THE CRITICAL WINDOW LUMINANCE CAUSING GLARE IN INTERIORS

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The simple daylighting design era ended with the introduction of various new patterns of sky luminance distributions ´wandering´ over the sky vault with the sun path which rendered the Daylight Factor criteria obsolete. No simple daylight design replacement is yet available and, the appropriate computation of discomfort glare remains controversial. Furthermore, the CIE has now initiated, at least moral support, for the deployment of ´smart´ luminous environment devices, and design and operation methodology with the intention of assuring building occupant comfort while nurturing the natural environment. Thus, it is important to bridge the gaps and correct the technologies that are present in the daylighting theory and technology, and manage these correctly in a comprehensive building energy use interface; in effect, to marry healthy human visual and thermal design comfort criteria to built environment ecological imperatives.

The range of intolerably glaring luminance from the sun disc outdoors cannot be coped with by human eyes. This extreme luminance of the Sun seen from the outer border of earth atmosphere approaches two million kcd/m^2 which in equatorial regions at noontime is reduced only by the extinction and turbidity of the zenith part of the atmosphere to roughly 1.6 – 1.2 million kcd/m^2 luminance level. However, in any arbitrary locale further reduction is caused by greater optical air mass and lower solar altitude changes within each day Thus requirements for the shading of windows to block or reduce this visually intolerable disability and discomfort from direct sunbeam glare in windowed rooms has to be considered. Qualities of shading devices and controls can vary due to the window orientation. However, the sun disk can be viewed directly during the sunset as its luminance is depleted by a deep optical air mass and higher luminous turbidities. These lower luminances may be tolerable.

Unwanted brightness has two definitions in the CIE International Lighting Vocabulary:

- disability glare -glare that impairs the vision of objects without necessarily causing discomfort,

- discomfort glare - glare that causes discomfort without necessarily impairing the vision of objects.

Both types of unwanted brightness are hazards to be respected in every daylit visual environment. Critical sky luminances seen by working occupants in office and school environments have to be taken into account. Of course, interior occupants can see the sky luminance through the windows from their positions reduced only due to the glazing transmittance and external obstructions.

There are now 15 sky types accepted by CIE. But there is no design luminance currently recommended for any sky. In order to integrate 'discomfort glare' with daylighting design, no matter whose glare formula is used, it is necessary to know the design luminance characteristics of the light delivery systems, in daylit as in artificially lit spaces. However, discomfort glare prediction requires the opposite end of the luminance range needed for daylighting design. The requirement for discomfort glare is to know the probability of sky

luminance, on a non-insolated surface, which would only be exceeded, for instance, for 5 - 15% of the working day. And, when that 5 - 15% luminance is reached, or that surface is insolated, shading treatment and control system have to be employed to protect against excessive levels of unwanted brightness (Discomfort Glare).

In general the appropriate design window luminance at any interior working position depends on quite many circumstances and conditions, such as:

- the locality defined by its geographical latitude and longitude influencing the local year-round sun path,
- the actual date or the day number within a year which determines the solar declination,
- the exact time expressed either by the hour in true solar time or by the local clock time,
- the state of the atmosphere or the general sky type standardised by the ISO/CIE determining the relevant luminance sky patterns,
- the actual sun position with respect to cloud position as well as with respect to the orientation of the window façade and obstructing surrounding house fronts,
- the orientation of the window to cardinal points due to the momentary orientation of the actual sky pattern or solar meridian,
- the visual work tasks in the interior occupants including view toward their work and windows,
- the type of window glazing, its transmittance characteristics,
- type of shading devices, whether adjustable or permanent, their shading effects, transmittance, diffusion, redirecting solar beams etc.

It is evident that the designer´s task to predict and evaluate the window luminance is not easy and could be quite time consuming without the help of a computer program which would quickly calculate it in a user-friendly way. The genesis of such a program exists, the MAM Modeller, which was demonstrated at the Budapest symposium in 2005, but with no glare applications specified. These will be explained and documented in this contribution with critical situations considered.

To avoid discomfort glare in single smaller interiors the work positions should be placed in the preferred zone two to three meters from the window, where the ratio of window luminance to task luminance does not exceed 20. When the minimal task luminance requires at least 125 cd/m^2, then to achieve the Just Acceptable (JA) discomfort glare situation the window luminance should not exceed 2500 cd/m^2. If in deeper rooms the daylight illuminance is not able to produce sufficient task luminance then supplementary artificial lighting should be employed. The reduction of visual discomfort could also be achieved by increasing a task's video display luminance (video display luminances exceeding 1000 cd/m^2 are already in development). Current video displays can produce luminances of 300 cd/m^2 are common and could permit normally viewed window luminances as high as 6000 cd/m^2, equal to sky luminances of over 7500 cd/m^2 or greater, depending on window transmittance passive or active control.