Light flicker. Why it matters.

The unseen issue with LEDs.

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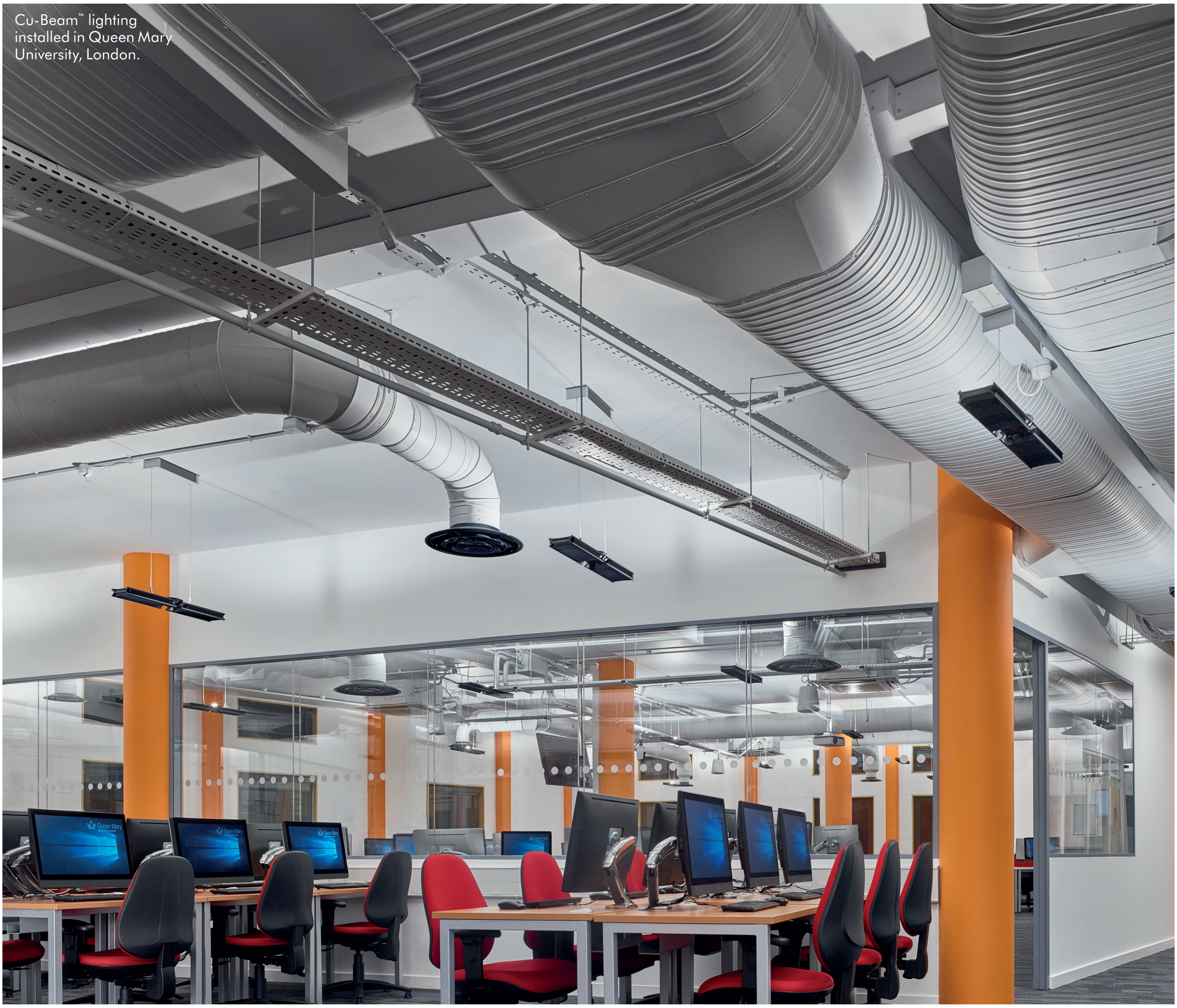

Cu-Beam™ lighting installed in Queen Mary University, London.

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What is flicker?

Most people will have experienced visible flicker. In simple terms, it's when a light appears to repeatedly flash on and off at a very quick rate. Or in more scientific terms, it's a change in the luminous flux due to fluctuations in the voltage of the power supply [1].

However, it's not just visible flicker that's a problem. There's also invisible flicker.

Invisible flicker

Also known as stroboscopic effect, it occurs above a certain frequency – usually between 60-100 Hz. Although the fluctuation is not always noticeable to the human eye, it can still have effects. For example, moving objects are perceived to move discretely rather than continuously [2], creating confusion.

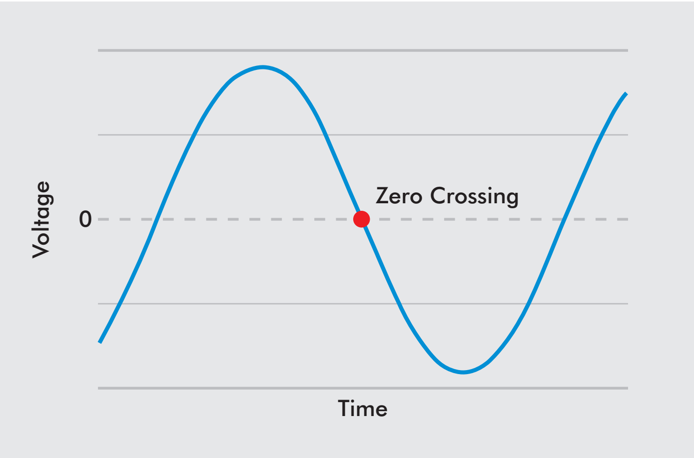

Fig 1. Sine wave zero crossing

Flicker appears when the light wave forms cross the zero-line, known as the zero crossing. At this point the light will be in an 'off' state. With conventional electromagnetic ballasts, this occurs at twice the line frequency – in the EU 100 times per second, in the US 120 times per second [3].

