1. Understand the definitions of discomfort and disability glare, and their impact on the comfort and safety of occupants.

2. Understand the use of BUG ratings,cut-off classifications and how cut-off angles and quiet optics reduce source visibility.

3. Understand the use of UGR to evaluate glare in context, and the importance of contrast with the surrounding surfaces to ensure visual comfort and safety for occupants.

4. Understand the limits imposed by far-field photometry in capturing glare from a non-uniform lensed luminaire, and discuss the best practice to evaluate glare with mockups to support the documentation.

My take on glare:

Shaun

How do we define glare?

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Shield Angle

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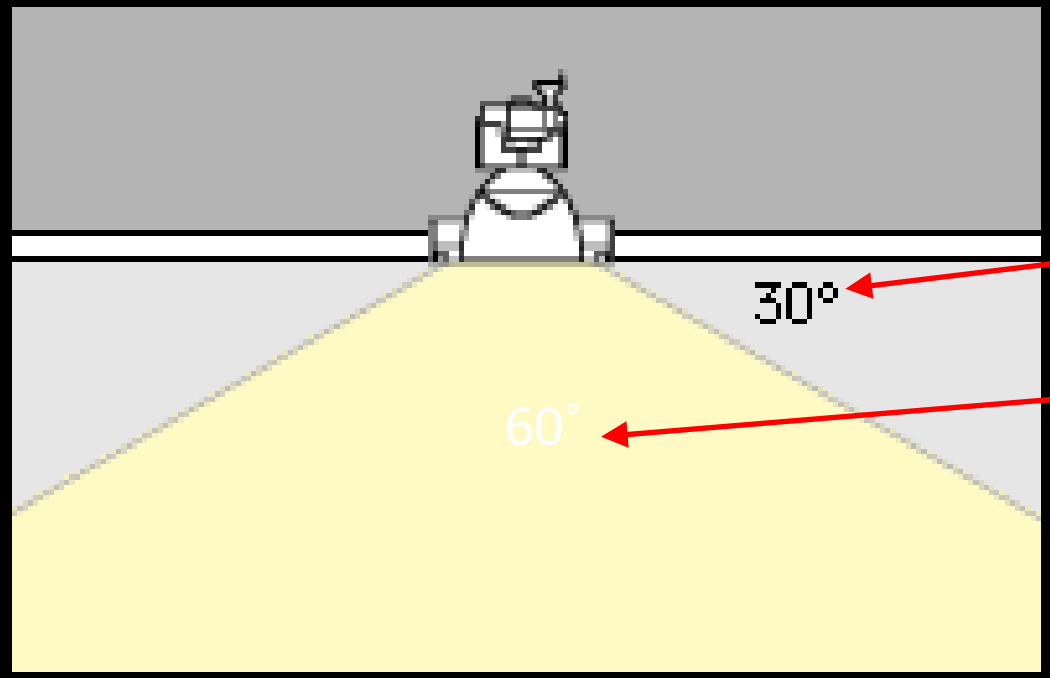
Distribution of Light

Cutoff angle – the angle measured up from nadir, between the vertical axis and the first line of sight at which the bare source is not visible.

Shielding angle – the angle between a horizontal line through the light center and the line of sight at which the bare source first becomes visible.



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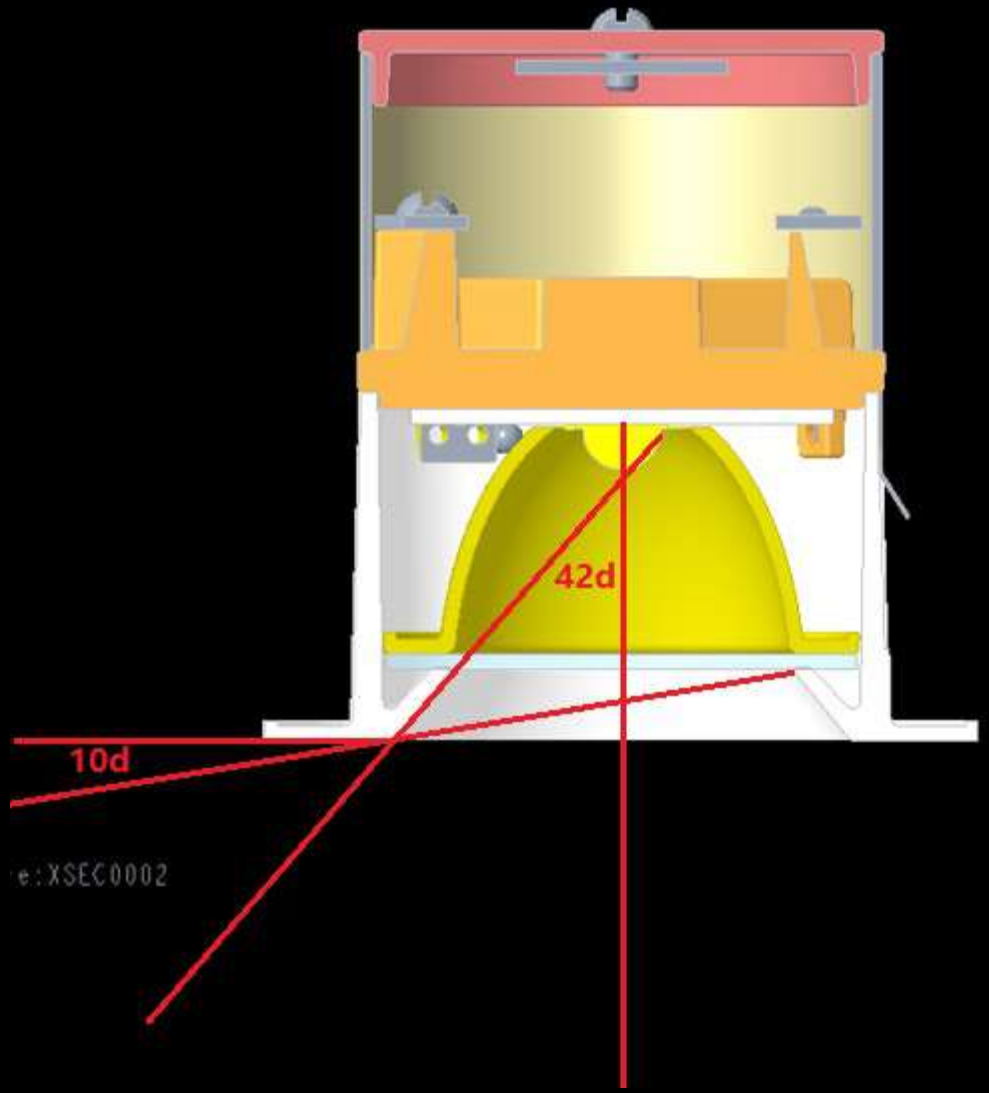
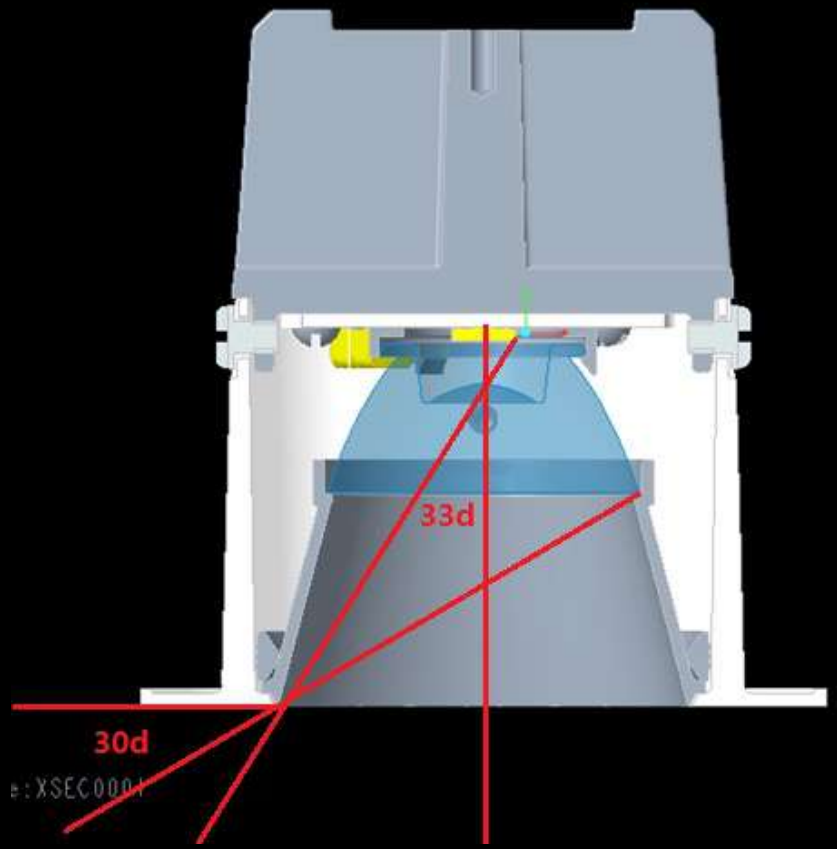
Luminaire A



Luminaire B



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Cutoff Classifications

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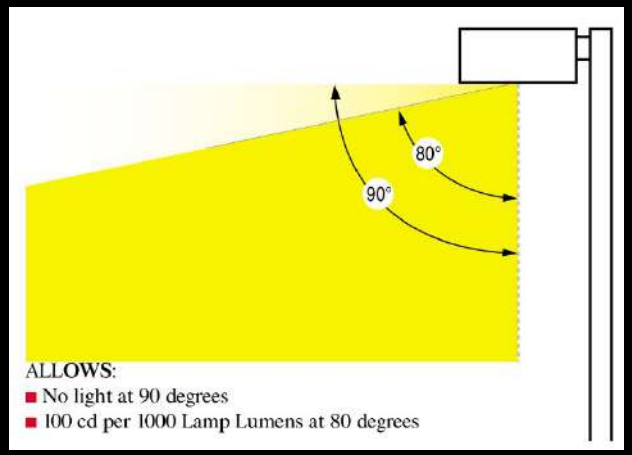
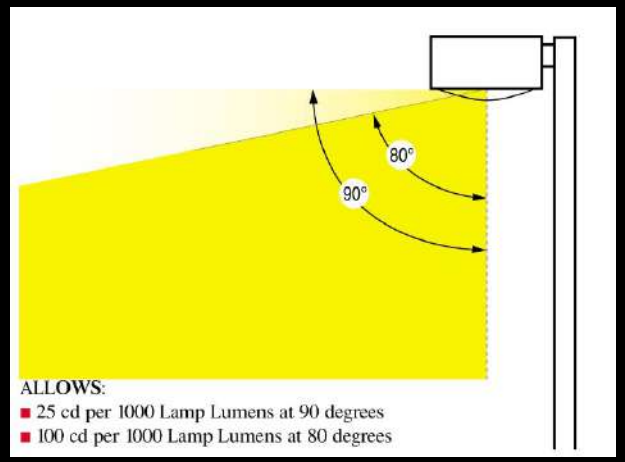
Distribution of Light

Exterior Lighting

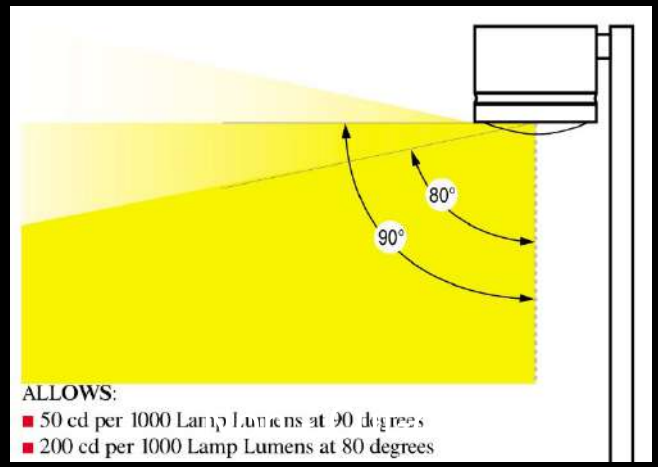
Full Cut-off



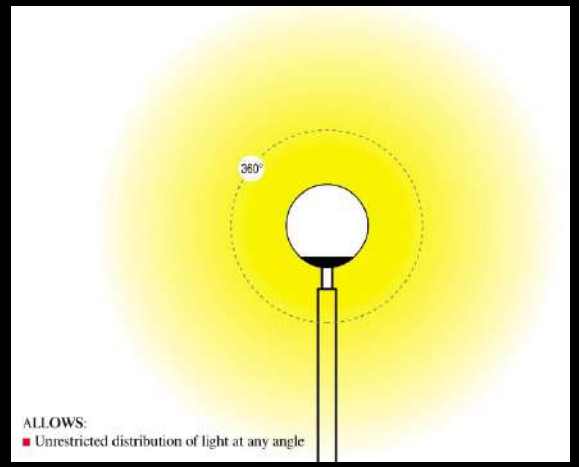
Cut-off



Semi-Cut-off



Non-Cut-off



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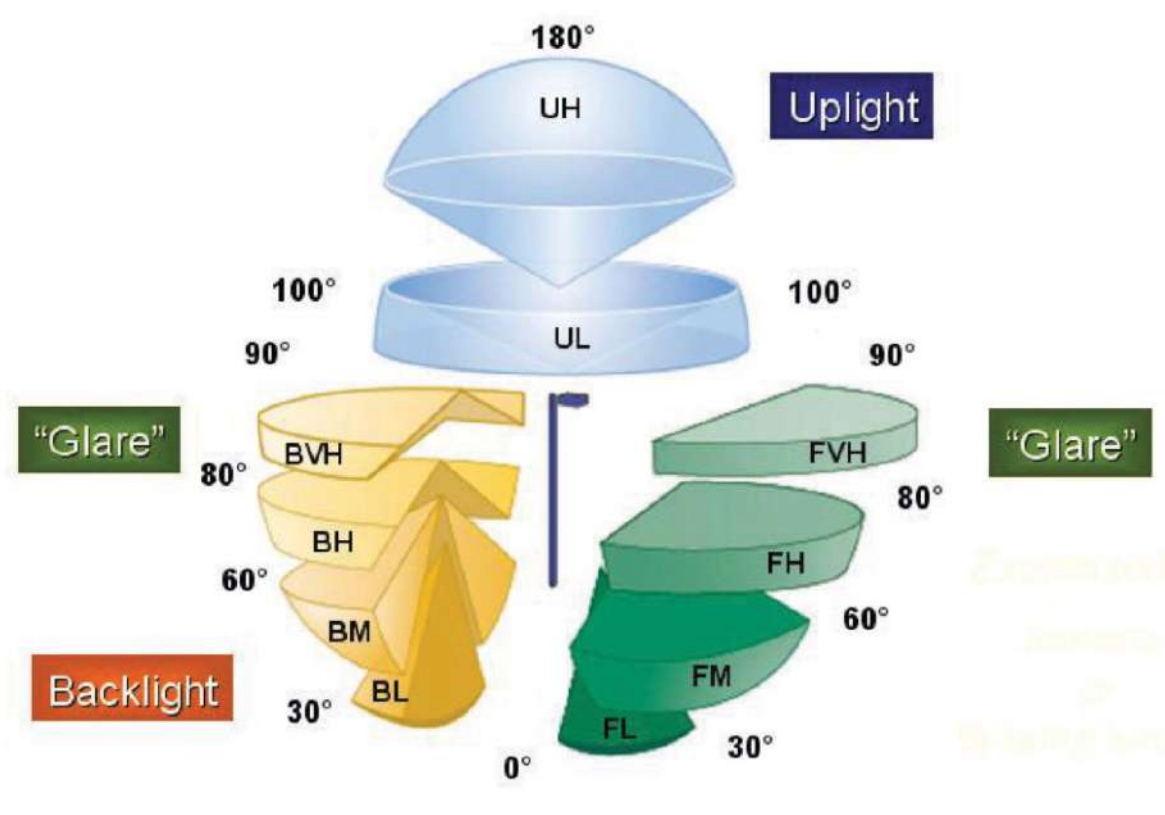
BUG Ratings

Distribution of Light

Exterior Lighting



Luminaire Classification System (LSC)

BACKLIGHT/TRESPASS						
SECONDARY SOLID ANGLE	B0	B1	B2	B3	B4	B5
BH	110	500	1000	2500	5000	>5000
BM	220	1000	2500	5000	8500	>8500
BL	110	500	1000	2500	5000	>5000

