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The Photopic/Scotopic Discussion:

Photopic vision is a person's day vision. Photopic vision requires high illumination levels and produces color vision by acting as stimulus for the cone receptors of the eye. Photopic sensitivity peaks near 550 nanometers, in a yellow region of the spectrum. The lumen, the measuring unit of light, is measured using the photopic sensitivity curve – a sensitivity curve that weights the yellow region of the spectrum heavily.

Scotopic vision is night vision. Scotopic sensitivity peaks at about 500 nanometers - in the blue/green region of the spectrum. The eye's sensitivity to red and yellow regions is greatly reduced under these conditions. Scotopic vision is monochromatic and is produced by stimulus to the rod receptors of the eye.

The mesopic region is the range of illumination that transitions between photopic and scotopic regions. The spectral response gradually shifts from the photopic to the scotopic curve.

Why is this important? The eye's visual response changes with the intensity of illumination. Under scotopic conditions, the eye's sensitivity to yellow and red light is reduced, while the response to blue light is greatly increased. If lamp output under scotopic conditions is determined using photopic measurements, the lumen output value does not accurately measure the scotopic light produced by the lamp.

The High Pressure Sodium (HPS) lamp has high light output in the yellow region of the spectrum and minimal output in the blue region. This produces high photopic illumination, but low scotopic illumination.

Metal Halide (MH) sources used for roadways, parking lots, pathways and pedestrian spaces offer great scotopic advantage. Metal halide has its highest output in the blue region of the spectrum and is therefore scotopicly rich.

In order to compare visibility produced by the two sources, we need to correct the lumens based upon scotopic efficacy. The Scotopic/Photopic ratio of a 400 watt MH lamp is 1.49. The S/P ratio of a 400 watt HPS is .62. Using a .5 footcandle illumination level, the HPS source produces .31 scotopic FC. .5 footcandle of MH light produces .74 scotopic fc, nearly 2.4 times as much scotopic light!

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The scotopicly rich MH lamp produces much higher visibility at lower light levels under scotopic conditions.

The values above would only work under full scotopic vision, and most outdoor illumination levels produce mesopic conditions, where both the scotopic and photopic systems are engaged. Research on mesopic spectral sensitivity is ongoing and at the time that this is being written, no conclusive results are known. What is known is the relationship of both photopic and scotopic spectral sensitivity.

Based upon these two pieces of information, and our observations of different outdoor lighting conditions, we are making the assumption that the mesopic range is roughly a straight line in terms of peak spectral sensitivity between 550 nanometers and 500 nanometers. Based upon that assumption, we can make a case for reducing the illumination levels when metal halide sources are used in place of HPS sources for outdoor lighting.

Luma recommends reducing the minimum illumination levels when using metal halide sources to 2/3 the illumination levels (photopic, as measured in footcandles). This results in higher levels of scotopic and mesopic illumination when using metal halide sources rather than the higher level of illumination using HPS.