Regulation issue

Iain Macrae assesses the solid state of play for safety and performance standards

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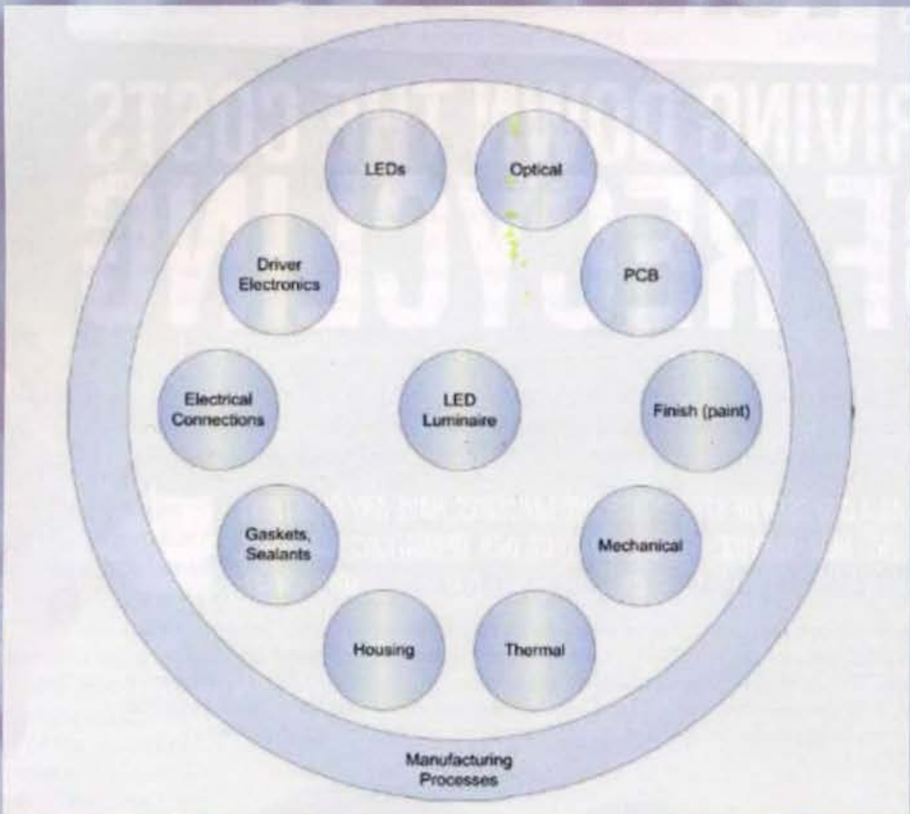


Considerations when designing an LED luminaire

With the pace of LED adoption showing no signs of slowing it's worth remembering that legislation and standards take time to catch up with technology. The driving forces for new guidance come from a number of different generic national or international sources. Each group involved represents a different position producing outputs with differing impact, from the hard requirements of legislation to the softer guidance from societies and associations. Some of these sources are quicker to produce guidance than others, so be careful not to get caught out.

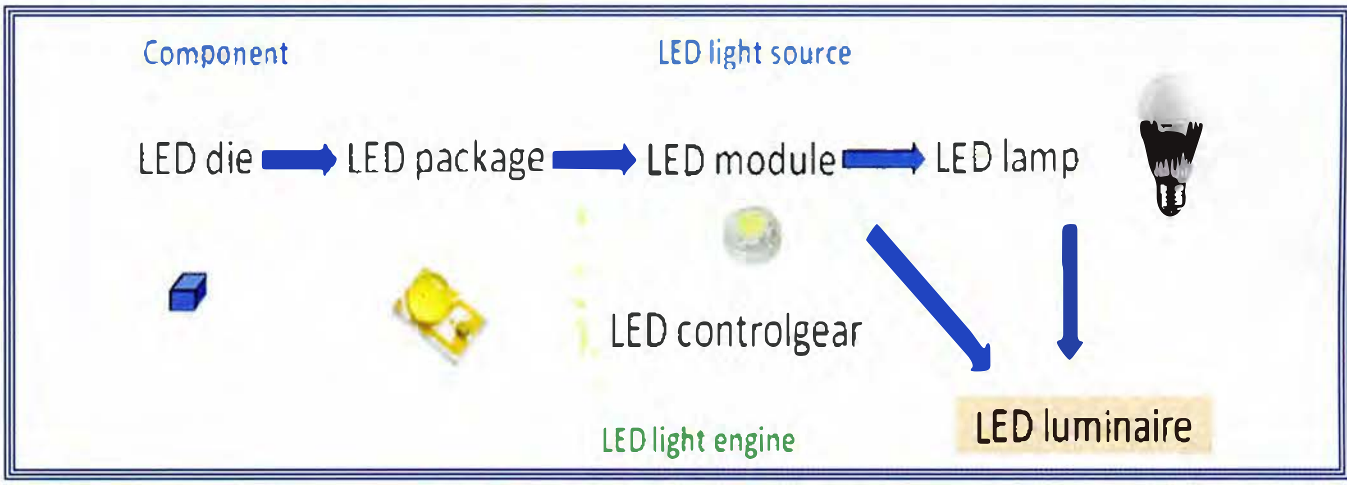
The application and safety standards currently known for lighting are generally unaffected when considering LEDs, as the quantity and quality requirements of light are independent of technology. For example, a CEN standard will be commented and voted on by every recognised national standards body, such as BSI, within Europe.