UPLIGHT/SKYGLOW						
SECONDARY SOLID ANGLE	U0	U1	U2	U3	U4	U5
UH	0	10	50	500	1000	>1000
UL	0	10	50	500	1000	>1000

GLARE							
	SECONDARY SOLID ANGLE	G0	G1	G2	G3	G4	G5
GLARE FOR TYPES I, II, III, IV, V and V SQUARE	FVH	10	100	225	500	750	>750
	BVH	10	100	225	500	750	>750
	FH	660	1800	5000	7500	12000	>12000
GLARE FOR TYPES I, II, III AND IV	BH	110	500	1000	2500	5000	>5000
GLARE FOR TYPES V AND V SQUARE	BH	660	1800	5000	7500	12000	>12000

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Unified Glare Rating

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Indoor Report: ARBAY2-160 DLF1906103-4a.ies

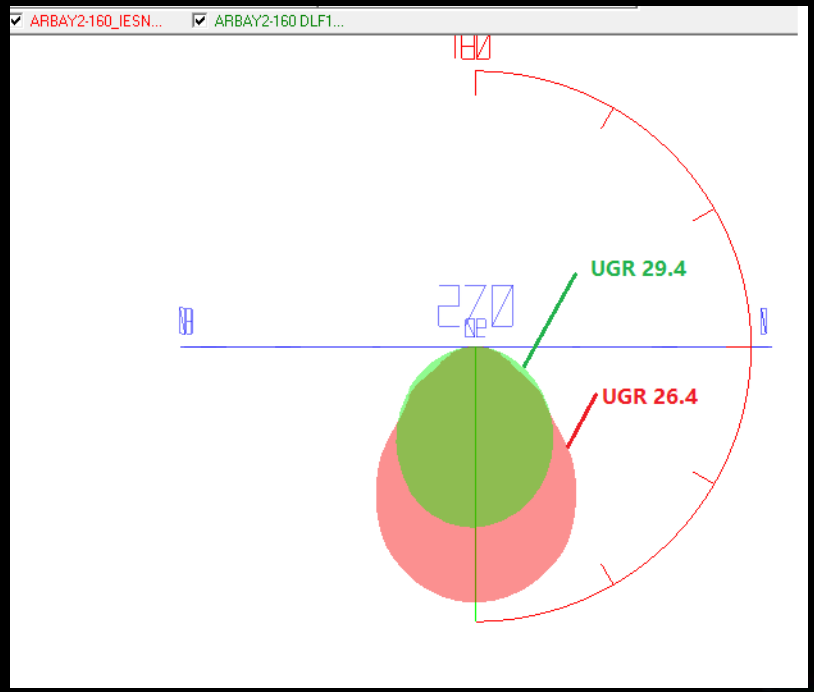
Summary | Candela Array | Zonal Lumens | CU Table | **UGR Table** | Pola

UGR Values: (•) Corrected (based on actual lumens) ( ) Uncorrected (normalized to 1000 lumens)

UGR Table - Corrected

Reflectances											
Ceiling Cavity		70	70	50	50	30	70	70	50	50	30
Walls		50	30	50	30	30	50	30	50	30	30
Floor Cavity		20	20	20	20	20	20	20	20	20	20
Room Size		UGR Viewed Crosswise					UGR Viewed Endwise				
X=2H	Y=2H	23.9	25.6	24.3	25.9	26.2	24.7	26.4	25.1	26.7	27.0
	3H	25.7	27.2	26.1	27.5	27.9	26.6	28.1	27.0	28.4	28.8
	4H	26.4	27.8	26.8	28.1	28.5	27.4	28.8	27.8	29.1	29.5
	6H	26.9	28.2	27.3	28.6	29.0	28.0	29.3	28.4	29.7	30.0
	8H	27.1	28.3	27.5	28.7	29.1	28.2	29.5	28.7	29.9	30.3
	12H	27.2	28.4	27.6	28.8	29.2	28.4	29.6	28.8	30.0	30.4
4H	2H	24.6	26.0	25.0	26.3	26.7	25.3	26.7	25.7	27.1	27.5
	3H	26.6	27.8	27.0	28.2	28.6	27.5	28.7	27.9	29.0	29.4
	4H	27.4	28.5	27.8	28.9	29.3	28.4	29.4	28.8	29.9	30.3
	6H	28.0	29.0	28.5	29.4	29.9	29.1	30.1	29.6	30.5	31.0
	8H	28.3	29.1	28.7	29.6	30.1	29.4	30.3	29.9	30.7	31.2
	12H	28.4	29.2	28.9	29.7	30.2	29.7	30.4	30.1	30.9	31.4
8H	4H	27.7	28.6	28.2	29.1	29.5	28.7	29.6	29.2	30.0	30.5
	6H	28.5	29.3	29.0	29.7	30.2	29.6	30.3	30.1	30.8	31.3
	8H	28.8	29.5	29.4	30.0	30.5	30.0	30.7	30.5	31.2	31.6
	12H	29.1	29.7	29.6	30.1	30.7	30.3	30.9	30.8	31.4	32.0
12H	4H	27.8	28.6	28.3	29.0	29.5	28.7	29.5	29.2	30.0	30.5
	6H	28.6	29.3	29.1	29.7	30.3	29.7	30.4	30.2	30.8	31.4
	8H	29.0	29.5	29.5	30.0	30.6	30.1	30.7	30.6	31.2	31.8

Maximum UGR = 32.0



Indoor Report: ARBAY2-160_IESNA2002.IES

Summary | Candela Array | Zonal Lumens | CU Table | **UGR Table** | Polar Curve

UGR Values: (•) Corrected (based on actual lumens) ( ) Uncorrected (normalized to 1000 lumens)

UGR Table - Corrected

Reflectances											
Ceiling Cavity		70	70	50	50	30	70	70	50	50	30
Walls		50	30	50	30	30	50	30	50	30	30
Floor Cavity		20	20	20	20	20	20	20	20	20	20
Room Size		UGR Viewed Crosswise					UGR Viewed Endwise				
X=2H	Y=2H	22.7	24.1	23.0	24.5	24.8	22.6	24.1	23.0	24.4	24.7
	3H	23.9	25.3	24.3	25.6	26.0	23.9	25.3	24.3	25.6	25.9
	4H	24.6	25.8	25.0	26.2	26.6	24.5	25.8	24.9	26.1	26.5
	6H	25.1	26.3	25.5	26.6	27.0	25.1	26.2	25.5	26.6	27.0
	8H	25.3	26.4	25.8	26.8	27.2	25.3	26.4	25.7	26.8	27.2
	12H	25.5	26.6	25.9	27.0	27.4	25.5	26.5	25.9	26.9	27.3
4H	2H	23.0	24.3	23.4	24.6	25.0	23.0	24.3	23.4	24.6	25.0
	3H	24.6	25.6	25.0	26.0	26.4	24.5	25.6	25.0	26.0	26.4
	4H	25.3	26.3	25.8	26.7	27.1	25.3	26.2	25.7	26.6	27.1
	6H	26.0	26.8	26.5	27.3	27.7	26.0	26.8	26.4	27.2	27.7
	8H	26.4	27.1	26.8	27.5	28.0	26.3	27.0	26.8	27.5	27.9
	12H	26.6	27.3	27.1	27.7	28.2	26.5	27.2	27.0	27.7	28.2
8H	4H	25.6	26.3	26.0	26.8	27.2	25.5	26.3	26.0	26.7	27.2
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	12H	27.2	27.7	27.7	28.2	28.7	27.1	27.6	27.6	28.1	28.7
12H	4H	25.6	26.3	26.1	26.8	27.2	25.5	26.2	26.0	26.7	27.2
	6H	26.5	27.1	27.0	27.5	28.1	26.4	27.0	26.9	27.5	28.0
	8H	27.0	27.4	27.5	27.9	28.5	26.9	27.4	27.4	27.9	28.5

Maximum UGR = 28.7

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Glare is about the surroundings,
What does the eye see

Independence Hall

Photo from Lacquered Life.com

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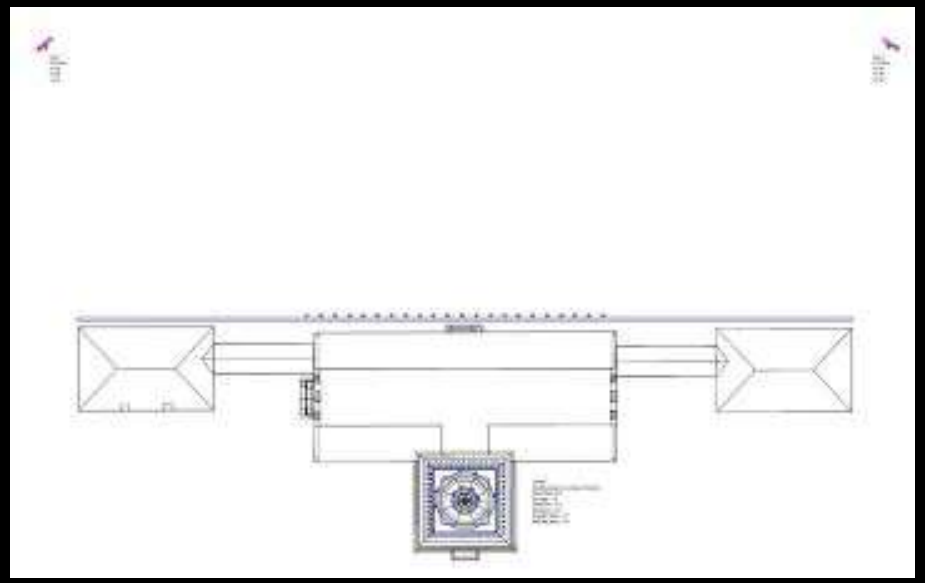

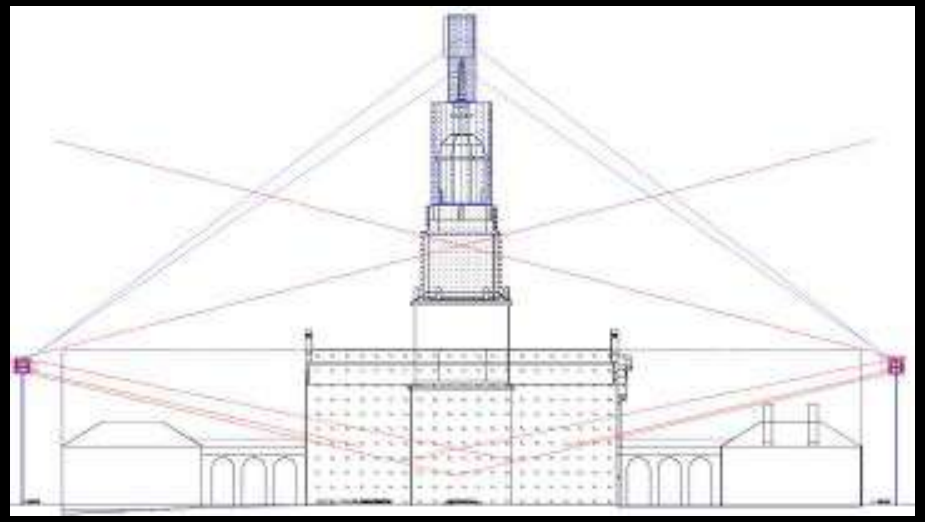

Photos courtesy of Tyler Garlock

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Unshielded Floodlights

Shielded Floodlights

Photos courtesy of Tyler Garlock

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Photo: http://gabisworld.com/photo/places/independence-hall/03/

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My take on glare:

Aaron

- Glare decisions shouldn’t be boiled down to one number
- Informed design decisions, will lead to better occupant experiences and better lighting

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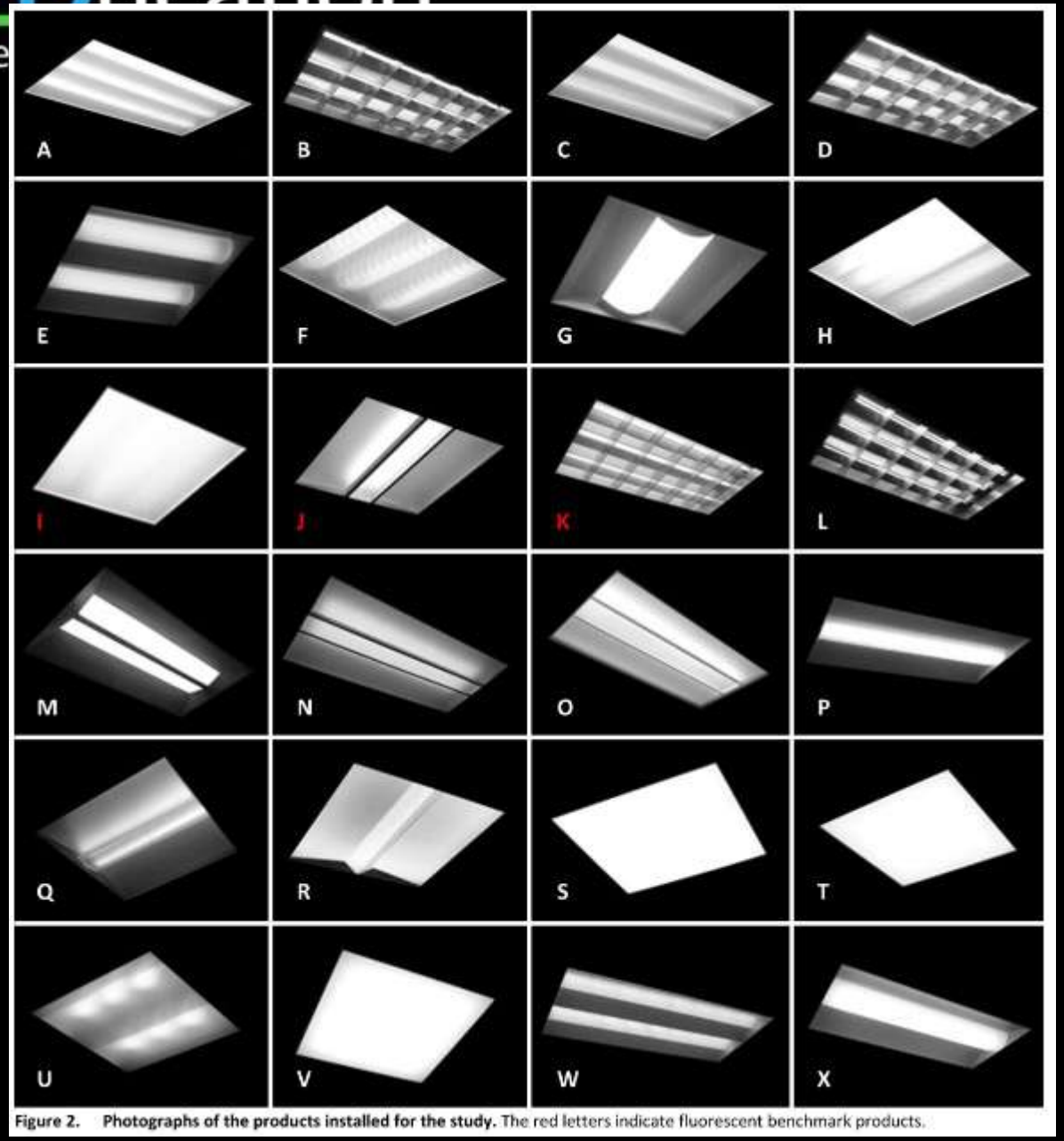

Figure 2. **Photographs of the products installed for the study.** The red letters indicate fluorescent benchmark products.

