UGR ON THE RISE

Combating the impact of glare through the Unified Glare Rating metric requires an application-, not product-based, approach

By James K. Eads

Customers today are seeking solutions for work environments that sustain productivity while emphasizing visual comfort beyond CCT and CRI values. This trend has gained momentum from organizations that seek to foster healthy environments, such as the WELL Building Institute. One of the key metrics in Versions 1 and 2 addresses glare control with Unified Glare Rating (UGR) levels identified. The demand for UGR has grown within the past year, with Version 5.1 now part of the Design Lights Consortium draft. Moreover, customers are also integrating UGR values as part of the bid process. But as the emphasis on fighting glare has grown, so has the haphazard approach to addressing it.

UGR was developed in the late 1970s as lensed fluorescent products were coming into the marketplace. Adopted by the International Commission on Illumination (CIE) in CIE 117-1995, the metric was centered solely around a methodology to assign a numerical threshold when glare becomes uncomfortable to an observer. The UGR scale has a range of 10 to 30 with seven thresholds classified to identify the predicted measure of discomfort glare (**Table 1**). A UGR rating of 19 is the maximum acceptable value based on this scaling methodology.

The UGR formula accounts for several factors, including:

- Background luminance
- The luminance of the aperture of each luminaire in the direction of the observer's eye
- The solid angle of the luminous parts of each luminaire at the observer's eye
- The Guth position index for each luminaire (displacement from the line of sight)

There are known flaws in each of these factors, giving rise to questions over accuracy. CIE is working to modify the approach of this equation with JTC7, currently in its late stages of development. Also, the UGR equation does not account for color, though studies have shown that color affects glare perception (*https://doi.org/10.1002/j.2168-0159.2013.tb06416.x*).

The most common methodology used to capture a UGR value is the UGR table representing 190 individual calculations based on various room sizes and room reflectances for two observer positions. These calculations are based on a single IES file. The table provides a broad assessment of the UGR value for a specific fixture with some limitations. The biggest issue with the tool is that the spacings are not tied to a specific lighting level. While the report is based on a single IES file, the calculations are based on multiple luminaires evenly distributed within those spaces. However, there is a concerning pattern where some manufacturers "stamp" entire product families as UGR 19 and below, based on one or two calculations that happen to be below the table's UGR 19 level. Specifiers want to know the UGR of a specific fixture and these manufacturers are trying to provide them with one simple answer.

This approach is not the intent of the CIE documentation, which clarifies that the tabular method is based on "standard conditions and reference values." Certainly, specific room geometry with known ceiling heights, reflectances and exact locations of luminaires will differ significantly from what the tabular tables will show. It is often the case that a high UGR value shown in the Table 1 list estimates can still provide a favorable rating within an actual application when the variables are better defined.

UGR	Hopkins Ratings Scale
10	Imperceptible
13	Just Perceptible
16	Perceptible
19	Just Acceptable
22	Unacceptable
25	Just Uncomfortable
28	Uncomfortable

Table 1. UGR values compared with Hopkins Rating Scale.

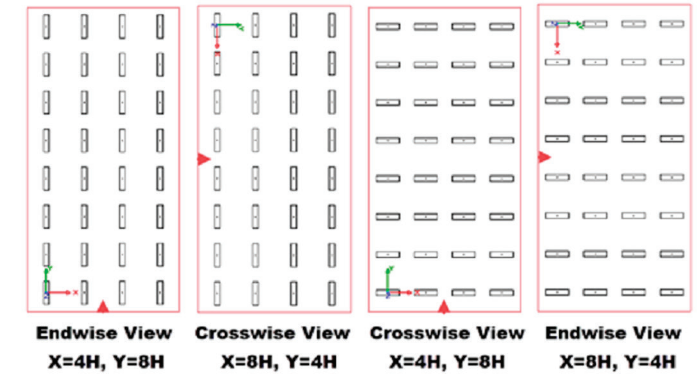


Figure 1. Examples of the four standard observer positions used in UGR calculations.

