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TM-30: The Sequel New IES guidance on specifying color rendition

The Illuminating Engineering Society is in the process of publishing two new annexes for ANSI/IES TM-30-18. Annex E provides guidance for applying the measures defined in TM-30 and describes important considerations for specifying light source color rendition, while Annex F provides additional explanation and supporting evidence. The annexes should make it easier to use TM-30, the ANSI- and IES-approved method for characterizing light source color rendition.

A given light source can have a range of effects on the color appearance of an architectural space, rendering the hue, chroma, and/or lightness of surfaces and objects in various ways. The overall rendering of the scene can change how people view the space. For example, the colors could be dull, vivid, natural, distorted, pleasing, unsatisfactory or some combination thereof (these are not mutually exclusive). The value of color rendition measures and their subsequent specification criteria is that they enable us to capture and communicate such effects without resorting to visual evaluations of many light sources.

The TM-30 method uses a common calculation framework based on modern color science to determine a wide range of measures that quantify different objective aspects of color rendition, such as average color fidelity (similarity to a reference illuminant) and gamut area (average change in saturation versus the reference) as well as 16 values each for hue-specific chroma shift (saturation change), hue shift and color fidelity. There's a lot more information about color rendition available today than there was in the past, and with that availability comes new decisions and considerations—yes, there's a lot to learn—but also greater usefulness. Still, none of these measures alone identifies whether a light will make the colors look "good."

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As explained in the new annexes, TM-30's system of objective measures and graphics can be used in combination to specify a light source that enhances a desired subjective impression or meets other requirements of a space, and it is flexible enough to meet the specific needs of many different lighting applications according to the discretion of the lighting specifier or technology developer. The new annexes provide explicit guidance on how this is achieved, establishing a critical link between science and practice.

Specification Criteria are the primary way in which color rendition enters the design process. They are implemented and used by many organizations and people. Effective color rendition specification criteria define the acceptable or desirable range of values for one or more color rendition measures that are needed to achieve a goal. Many factors influence what measures and values of those measures are needed, with a key element being the desired outcome (i.e., the intent), which may include promotion of subjective qualities (e.g., acceptability, naturalness, vividness, preference), objective qualities (e.g., color fidelity, gamut area or any other TM-30 measure), or task performance (e.g., color discrimination, color matching or object detection via color contrast). There are also trade-offs—such as minimum qualification versus highest quality, flexibility versus prescription and simplicity versus complexity—related to the priority of color rendition within the overall scope of lighting characteristics.

Beyond the considerations of intent and priority, multiple application-specific factors should be considered when establishing color rendition specification criteria. These factors—including the objects being illuminated, illuminance level, need for hue stability, tolerance for uncertainty, age and culture of the viewing population, viewing conditions and the practitioner's discretion—can affect not only the type of measures specified, but also the threshold values that are set, refining what might otherwise have been determined based on intent and priority level alone. (Many lighting design factors—such as chromaticity, CCT and glare—can be changed without any effect on color rendition and thus were not considered in the determination of the recommended color rendition specification criteria.)

Simplifying a complex situation, Annex E provides recommended criteria for three design intents and three priority levels, which are applicable at typical interior light levels (200 to 700 lux) when the space being illuminated features a variety of colors. The design intents—Color Preference (P), Color Vividness (V) and Color Fidelity (F)—were chosen based on the ability to establish recommended criteria and anticipated relevance to lighting specification. More could be added in the future. The three priority levels (1 through 3, with Level 1 considered highest) relate to the stringency of the criteria: Higher levels increase the likelihood of achieving the design intent, whereas lower levels offer increased flexibility to account for other considerations, such as energy efficiency, which in some applications may be considered more important than color rendition. With this format, trade-offs can be carefully considered, and a simple two-character designation (e.g., P1 or V3) can indicate the performance of a lighting product.

- The *Color Preference* design intent applies to situations where creating a pleasing, natural-looking environment is important. The specifications use three TM-30 measures: R_f (average color fidelity), R_g (gamut area), and $R_{cs,h1}$ (chroma shift for nominally red objects). The specifications for the three priority levels are:

P1: $R_f \geq 78$, $R_g \geq 95$,
$-1\% \leq R_{cs,h1} \leq 15\%$
P2: $R_f \geq 74$, $R_g \geq 92$,
$-7\% \leq R_{cs,h1} \leq 19\%$
P3: $R_f \geq 70$, $R_g \geq 89$,
$-12\% \leq R_{cs,h1} \leq 23\%$

These criteria address the importance of red and the recurrent finding that modest increases in vividness are desirable in many circumstances, countering the natural dulling that occurs at interior light levels compared to outdoors. These criteria also maintain minimum levels for average color fidelity, which prevents too much overall distortion.

- The *Color Vividness* design intent includes minimum thresholds for R_g and $R_{cs,h1}$. The three priority levels are:

V1: $R_g \geq 118$, $R_{cs,h1} \geq 15\%$
V2: $R_g \geq 110$, $R_{cs,h1} \geq 6\%$
V3: $R_g \geq 100$, $R_{cs,h1} \geq 0\%$

The Color Vividness design intent provides guidance on how to make a scene appear vibrant but does not take into account whether that vibrancy will be considered pleasing; such a combination can be found in the overlap between the Color Preference and Color Vividness criteria.

- Finally, the *Color Fidelity* design intent focuses on achieving similar color appearance (at equal illuminance) relative to the spectrum of the reference illuminant—which, generally speaking, is either a phase of daylight or an incandescent-like spectrum at the same correlated color temperature as the light source in question. Two measures are used for this design intent, R_f and $R_{f,h1}$ (red color fidelity), which again acknowledges the particular importance of red. The three priority levels are:

F1: $R_f \geq 95$
F2: $R_f \geq 90$, $R_{f,h1} \geq 90$
F3: $R_f \geq 85$, $R_{f,h1} \geq 85$

While the three design intents are distinct, the qualification ranges aren't mutually exclusive, so it's possible for a light source to meet one of the three levels for each, although it's not possible to meet Priority Level 1 for all three simultaneously. For example, a product could be a P1/V2/F3 or P2/V-/F2 (where the "-" indicates no qualification), but P1/V1/F1 isn't realizable.

If the color rendition needs of an application are specialized or fall outside the intents and assumptions of the recommended criteria, Annex E explains how to develop a customized solution that takes into consideration all of the factors influencing the choice of color rendition specification criteria. Examples of such specialized situations may include single-material architectural façades or surfaces (not polychromatic), dimly lit interior architectural environments (low illuminance levels), and some storage spaces (color rendition is not a priority).

This new guidance on specifying color rendition goes beyond a singular rule of thumb, such as CRI ≥ 80, because such oversimplification can limit effectiveness and applicability, especially as the ranges of light sources and color rendition characteristics grow larger and larger. The recommended approach increases transparency and specificity, which in turn increases the effectiveness of the specifications for delivering on the chosen design intent(s). Annex F documents substantial improvement in matching human evaluations when using the TM-30 color preference specifications—compared, for example, to using CRI-based specifications.

The new annexes are intended to support practitioners, technology developers and specification-writing organizations. They will be published soon and will be available at *https://www.ies.org/product/ies-method-for-evaluating-light-source-color-rendition/* (free download for IES Members). Be sure to download the document to get the full value and understanding of this important development for ensuring high-quality lighting.

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