Department of Energy
Washington, DC 20585

Response to IES Position Statement PS-02-09, "Use of Spectral Weighting Functions for Compliance with IES Recommendations"

Background

The recently issued IES Position Statement PS-02-09 concerns the use of spectral weighting functions for the purpose of complying with IES recommendations. Specifically, the Position Statement reads:

"It is the policy of the IES that for compliance with all IES recommendations, photometric quantities shall be calculated using the photopic luminous efficiency function as defined in the IES Lighting Handbook, unless specifically stated in the IES document that contains the recommendations. This policy applies to all photometric units, such as lux or candela per square meter, and all standards, existing and future."

The IES Position Statement was written in response to concerns about misleading information that has entered the lighting marketplace. In some cases, advertisers have made claims about increased energy efficiency based on various spectral modifying factors and alternative weighting functions. Toward this end, the Department of Energy (DOE) fully agrees with the need to clarify the metric(s) recognized by the IES and recognizes the IES standard of photopically derived photometric measurements as the standard used in IES recommendations.

The IES Position Statement makes it clear that any lighting metric that is not strictly photopically based, such as "scotopic lumens" or "mesopic lumens" cannot be used to demonstrate compliance with the IES Handbook, unless there is an IES document that specifically states otherwise.

Relevance to the DOE Spectrally Enhanced Lighting Program

The foundation of the DOE Spectrally Enhanced Lighting (SEL) program rests on formulas that were empirically derived from increased visual acuity scores under conditions of varying colors of fluorescent lighting. The findings conclude that when people are exposed to a full field of view, the pupil of the eye gets smaller and the resulting ability to resolve detail improves under light sources with relatively larger amounts of blue content, even though the photopic illuminance stays constant. These findings are transferred to energy savings by using high correlated color temperature (CCT) lamps at lower illuminance levels than lower CCT sources, while maintaining equal visual acuity.

The photopic luminous efficiency function therefore does not fully account for visual acuity gains that are realized through changes in spectrum under the normal conditions of a full field of view. This is most likely because the photopic luminous efficiency function was determined through an extremely limited 2-degree field of view, which misses any contribution that photoreceptors outside this narrow cone of vision contribute to vision. In fact, the photopic luminous efficiency function, otherwise known as the $V(\lambda)$ function, includes the response of only 2 photoreceptors (L and M cones) and does not include any contributions from the S cones, rods, or the ipRGC photoreceptors. It is noteworthy that all of these photoreceptors have their maximum sensitivity in the blue region.

In searching for a method for quantifying the improvements in visual acuity, researchers checked to see if the only other IES-recognized luminous efficiency function available, namely, the scotopic luminous efficiency function or $V'(\lambda)$, could be used to describe the behaviors of pupil size and visual acuity improvements. Using the data from the experiments, it was determined that the best fit includes both the photopic and scotopic luminous efficiency functions. The formula used in SEL calculations for determining equivalence for visual acuity therefore uses the ratio of scotopic to photopic weighted lumens, or the S/P ratio. The S/P ratio is an objectively derived metric that can be determined for any light source based on IES-approved luminous efficiency photopic and scotopic

functions, i.e., V(λ) and V'(λ). Formulas used in SEL therefore use luminous efficiency functions that are described in the IES Handbook, and the mathematical relationship using the S/P ratio is based on improvements in visual acuity. The smaller pupil size and improvements in visual acuity under light sources with relatively more blue content have not been contested and are generally agreed to by most lighting researchers. An IES committee dedicated to the purpose of determining how these calculations might be included in IES calculations is currently working on this important task.

In the meantime, the SEL calculations can be used as long as light levels fall within IES recommendations, meaning that resultant quantities must meet the IES photopically based recommendations. The SEL method saves energy through a concept termed "visual equivalence," which operates under the following theory:

For any illuminance level (x) based on a given light source with a given S/P ratio, a different illuminance level (y) can be determined using a light source with a different S/P ratio such that equal visual acuity is maintained.

SEL calculations are therefore comparative in form: for example, a luminance of 50cd/m^2 from an 850 fluorescent lamp yields the same visual acuity as that of an 830 lamp producing 65 cd/m^2 for the same task. While the two photopic luminances are not equal, they are visually equivalent insofar as detailed vision is concerned. The calculated 23% reduction in luminances from the higher CCT light source represent a potential 23% energy savings, assuming the efficiency of both lamps and ballasts are the same.

The DOE maintains that care should be taken to ensure all final light levels fall within IES recommendations, meaning that photometric quantities should comply with the IES photopic recommendations. This must be adhered to since IES recommendations are spectrally neutral, i.e., they are not based on any specific lamp type, and thus no comparative method can be used for the IES recommended values.

The SEL method is therefore valid for comparing light levels in applications where visual acuity is important and when the energy benefit can be achieved within the range of values acceptable per IES recommendations. The IES Position Statement does not change the DOE position in this matter, i.e., we advise all people using the method to still use the IES recommendations as their guideline for minimum light level design criteria.

For more information on Spectrally Enhanced Lighting, see:
http://www1.eere.energy.gov/buildings/spectrally_enhanced.html.