Standards are important, and may be used legally to provide a benchmark against which all products or applications can be compared – they provide a level playing field. Comparison using a standard ensures apples are being compared to apples, and provides a check that a third party can independently verify. But even before standards can be created we need a common language. In the UK a car has a boot, an elephant a trunk and a joint might mean drugs, but in America a car has a trunk and a joint can be a public bar. Language can be confusing.

We in the lighting industry may have made LEDs unnecessarily complicated too, so the four basic definitions need t be understood:

- **LED light source:** light source base on LED technology
- **LED module:** light source having no cap, incorporating one or more LED light sources on a printed circuit board, and often including electrical, optical, mechanical and thermal components, interfaces and control gear.
- **LED lamp:** LED light source provide with a cap
- **LED luminaire:** luminaire designed t include LED light sources

Performance concerns have not changed much with the arrival of LEDs but the meaning and techniques have. Lumen maintenance and lifetime for a product that can last 50,000-100,000

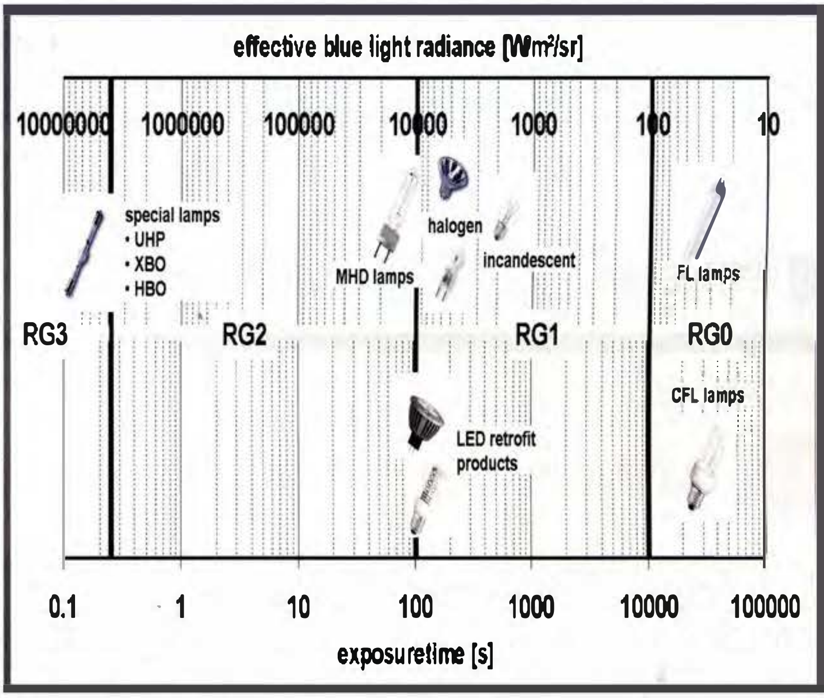


LED definitions

LED technology moves quickly and rather than firm standards we see more frequent publicly available specifications being published by international standards organisations. These provide balance to energy efficiency targets that are sometimes written for political gain.

Public documents come in one of three formats:

- Technical reports: written when consensus is not achieved to establish a standard, or when published information would not be suitable for a standard.
- Publicly available specification (PAS): considered a pre-standard, frequently used to publish recommendations quickly before a full approval process has been completed.
- Standard: With a thorough process of comment, voting and approval by a body of independent experts.



Light source risk groups

hours without a 'catastrophic' failure mechanism present new challenges to the industry and customers alike. Product standards always assumed a light source to be replaceable, so our current tests were configured with this is mind. LEDs have created a need to adapt those standards to a light source that may be permanently fixed. Even the definition of non-replaceable is a variable one, because do we mean an absolutely non-replaceable light source, or only replaceable with special expertise and tools?

The move from a traditional light source, being a replaceable self-contained chemistry laboratory, to LEDs, being an electric circuit board, also demands different electrical safety, where ensuring adequate electrical insulation could be critical to life. Thermal and electrical risks have made us adapt to the needs for heat-sinks, for example, which are designed to transmit heat but could also potentially become electrically live in a fault condition.

