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A Much-Needed Recommended Practice for LED Flicker

The emergence of high-frequency electronic ballasts for use with fluorescent lighting did away with most general-illumination flicker concerns back in the 1990s. That is, until the advent of LEDs, which have put flicker back on the table. To help address it, the Institute of Electrical and Electronics Engineers (IEEE) has just published the first recommended practice on the topic, IEEE Std 1789-2015. Entitled “Recommended Practice for Modulating Current in High-Brightness LEDs for Mitigating Health Risks to Viewers,” it explains what’s known about flicker in LED lighting and provides guidance that can help manufacturers design drivers or select them for their products, to minimize possible flicker-associated health and productivity effects.

Flicker is the variation in illuminance or luminance over a period of time. All AC-powered light sources flicker, typically in a periodic manner. However, flicker can be more pronounced in LEDs because, unlike other sources, LEDs have no persistence. This means that LEDs respond to change in forward current with a near-instantaneous change in light output. This is even true for phosphor-coated LEDs, as common LED phosphors respond much faster than some of their fluorescent brethren.

But LEDs pose no inherent flicker hazard, and there are LED lighting products on the market that exhibit less flicker than their conventional counterparts. What primarily determines the degree of flicker in LEDs is the driver. However, it’s often more costly to make drivers that minimize flicker — and such drivers often have to be larger in size, to accommodate the components that smooth out the light emission. For that reason, LED flicker is more likely to be a problem in lower-priced products, as well as in those (such as MR16s) that have size constraints.

In addition, the use of dimmers can exacerbate or cause flicker. The key is compatibility between the dimmer and the driver, which is something that should be checked with the manufacturer of the dimmer or luminaire, by asking for the *percent flicker* (a figure obtained by subtracting the minimum from the maximum light output in a cycle, and dividing that by the maximum plus the minimum light output in a cycle) and the *PWM frequency* (for luminaires dimmed using pulse-width modulation) when the system is dimmed. But if the manufacturer can’t supply you with those figures, you may have to test the product yourself.

Why is flicker bad? For one thing, in addition to being annoying and distracting, it can cause eyestrain, blurred vision, and impairment of performance on sight-related tasks. And in those who are flicker-sensitive, it can cause debilitating headaches and migraines — 10% of the population is estimated to suffer from migraines, and that’s only one of the groups prone to flicker sensitivity. According to the IEEE recommended practice, flicker has been reported to contribute to autistic behaviors, and can be a trigger for epileptic seizures, although the frequencies seen in architectural products are generally above the critical range for epilepsy. Some of these problems might occur even when the flicker isn't detectable by the eye. Periodic flicker can be characterized by its amplitude modulation, its average value over a periodic cycle, its shape, and its periodic frequency. And all of these characteristics affect the viewer's biological response.

IEEE Std 1789 makes recommendations for managing the biological effects of flicker within two defined risk levels. While operating outside these levels does not mean there will be biological effects, operating within them limits the risk of creating biological effects to defined levels. Determination of which level is appropriate depends on many factors, including characteristics of the user population, exposure time, types of tasks undertaken in the lighted space, and one’s risk sensitivity. Tradeoffs with product cost, size, and performance are associated with the various recommendations:

- **To *prevent* seizures** at frequencies below 90Hz, keep the percent flicker below 5% (light doesn't trigger seizures at frequencies above 70Hz).

- **To *limit* the other biological effects of flicker (so that the risk of creating other biological effects is low),** use the following formulas to determine the maximum percent flicker:
  - At frequencies below 90Hz, maximum percent flicker = frequency x 0.025 *[e.g., at 80Hz, the maximum percent flicker is 80 x 0.025 = 2%]*
  - At frequencies between 90Hz and 1250Hz, maximum percent flicker = frequency x 0.08 *[e.g., at 250Hz, the maximum percent flicker is 250 x 0.08 = 20%]*
  - At frequencies above 1250Hz, no restrictions on the percent flicker. (Note: this is the minimum allowed frequency for basic PWM.)

- **To *prevent* the other biological effects of flicker (so that there’s no risk of creating other biological effects),** use the following formulas to determine the maximum percent flicker:
  - At frequencies below 90Hz, maximum percent flicker = frequency x 0.01 *[e.g., at 50Hz, the maximum percent flicker is 50 x 0.01 = 0.5%]*
  - At frequencies between 90Hz and 3000Hz, maximum percent flicker = frequency x 0.0333 *[e.g., at 1200Hz, the maximum percent flicker is*

    1200 x 0.0333 = 40%]
  - At frequencies above 3000Hz, no restrictions on the percent flicker. (Note: this is the minimum allowed frequency for basic PWM.)

This important new recommended practice provides specifiers with flicker performance requirements for managing the risk of biological effects, thereby enabling specifiers to better determine project requirements, and encourages manufacturers to test for flicker and report the results on their cut sheets. That way, the flicker issue can be laid to rest for SSL, just as it was for fluorescent lighting 20 years ago.

As always, if you have questions or comments, you can reach us at postings@akoyaonline.com.