GLOBAL LIGHTING ASSOCIATION

Optical and Photobiological Safety of LED, CFLs and Other High Efficiency General Lighting Sources

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Abridged Version

1. Background

With the phasing-out of incandescent lamps in many countries, the introduction of new LED based light sources and luminaires sometimes raises the question of whether the spectral characteristics of the LED and other energy saving fluorescent lamps (such as CFLs) are suitable to replace traditional incandescent lamps. These concerns often centre on radiation emissions in the UV and blue parts of the spectrum. This document will address such concerns *for common 'white light' sources typically used in households as well as other general lighting use.*

2. Global Lighting Association (GLA) Position Statement

It is sometimes claimed that LED and CFL light sources are different from traditional incandescent lamps in that they contain higher proportions of blue wavelength light and are thus more likely to cause potential problems from exposure to 'blue light'.

The position of the GLA, based on accepted and widely adopted safety standards for lamps, is that all general lighting sources, including LED and CFL sources (either lamps or systems) and luminaires, can be safely used by the consumer when used as intended.

In terms of their level of photobiological safety, LED and CFL lamps are no different from traditional technologies such as incandescent lamps and fluorescent tubes. The portion of blue light produced by an LED is not significantly different from the portion of blue produced by lamps using other technologies at the same colour temperature. A comparison of LED and CFL retrofit products to the traditional products they are intended to replace reveals that the risk levels are very similar and well within the accepted range.

Nevertheless, looking straight into bright, point-like sources (including LEDs, but also other strong point-like light sources, like clear filament or discharge lamps or, in a natural setting, the sun) should be avoided. Fortunately, when people happen to look into a bright light source accidentally, a natural protective reflex occurs: people instinctively close their eyes or look away from the source.

It also well known that blue light exposure is important to the well being of humans. Blue light with a peak at around 460-480nm regulates our human biological clock, alertness, and metabolic processes. In natural conditions, outdoor daylight fulfils this function. However, in our modern society, many people spend most of their day indoors and are often lacking the necessary blue light exposure. Blue and cool white light sources can be used to create lighting conditions such that people will receive their daily portion of blue light to keep their physiology in tune with the natural day-night rhythm. Both LED and fluorescent lamps can be tailored to fulfil this purpose.

3. LEDs, CFLs and Optical Safety

Optical safety for lamps and other light sources refers to the prevention[1] of potential hazards caused by optical radiation (electromagnetic radiation of wavelengths ranging from 100 nm to 1 mm). Effects on the eyes as well as the skin are considered, including people with a higher sensitivity to light exposure.

Commonly discussed hazards from light affecting the eye are *blue light hazard* (BLH) and age-related macular degeneration (AMD) which can be induced or aggravated by high intensity blue light. When looking directly into a bright light source, a photochemical damage to the retina (blue light hazard) can occur, depending on the intensity involved and the time of exposure. People are familiar with this phenomenon from looking at the sun. To prevent retinal damage, appropriate spectacles must be worn when observing a solar eclipse, for instance. On a bright and sunny day, however, a natural aversion reflex occurs that protects the eye from being harmed. Furthermore, UV (ultraviolet) radiation may affect the eye, causing cataract or photokeratitis (sunburn of the cornea); IR (infrared) radiation can induce IR cataract (also known as glassblower's cataract); and radiation of all wavelengths at extreme intensities can lead to retinal thermal injuries.

Optical radiation can also affect the skin causing sunburns or, in severe cases, cancers upon long-term UV exposure. There exist certain groups of patients – for example, those suffering from lupus or photodermatoses - who are particularly sensitive to UV (and sometimes also blue light) radiation. Note that the abovementioned effects are predominantly caused by natural sunlight; some of them can never be evoked by artificial lighting since the *exposure levels from general illumination are too low.*

Nevertheless the optical safety of commonly used light sources needs to be ensured, and this is accomplished by lighting manufacturers meeting applicable safety standards that have been developed by experts and which are adopted or otherwise accepted in their respective countries or regions.

4. Photobiological Risk Assessment and Conclusions

The photochemical blue light hazard can be evaluated on the basis of several global standards that are based on the same accepted science but that may differ in title in various countries and regions. In Europe and other IEC oriented countries, IEC/EN 62471 is used and required under the European safety directives. In the US the same basic requirements are found in the IESNA RP27 series of standards. Other regions may reference CIE S009 as published by the International Commission on Illumination (CIE).

The IEC and IESNA standards classify light sources into risk groups 0, 1, 2 and 3 (from 0 = no risk through to 3 = high risk) and provide for cautions and warnings for consumers if needed. (The sun would be classified as being in the highest risk group.) Typical consumer products are in the lowest risk category.

The risk level is determined according to measurement criteria intended to reflect how various sources are used in realistic applications.

One method evaluates a light source under an illuminance of 500 lux (a typical value for general lighting purposes). This 500 lux criterion must be used for lamps intended for general lighting (including lamps for lighting offices, schools, homes, factories, roadways, or automobiles).

[1] Exposure limits for safety defined in the standard IEC/EN-62471 are required under European regulations (directive 2006/25/CE). Most IEC oriented countries or regions have adopted or are in the process of adopting or harmonizing with these IEC requirements. For example, Australia and New Zealand are currently adopting IEC 62471. China, via GB20145-2006, and Taiwan, via CNS 1000550 /CNS 0990586, have completed such harmonization. Indian industry requirements are harmonized with IEC 62471 and will become formally adopted in the future.

In the USA the FDA acknowledges the requirements of IESNA RP27.3 (see http://www.fda.gov/Radiation-EmittingProducts/RadiationEmittingProductsandProcedures/HomeBusinessandEntertainment/ucm116400.htm) and stipulates certain other regulatory requirements.