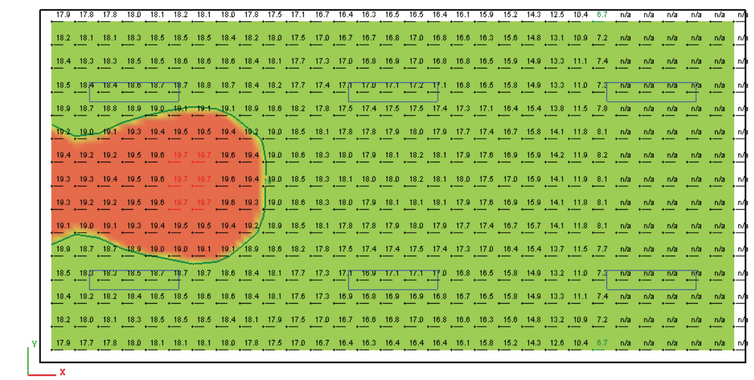


Figure 2. A typical UGR calculation result, for an observer looking east.

Below are some general rules regarding the factors that can negatively impact a UGR rating:

- Higher lumens/higher UGR
- Distributions more volumetric/higher UGR
- Spacing criterion – larger spacings/higher UGR
- Room size – larger room/higher UGR
- Reflectances – lower reflectances/higher UGR
- Mounting heights – lower MH/higher UGR
- Luminance of the background and source
- Size of the source (aperture)
- Luminaire position in relation to observer

Several sources online suggest ways to add shielding, louvers and diffusers to improve the UGR value, but this may cause a designer to choose luminaires with higher lumen output and wattage, adding more units to a space to achieve appropriate footcandle levels, or be forced to use another luminaire type.

The approach to generating accurate UGR values must begin by acknowledging that UGR calculations cannot be "product specific." Instead, the approach needs to follow an application-based study. The designer can have a single IES file that has unacceptable UGR levels with a 8-ft mounting height but by raising that mounting height by just 2 ft, the designer may achieve the desired UGR 19 level.

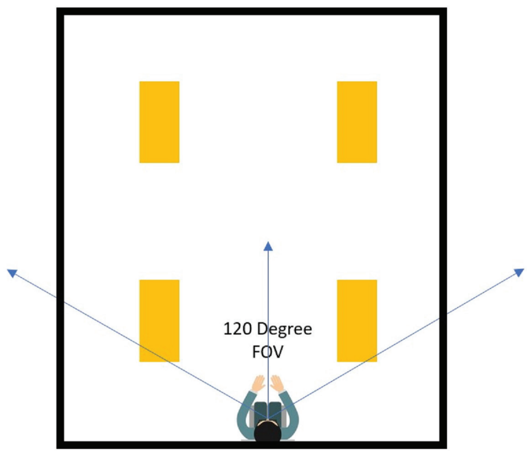
Observer positions are the single most critical issue for proper UGR analysis. Within the UGR tables there are two observer positions sitting along the back wall in the endwise views and crosswise views, based at 1.2 meters height and looking straight across the space (**Figure 1**).

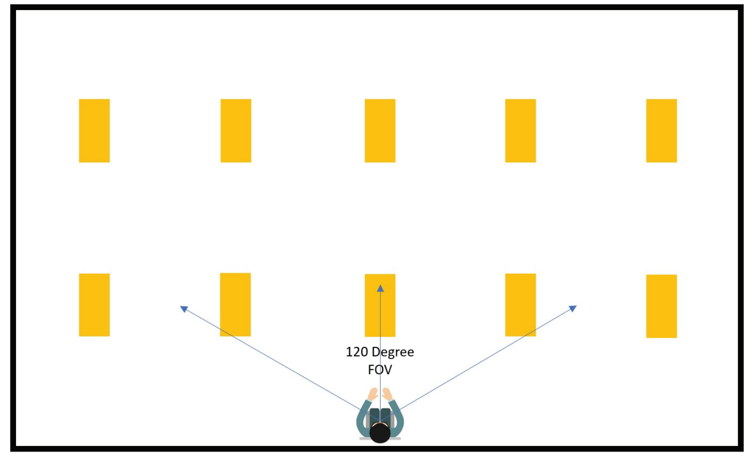
When creating a full design to obtain a UGR level, the designer can place as many observers as desired within a space and orient them to suit a better outcome. The CIE does not suggest any standards around how many observers are needed based on square footage. Nor do they identify whether the observers are uniformly spaced or placed along key traffic lanes within a floorplan. This can be problematic when you are obtaining a UGR value.