CALiPER Exploratory Study: Recessed Troffer Lighting

NJ Miller
MP Royer
ME Poplawski

March 2013

- Key Research
  - Overhead glare
  - Discomfort glare
  - Patterns of light
  - Appearance

4	Full	Is the luminaire comfortable (not glaring) to sit under in a heads-down-type visual task (office)?	1 = Not comfortable 2 = Moderately uncomfortable 3 = Moderately comfortable 4 = Very comfortable
5	Full	Is the luminaire comfortable (not glaring) to sit under in a heads-up-type visual task (classroom)?	1 = Not comfortable 2 = Moderately uncomfortable 3 = Moderately comfortable 4 = Very comfortable
6	Full	Is the direct view of the luminaire comfortable (not glaring) for normal office tasks?	1 = Very uncomfortable 2 = Moderately uncomfortable 3 = Moderately comfortable 4 = Very comfortable

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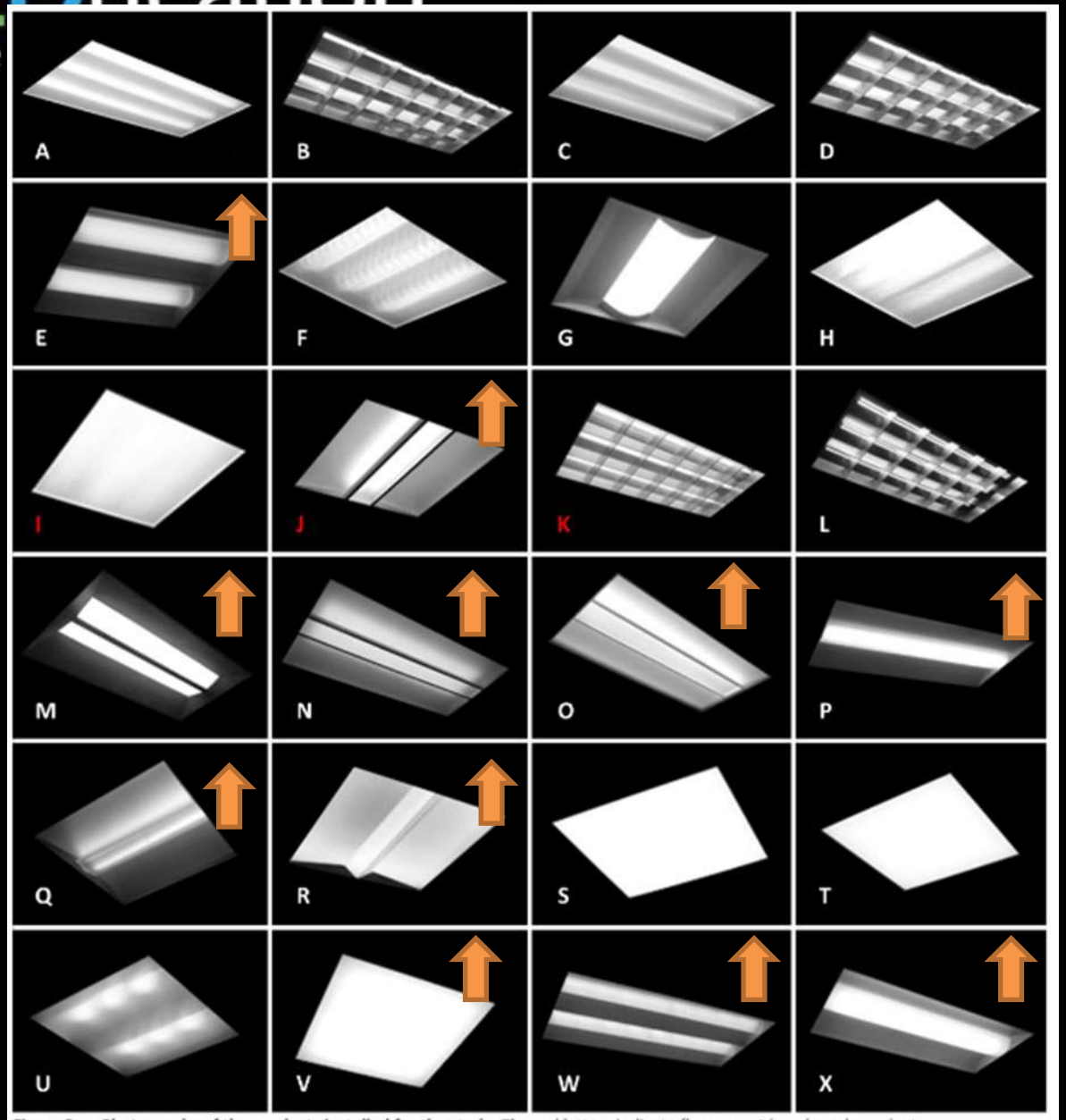

Figure 2. **Photographs of the products installed for the study.** The red letters indicate fluorescent benchmark products.

Experts

Naive

Is the luminaire comfortable (not glaring) to sit under in a heads-down-type visual task (office)?	1 = Not comfortable 2 = Moderately uncomfortable 3 = Moderately comfortable 4 = Very comfortable
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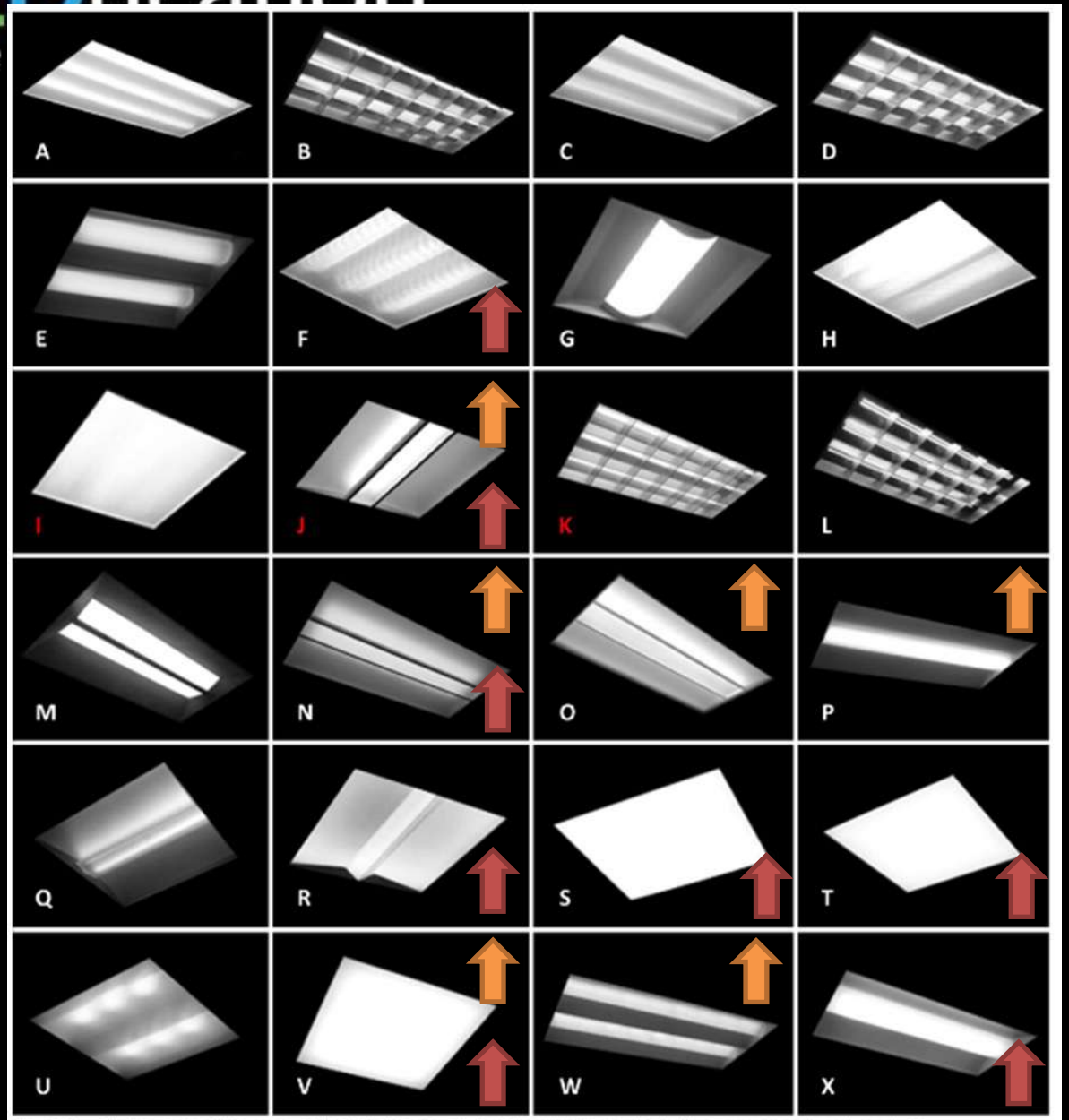

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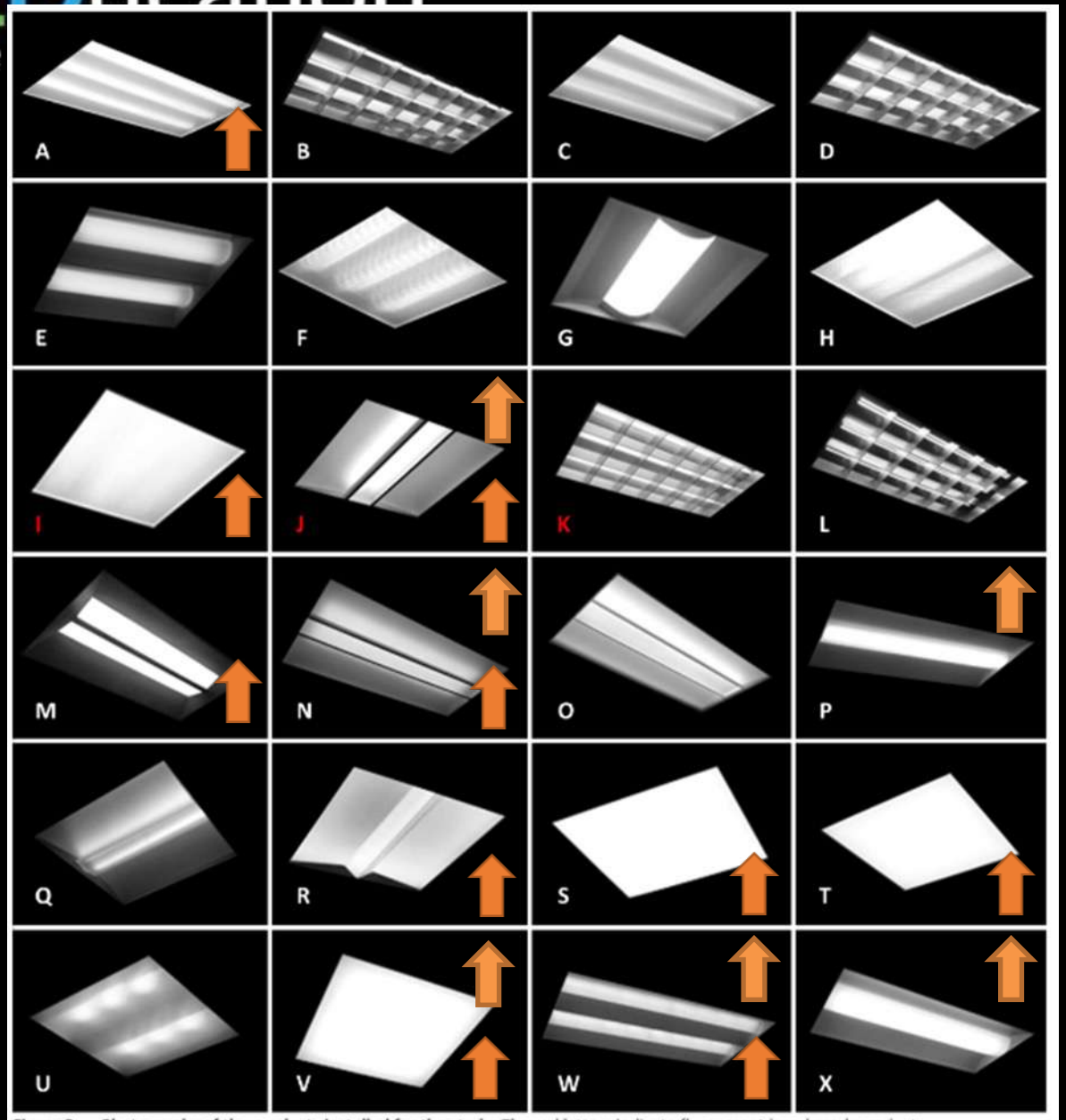

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Overhead Glare

- The visual discomfort that is sensed when luminaires are situated above the normal field of view, usually from 55° to 85° above a horizontal gaze.
- The most highly correlated metric was the maximum luminaire spot luminance as measured at a steep angle of 10° from vertical ($R^2 = 0.46$)
- Those products with maximum spot luminance higher than 20,000 cd/m^2 generally received poorer ratings.
- Correlation between the observers' ratings and other measurements of luminous intensity distribution were weak.
- The patterns created on walls that have a more distinct edge that observers did not like.
- Top-rated luminaires for visual comfort, and all of them are 2×4s with a diffuser panel with linear details, producing a smooth gradient of light across the diffuser.
  - The maximum measured lens luminance among these was 12,480 cd/m^2.

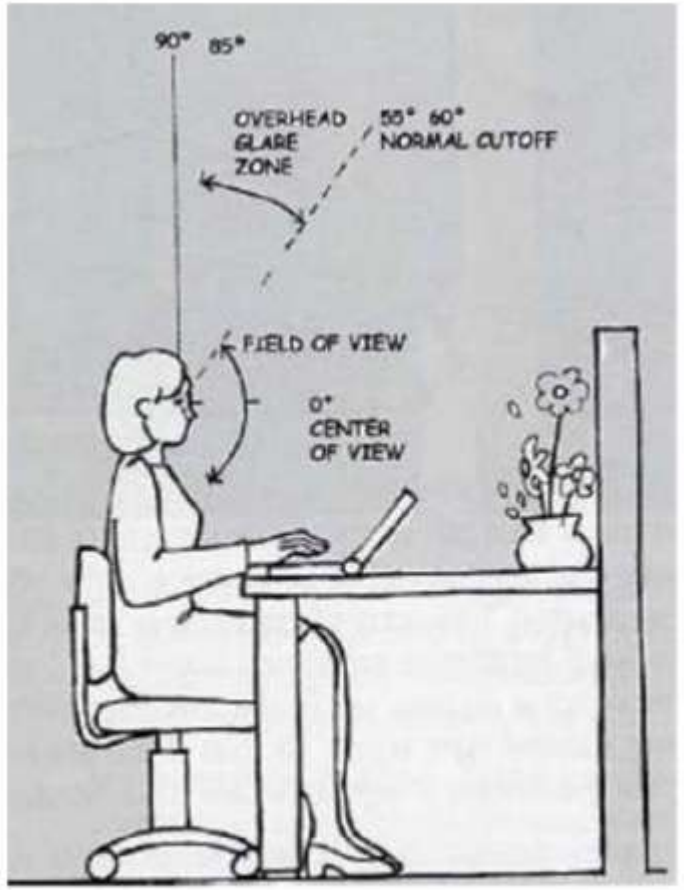

Figure 10. Illustration of overhead glare zone for office worker. Source: *IES DG-18-08, Light + Design: A Guide to Designing Quality Lighting for People and Buildings*

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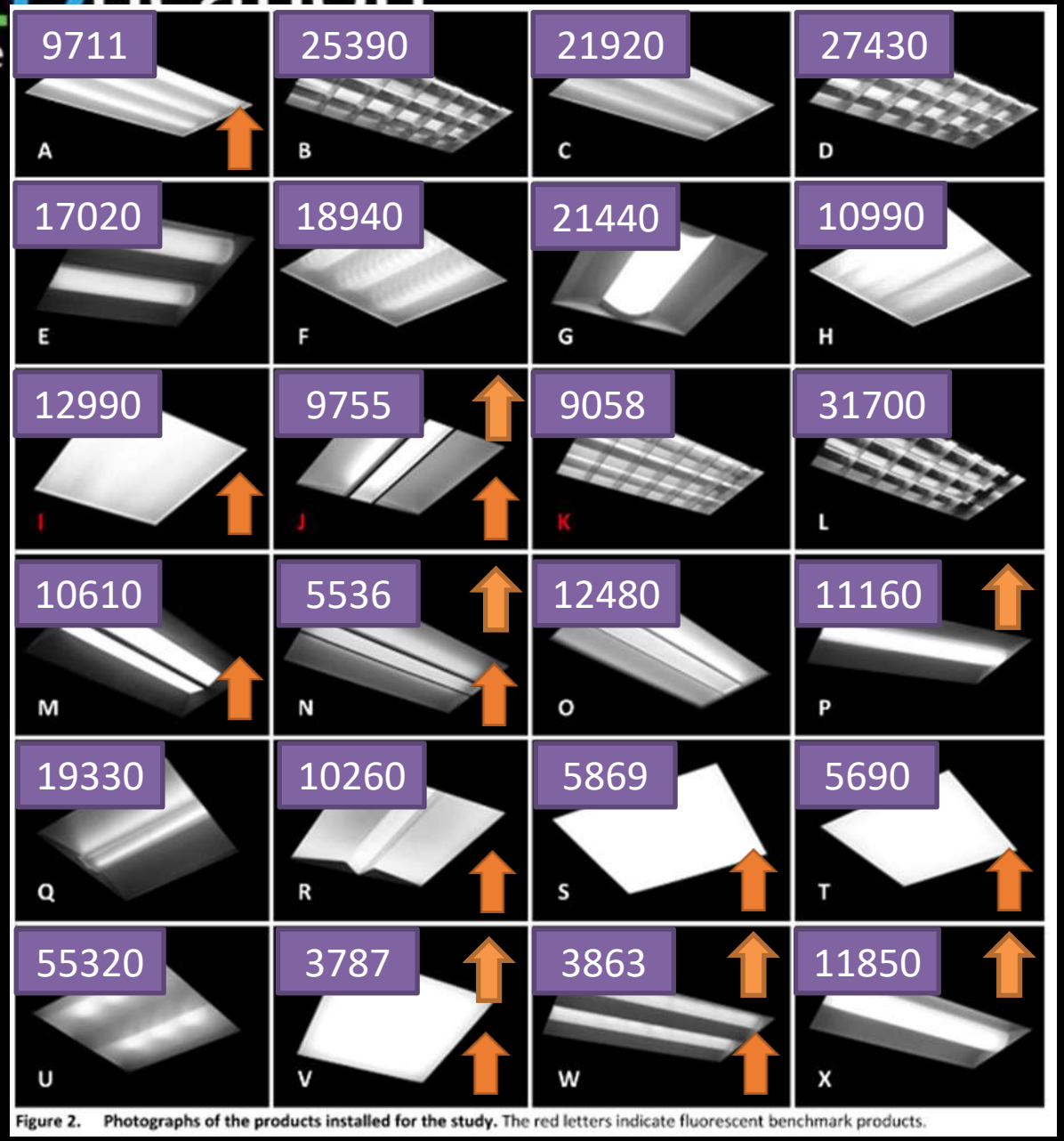

