LIGHTING FOR QUALITY

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Overhead Glare

When we are presented with a bright source that is located straight ahead of us, we experience glare. If the source is excessively bright we will experience disability glare. That is, the intensity of the source is so harsh that it prevents us from being able to see well. A good example of this will be the high beam from an approaching car. In interior lighting environments, it is unusual that we will experience this type of disability glare. But rather, we may be subjected to a high enough source brightness that will make us feel uncomfortable. Hence we term it discomfort glare.

Discomfort glare has been investigated for over half a century. We know quite well the factors that influence discomfort glare—namely, the size of the glare sources, the luminance of the sources, the overall luminance of the environment, the angle of deviation of the sources from the horizontal line of sight and the number of glare sources within the field of view. In North America, we use the Visual Comfort Probability (VCP) System to estimate the glare potential of a luminaire under predetermined conditions. At the present time, there are some questions among lighting specialists as to whether VCP is the best predictor of discomfort glare or not. However, the overall underlying concept is sound.

Our glare sensation is very much affected by the location of glare source from our horizontal line of sight. If it is straight ahead in front of us, we will experience much greater visual discomfort than if it is away from our line of sight. Conversely, the farther away it is from our line of sight, the less we will be affected by the brightness of the source. One fundamental assumption of this system is that discomfort glare exists if the source of glare is within 53 degrees above our line of sight. This implies that a glare source located above 53 degrees from horizontal (when we are looking straight ahead) is unlikely to cause any discomfort glare.

Or is it?

All of us, at one time or another, have had the experience of sitting in an office directly under a two-by-four type parabolic luminaire with either three or four T8 fluorescent lamps. Do we feel very comfortable? Does the brightness of the luminaire bother us? I believe there are just as many people who would say that it is uncomfortable, as there are people saying it is comfortable. The luminaire undoubtedly is beyond 53 degrees from our horizontal line of sight. Our traditional belief is that it should not cause any visual discomfort because we cannot see the bright object. But it does, at least to some. The reason for this is simple: our sensation to brightness does not fall off the cliff right beyond 53 degrees. We are still sensitive to glare at 55 degrees and higher but at a continually reduced level. If source luminance is high enough, we will experience discomfort. The discomfort glare that is associated with a glare source located higher than 53 degrees from our horizontal line of sight is termed "Overhead Glare. "

The subject of glare is well investigated, from Luckiesh and Guth to Hopkinson to Fry to Kanaya just to name a few. Kanaya showed that as the angle of deviation from horizontal line of sight increased from 60 to 75 degrees, discomfort was also reduced accordingly. However, the first research that solely focused on glare from overhead sources was done by Sheedy and Bailey of the University of California School of Photometry in 1995. They studied the effect of overhead glare on visual discomfort produced by a glare source located directly overhead the subject. The intensity of the glare source was held constant. But the amount of glare sensation felt by the subject was varied by means of a cap with a visor of different transmissions. In this way, all the photometric quantities associated with the experimental set-up were held constant except the amount of overhead glare impacting the subject. The researchers' conclusion was that the higher the luminaire luminance, the higher the subject's discomfort. This study definitely showed the effect of visual discomfort produced by glare source above 53 degrees, proving the existence of overhead glare.

Another study on overhead glare was done at an IESNA and IALD joint committee QVE/MOQ workshop in 1999. In this study, a series of four experiments was performed to understand the phenomenon of overhead glare. Subjects experienced in lighting provided assessment of the degree of discomfort caused by a glare source positioned at five different positions corresponding to 55, 65, 75, 85 and 95 degrees above a horizontal line of sight in a simulated office space. The glare source was set to high, medium and low values and so was the ambient illuminance. The results showed that people do experience discomfort from overhead glare source if the luminance of the glare source is high enough. Specifically, the study found that there is an increase in discomfort with increasing source luminance and size of the glare source. The discomfort is reduced by increasing the light levels in the room. And as expected, there is a decrease of discomfort with an increase in deviation from horizontal line of sight. The results showed that the median BCD (boundary between comfort and discomfort) luminance for deviations up to 85 degrees is around 9000 cd/m^2. That is, a glare source with luminance of 9000 cd/m^2 will cause discomfort to 50 percent of the people even when it occurs 85 degrees above a horizontal line of sight.

In 2000, another study complementary to the above mentioned research using similar method but with naïve subjects was conducted at the Lighting Research Center at Rensselaer. The findings from this study were similar to those of the previous study. The only difference

was in the level of luminance value beyond which subjects felt discomfort for all angles. The 1999 study with lighting professionals reported a value of 9000 cd/m^2 while the 2000 study showed a 16,000 cd/m^2 value for the naïve subjects. This suggests that lighting designers are more sensitive to discomfort glare than naïve subjects. While there may be technical debate on this discrepancy, this much is clear: for practical applications in long-term work environments, we need to consider a level of overhead source luminance that is much lower than the BCD values determined in the studies. This is because we do not want to design a lighting system in which only 50 percent of the people are satisfied. Moreover, this BCD level is for luminance of the glare source at 85 degrees. For angles below 85 degrees, say 55 and 65 degrees, the lamp luminance values should be much lower.

There was another interesting finding from this research: the pattern of the results are exactly what would be expected from the fundamental formulae on which the conventional discomfort glare prediction systems, such as VCP, Glare index and the UGR system are based. As a matter of fact, the 2000 study shows that the approximate level of discomfort produced by a glare source between 55 degrees from line of sight and the edge of the visual field of view can be predicted using the Unified Glare Rating system.

Is overhead glare a different kind of glare? No. The research results imply that overhead glare is simply an extension of discomfort glare and not an entirely separate phenomenon. It confirmed that discomfort glare does not cease at 55 degrees from line of sight, but continues until the glare source passes well outside the field of view. The data does show that the luminance required to produce discomfort glare at very high angles, i.e., when the it is overhead, is much higher than is required at lower angles i.e., when it is closer to the line of sight. There is no doubt such luminances are well within the range of our present day light sources and luminaires.

When is overhead glare a concern for lighting designers and engineers? Well, the short answer is that whenever visual comfort is an important issue. Take for example, lighting for school classrooms. Most of the time, students' attention will be on the teachers or the chalkboards. If the luminaires on the ceiling direct most of the light downward, it can create overhead glare and can create a very uncomfortable visual condition for the occupants of the classrooms. This is especially true for luminaires with high lumen and high brightness sources such as HID, compact fluorescent or the linear T5 and T5HO lamps where the bare lamps are visible. One can experience similar overhead glare in offices, conference rooms, libraries, hospitals, and courtrooms just to name a few. An adverse by-product of overhead glare is veiling reflection. When most of the intense brightness of the luminaire is directly overhead, veiling reflection is most prominent.

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As we stated earlier, in long-term work environments, we need to consider a level of overhead source luminance that is much lower than the BCD (9000 - 16,000 cd/m^2) level. There are still some aspects of overhead glare that need further explorations, such as the relationship between glare source size and visual comfort. However, at this time we recommend the maximum luminance of the luminaires should be no more than 10,000 cd/m^2. Those who feel "more comfortable" with a lower value should feel free to reduce the luminance. After all, 9000 cd/m^2 represents only a 50 percent satisfaction level for lighting professional.

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