White Paper

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University of Phoenix Glare Analysis

Overview

Glare – discomfort due to bright light – is an interaction between the physics of light and the biology of the human visual system, and is thus somewhat subjective by nature. We know it when we see it.

Typically, comparing glare between sports lighting systems requires traveling between venues, making it all but impossible to get any meaningful comparison. It is rare to have an opportunity to view two sports lighting systems working side-by-side, and we were given such an opportunity at the University of Phoenix Stadium while installing a new LED lighting system. The new system was wired to temporarily co-exist with the existing system, and we briefly took the opportunity to turn both on simultaneously. A group of several viewers (some of us, admittedly, biased) came to the conclusion that the LED solution performed as well as, or probably better than, the legacy metal-halide solution at managing glare, which had been a concern due to the increased output of the fixtures. This was satisfying for us and the customer representatives, but in the following analysis we attempt to lay out an objective basis for this conclusion.

Photographic Analysis

By taking photographs with a calibrated camera we are able to get reasonably accurate measurements of the luminance of a fixture (Peter D. Hiscocks, 2013).

In the below image taken during the side-by-side testing at University of Phoenix, we see roughly 65 metal halide lights on alongside 24 of the new LED fixtures, as seen from the stadium floor:

Figure 1: LED and Metal Halide fixtures side-by-side at University of Phoenix Stadium

From this image, we can immediately tell several things:

- Fixtures that are aimed in the direction of the viewer appear much brighter than those which are not.

- There is comparatively less spill-light from the LED fixtures (the fixtures aimed away are fairly uniformly dark).

- The color of the LED lights is much more uniform than that of the metal halide fixtures.

With the help of some math and some image processing software, we can identify which fixtures produce luminance values of greater than 1500 candela/M^2, considered a reasonable approximation of a level which is perceived as glare in an indoor environment (Osterhaus, 2002).

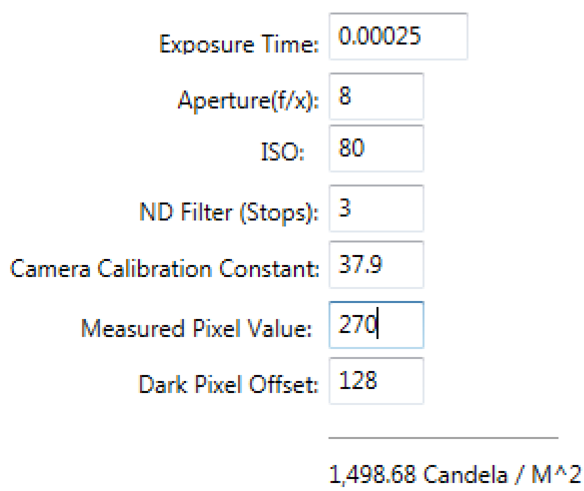

Figure 2: Determining a pixel value limit of 270 for an luminance value of 1500 Candela/M2

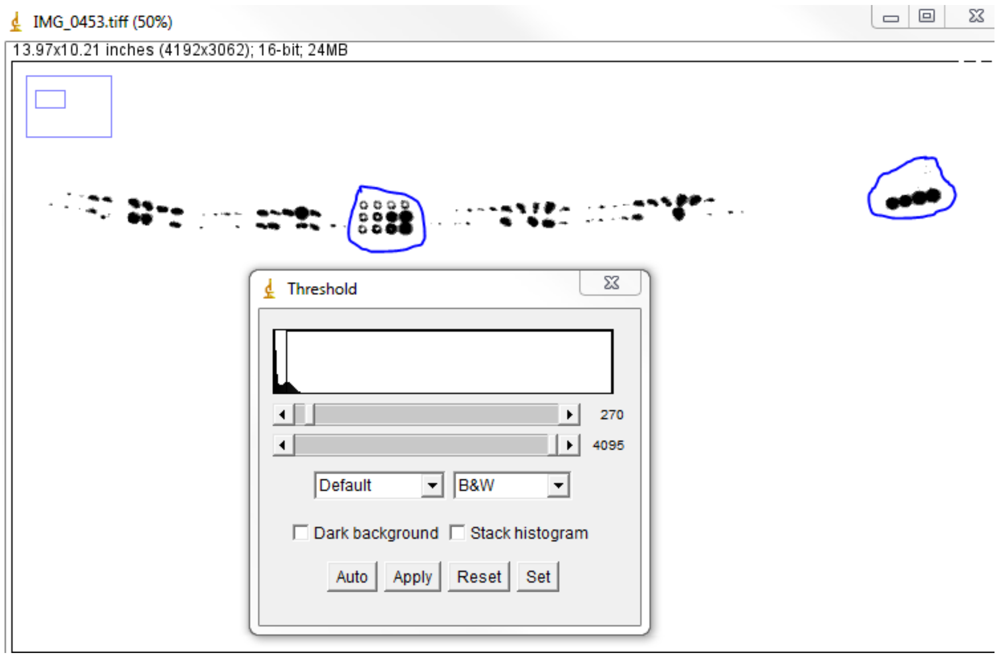

Figure 3: Areas exceeding threshold of 1500 Candela/M² (LED fixtures circled in blue)

