Module 3

Illumination Systems

Lesson 13

Glare

Instructional objectives

1. Define Glare.
2. List types of Glare.
3. List the effects of Glare.
4. What are various Glare Indices
5. How is Glare Evaluated?
6. List measures to reduce the Glare.

An important issue in effective use of an illumination system is Glare. Glare by definition brightness within the field of vision that causes discomfort, annoyance interference and eye fatigue. It reduces the visibility of an object. This is the common fault of lighting installations. It injures the eye, disturbs the nervous system, causes discomfort and fatigue, reduces efficiency, interferes with clear vision and increases risk of accident.

Glare is experienced, when Lamps, Windows, Luminaries, other areas are brighter than general brightness in the environment. Glare may be Direct and Reflected. Direct glare results from bright luminaire in the field of vision. Reflected glare arises due to reflection of such a source from a glossy surface it is more annoying than direct glare can be avoided by appropriate choice of interiors.

Direct glare, minimization or avoidance is possible by mounting luminaries well above the line of vision or field of vision. Limit both brightness and light flux (in the normal field of view). Disability glare is that level of glare that impairs the vision. Whereas Discomfort glare only causes feeling of discomfort that increases or depends on time of exposure. There is no reduction of visual acuity but leads to fatigue. Annoyance is at lower ever luminance of the glare but source is more than the general luminance. Solid angle subtended at the observer's eye in the field of view is a measure of glare. There is a need to look at the Glare Evaluation System.

Glare Evaluation

Visual comfort system is most common evaluation in the USA/Canada. This is expressed as percentage of people considering an installation comfortable as viewed from one end. Glare tables list various proportions and layout of room for glare free lighting. Figure of merit is based on a source of 1000 lm.from a luminaire. If VCP $\approx$ 70% then the system is said to be glare free. British method employs Zone of luminaire with a classification for quality of light expressed as Glare index. Luminance limit system is adopted in Australia. Standard code for Luminaire base lamp. dep. on room dimensions, mounting height and a Empirical shielding angle

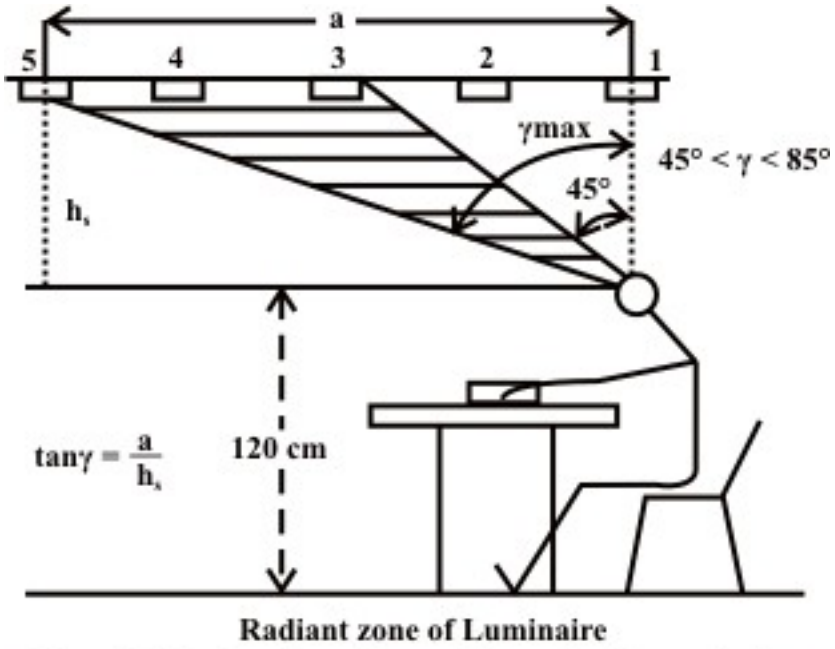


Fig. 1: Illumination Zone of a typical Luminaire

Luminance curve system is employed in Europe.
Luminance limits for luminaires critical angles, γ are $45^{\circ} < \gamma < 85^{\circ}$. Quality class is expressed from A to E type is based on Luminaire orientation.
Type 1. Luminous sides when Luminous side plane> 30 mm

