American Fluorescent
design, efficiency, technology

October 29, 2010

Alex Baker
Lighting Program Manager, ENERGY STAR
U.S. Environmental Protection Agency

Re: ENERGY STAR Luminaires Draft 2 Comments

Dear Mr. Baker,

In collaboration with other industry associates and experts in the field, we wish to submit the enclosed thoughts and information. Respectfully, we request consideration toward this submission as it relates to the proposed Luminaires Draft 2.

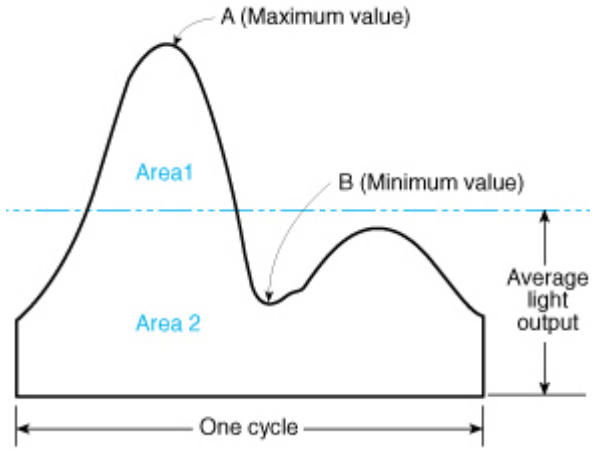
Page 32 / Solid-State

The phrasing as presented indicates that SSL products will be required to meet (2) separate criteria:

≥120Hz and modulation depth of < 50%

There are four specific issues that need to be addressed in order to make any definition or standard intended to address flicker, while avoiding undue expense of no value:

Issue One: The use of modulation depth is an obsolete standard, abandoned by the IES for a more meaningful Flicker Index. Flicker Index is defined by the relationship of luminance area above average to total area as follows (from IES Handbook 9):



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Calculation: Area 1 / (Area 1 + Area 2) = Flicker Index

A flicker Index of "0" is the highest rating achievable, with a rating of "1" being the worst. Photometric data collected by LTL (Grather 2009) indicates an incandescent lamp has a flicker index of roughly .0194, while a Metal Halide Lamp has a flicker index of 0.1398, and a T12 fluorescent lamp on magnetic ballast operates with a flicker index of 0.0897.

Based on this, a maximum Flicker Index of 0.130 should be established.

This places SSL on par with the other typical sources included in the standard, and assumed to be acceptable based on the lack of any flicker calculations required beyond the frequency stated. Any greater requirement for Flicker Index would then be required to be applied to all other light sources to avoid holding SSL products to a standard that will not be met by products approved without a standard limit.

Further, since a test standard will need to be developed to establish compliance (none now exist), it is recommended that the proper metric of Flicker Index be used and references to, or inclusion of Modulation Depth be omitted.

Issue Two: The Flicker Index does not reflect or include any representation of modulation frequency. Considerable research has proven that as frequency increases, human perception and sensitivity to flicker, in both visible and non-visual response is decreased. There has been no evidence indicating that modulation of any type is problematic in either perception or impact on human health at frequencies >2KHz. Therefore, any additional cost or effort on the part of manufacturers needing to meet both the modulation frequency and Flicker Index requirement over 2KHz is a wasted effort and is likely to add cost that is unnecessary to the proper and satisfactory function of the end product.

Based on this, only products operating between 120Hz – 2KHz should be required to comply with the Flicker Index maximum of 0.130.

Issue Three: The issue of perceived flicker is highly dependent on visible brightness and emission source size. The higher the luminous output and smaller the source, the greater the perception of flicker will become. Failure to address this dynamic for an overly simplistic frequency/Flicker Index value standard will likely lead to products utilizing highly visible LED sources to gain optimal efficiency, that are both glare inducing, and aggravating of the flicker issue. This is particularly important for task lighting and directional products, and for products that may be viewed at unexpected viewing angles, such as children looking upward into under-cabinet lighting employing exposed discrete LED sources.

There should be a maximum luminance metric (MPE, or W/cm²) divided by the total luminous area of an optic or source, established to mitigate the perception of flicker from low frequency sources, and potentially elsewhere in the standard relative to eye safety. This is not a difficult standard to test to (is included in photometric test data collected in LM-79, plus one additional calculation), but requires some investigation as to the maximum energy allowed to be meaningful that is not now defined.

Issue Four:

The simplistic definition of Flicker Index and Frequency also fails to recognize that in non-rectified AC LED arrays that operate ½ of LEDs on one side of the 60Hz sine wave, and the other on the flip side, sources must be in close enough proximity to be integrated in the eye. If a luminaire simply utilizes (2) LEDs, separated by a distance large enough to preclude integration, the standards will have been met, as measurement equipment will not reflect this separation effect, while the end product generates a visible flicker to human observers of 60Hz, regardless of Flicker Index.

Visible pitch spacing between individual LEDs in an array must be close enough together to preclude the visibility of any individual LED modulation.

Recommendation:

Frequency ≥120Hz

For all AC and DC products operating at ≤2KHz the following additional requirements shall apply:

> Maximum Flicker Index – 0.130
> Maximum intensity of (x)W/cm² / Total Surface Area, from individual visible light source or optic

For all un-rectified AC products utilizing opposing LED strings for operation directly on 60Hz sine wave:

Spacing between individual die or light sources must not exceed "y" x the smallest dimension of the individual visible apparent sources employed. We suggest 2mm center to center for the die on individually packaged LEDs and less for multi-die integrated AC LED circuits and/or single chips.

Sincerely,

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