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The Safety of LED Lighting

The safety of LED lighting—not just for people, but also for objects of value—continues to be a topic of conversation among lighting professionals and consumers alike, so to set the record straight, DOE has come out with a technical brief on the topic. Entitled True Colors: LEDs and the Relationship Between CCT, CRI, Optical Safety, Material Degradation, and Photobiological Stimulation, it separates myth from fact about the potential of LEDs to cause retinal damage, changes to artwork or other media, and stimulation of human circadian functions (which affect health). The brief is based on standard blue-pump, phosphor-converted LEDs and uses an example dataset of 20 CALiPER-tested LED lighting products with nominal CCTs between 2700 K and 6500 K and CRIs between 62 and 98—which is essentially the full range of what’s commonly available on today’s market.

It’s important to note that the type of visible radiant energy emitted by LEDs is the same as that emitted by every other light source. LEDs do, however, have their own unique spectral power distribution (SPD) “signature”—a peak in the short-wavelength “blue” region, around 450 nm, and a broader peak somewhere between 550–650 nm. In general, higher-CCT LED products have a more-prominent blue peak, dictated by the need to have proportionally more blue radiation (all high-CCT sources have relatively more short-wavelength energy).

Because of the peak in short-wavelength optical radiation that’s present in the SPD of most LED lighting products, many concerns about LED safety focus on “blue light” light in the violet and blue range of the spectrum (between about 400 and 500 nm), which is known to cause retinal damage with too much exposure, readily stimulate the circadian system, and have greater potential to damage artwork than longer wavelengths. However, just because there may be a distinct blue peak in their SPDs—in contrast with some other light sources, such as incandescent or daylight—doesn’t mean that LEDs necessarily have greater potential to cause retinal, material, or photobiological harm. In fact, those risks are roughly the same for typical commercially available LEDs as for other sources having the same CCT—because, in general, they all contain equivalent amounts of blue light. Any correlation between CCT and optical safety, material safety, and photobiological safety exists because CCT calculations also include a weighting function covering the blue-light region. So if the proportion of blue light (and any associated risk) changes, so too does the CCT.

The optical safety of LEDs is explored in the DOE SSL Fact Sheet Optical Safety of LEDs, which illustrates the strong correlation between CCT and risk per lumen for all
types of light sources. Based on current standards, it can be concluded that white-light architectural lighting products do not pose a risk for blue-light hazard, although non-white light sources (e.g., pure blue LEDs) and some specific applications with high-risk populations should be considered more carefully.

Although the notion that LEDs are more damaging to works of art and other materials than are other light sources has been debunked by museum and lighting experts, uncertainty still lingers in some quarters. One way to characterize the potential of a light source to damage materials is with the International Commission on Illumination (CIE) spectral damage function (SDF), which includes a coefficient to tailor the action spectrum to various materials and illustrates that LED products carry no greater risk than do other sources of the same CCT. There’s a strong linear correlation between damage potential and CCT among each source type, with a predictable increase in damage potential as CCT increases. What’s more, blue-pump LEDs are generally the least likely product type to cause material degradation at any given CCT, at least among the products considered by the new DOE study, and pose no more risk than a typical (unfiltered) incandescent lamp.

The concern that LED sources may have greater potential than other light sources to negatively impact health by stimulating the circadian system once again stems from the short-wavelength peak of a blue-pump LED package, which leads to the perception that LEDs emit more blue light. But again, the new study shows a strong correlation between CCT and stimulation of ipRGCs (intrinsically photosensitive retinal ganglion cells), specialized nonvisual eye cells that are a key component of the circadian photoreception system. Admittedly, the overall sensitivity of the human circadian system is still being debated, and it’s known that this system is affected not only by input to the ipRGCs, but also by rods and cones, the photoreceptors associated with visual function. What’s more, this nonvisual photosensitivity is potentially mediated by a person’s state of adaptation, the time of day, and the quantity of light. So there’s still plenty to investigate in this field.

One important characteristic of LEDs is that they can be easily engineered to have any CCT desired. Although LEDs don’t emit any more blue energy than other light sources at the same CCT and lumen output, increasing the CCT does necessitate a higher proportion of blue light. In general, CCT can be used as an effective predictor of short-wavelength content across various source types, and specifically as a reasonable predictor of optical safety, material degradation, and circadian stimulation.

For more details, see the technical brief, which is available online at www.energy.gov/eere/ssl/technical-reports-briefs.

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