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Luminance
@ 10 deg from nadir

Is the luminaire comfortable (not glaring) to sit under in a heads-down-type visual task (office)?	1 = Not comfortable 2 = Moderately uncomfortable 3 = Moderately comfortable 4 = Very comfortable
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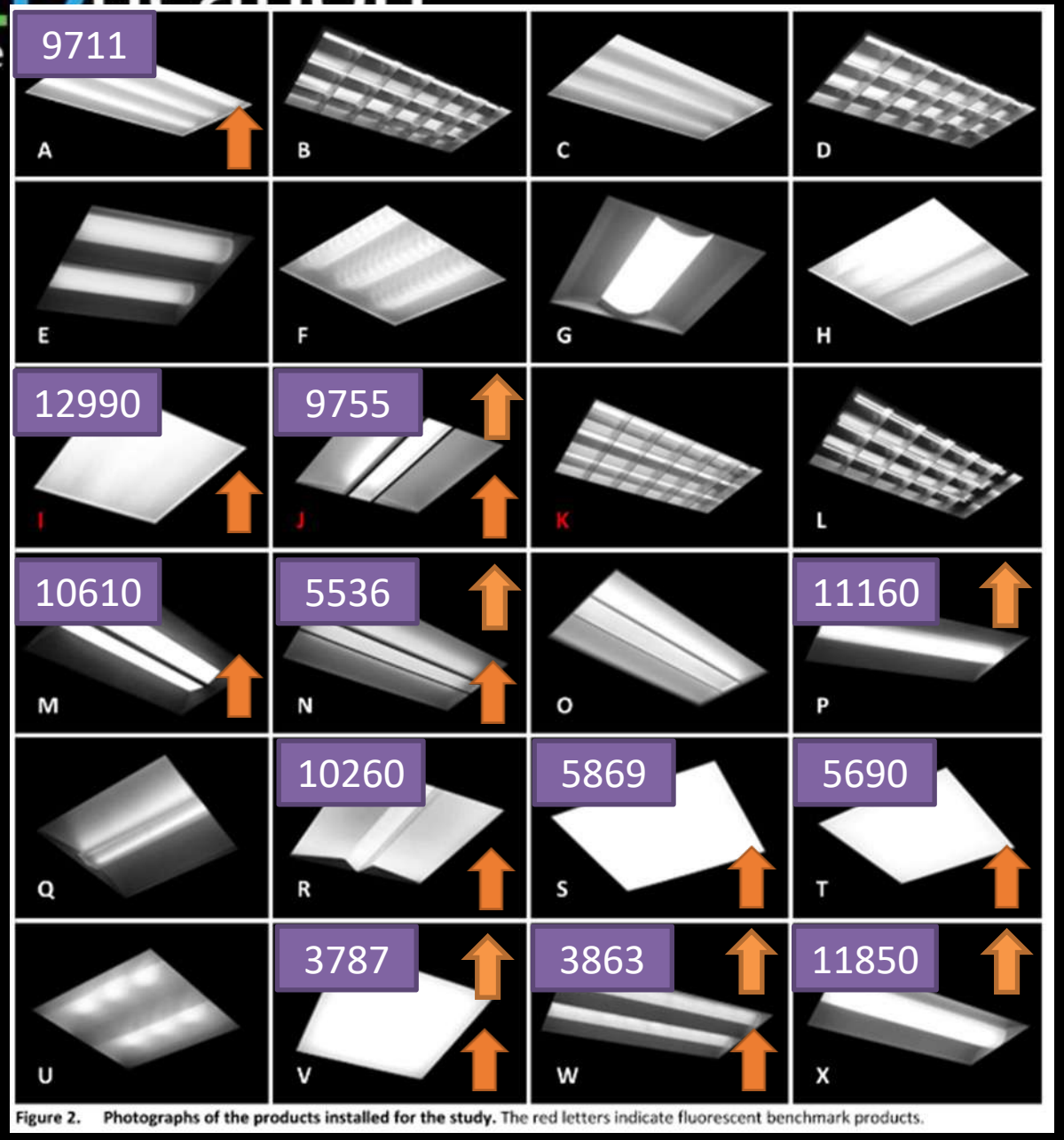
Luminance @ 10 deg from nadir



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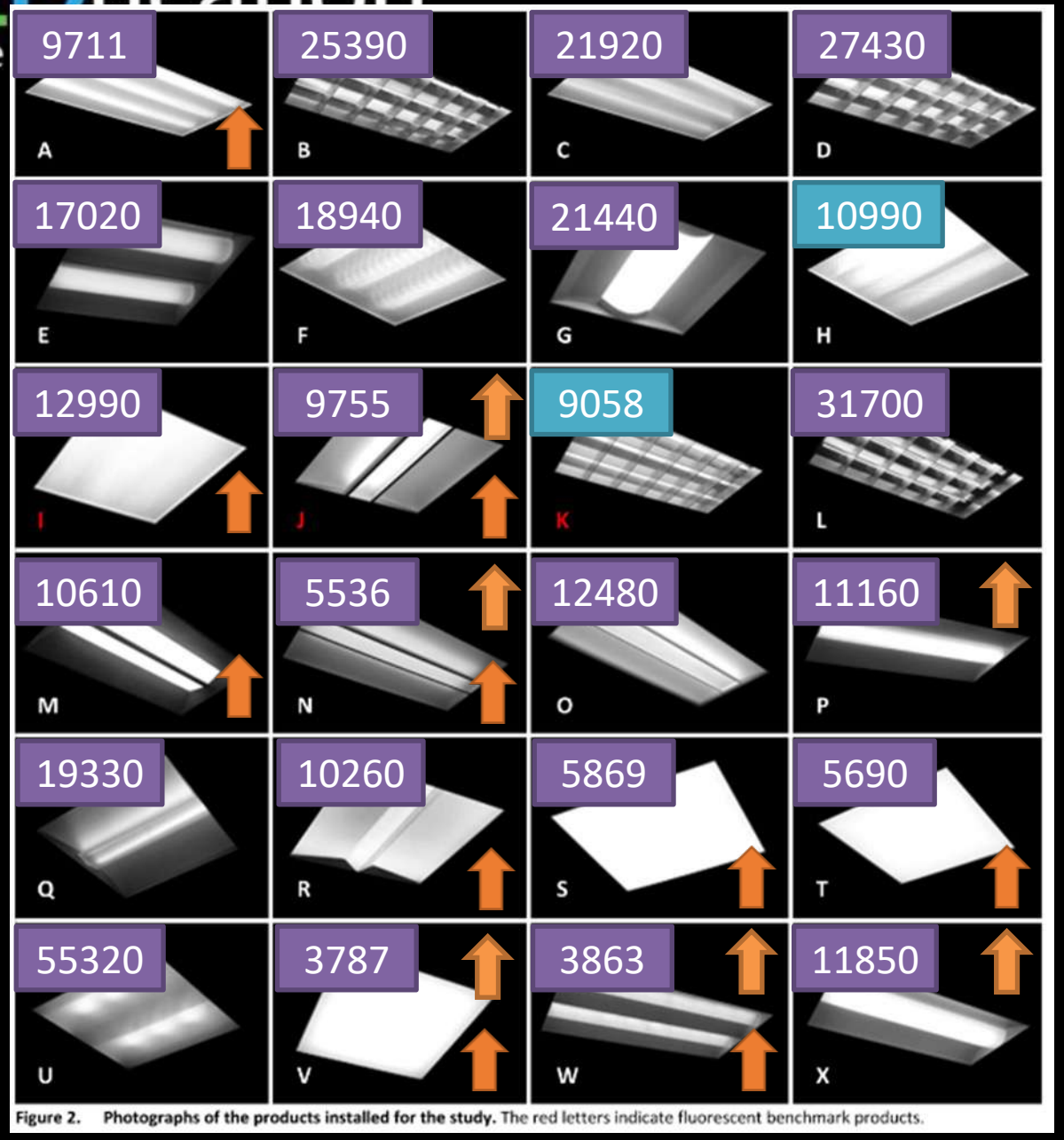
Luminance @ 10 deg from nadir



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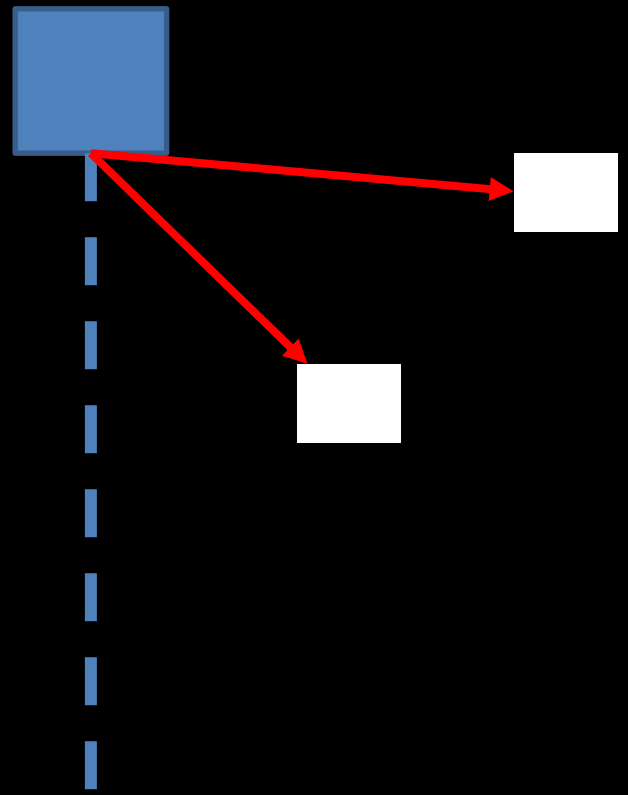
Discomfort Glare

- To find a metric to predict discomfort glare problems, observer responses were compared to a range of quantities derived from photometric reports or from in-situ luminance measurements.
- None of the following metrics produced a reliable correlation (R^2 values were less than 0.18):
  - Maximum spot luminance measured on the surface of the luminaire from a measurement angle of 25° above horizontal (65° from the luminaire nadir), measured in the luminaire's 90° plane.
  - Ratio of maximum to minimum spot luminance measured across the surface of the luminaire from the same 25° above horizontal.
  - Ratio of maximum luminance to adjacent ceiling tile luminance, measured from the same angle.
  - Maximum luminaire candela value at 55°, 65°, 75° or 85° luminaire elevation angles.
  - Average luminaire luminance at 55°, 65°, 75° or 85° luminaire elevation angles.
  - Percent lumens emitted between 60° and 90°, or absolute lumens emitted between 60° and 90°.
  - Total luminaire lumen output.



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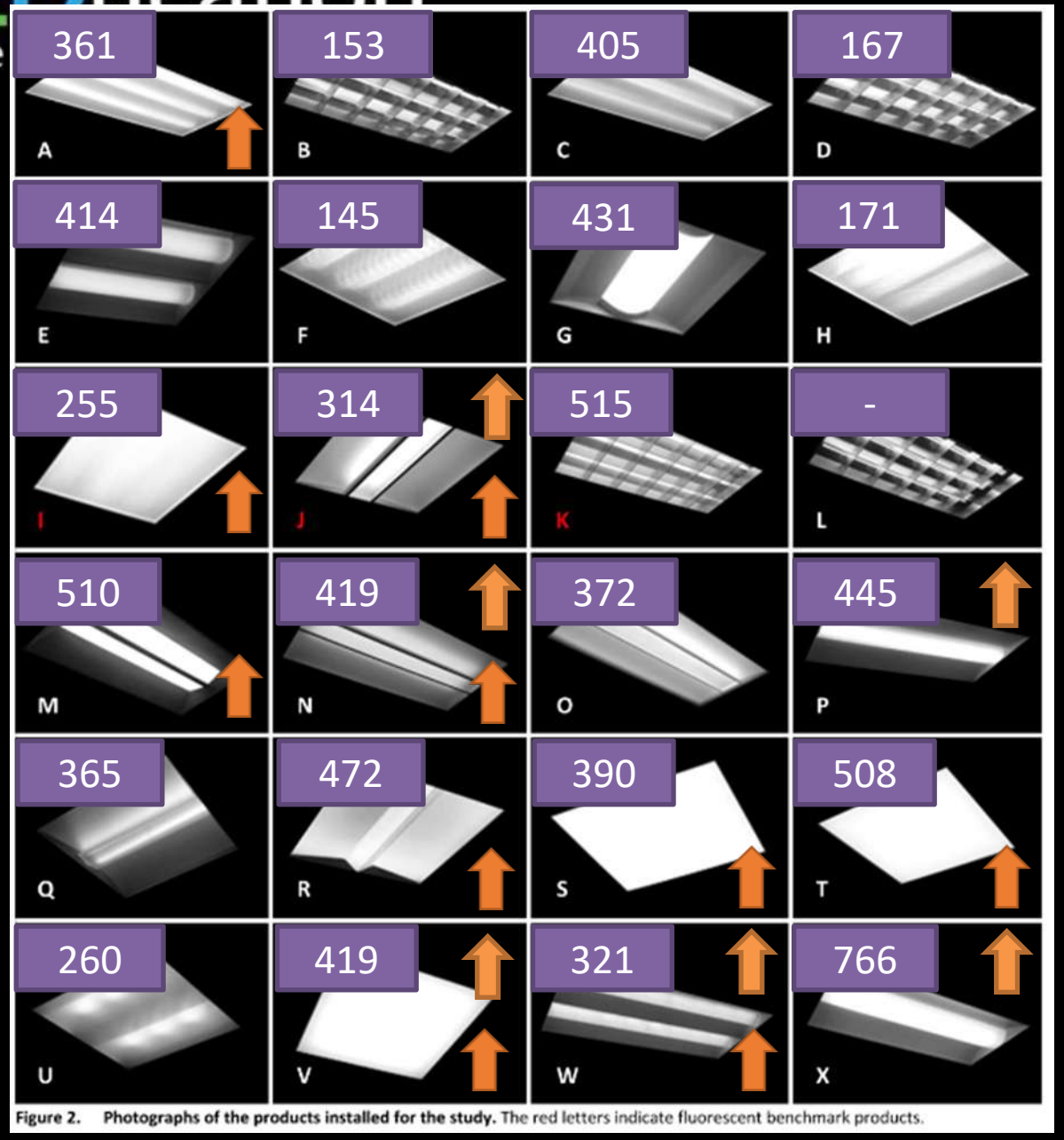

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Intensity @ 65 Deg

Is the luminaire comfortable (not glaring) to sit under in a heads-down-type visual task (office)?	1 = Not comfortable 2 = Moderately uncomfortable 3 = Moderately comfortable 4 = Very comfortable
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Is the direct view of the luminaire comfortable (not glaring) for normal office tasks?	1 = Very uncomfortable 2 = Moderately uncomfortable 3 = Moderately comfortable 4 = Very comfortable