Type 2. Elongated - $\frac{\text{length}}{\text{width}} > 2$

Orientation C0 – C180 Plane

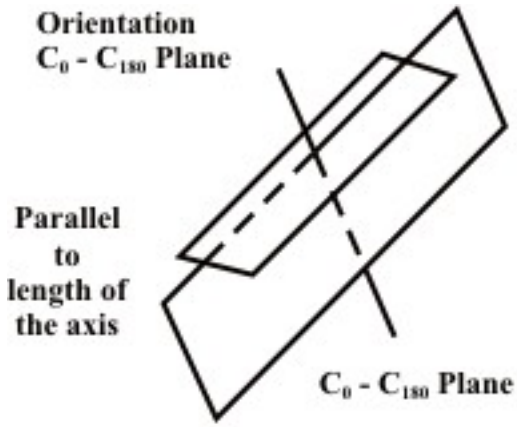


Fig. 2: Typical Type I Luminaire

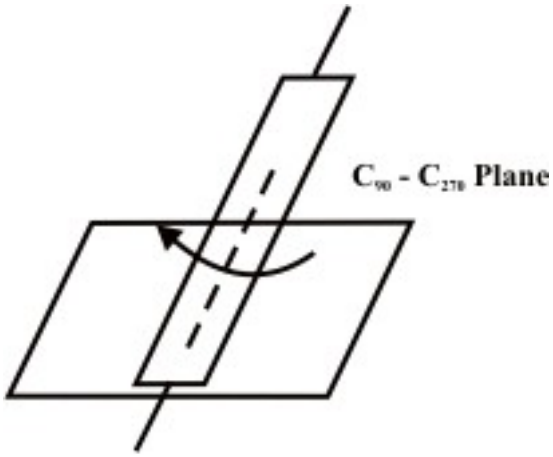


Fig. 3: Type II Luminaire

Table I

Shielding Angle	Glare Limit			Lamp
Luminance Cd/m2	B	D	E	Fluorescent lamp.
L ≤ 2.104	10º	0	0	HP discharge lamp
2.104 < L ≤ 50.104	15º	5º	0º	LP Sodium lamp
L > 50.104	30º	15º	0º	HP Discharge clear

Table I lists for different types of lamps effective shielding angle. Quality class A denotes very high level; B denotes high, C medium D low and E very low.

General light is predominantly light coming downwards. Typically reflectance of 0.5 for walls / ceiling and 0.25 for furniture.

How is Glare evaluated?

1. Determine luminance of the source between 45º - 85º
2. Determine the quality class and illuminance required.
3. Select the curve – class / level.
4. Determine. Max. Angle to be considered from length & height and plane of eye level & plane of luminaires. (Refer to Fig 1)
5. Horizontal limit based on" a / h", part of the line (or curve) to be ignored.
6. Compare luminance of one luminaire with selected part of the limiting curve.

No glare if luminance given by the curve > actual luminance over the whole range of Emission.

Table II

	Quality class	Service values of Illuminance (lux)								Glare rating
Luminance curve system	A	2000	1000	500	≤300					1.15
	B		2000	1000	500	≤300				1.50
	C			2000	1000	500	≤300			1.85
	E				2000	1000	500	≤300		2.20
	F					2000	1000	500	≤300	2.55
	Curve letter	a	b	c	d	e	f	g	h	
British Glare Index		15,5	17,0	18,5	20,0	21,5	23,0	24,5	26,0	
American VCP				75%	65%		45%			

Table II lists glare in dicer and curves to be used for different levels of illuminance and quality.