Tools such as AGi32 and Visual enable the designer to perform the calculations. Imagine you have provided a design that has met the footcandle and uniformity requirements only to fall flat over a UGR calculation? **Figure 2** shows a simple space designed to meet 30 fc with a standard 80/50/20 reflectances and 10-ft luminaire mounting height. Within the room there are observers placed uniformly throughout the space looking east. Notice that the values in red show how the levels rise unfavorably in the left portion of the image, while most of the space is acceptable.

How many readings above 19 are acceptable within a space? Does it force you to choose an alternative product or obtain concessions from involved parties?

If we used the standard two observers' locations where the crosswise view result went above UGR 19 and the endwise view was below UGR 19, does this situation fall within an acceptable range for the customer? Does it force you to completely disregard





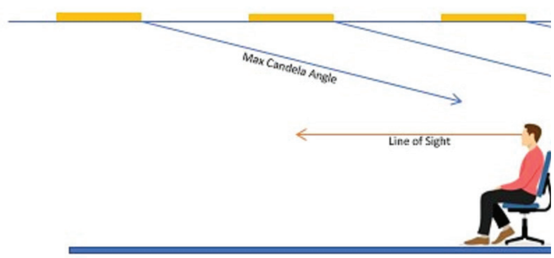


Figure 3. An example of luminaire max-candela angle shown with respect to observer line of sight.

this product option if any view direction is above the UGR 19 range? These are the decisions designers and customers will need to evaluate further.

Commonly narrow distributions in general can help achieve a favorable UGR value, that should never imply volumetric distributions with a spacing crtieria of 1.0 or greater cannot be utilized. What becomes key are the relationships of the observer positions to the quantity of fixtures within line of sight of the observer(s).

For example, let's assume an observer is seated with fixture placed overhead (**Figure 3**). If we created a line to represent the max-candela angle as a general reference, you can better understand the distance and quantity relationships to volumetric distributions. It is quite reasonable that small to medium-sized spaces can have favorable UGR values with volumetric distributions because the max-candela angles are above the line of sight to the observer. In addition, the number of sources within the observer's view are also limited. Only the units farther away from the observer will be problematic for much larger open spaces.

In short, the CIE does not address IES recommendations for lighting levels and uniformity requirements. However, since 2003 the European Lighting Standard EN12464-1 has recognized that all application spaces are not the same and have created tables of application types assigning a UGR value with a recommended lux level. These tables help clarify that all spaces do not have to adhere to a UGR 19 or better metric.

UGR is just one tool at our disposal to ensure we are providing a visually comfortable setting. The core principles of design dealing with the aesthetics of a space through the selection of form factor for the luminaire, building layers of lighting, and satisfying IES recommendations, are all part of this equation as well.

From the end-user perspective, they should be able to use a luminaire that best meets *all* factors important to that space and be involved as much as possible in the design process.

The industry, as a whole, must be more proactive to help educate professionals and/or consider incorporating UGR as part of the Recommended Practice or Design Guide reference materials, along with specific application-based levels similar to the EN12464 documentation. As professionals within the industry, we are equally responsible to engage with IES technical committees to drive results. As customer needs and technologies continue to develop, we should do what has a positive impact on the final visual result of a design and the occupants using that space. Take pause to understand and make those sound, practical and effective choices. ◎

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