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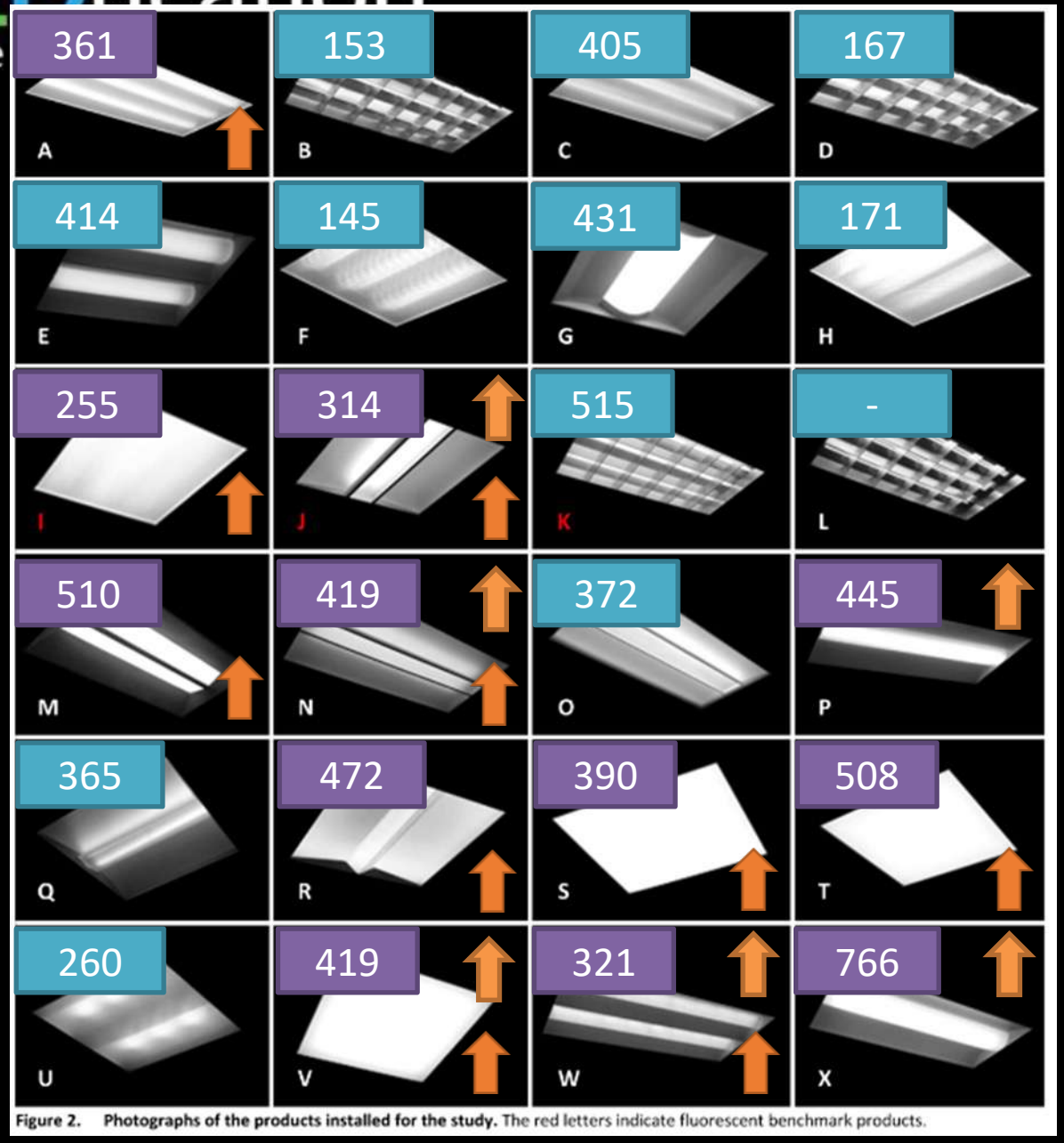

Figure 2. **Photographs of the products installed for the study.** The red letters indicate fluorescent benchmark products.

Intensity @ 65 Deg

Is the luminaire comfortable (not glaring) to sit under in a heads-down-type visual task (office)?	1 = Not comfortable 2 = Moderately uncomfortable 3 = Moderately comfortable 4 = Very comfortable
Is the luminaire comfortable (not glaring) to sit under in a heads-up-type visual task (classroom)?	1 = Not comfortable 2 = Moderately uncomfortable 3 = Moderately comfortable 4 = Very comfortable
Is the direct view of the luminaire comfortable (not glaring) for normal office tasks?	1 = Very uncomfortable 2 = Moderately uncomfortable 3 = Moderately comfortable 4 = Very comfortable

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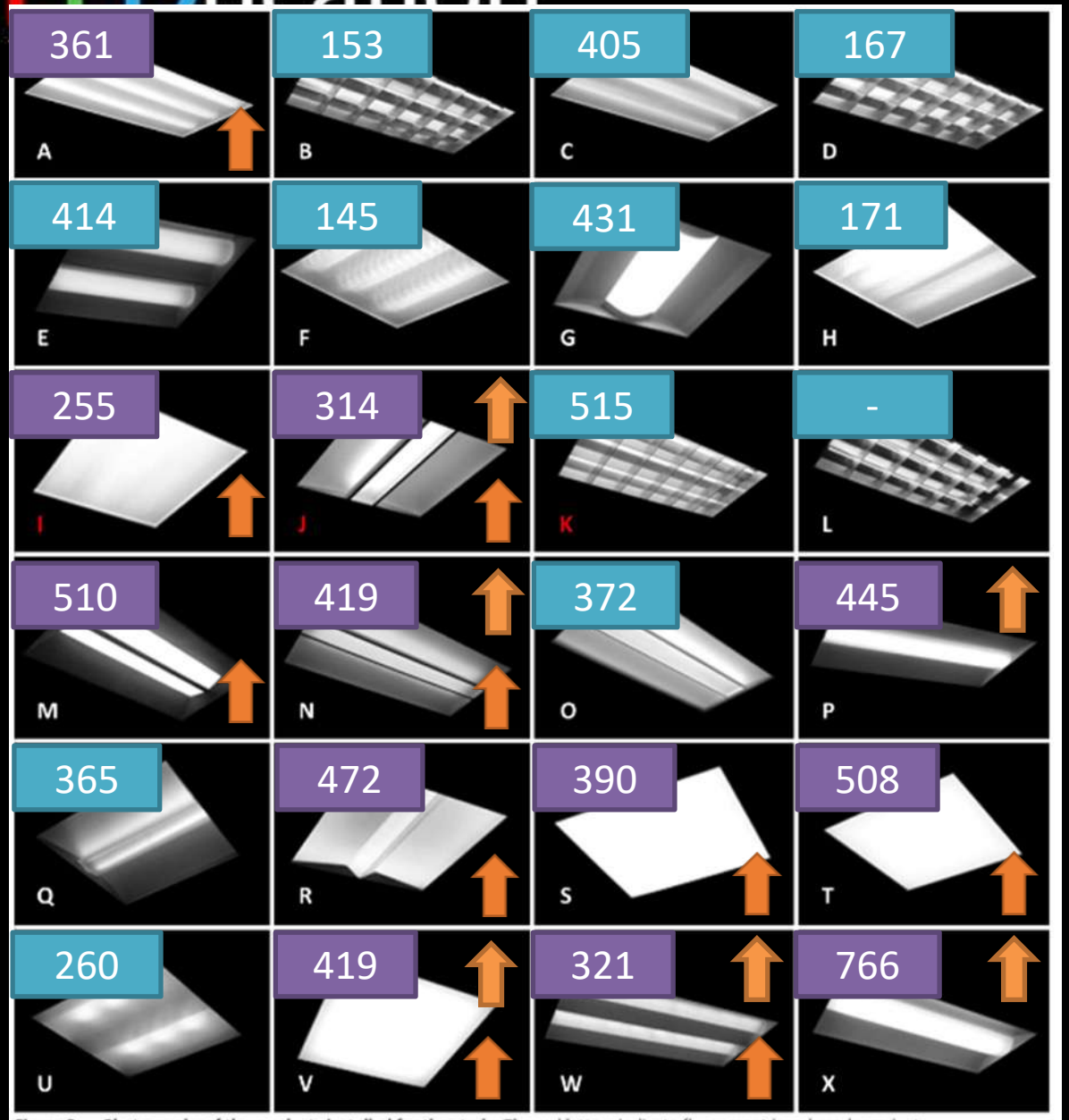
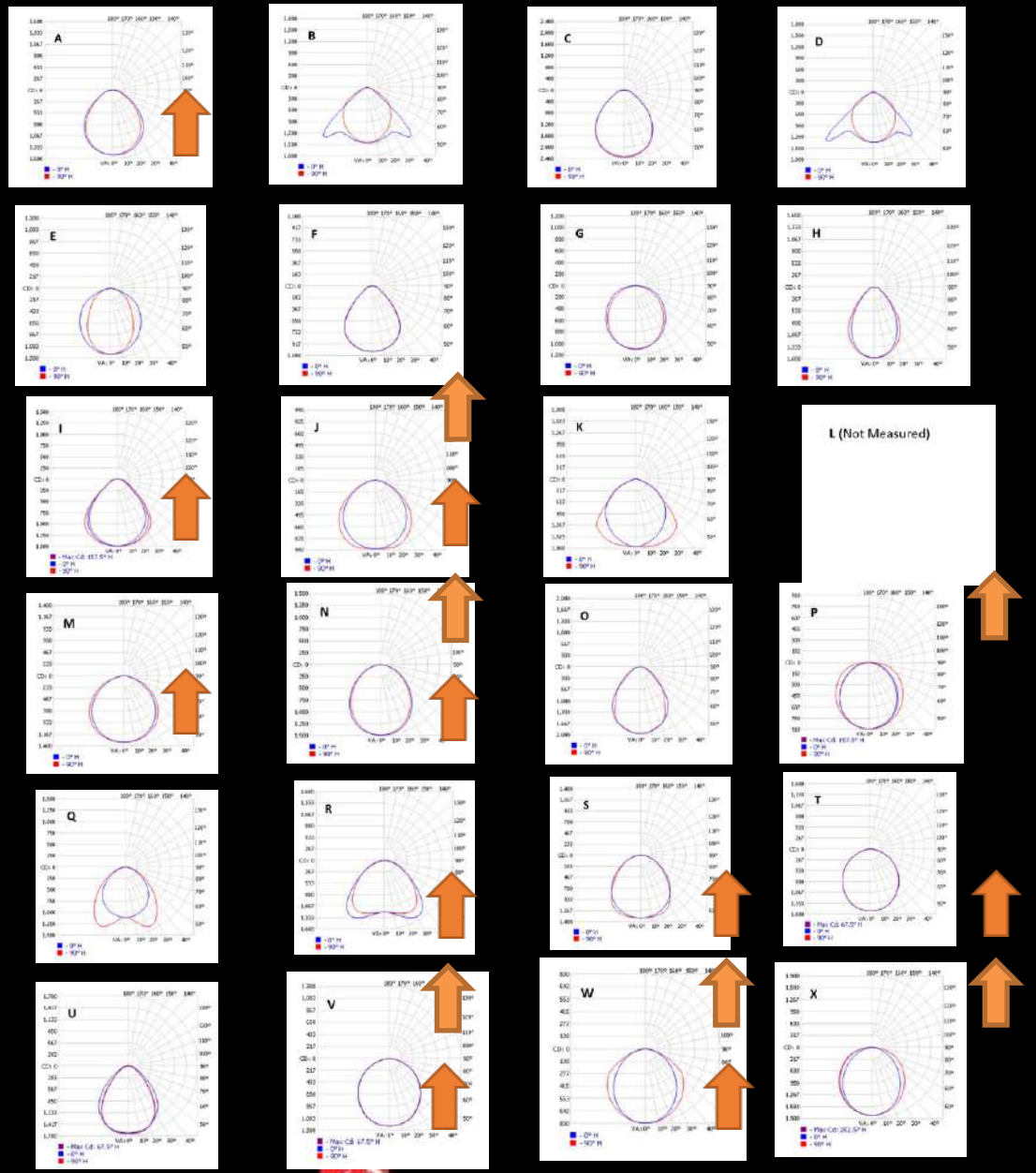


Figure 2. Photographs of the products installed for the study. The red letters indicate fluorescent benchmark products.



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The wall pattern paradox

3	Full	Imagine the luminaire installed 2' or 3' from the walls. Is the light distribution on the adjacent wall appropriate for the application?	1 = No 2 = Somewhat inappropriate 3 = Somewhat appropriate 4 = Yes

- Light distribution on adjacent office walls is a factor that seems to be related to the percent of light
- emitted from 60° to 90°. Troffers that emitted more than 10% of their lumens in that zone produced
- better—meaning higher and “softer”—wall patterns.

- For all questions related to glare, it is notable that the experts' mean responses were correlated with their rating for the overall **appearance** of the luminaire, oftentimes more so than any other single metric.
- It is likely that glare perception is related to a more complex picture of luminous intensity distribution than can be captured with a single number.
- It is difficult to say, however, if glare is a driving factor behind overall **preference**, or if the **observers' feelings** towards each luminaire led to bias in certain areas, like glare, which can be more difficult to conceptualize.

Glare Conclusions

- **Glare remained an enigma**. Whether overhead glare or direct (discomfort) glare, only one measured or calculated photometric quantity proved to be a promising predictor.
  - That metric was **maximum spot luminance** measured across the face of the troffer from a steep angle of 10° from vertical.
- The **lowest rated** troffers for glare were those LED products with prismatic lenses and odd or **distracting patterns** (types U, F, and C), along with an LED retrofit kit with **extremely high lens luminance** (type G).
- Products with **diffuse lenses** and **simple visual details** (types N, J, W, P, and X) received the most favorable ratings for glare.

The rise of UGR (circa 1995)

- Like most single number metrics UGR is a low precision tool
- Applying UGR sight unseen may not produce desirable results, like a boring design.

Limitations

- For indoor lighting and electrical design only
- For uniform background luminances
- Not for small light sources
- Not for large light sources
- Not for indirect lighting
- Not for non-uniform lighting
- Not for applications with daylight

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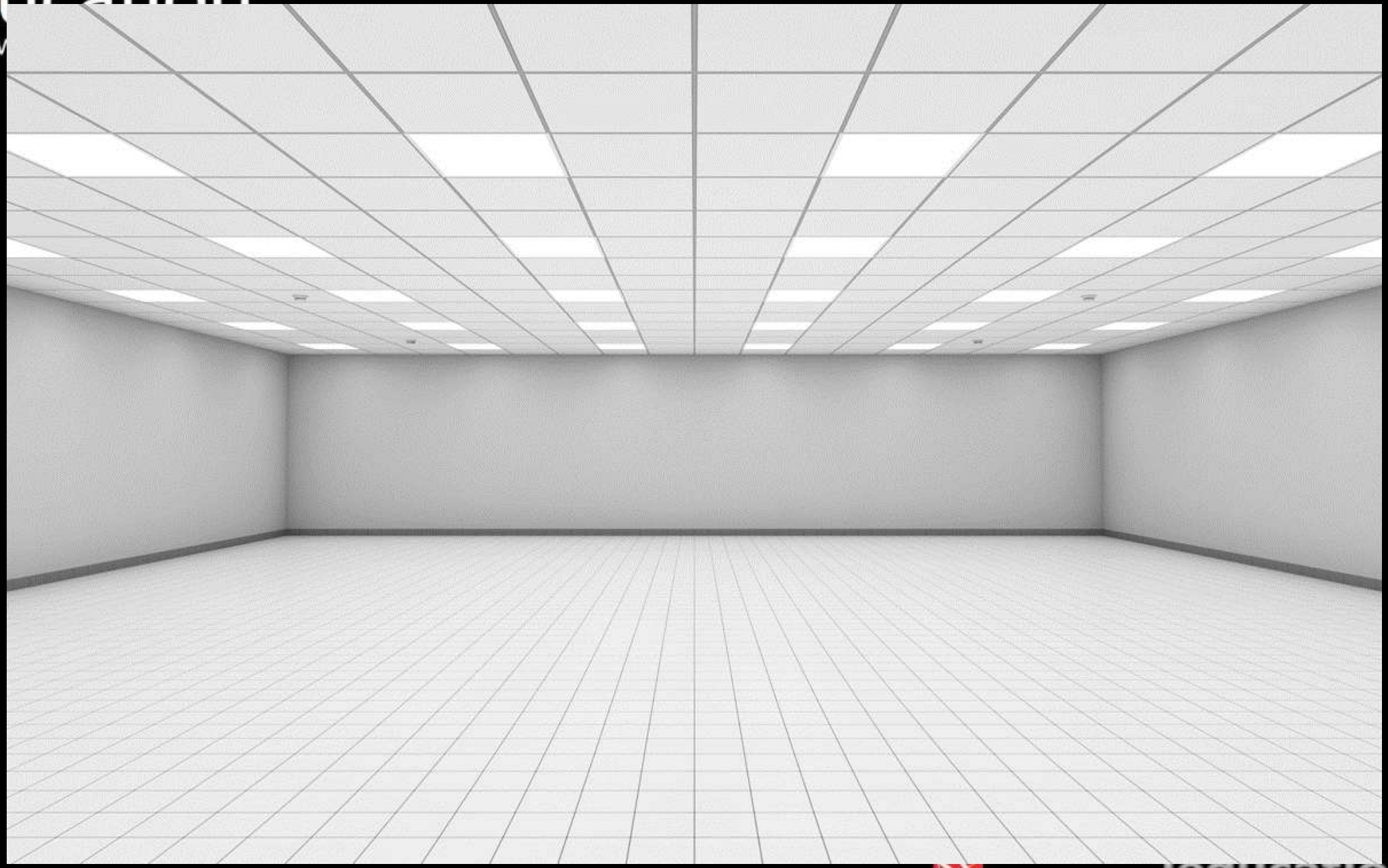