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The history and causes of flicker

Even before Edison invented the electric lamp in the late 19th century, there was flicker from fires and candles. In the electrical era, all light sources have continued to flicker to some degree – usually because of drawing power from AC mains sources.

With incandescent (filament) lamps, flicker isn't really visible. This is because the filament cools down slowly (referred to as 'afterglow'). So the bulb won't appear completely dim even at the zero crossing [4].

Flicker was recognised as a real problem in the 1950's when fluorescent lamps operating on electromagnetic ballasts were introduced as a drive to save energy. Their flicker could be easily visible.

In the late 1990's, when high frequency electronic ballasts were introduced for improved energy efficiency, the negative effects of flicker were reported less frequently [3].

With the introduction of Solid State Lighting (SSL) products, such as LEDs, in the early 2000's, flicker re-emerged as a serious consideration. SSL is widely recognised as revolutionary – the technology promises to dramatically reduce lighting energy consumption. Yet the huge energy saving potential can only be realised if the technology being adopted is well received by society. LEDs have been shown to cause flicker – both visible and invisible, with a frequency of modulation ranging from 3 Hz to ~1 kHz [11].

There are several causes of this, primarily the malfunctioning of the LED driver. This is often due to poor, cheap electronics, and incompatibility issues when operating LEDs with conventional residential dimmers.

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What are the health impacts of flicker?

From the early 2010's the scientific committees IEEE PAR 1789 (US) [5] and EC SCENIHR (EU) [6] have assessed the potential health, performance and safety-related effects resulting from visible and invisible flicker.

Research shows that the potential health effects can be split. Firstly there are those that can result immediately, from a few seconds of exposure. Secondly there is a less obvious kind, as a result of long-term exposure [5].

However, all flicker can be linked to headaches, reduced visual performance and discomfort, as well as other possible wellbeing issues [5]. Additionally with invisible flicker, the stroboscopic effect can be dangerous when operating heavy machinery with moving parts.

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Where is flicker most concerning?

There are some specific lighting applications where flicker is a bigger concern than in others.

For general lighting in spaces where people spend considerable time – including overhead lighting in corridors, offices, classrooms, laboratories etc – it is advisable to avoid luminaires with any kind of flicker. This is because general lighting fills most of the visual field and is unlikely to be mitigated by other non-flickering sources of light.

When considering task lighting, it's equally important to avoid luminaires that flicker as this light may also fill the majority of the field of view [1].

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How is flicker measured?

There have been many recent attempts to measure flicker, in order to develop industry standards for safe, as opposed to potentially harmful, lighting. The most frequently referred to metrics are Flicker index (FI) and Percent flicker. Both metrics are easy to compute, but Percent flicker does not take frequency and waveform into account. Flicker index, whilst looking at the waveform, does not consider frequency.

Authors of the IEEE 1789 standard did introduce a risk assessment to create linkage between Percent flicker and frequency [5]. However, this has been criticised by the industry – including Lighting Europe and NEMA TLA WG in the US – deeming it to be too restrictive, as even incandescent lamps did not fall into low risk or no-effect regions [8] [10].

The current IEC (International Electrotechnical Commission) metric to quantify visible flicker is the short-term flicker severity [10], which is in good correlation with the IEEE PAR 1789 recommendations [5].

Other test methodologies are under development to measure stroboscopic effect, but at this point in time, no absolute standard exists to measure the potential harmfulness of different luminaires.

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Conclusion

While visible flicker is rarely seen in modern lighting, invisible flicker remains a concern. Therefore, careful design of the LED driver electronics is important, to result in smooth waveforms and minimal invisible flicker.

Many independent photometric labs offer testing to measure flicker. One of the challenges is that test methodologies may vary from lab to lab due to lack of comprehensive standards. In addition, without standardised test methods different interpretations of flicker specifications also occur.

It is therefore important to choose an LED luminaire manufacturer that designs its products to create optimal lighting conditions. They should understand the performance of their products, tested in a laboratory with the correct instrumentation and expertise on the latest standards, specifications and trends.

Dyson lighting uses custom-engineered drivers, taking into account the properties of its LEDs. Besides ensuring colour stability and long life, Dyson lighting can contribute to better lighting conditions.

All Cu-Beam™ suspended lights have been independently tested and certified in accordance with UL's (Underwriters Laboratories') Low Optical Flicker Verification Marking guidelines [9].

All Cu-Beam™ suspended lights have also been certified with 'Low Optical Flicker Less Than 1% up to 400 Hz.'

Optical conditions and avoiding invisible flicker should be a consideration for educational institutions when choosing lighting for halls, classrooms and laboratories.

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