Both IEC/EN-62471 and the IESNA RP27 series have essentially the same requirements as CIE S009 published by the International Commission on Illumination.

A second method measures photobiological safety from a distance of 200 millimetres. The 200 millimetre criterion is to be used for all other lamps (including for example lamps for such professional uses as film projection, reprographic processes, sun tanning, industrial processes, medical treatment and searchlight applications).

It is important to make such distinctions based on the application. One does not typically stare into a ceiling luminaire in an office from a distance of 200 millimetres, but possibly in certain industrial applications workers might be required to look into light sources from a short 200mm distance – for example, during quality control processes. In such occupational cases special instructions might be needed to prevent eye damage.

After proper evaluation by either method, a light source is given a risk group (RG) classification, which indicates whether the source presents a potential exposure risk and, if so, what labelling requirements should be undertaken to alert the user.

Typical common general illumination sources pose no risk. When these sources are used in fixtures or luminaires, the fixture or luminaire would also typically pose no risk.

RG classification of the source or luminaire is addressed as follows:

1. A luminaire employing a light source classified RG0 or RG1 requires no warning or caution.
2. If a luminaire uses a light source from a higher risk group (RG2 or RG3), product information must indicate the mentioned RG class and include suitable warnings or cautions.

In this manner, the end use product is suitably labelled if a potential risk exists.

4.1 Conclusions on blue light emission

Evaluation at a distance producing 500 lux:
Taking the 500 lux criterion as the measurement basis, typical consumer LED and CFL products do not fall into risk group 2, which is the first cautionary risk group. This was also confirmed by a study of the French agency for food, environmental and occupational health and safety (ANSES) in 2010 which found that even high-output discrete LEDs are classified into risk groups 0 or 1.

LEDs compared to other light sources
Since LEDs are the newest lighting technology, and since earlier products tended to have bluer (cooler) color temperatures, some have mistakenly concluded this technology has an inherent ‘blue light issue’.

With regard to photobiological safety, LEDs are not fundamentally different to lamps using traditional technologies, such as incandescent or fluorescent (including CFL) lamps. The portion of blue light produced by typical LEDs is not higher than the portion of blue light in lamps using other technologies at the same colour temperature. If LED or CFL retrofit products are observed in comparison to the products which they are intended to replace (e.g. LED MR16 vs. Halogen MR16, or a LED retrofit with screw base vs. frosted incandescent lamp), the risk group ratings are similar.

Energy efficient lighting and children
The lens of a child’s eye filters blue light less efficiently than an adult’s lens. Children are thus more sensitive to blue light hazard. However, it is not necessary that LEDs and CFLs (or blue light in general) should be avoided in an environment with children present, since general illumination products used in homes, offices, stores, and schools do not produce intense levels of blue light. Since such applications have a low surface brightness (intensity) even "pure" blue light is completely harmless, regardless of whether it is the blue produced by LEDs, CFLs or other common residential light sources, or the blue light found in sky light. (By way of a very simple example, the blue light from a blue LED holiday string is no more hazardous than the blue light produced by its less efficient blue incandescent holiday string.)

Guidance for people with high sensitivity to blue light
The above statements are valid for healthy people in the general public. However, people who have been *medically diagnosed* with highly sensitive skin or eyes to blue light may be wise to investigate alternative light sources that operate on a more specific radiation band not covered by the applied action curves that cover a broad range of radiations. *As with any medical condition, people with diagnosed blue light sensitivity (such as lupus) should consult their health care provider for special guidance.*

The biological importance of blue light
Blue light exposure is important to human beings. Blue light with a peak around 460-480nm regulates the biological clock, alertness and metabolic processes. GLA members have established a special working group to translate these findings into practical application norms and standards. In natural conditions, outdoor daylight fulfils the function of synchronizing the biological clock (called the circadian cycle). However, in today's society, many people spend most of the day indoors (offices, schools, retail space, etc.) and may lack the blue light exposure that was common in the past. Blue and cool white light sources can be used to create lighting conditions such that people will receive their daily portion of blue light to keep their physiology in tune with the natural day-night rhythm.

4.2 Conclusions on ultraviolet radiation (UV)

LED based light sources used by the general public typically do not emit any UV radiation. CFLs and other fluorescent lamps emit only a very small amount. Since LEDs emit no UV, they are particularly well suited for use by people with a specific sensitivity for certain UV radiation and can bring relief to certain groups of patients. In this respect, LED based light sources provide advantages over traditional incandescent, halogen and compact fluorescent lamps. Please note that only a doctor or other trained medical professional can determine if a person suffers from UV sensitivity.

4.3 Conclusions on infrared radiation (IR)

In contrast to most other light sources – for example halogen and incandescent lamps - LEDs and CFLs used for general illumination emit very little IR. The reason for this is that by their very nature, the high efficiencies of such technologies require generation of heat (IR) to be kept to a minimum. For commonly used types of indoor light sources that would be encountered by the public, any IR radiation produced is not intense enough to pose a risk to humans, and so all such light sources would be in the lowest of risk groups.

Hence LED and CFL lamps, as well as other general use lighting products which meet applicable accepted optical safety requirements, are safe to use by the vast majority of consumers in general lighting applications. A small portion of the population has an enhanced sensitivity to UV. These individuals may wish to consider using LED based lighting for their high efficiency lighting needs if there are any concerns about even the small levels of UV that are produced by CFLs. (Another option for such UV sensitive individuals is to use a covered CFL or ensure the CFL is in a covered luminaire.)

A more technically complete version of this paper is available that includes typical spectral emission data from common light sources and that more completely explains many of the concepts presented in this abridged version.