Regarding safety, the biggest change LEDs bring is the increased prominence of photobiological safety. This characteristic is not actually new, but previous technologies have not raised as many concerns. The potential risk from a lamp falls into well-defined groups. Exempt (sometimes classed as Risk Group 0) and Risk Group 1 pose no risk at all; Risk Group 2 poses minimal risk for the majority of the population under normal conditions; and

Biological risk to the skin

Risk Group 3 is extremely hazardous, and includes the sun.

This has become a high-profile topic, after some issues have been raised in the UK and French national press. It is a topic that sounds frightening and is generally poorly understood. But the mechanisms can be divided into two thermal interactions: the production of a temporary effect such as suntan, which generally comes from large wavelengths (infrared) or permanent alterations of tissue caused by photochemical interaction, which generally stems from small wavelengths (ultraviolet). An important distinction is that thermal interaction is generally concerned with the dose quantity at a particular point in time, whereas photochemical interaction is dependent on the dose quantity through time.

Traditionally, conventional lamps have fallen between RG0 and RG1. LEDs, being more efficient at converting blue light into white light, have pushed toward the boundary between RG1 and RG2, and for a small number of high-output LEDs, into RG2. However, some more established light sources are also in RG2, so with reputable product and application design this is not necessarily a cause for concern.

The blue light hazard, as it's called, is a concern due to the eyes' natural aversion response. If we look into a bright source we naturally blink and look away, exposure time is very short. This does not necessarily work with blue light, the eye response being more responsive to yellow wavelengths, so it is potentially hazardous.

That said, it is theoretically impossible for a white LED with an intermediate or low colour temperature to fall above RG0 or RG1 when used for lighting at a distance to 500 lux, whereas the same LED intended for use as a close-to-task light could cause a high risk when within 200mm of the eye. In addition, given that the spectra of white LEDs are closely controlled, the only realistic hazard is from specific blue light sources. So it is clear that more specific requirements and standards for LED luminaires with regard to photobiological effects are needed and are currently being written.

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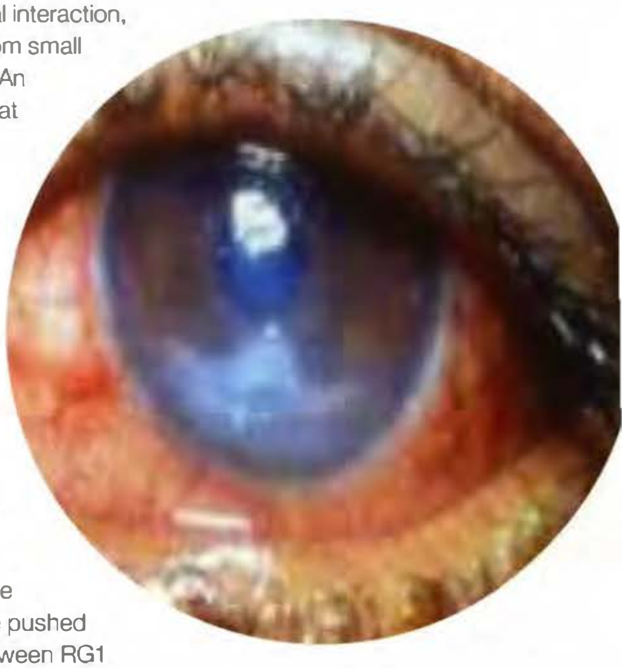
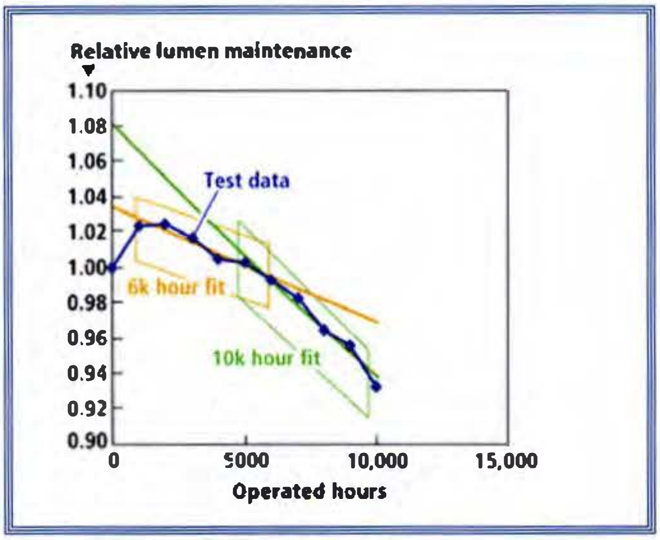