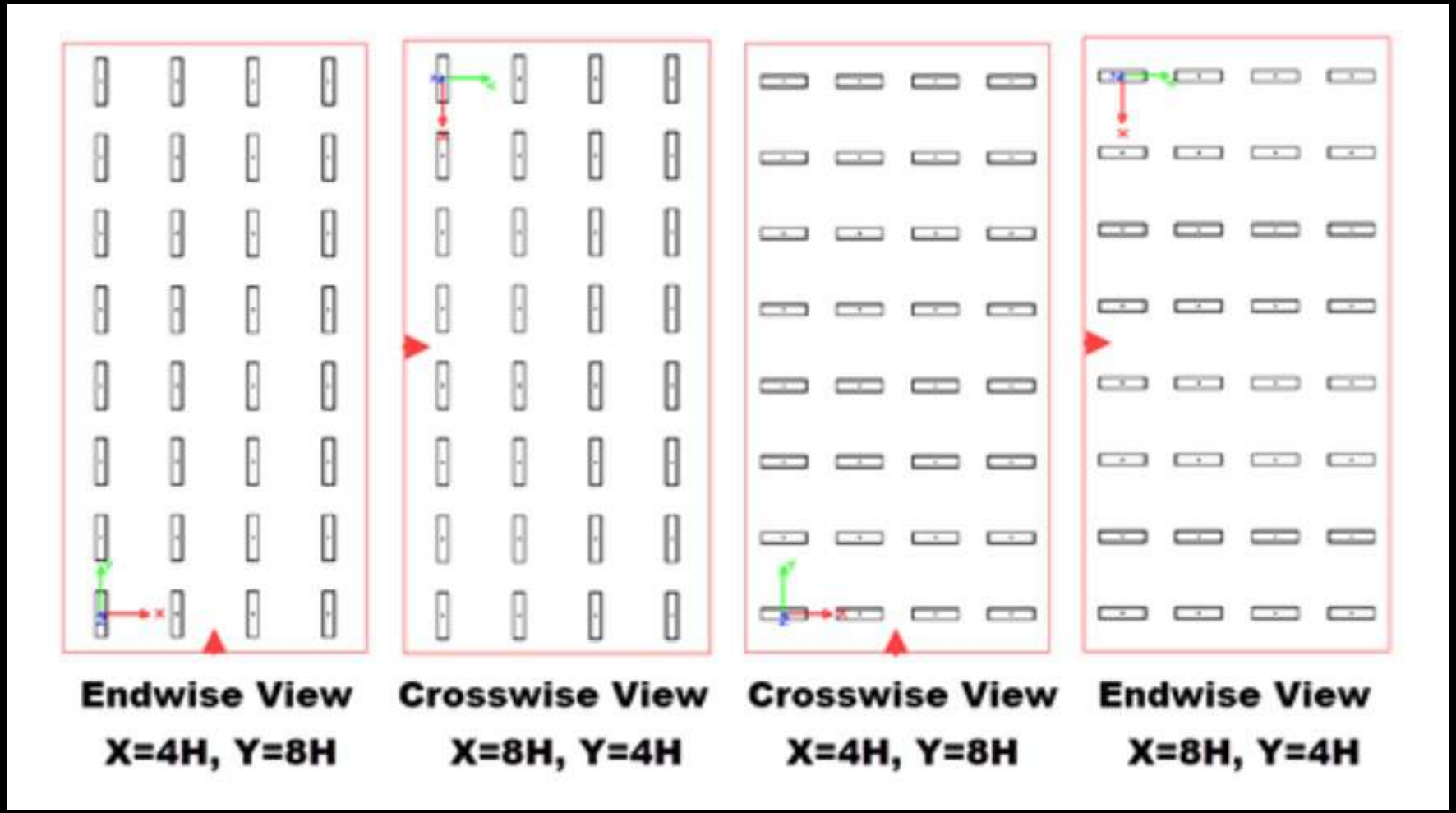
Endwise View
X=4H, Y=8H
Crosswise View
X=8H, Y=4H
Crosswise View
X=4H, Y=8H
Endwise View
X=8H, Y=4H

UGR sources < 16


FAST
storable

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Glare Factors

- Room Size
- Room reflectance
- Luminaire pattern
- Mounting height
- Position in space
- Background luminance
- Source luminance
- Source area
- Age
- Adaptation
- Biology
- Task illumination
- Task uniformity
- Room Color
- Application uniformity
- Circadian impacts
- Architectural interest
- Luminaire Interest
- Vertical lighting
- Daylighting
- Sky lighting
- Gaze direction
- Mobility
- Dimming
- Distribution
- Intensity
- Flux
- Spectrum
- Shielding
- Test Setup
- Experience of viewer
- Lens patterns
- Shadow patterns
- Wall illumination
- Cave effects
- Task in progress
- Immediate surround

NEMA LS 20001-2021

White Paper on Unified Glare Rating (UGR)

NEMA Whitepaper

- It is not advisable to use UGR to predict acceptability or in any other way as an absolute measure of perception.
- UGR application method may be used to estimate glare sensation, yielding **relative comparisons**; for example, if the light sources with the space are bigger, brighter, and closer to the observer, or if the light source is kept the same but evaluated in a darker environment, then it will create more glare than the same source without those conditions, and UGR application method will indicate so.
- Confusion will result if absolute statements such as “70% of people experience glare discomfort” or “UGR 19 is acceptable glare” are used. It is impossible to make such statements without the **complete context**, and even then, there will be variations among individuals as to what is acceptable or not.


Prescriptive
UGR
Knows Better

What should we do?

- Apply design principles
- Review luminaires
- Document our results


EXIT
CLOUDFLARE


Gensler
B
Gensler

Design Principles

- Brighten surfaces
- Optimize Interiors
- Lower Intensities

- Increase the overall background luminance
  - Create a visual hierarchy
  - Balance adaptation
- Light the ceiling
  - Luminaires with uplight
  - Wall-mounted uplight
  - Recessed luminaires with dropped luminous elements
- Light the walls and vertical surfaces
  - Wall washing/grazing
  - Translucent / self luminous partitions
  - Accent areas of focus
- Integrate Task Lighting
  - Light the area of use
  - Carefully locate and shield
  - Enable personal control

- Daylight fenestration
  - Shade direct sun
  - Consider solar glare risk
  - Window treatments to balance luminance
- Displays
  - Selection of screen types
  - Locations and Sizes
  - Dimming features
  - Dynamic dimming
- Surfaces
  - Primarily Diffuse
  - Limited / carefully placed specular features
  - Lighter colors & higher reflectance ceiling and walls/partitions

Lower Intensities

- Carefully consider direct-view of light sources including LEDs, optics and diffusers
- Utilize Dimming
  - Luminaire dimming options
  - Luminaire dimmed based on time of day
  - Dim gradually and continuously
- User Views
  - Keep sources of brightness in context
  - Shield direct view sources (except sparkle)
  - Consider user position related to luminaire and orientation

What should we do?

- Apply design principles
- Review luminaires
- Document our results
- Enjoy beautiful spaces

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My take on glare:

Dan

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UGR discussion with DLC

UGR Fast Facts

- **UGR threshold requirements are included in European and Australian/New Zealand** commercial and industrial lighting standards.
- **The factors that affect UGR** include background luminance, average luminaire luminance and solid angle, and displacement from the line of sight.
- **UGR values generally range from 10 to 31**, where a rating of 10 indicates no perceived discomfort and a rating of 31 indicates intolerable discomfort. The DLC's UGR thresholds range from 22 to 28, based on Primary Use Designation.

UGR Formula

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

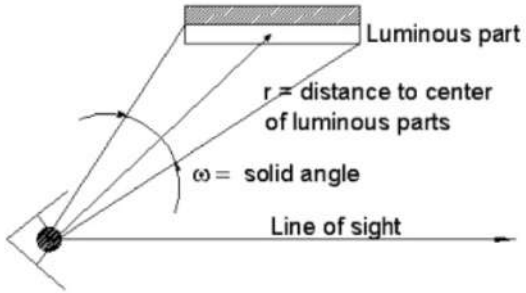
where

L_b is the background luminance (cd/m^2);

L is the luminance of the luminous parts of each luminaire in the direction of the observer's eye (cd/m^2);

ω is the solid angle of the luminous parts of each luminaire at the observer's eye (sr);

ρ is the Guth position index for each luminaire (displacement from the line of sight);



For the measurements of glare the discomfort glare constant is used.

Glare index:	Reaction:
0 - 10	Imperceptible
10 - 16	Noticeable
16 - 22	Acceptable
22 - 28	Uncomfortable
> 28	Intolerable

More visually demanding tasks with high luminance levels as drawing and fine visual inspections are less **tolerant of glare**. Very sensible to **glare** is working behind a computer. Since computer screens have shiny surfaces and are very susceptible to **glare**.

Limiting:	GI occupations
16	Drawing offices, very fine visual inspections
19	Offices, libraries, keyboard and video display terminal work
22	Kitchen, reception area, fine assembly
25	Stock rooms, assembly line for easy tasks
28	Indoor car park, rough industrial work

Glare and UGR

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DLC 5.1 requirements

What is the Unified Glare Rating?

The Unified Glare Rating (UGR) predicts the glare caused by an electric lighting system along a psychometric scale of discomfort. In simpler words, UGR predicts the amount of discomfort-causing glare produced by a lighting installation for a fixed set of conditions. Discomfort glare can result in annoyance, headaches or eyestrain.

Discomfort glare is different from disability glare, which impacts the viewer's ability to discern objects accurately. **UGR is a measure of discomfort glare, not disability glare.**

Table 6: *Additional Testing and Reporting Requirements for Discomfort Glare (DLC Premium)*

Metric	V5.1 Premium Requirements	QPL Listing	Method of Evaluation
Discomfort Glare	*Troffer (Luminaire and Integrated Retrofit Kits only):* **Corrected UGR < 22.0** (Note: Linear-Style Retrofit Kits for 2x2, 1x4, and 2x4 Luminaires are not eligible for Premium qualification under V5.1.)	UGR values not published on the QPL	Corrected UGR values generated per CIE 190-2010 at the reference condition below. Room dimension: X = 4H, Y = 8H Spacing to height ratio (S/H): 1 Reflectances: 70/50/20%
	Linear Ambient (Luminaire and Retrofit Kits): **Corrected UGR < 22.0**		
	Low-Bay (Luminaire and Retrofit Kits): **Corrected UGR < 25.0**		
	High-Bay (Luminaire and Retrofit Kits): **Corrected UGR < 28.0**		
	All other products: **n/a**		

Note: DLC reviewers will use Photometric Toolbox (Lighting Analysts, Inc., version 2.7 or newer) to verify UGR using the submitted tested .ies file.

Why is UGR required for DLC Premium qualification?

The DLC's goal is to support the lighting industry in improving the quality of light in the built environment and ensuring safe and comfortable work environments for people. With a UGR requirement for Premium products, lighting decision makers can select from the Premium list for better confidence in the glare performance of the products they specify or install.

Products with better glare design have the potential to:

- Mitigate glare-related headaches and eyestrain
- Support task performance
- Promote comfort of building occupants

Table 11: *V5.1 Allowances to Efficacy*

Feature	General Application	Performance Metric	Allowance under V5.1
Enhanced Discomfort Glare Control	Troffer (Luminaires and Integrated Retrofit Kits only)	**Corrected UGR < 16.0** at the glare evaluation reference condition of • Room dimension: X = 4H, Y = 8H • Spacing to height ratio (S/H): 1 • Reflectances: 70/50/20% (Note: Linear-Style Retrofit Kits for 2x2, 1x4, and 2x4 Luminaires are not eligible for efficacy allowances under V5.1.)	-10%
	Linear Ambient (Luminaires and Retrofit Kits)	**Corrected UGR < 16.0** at the glare evaluation reference condition of • Room dimension: X = 4H, Y = 8H • Spacing to height ratio (S/H): 1 • Reflectances: 70/50/20%	-10%
	Low-Bay (Luminaires and Retrofit Kits)	**Corrected UGR < 19.0** at the glare evaluation reference condition of • Room dimension: X = 4H, Y = 8H • Spacing to height ratio (S/H): 1 • Reflectances: 70/50/20%	-10%
	High-Bay (Luminaires and Retrofit Kits)	**Corrected UGR < 22.0** at the glare evaluation reference condition of • Room dimension: X = 4H, Y = 8H • Spacing to height ratio (S/H): 1 • Reflectances: 70/50/20%	-10%

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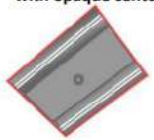
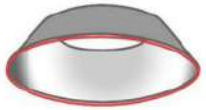
Guidance for Modeling Luminous Area

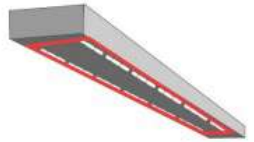
The following examples are given as guidance for modeling common types of luminaires, with luminous areas per IES LM-63. The red boundary line indicates the boundary of suggested luminous opening. Each .ies file can only have one luminous area, so the following conventions are recommended.[1]

High Bay/Low Bay Luminaires

Multiple LED configurations below heat sink	Luminous channels on edges with opaque center	Luminous disk in center with reflector/refractor
		
Model as a circular opening encompassing all LED configurations	Model as rectangle (enclosing opaque area in the center) encompassing both luminous channels	Model as circular opening or vertical cylinder with sides encompassing all luminous components

Linear Ambient Luminaires

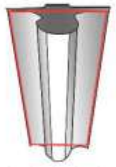
Internal channel with luminous sides and horizontal plane	Cylinder with open top (uplight) and luminous panels on curved portion (downlight)	Cylinder with wraparound luminous panel
		
Model as rectangle encompassing luminous components/inset	If uplight only, luminaire cannot be assessed for UGR. With luminous panels, luminaire can be modeled as a rectangle with luminous sides encompassing all luminous components	Model as rectangle with luminous sides[2]

Vertical luminous panel	Luminous insets with/or without uplight	Linear with bare LEDs
		
Model as thin rectangle (e.g. 0.01 ft. width) with luminous sides	Model as rectangle encompassing all the luminous components/ insets	Model as rectangle encompassing all bare LEDs

Bidirectional with luminous opening on top (uplight) and bottom (downlight)

If uplight only, luminaire cannot be assessed for UGR. With luminous panels, luminaire can be modeled as a rectangle with luminous sides

Troffers

Luminous center basket and opaque sides	Luminous center basket and luminous sides	Multiple luminous baskets inside luminaire with opaque center channel
		
Model as rectangle or rectangle with luminous sides encompassing entire luminaire	Model as rectangle or rectangle with luminous sides encompassing entire luminaire	Model as rectangle encompassing entire luminaire

Multiple luminous baskets inside luminaire	Luminous surround with opaque center or no luminaire in center	Luminous center panel with luminous side panels
		
Model as rectangle or rectangle with luminous sides encompassing all luminous components	Model as rectangle encompassing entire luminaire	Model as rectangle or rectangle with luminous sides encompassing entire luminaire

Two luminous panels in center, separated by opaque channel	Luminous wedge in center	Luminous basket in center with opaque panels on each side
		
Model as rectangle (enclosing opaque area in the center) encompassing entire luminaire	Model as rectangle or rectangle with luminous sides encompassing entire luminaire[3]	Model as rectangle or rectangle with luminous sides encompassing entire luminaire

Glare is about context.

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HOW DO MANUFACTURERS MEET DLC 5.1 UGR REQUIREMENTS?

1. Increase luminous opening including length, width and height.
2. Reduce lumen per fixture
2. Improve photometric distribution to reduce intensity at high angles.