By summing the areas above the threshold inside vs outside of the blue circles we can see the ratio of the area of the LED fixtures that would be considered "glare producing" versus the area of the metal halide fixtures:

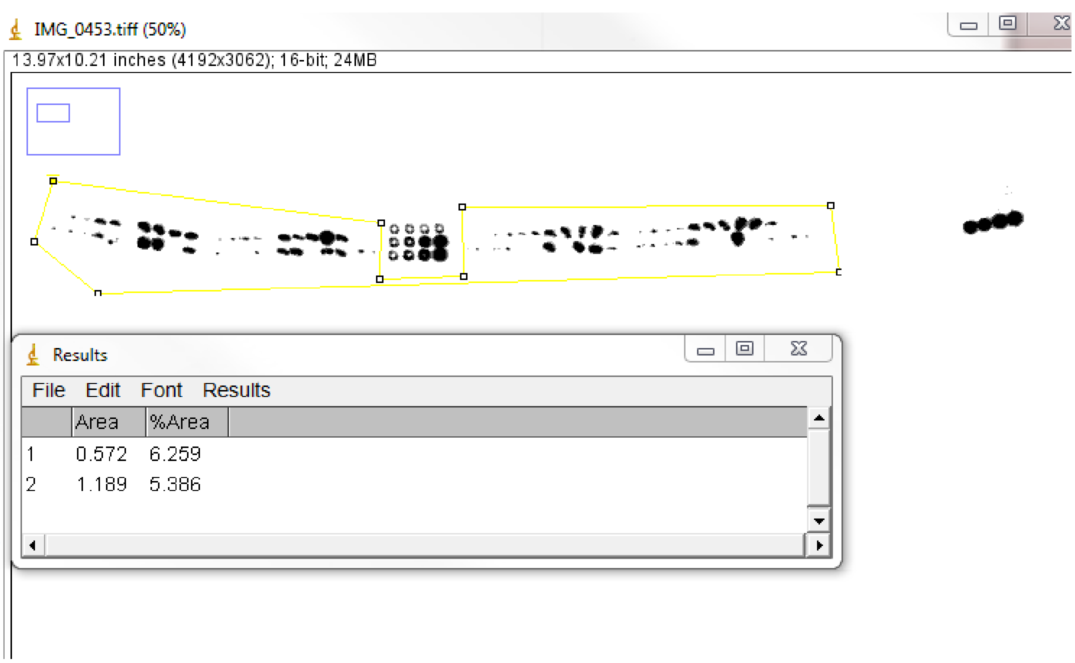

Figure 4: Measuring the Glare Producing Areas

The resulting measurements give us dimensionless units of area, but a useful ratio: LED Glare area / Metal Halide Glare area = (.572 * .06259) / (1.189 * .05386) = .56 or 56%.

Calculations:

To make sense of this, we take into context that in Phoenix, 780 Metal Halide fixtures were replaced with 312 Ephesus LED fixtures while increasing foot candles (illuminance) on the playing surface from 148 to 277. We can calculate that the Ephesus LED fixtures are, on a per-light basis, providing 4.68 times the foot-candles on the field of play when compared to the metal halide fixtures they are replacing.

While the LED fixtures in the picture analyzed above are producing roughly twice as much light on the field as the metal halide fixtures (24 LED fixtures * 4.68 times as much light per fixture = equivalent of 112 metal halide fixtures), the area of an observer's field of view that would be considered uncomfortable with the LED fixtures is 56% of the area that would be glare-producing under the former metal halide fixtures.

Conclusion:

The Ephesus LED fixtures deliver significantly more light to the playing surface, and this light is dispersed from its source such that the light is concentrated in less overall area. This minimizes the potential locations throughout the stadium which could exhibit glare, and the significant reduction in the number of fixtures compared to the obsolete installation further reduces potential glare sources. The precise aiming/directionality of each LED fixture ensures that an observer is exposed to any potential glare very briefly, when viewing from that particular angle. This is as opposed to the more diffuse light of the metal halide lights with their associated light spillage. The additional light provided on the field furthers the LED solution's advantage in reducing glare, as the greater light on the field will allow the viewer's pupils to constrict, lessening susceptibility to the areas of high intensity.

References

Osterhaus, W. (2002). Recommended Luminance Ratios And Their Applications In The Design Of Daylighting Systems For Offices. *Centre for Building Performance Research, School of Architecture*.

Peter D. Hiscocks, P. (2013). *Measuring Luminance with a Digital Camera: Case History.* Toronto, Canada: Syscomp Electronic Design Limited.