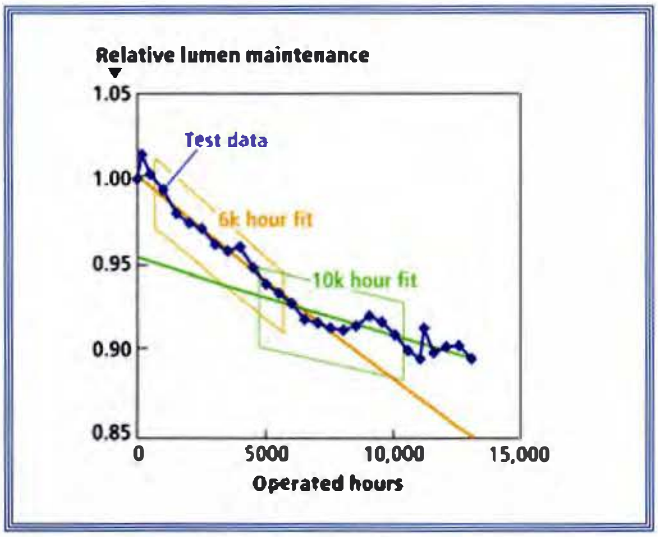
Photobiological damage to the eye

most common problems with LEDs are in the area of chemical, electrical and thermal design. Good thermal control and quality electrical components help but we must ensure that all luminaire materials are compatible with each other. Think about an LED now as that portable and self-contained chemistry laboratory, but much more compact, making any risks more severe.

With age, impurities become trapped within silicone structures and can lead to discolouration. With LEDs this happens in the protective lens that focuses the light after the phosphor and LED wafer. As the LED ages, so the light output reduces. This needs to be considered when discussing the useful life of an LED, as well as a number of other factors. The failure fraction (Fx) due to catastrophic failure, as well as the number of LEDs that are below a minimum rated lumen output level, define the life. While catastrophic failure



Life over predicted by TM-21 (IESNA)



Life under predicted by TM-21 (IESNA)

is rare, we must allow for it. A failure fraction of F10 (50,000hr) means that 10 per cent of LEDs can be expected to have catastrophically failed by the end of 50,000-hour use.

A second life measure relates to LED ageing, or lumen maintenance (Lx), where x is the percentage of light output remaining at the end of use. For example, L70 (50,000hr) means that 70 per cent of initial light output can still be expected to be produced after 50,000 hours of LED operation. This assumes, of course, that you do replace your LEDs at this time. There is a publically available specification, IEC/PAS62717, that allows you to check these numbers by using a defined 6000-hour test.

But the designer has a responsibility to design correctly too. If our lumen maintenance is L70 (50,000hr), our design maintenance factor would be at least 0.7. Combined with a failure fraction of F10, our design maintenance factor could not be more than 0.7*0.9 =0.63. Not many lighting designers are using maintenance figures as low as this, nor would many be brave enough to.

Other life designations exist, but currently lumen maintenance is the most popular one, being measured up to 6000 hours and then statistically extrapolated. This means, of course, that rated life is theoretical, and that lumen maintenance through life is generally not proved. It always makes sense to be aware that testing to the standard does not verify a manufacturer's life-time claim.

The American IES published TM-21 in August 2011. This document seriously questions the use of 6000-hour data. Analysis showed that LED lumen depreciation trends often change after 6000 hours and there is no reliable, consistent approach to predict them. Even 10,000-hour data is often insufficient to provide rigid statistical confidence of, say, 35,000 hours. TM-21 examined more than 40 sets of data and discovered that basing lumen maintenance predictions on 6000-hour

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test data could seriously misrepresent the lifetime of the LED. If this is the case, can you trust a 50,000-hour life?

The developing IEC performance standard also defines tolerances, colour temperature consistency and stability, colour rendering, and two thermal ratings. Tc is the maximum temperature rating to ensure product safety and Tp is the maximum temperature rating to ensure product performance.

Confused? Try reading useful information on the purchase and use of LED products, such as the Lighting Liaison Group publication available on the internet, or hire a qualified and experienced LED lighting designer.

Remember though that some are referring to current documents that are actually publically available specifications, not standards, with a relatively short life. Therefore these may change before the publication of a standard, though not dramatically, so that requirements within these documents should be quoted with care in project specifications.

In general safety standards are good to quote, except for those concerning the photobiological issues mentioned earlier. Performance standards are still developing as our understanding of LED technology grows. Even if you get all the standards in place there are times it gets confusing, especially when a new technology comes along. Standards are only part of the answer; policing has to happen and homework has to be done. Research the quality products, from a reputable manufacturer, and ensure they are suitable for the application. If you fail to do these things, whether it's LEDs or otherwise, you cannot expect to get the best solution to your lighting problem.

This feature is based on the presentation given by Iain Macrae, SLL president of and head of global lighting applications management at Thorn Lighting, at the ILP's 2012 Professional Lighting Summit