Quality class	G	Service values of Illuminance (lux)							
A	1.15	2000	1000	500	≤300				
B	1.50		2000	1000	500	≤300			
C	1.85			2000	1000	500	≤300		
E	2.20				2000	1000	500	≤300	
F	2.55					2000	1000	500	≤300
		a	b	c	d	e	f	g	h

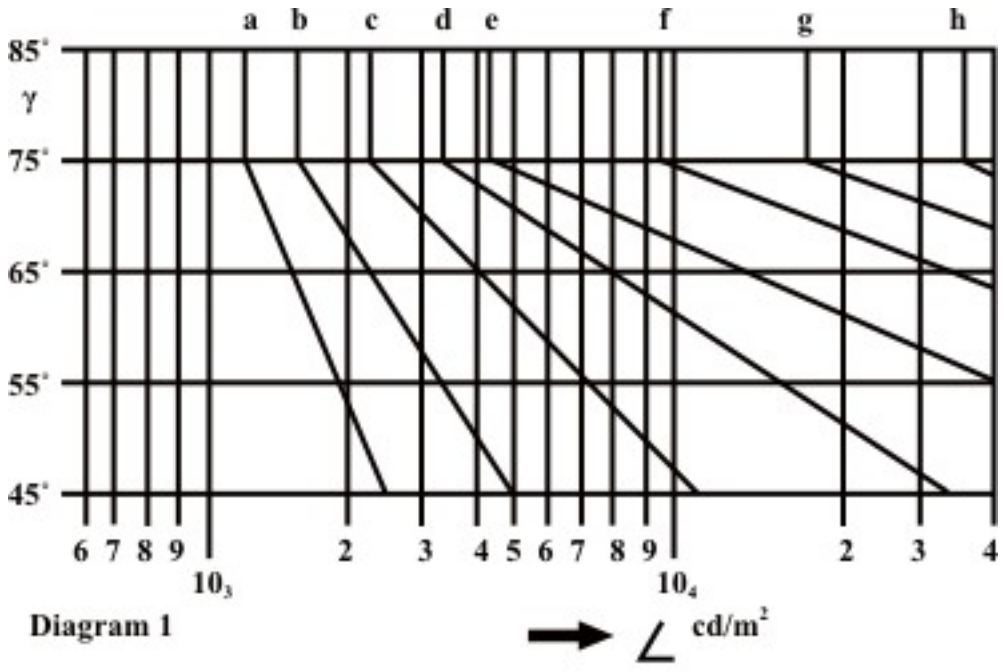


Fig. 4: Luminance Curves for Type I Luminaire

Fig 4 and 5 show the luminaire curves to be employed for different levels for Type I luminaire and Type II luminaire.