My take on glare:

AC

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Design Strategies

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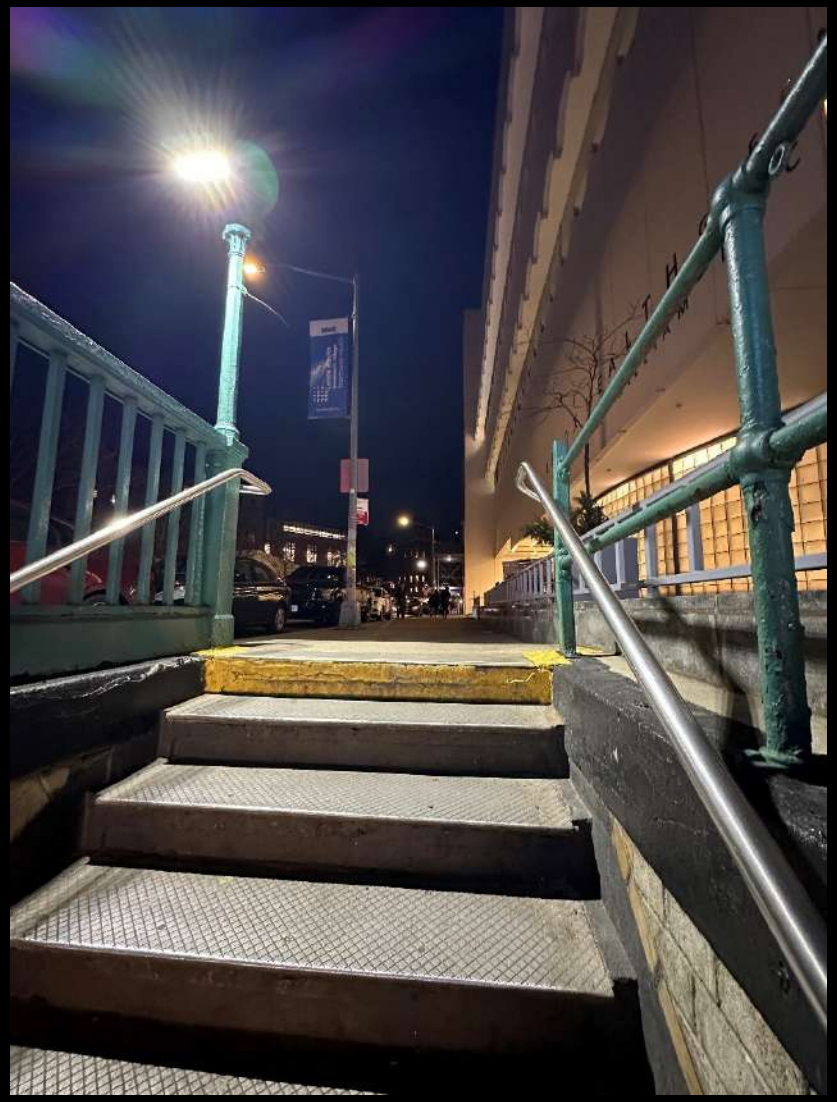

GLARE IS IN THE EYE
OF THE BEHOLDER

A

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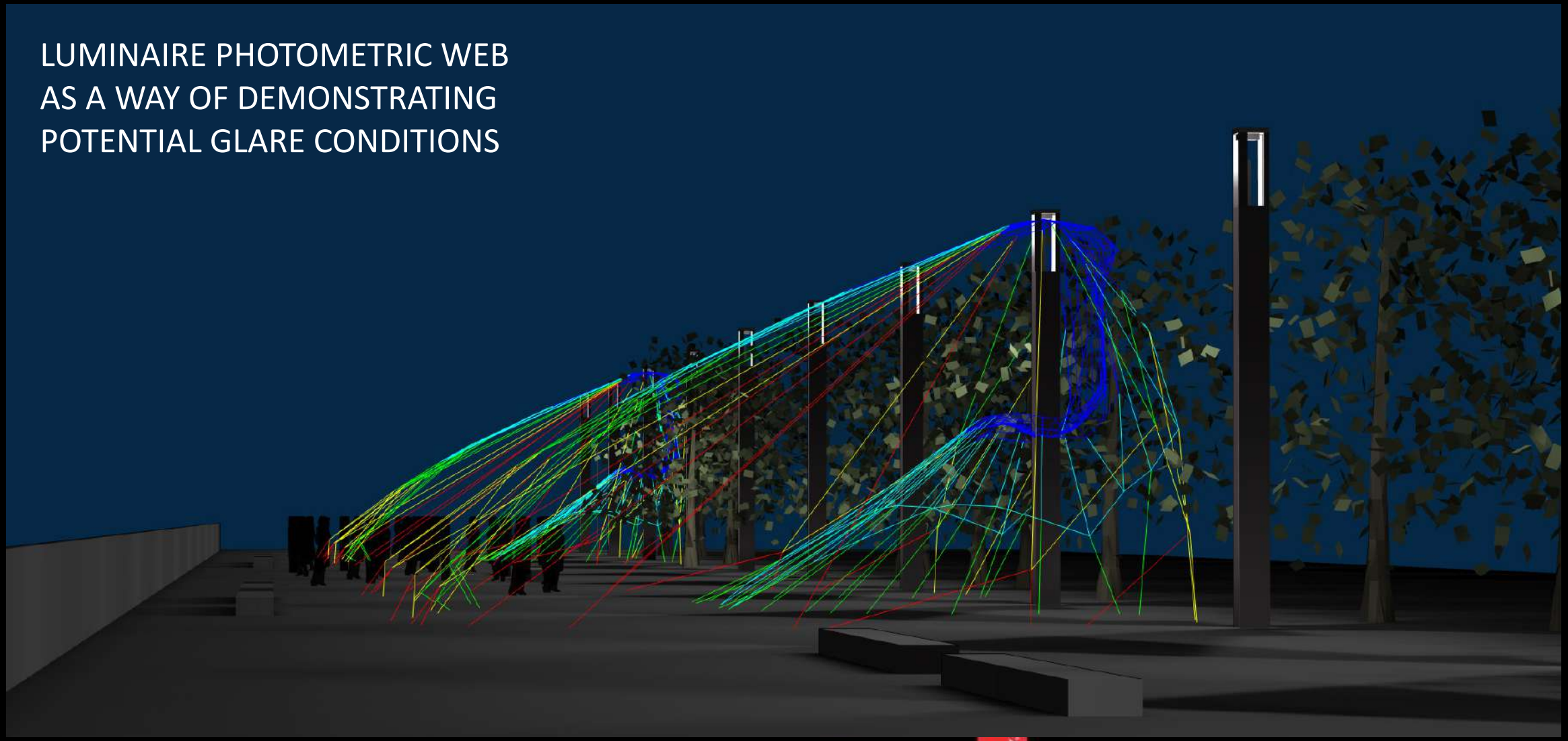
LUMINAIRE PHOTOMETRIC WEB AS A WAY OF DEMONSTRATING POTENTIAL GLARE CONDITIONS



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PLANNING: MOCKUPS +
AIMING AND ADJUSTING >
GLARE MITIGATION

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GOAL: AVOID SPILL BY CABLE LIGHTING INTO DRIVE LANES

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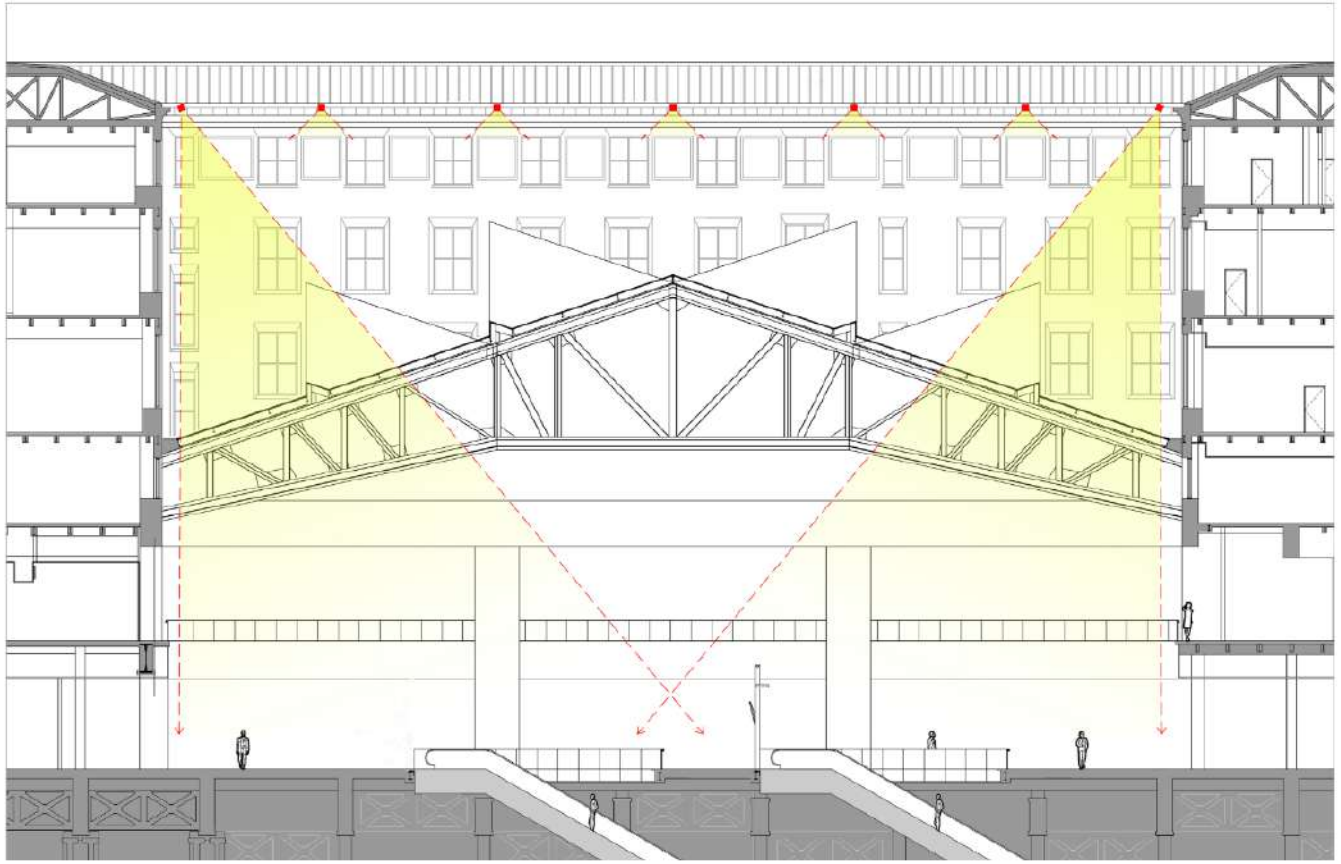
TRAIN HALL LIGHTING
PROGRESS CONCEPT DESIGN RENDER

LIGHTING ELEMENTS

- MOONLIGHTING
  Parapet mounted white LED floodlight with snoot.

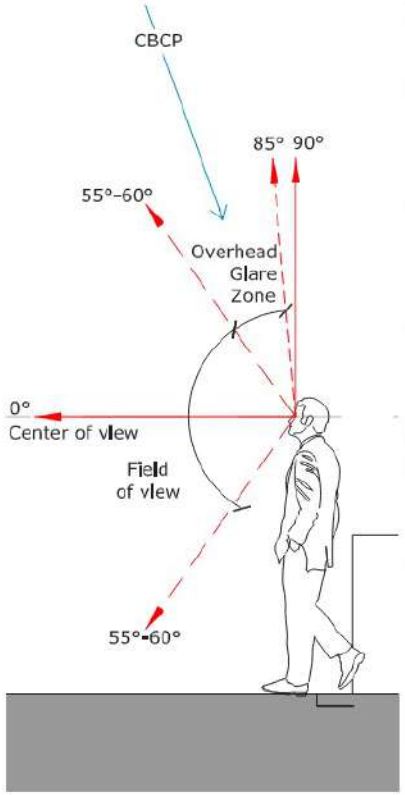


MOYNIHAN STATION PHASE 2
DOMINGO GONZALEZ ASSOCIATES

TRAIN HALL LIGHTING - MOONLIGHTING

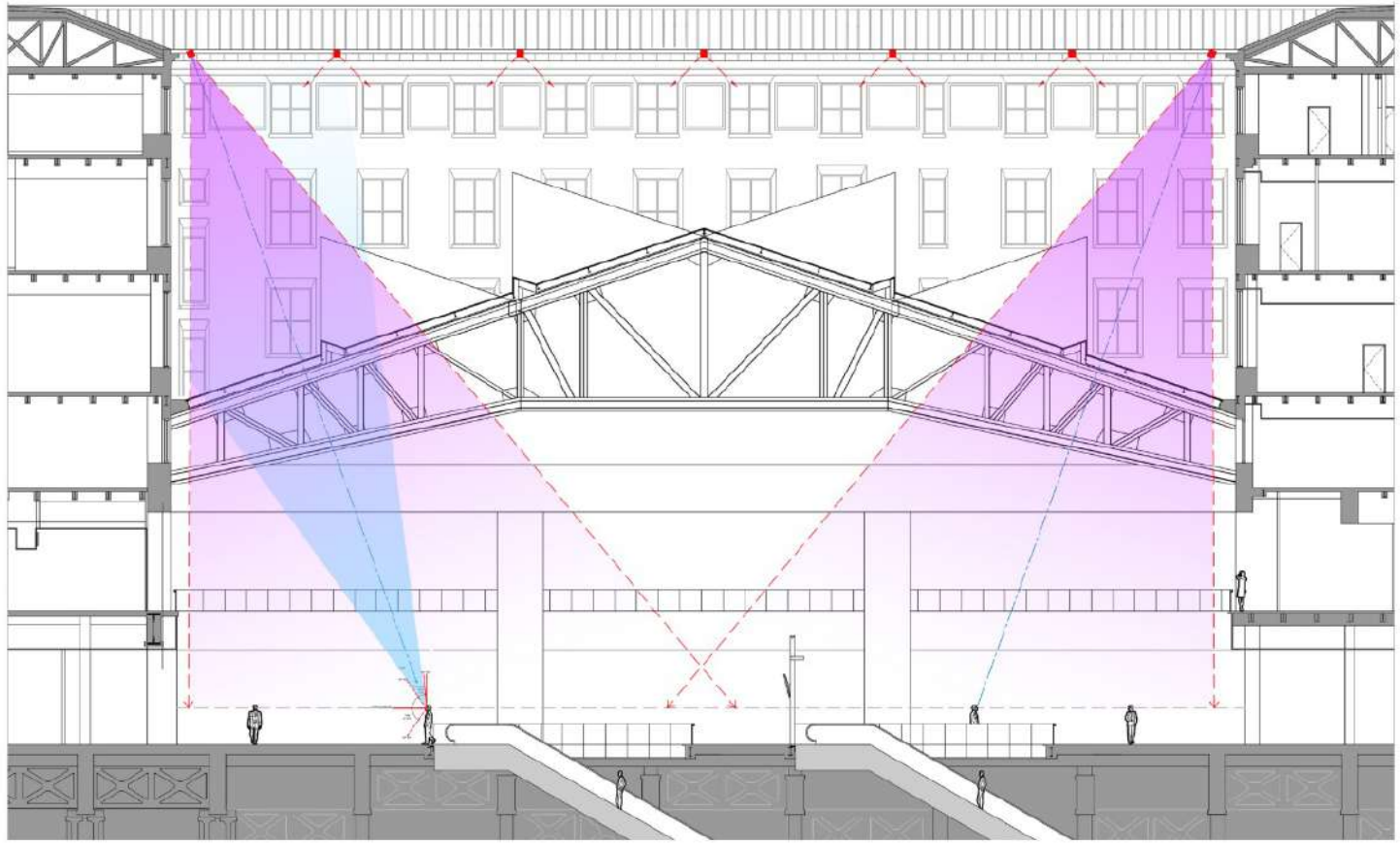
GLARE STUDY VIA HUMAN VISUAL SYSTEM

GLARE CONCERNS FROM THE PERSPECTIVE OF HUMAN VISUAL SYSTEM & HUMAN FIELD OF VIEW:



DIRECT OVERHEAD GLARE: *Caused by directly viewing a light source, such as a bright window or a high-brightness light source.*

CBCP (center beam candle power): *CBCP is the luminous intensity at the center of a beam, expressed in candelas (the brightest zone of a luminaire).*



TRAIN HALL LIGHTING - MOONLIGHTING
GLARE STUDY VIA LUMINAIRE OPTICAL DESIGN

GLARE CONCERNS FROM THE PERSPECTIVE OF LUMINAIRE OPTICAL DESIGN:

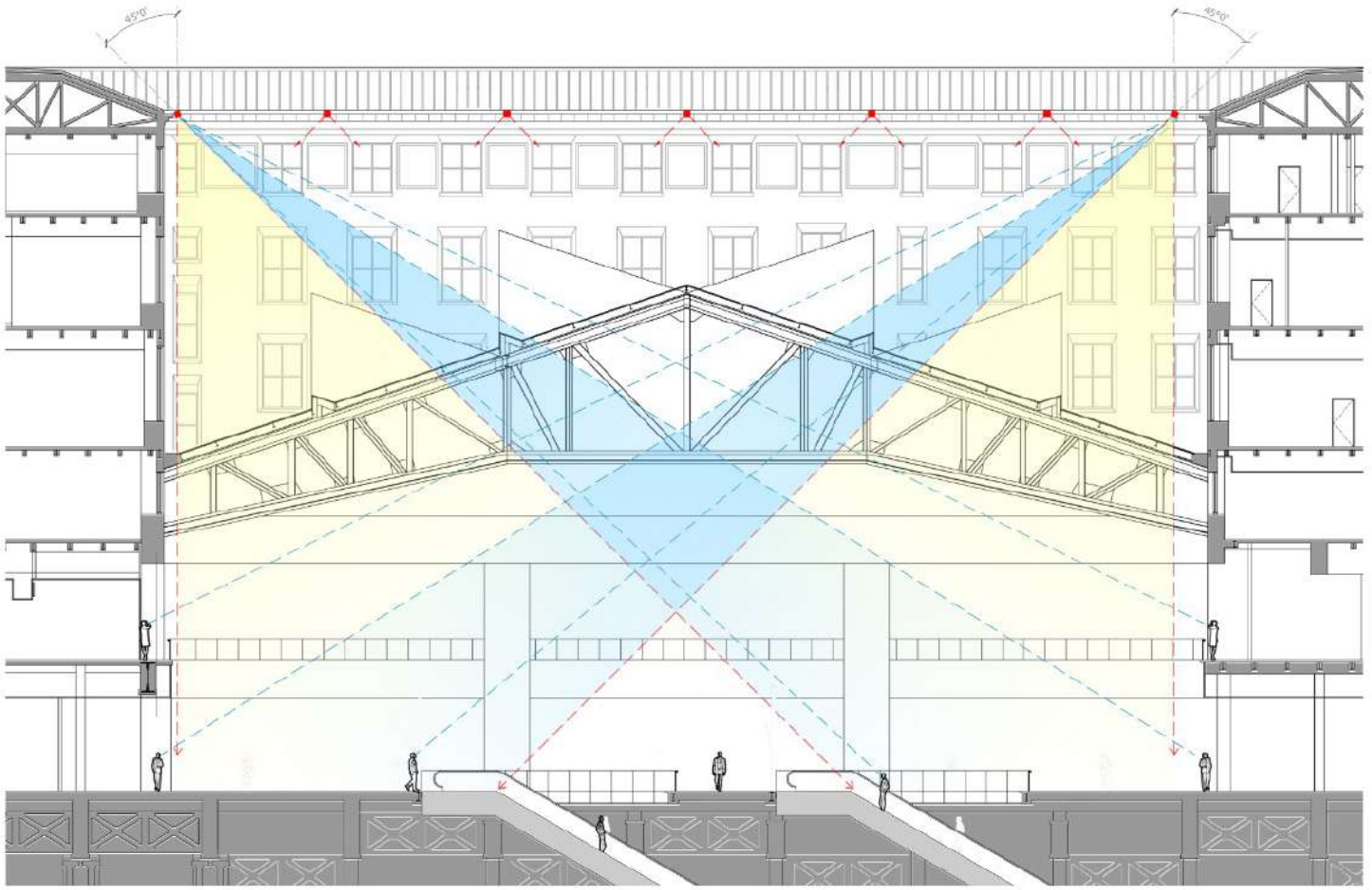
LUMINAIRE OPTICAL DESIGN *advises that any light emission above 45 deg. from nadir, could cause discomfort glare.*

DISCOMFORT GLARE *occurs when glare sources in the field of view produce a sensation of irritation in the eye.*

BLUE COLORED ZONES *would fall under the offending zones that could cause discomfort glare.*

YELLOW COLORED ZONES *would be considered non-glare zones.*

BLUE DASHED LINES *represent possible direct view angles from a person inside the train hall to the light fixtures mounted at the parapet. Particularly sensitive positions would be the person in the escalator coming up (inherent desire to look up) and anyone standing at the retail balcony which would possibly be more inclined to look up and around.*



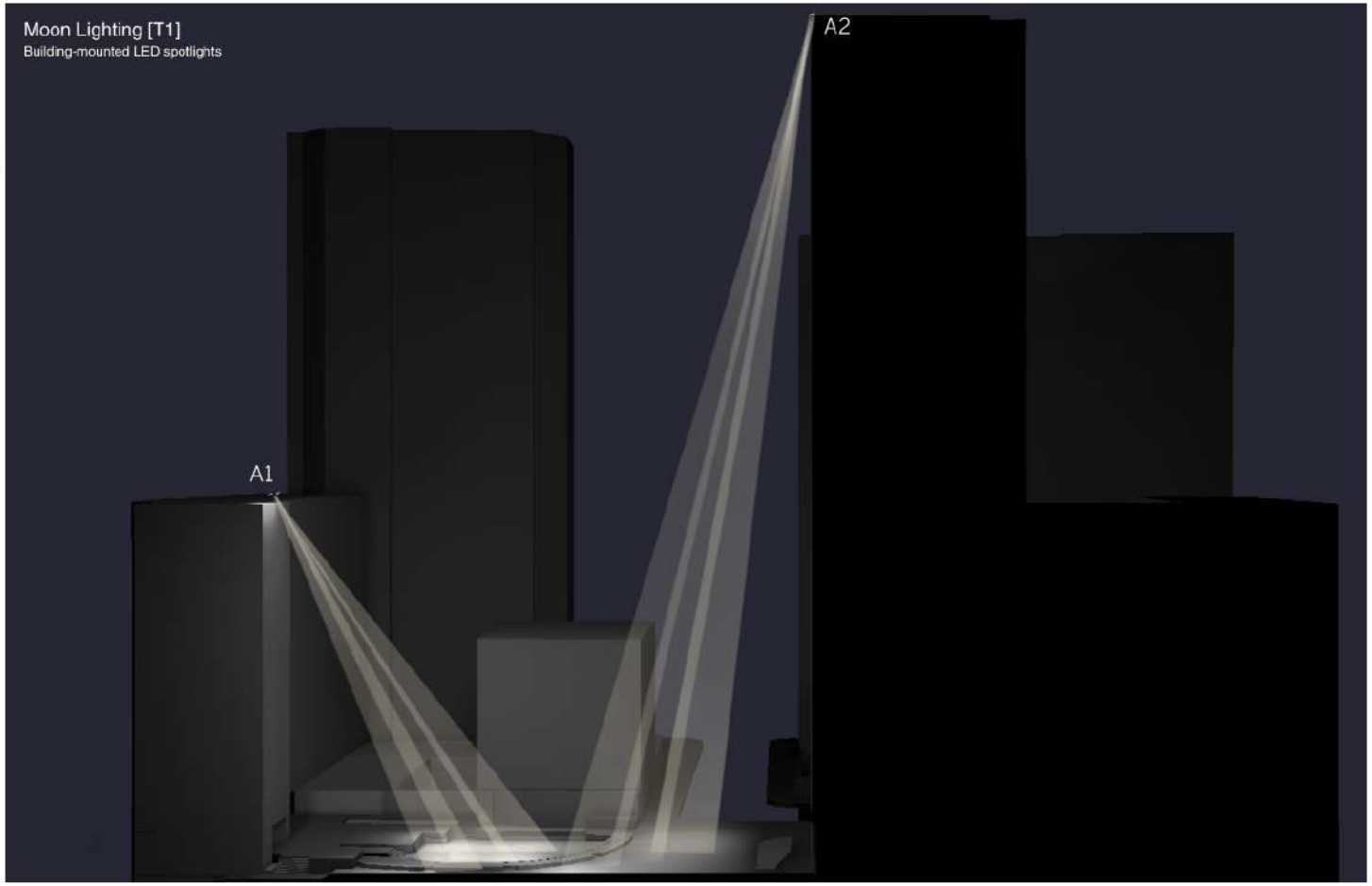
TRAIN HALL LIGHTING
MIDTOWN PLAZA - MOONLIGHTING

SUCCESSFUL MOONLIGHTING REQUIREMENTS:

The photo on the right represents a moonlighting approach since the context provided adequate mounting heights of lighting equipment thus minimizing the aiming angles and glare. [mounting heights for image on the right: 150-300 FT]

Aiming angles

For a successful moonlighting approach aiming angles need to remain between 10-20 deg max.
*The image at the right has both locations aimed within the range.
*The train hall aiming angles vary from 35-60 degrees.



TRAIN HALL LIGHTING
PROGRESS CONCEPT DESIGN RENDER

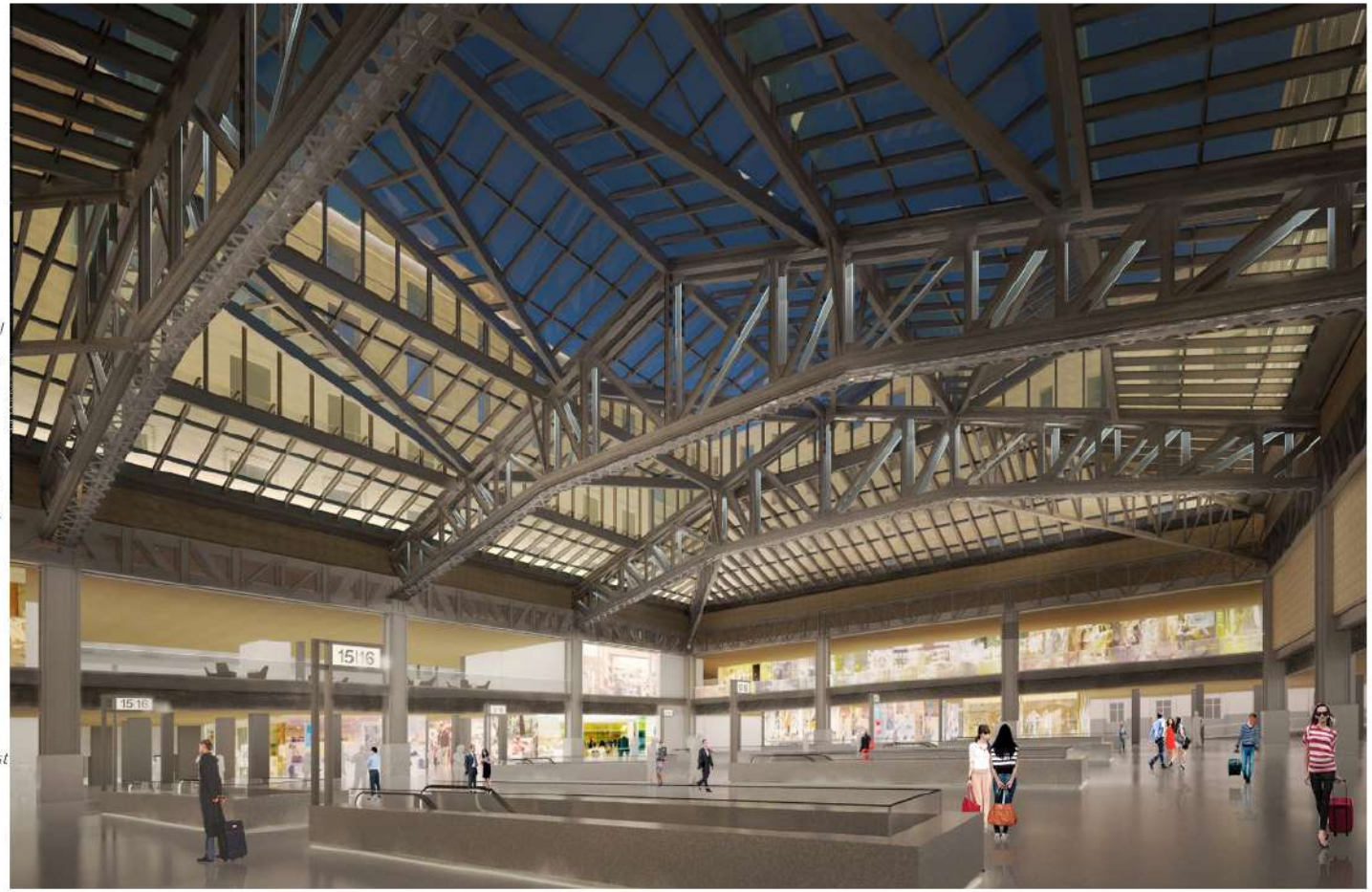
ALTERNATE LIGHTING APPROACH THAT PRESERVES "SKY-VIEW" WHILE STILL CELEBRATING THE STRUCTURE AND VOLUME:

- COURTYARD FACADE LIGHTING

  Continuous Tunable White Linear LED uplight with shielding for precise beam control. Fixture could be mounted on flexible brackets at 1-2FT away from facade to provide adequate grazing. Fixture can be a continuous approach or a regular pattern of equal spacing. The controls embedded into this system would provide dimming capabilities, color-tuning scenes (warm to cool - i.e sunset to nightfall) as well as more sophisticated scenes. As an alternative we could consider RGBW which would offer greater seasonal events and branding range.

- TRUSS ACCENT LIGHTING

  This approach investigates a more subtle animation of the trusses lighting/grazing only the inner face of truss. The accent light + snoot is placed above and between the truss structure, Not lighting the front faces of the truss could create a more dramatic effect and a more contrast between the different surfaces. Perhaps a truss mounted adjustable LED (aimed away from the truss's front face) could be considered for uplightign the skylight mullions.



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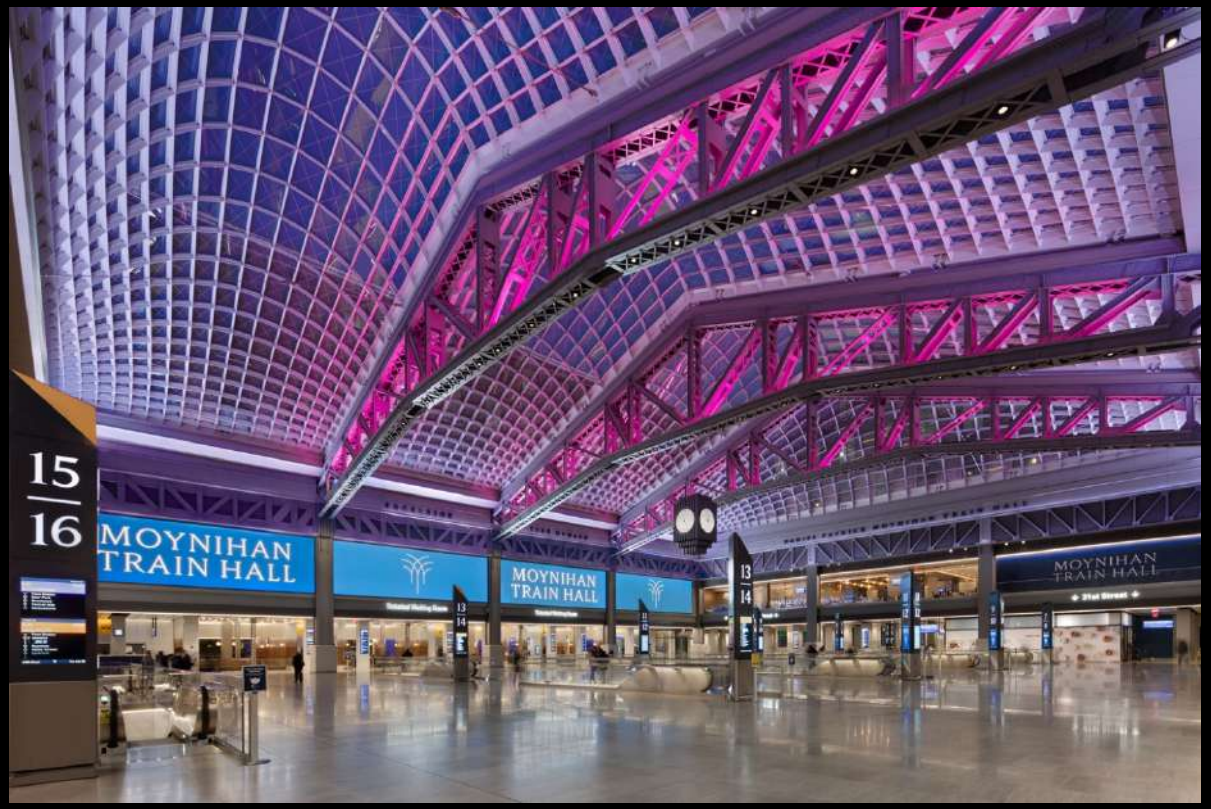

J. BARTELSTONE PHOTOGRAPHY

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Metrics + Mockups

Conclusions

- Glare is in the eye of the beholder
- Metrics can help, but context is critical.
- Apply design principles
- Review luminaires
- Document our results
- Enjoy beautiful spaces

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This concludes The American Institute of Architects Continuing Education Systems Course

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