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INTEGRATIVE LIGHTING

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Over the past 25 years, research concerning the human responses to light has been largely expanded, and currently, there is strong scientific evidence that light is not only essential for vision, but it also affects the biological functioning of people and has an important impact on human health and performance. Numerous studies have demonstrated that light also influences circadian rhythms and neurobehavioral responses. These types of responses have been defined as "non-image – forming" (NIF) effect of light. Non-visual effects are mediated by signals from retinal photoreceptors, i.e. from circuits of rods, cones and intrinsically photosensitive retinal ganglion cells (ipRGCs). These retinal photoreceptors are specialized ganglion cells that contain the photopigment "melanopsin" and are intrinsically sensitive to light spectrum. Their peak sensitivity (approx. 460-480 nm) occurs at a shorter wavelength compared to that of rods (at 507 nm) and cones (at 555 nm) suggesting the relevance of the spectral distribution as a factor that influences non-visual effects of lights.

Considering the relevant impact of non-visual response to light on human health and well-being significant research, has been carried out, which led to the proposition of new, dedicated circadian metrics to estimate and quantify non-visual effects of light.

Up-to-date there main approaches have been proposed: The Circadian stimulus (CS) model, The "Equivalent Melanopic Lux (EML)", The melanopic Equivalent Daylight Illuminance (m-EDI).

The "Circadian stimulus" model was proposed by Rea and Figueiro and indicates the human responses to light in terms of the percentage of melatonin suppression. CS is defined as the calculated effectiveness of the spectral weighted irradiance at the cornea from threshold (CS=0,1) to saturation (CS=0,7), assuming a fixed duration of exposure of 1h. According to indications provided by Figueiro, a CS value of 0,3 or greater at the eye during the morning is suitable for the promotion of good circadian entertainment. The target threshold values are reduced to a maximum of 0,2 in the evening and a maximum of 0,1 during the night.

The "Equivalent Melanopic Lux"(EML) is based on the spectral sensitivity of the melanopsin photoreception of ipRGCs with reference to the illuminant E (an equal-energy illuminant) and is based on studies connected by Lucas and Enezi.

The “melanopic Equivalent Daylight illuminance” (melanopic EDI or m-EDI) is an SI-compliant “α-opic” metric defined as illuminance produced by radiation comporming to standard daylight (D65) illuminant that provides an equal “α-opic” irradiance as the test source. The m-EDI was recently defined by CIE (CIE S: 026:2018) to supplement the EMI, which did not provide an SI unit for calculating lux. As daylighting is the most natural “circadian” light, it was assumed as reference for the definition of m-EDI, unlike EML, which refers to an equal-energy spectral power distribution. The EML and m-EDI metrics are thereby correlated through the expression m-EDI=0,9058*EML.

Despite the growing knowledge concerning integration light current design approaches and standards for indoor lighting are mainly intented to ensure visual requirements and needed to define specific and agreed recommendations that address both photopic and melatonic aspects.

The recent European Standard 12464 has indroduced other requirements to also include the illuminance level in the room (average illuminance and uniformity over the walls and the ceiling) and the illuminance at the eye level of the occupants, through the cylindrical illuminance to integrate the luminance-based unified glare rating UGR requiment. There is no melanopic requiment to also account for circadian entraiment. On the contrary, the WELL Building Standart (USA 2023) protocol introduced circadian recommendations in its rating system through the m-EDI, in associatoin with daylighting recommendations through the special daylighting. On the one hand, lighting designers must comply with workplane requirement in terms photopic illuminance, on other hand, they may want to also meet melanopic requiments to quality for the circadian credit of the WELL, thus consedering the vertical plane at the eye level.

Recently an international expert workshop on circadian and neurophysiological photometry published a set of light recommendation to best support human physiology sleep and wakefulness within indoor settings. The workshop concluded that under most practically relevant situation, the spectral sensitivity of non-visual responses to light can be well described by the intrinsic melanopsin-based spectral sensitivity of ipRGCs

The workshop recommendations were therefore expressed in terms of melanopic EDI (measured at the eye position of the user with a detector orientation that corresponds to the dominant direction of gaze) according to:

Throughout the daytime the recommended minimum melanopic EDI is 250 lx;

During the evening starting at least three hours before bedtime the recommended maximum melanopic EDI is 10 lx;

The sleep environment should be as dark as possible with are commended maximum melanopic EDI of 1 lx and 10 lx in case unavoidable activities during the nighttime require vision.

These recommendations are intended for healthy adults (18-55 yrs.) with a day-active-schedule.

It seems that the integrative lighting approach is of crucial importance but needs further research to be implemented in the current design practice especially for what concerns the amount of the melanopic recommendation and the duration of the time to which to refer the application of such recommendation. This involves considering a new paradigm for the lighting design practice, which involves the following aspects: the spectral power distribution of the light output luminaires that are specifically conceived for an integrative light approach, especially in terms of their photometric curve.

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