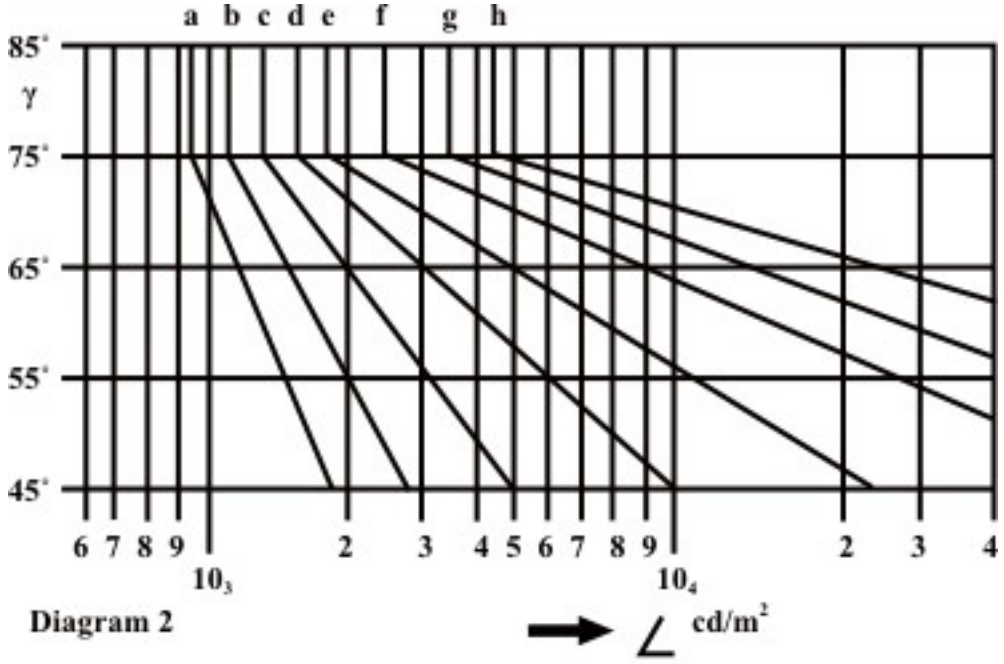


Fig. 5: Luminance Curves for Type II Luminaire

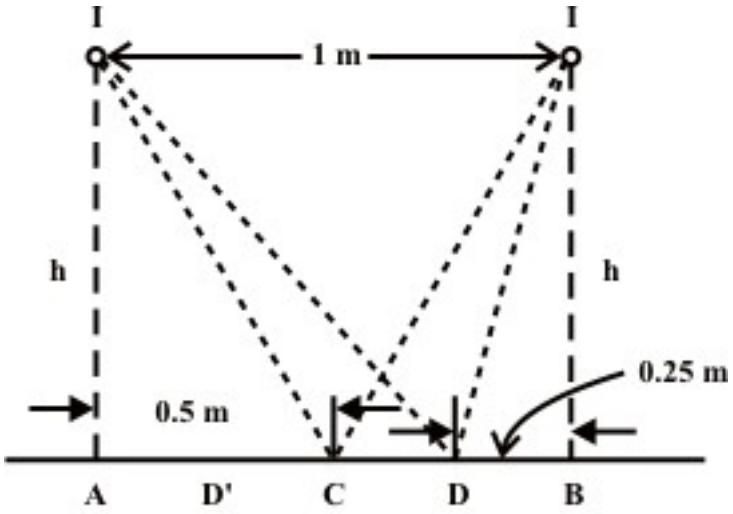


Fig. 6: Illuminance at Ground Level

h	$Illum_{A\ (B)}$	$Illum_D$	$Illum_C$
1	1.35 I/h2	1.425	1.43 I/h2
2	1.72 I/h2	1.798	1.827 I/h2
3	1.85 I/h2	1.902	1.919 I/h2
4	1.91 I/h2	1.943	1.95 I/h2

$$\text{Illuminance at A (B)} = \frac{1}{h^2}\left[1+\left(\frac{h}{\sqrt{h^2+1}}\right)^3\right] \qquad \text{(i)}$$

Namely height is an issue in avoiding glare. Fig. 6 shows two lamps placed at a height 'h' from ground at A and B. As can be seen from relations (i), (ii),(iii). Illuminance below the lamp falls rapidly, less rapidly at the mid point 'C'.

$$\text{Illuminance at C} = \frac{1}{h^2}\left[\left(\frac{h}{\sqrt{h^2+0.25}}\right)^3\right]*2 \qquad \text{(ii)}$$

$$\text{Illuminance at D} = \frac{1}{h^2}\left[\left(\frac{h}{\sqrt{h^2+(0.75)^2}}\right)^3+\left(\frac{h}{\sqrt{h^2+(0.25)^2}}\right)^3\right] \qquad \text{(iii)}$$

h ↑ (i) ↓↓↓ (ii) ↓↓ (iii) ↓

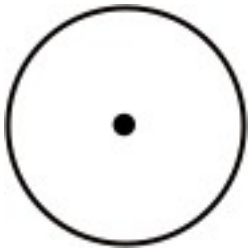
Glare from windows is the next issue. Sky has a typical luminance of 2000 Cd/m^2. Horizontal Illuminance ≈ 10,000 lx. under overcast conditions. It is prevented by curtains, blinds, louvers. Opening of windows can be reduced. Shift the work plane away from offending windows. i.e. normal field of view no light enters from the offending window on the work plane. Lightest decorative finish on surfaces surrounding window openings. Veiling reflections and reflected glare are allowed outside the task. Reflected by glossy surface – semi matt. Mild distraction can cause considerable discomfort. When glare (bright light) on the task. Veiling reflection – reduce task contrast with some loss of details.
Glare can be minimized by not locating in the forbidden zone, increase light from sideways at right angles to the direction of viewing. Luminaries having large surface area with low luminance may be employed. Working surface to be provided with reduced reflection preferably Matt surface

CRF (Contrast Rendition Factor) is yet another index and influence of Lighting on Task Contrast and Task Visibility is Contrast Rendition Factor. By definition

$$\text{Task visibility} = \frac{\text{Given Emmision}}{\text{Sphere Illuminance}}$$

Where Sphere Illuminance is the Illuminance by the source providing equal Luminous Intensity in all directional in a hypothetical sphere. (ESI)

Observer is located / views at angle of 25º to the vertical. Observer considered to be viewing pencil task which id believed to be slightly conveying.



This lecture has had a look at glare, how originated various evaluation procedures and ways to minimize.

Lecture Summary

- Glare is the brightness within the field of vision
- Effects of glare :
  - injures the eye
  - disturbs the nervous system
  - causes annoyance, discomfort & fatigue
  - reduces efficiency of work
  - interferes with clear vision
  - risk of accident increases
- Types of glare :
  - Direct Glare
  - bright luminaire in the field of vision
  - Reflected Glare
  - reflection from a glossy surface
- Reflected glare causes more annoyance than direct glare
- Direct glare can be minimized by mounting luminaires well above the line of vision
- Disability Glare impairs the vision
- Discomfort Glare increases with time of exposure
- Glare Evaluation Systems :
  - American system (VCP)
  - British system (Glare Index)
  - European system (Luminance Curves)
- Luminance angle limit for luminaires : $45° < \gamma < 85°$
- Glare from windows can be prevented by using :
  - curtains
  - blinds
  - louvers
- Glare from windows is of two types :
  - veiling reflections
  - reflected glare
- Techniques for minimization of glare from luminaires :
  - not locating luminaires in forbidden zone
  - increase light from sideways
  - luminaires having large surface area
- CRF (Contrast Rendition Factor) – influence of lighting on task contrast & task visibility

  $$\text{Task\_Visibility} = \frac{\text{Given\_Emmision}}{\text{Sphere\_Illuminance}}$$
- Sphere Illuminance – Illuminance by the source providing equal luminous intensity in all directions. Also known as ESI (Equal Spherical Illuminance)
- Three categories of lighting :
  - general lighting
  - local lighting
  - combination of local & general lighting
- Combination of general & local lighting are preferred to avoid glare

Tutorial Questions

- When is glare experienced?

  Glare is experienced when source of light is brighter than general brightness

- How can reflected glare be avoided?

  Reflected glare can be avoided by appropriate choice of interiors i.e. wall color & finish of furniture

- How can direct glare be minimized?

  Direct glare can be minimized by limiting both brightness as well as light flux, normal to the field of view. Luminaires should be mounted well above the line of vision

- What is VCP?

  VCP is the Visual Comfort Percentage. It is the American standard of glare evaluation.

- What is Glare Index?

  Glare Index is the British standard of glare evaluation

- What level of reflectance should be maintained for walls / ceiling & furniture?

  For ceiling / walls a reflectance of 0.5 should be maintained & for furniture it should be 0.25

- Why should we have long & narrow windows?

  As day progresses, illumination increases in vertical plane. Hence we have long narrow window

- How can we minimize glare from windows?

  - shift the work plane from the offending windows
  - use lightest decorative finish on surfaces surrounding window opening

- How can we minimize reflected glare?

  Reflected glare from glossy surfaces can be avoided by having semi-matt kind of finish

- What are the factors that govern good general lighting?

  General lighting should be based on the required horizontal illuminance. Lamps should be arranged in a regular fashion & all over the ceiling. They should be equally spaced.

- What is localized lighting? What care should be taken for localized lighting?

  Localized lighting is non-uniform lighting on horizontal plane at the place of interest. Care should be taken to avoid glare as localized lighting may produce glare

- Why is it important to have general lighting ON all the time?

  Localized lighting may cause glare. Moreover we should have sudden change in brightness. So we should have high level of illuminance at place of interests (localized lighting) & at other places minimum of 50% lighting (general lighting)

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