ANNEX E – RECOMMENDATIONS FOR SPECIFYING LIGHT SOURCE COLOR RENDITION

E.1 Introduction

This Annex provides guidance for applying the measures defined in this Technical Memorandum and documents important considerations for specifying light source color rendition. It includes a table of recommended sets of color rendition specification criteria, subject to simplifying assumptions, that can be selected for use based on the desired outcome and level of compromise with other lighting performance attributes. These recommendations were derived from experimental and analytical work and are made based on the experience and consensus of the IES Color Committee. Additional justification and explanation are provided in Annex F. The recommended specification criteria may be adjusted—or completely replaced—at the discretion of the user to better align with intended outcomes; guidance on how this can be accomplished is provided.

E.2 Quantifying Light Source Color Rendition

Color rendition is a complex phenomenon. A given light source can have a range of effects on the color appearance of an object, changing its hue, chroma, and/or lightness compared to another light source, typically defined as a reference illuminant. These changes are not the same for all objects; rather, they vary for objects throughout the range of possible colors. In some cases, any observable change may be unacceptable, but in other cases, certain changes from the reference illuminant may be desirable.

The ANSI/IES TM-30-18 method uses a common calculation framework—including the 99 spectrally neutral color evaluation samples, color space (CAM02-UCS), and blended reference illuminant scheme—based on modern color science to determine a wide range of measures that quantify different objective aspects of color rendition, including average color fidelity and gamut area, as well as 16 values each for hue-specific chroma...
shift, hue shift, and color fidelity. These are briefly summarized in Table E-1. Rather than weighting various color shifts or attempting to derive a single metric that quantifies preferred color rendition—or any other subjective quality—TM-30-18 provides a system of measures and graphics that can be used in combination to specify appropriate color rendition across many different lighting applications, at the discretion of the lighting specifier, or to develop new lighting products. Unlike single-number, higher-is-better metrics, applying TM-30-18 relies on the user’s understanding the lighting requirements, which can help identify which measures and the values of those measures that should be used for specification of color rendition.


<table>
<thead>
<tr>
<th>Measure</th>
<th>What it Characterizes*</th>
<th>Interpretation</th>
<th>Possible Values</th>
<th>Typical Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fidelity Index</td>
<td>$R_f$</td>
<td>Average similarity for all colors</td>
<td>0 to 100</td>
<td>70 to 100</td>
</tr>
<tr>
<td>Gamut Index</td>
<td>$R_g$</td>
<td>Approximation of the average change in chroma for color</td>
<td>0 to 150</td>
<td>80 to 120</td>
</tr>
<tr>
<td>Color Vector Graphic</td>
<td>CVG</td>
<td>Visual representation of hue and chroma changes for all colors (i.e., gamut shape)</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Local Chroma Shift</td>
<td>$R_{cs,hj}$</td>
<td>Average relative change in chroma for colors within 1 of 16 hue angle bins ($j$)</td>
<td>Approx. -100% to 100% (varies by hue)</td>
<td>Approx. -20% to 20% (varies by hue)</td>
</tr>
<tr>
<td>Local Hue Shift</td>
<td>$R_{hs,hj}$</td>
<td>Average change in hue angle (in radians) for colors within 1 of 16 hue angle bins ($j$)</td>
<td>Positive values for counterclockwise shift (e.g., red to orange), negative values for clockwise shift</td>
<td>Approx. -1 to 1 (varies by hue)</td>
</tr>
<tr>
<td>Local Color Fidelity</td>
<td>$R_{f,hj}$</td>
<td>Average similarity for color within 1 of 16 hue angle bins ($j$)</td>
<td>0 to 100</td>
<td>60 to 100</td>
</tr>
<tr>
<td>Sample Color Fidelity</td>
<td>$R_{f,cesi}$</td>
<td>Average similarity for a specific color sample ($i$)</td>
<td>0 to 100</td>
<td>60 to 100</td>
</tr>
</tbody>
</table>

* Relative to reference illuminant.
E.3 Establishing Specification Criteria for Light Source Color Rendition

E.3.1 Basic Considerations

Color rendition specification criteria define the acceptable or desirable range of values for one or more color rendition measures or metrics. There are many factors that influence what measures are included in specification criteria. A key element of setting color rendition criteria is deciding on the desired outcome, here called the intent. Different intents may include promotion of:

- **Subjective qualities**, such as acceptability, naturalness, vividness, preference, or other aspects of aesthetics
- **Objective qualities**, such as color fidelity, gamut area, or any other specific measure in ANSI/IES TM-30-18
- **Task performance**, such as color discrimination, color matching, or object detection via color contrast

Each intent requires consideration of different combinations of color rendition attributes, which are quantified with different measures. ANSI/IES TM-30-18 facilitates this process, allowing for a variety of intents to be considered. There are also tradeoffs related to the priority of color rendition—and the specific design intent—within the overall scope of lighting characteristics. These include:

- **Minimum qualification versus highest quality**: Color rendition criteria can be used to create minimum standards (i.e., a floor) as a counter to a performance aspect that is inherently in opposition, such as luminous efficacy. In other cases, color rendition criteria can be used to promote desirable lighting quality, ensuring the most appropriate color rendition performance for the intended outcome.
- **Flexibility versus prescription**: More-lenient criteria may allow a greater variety of products, enabling a diversity of capabilities but perhaps requiring more individual discretion. In contrast, more-stringent criteria can be more predictable in delivering the intended outcome but may limit innovation or the ability to deliver appropriate performance in another area, such as luminous efficacy.

The priority level helps to determine the values that are set as minimum or maximum for a given measure. It influences the balance between inadvertently allowing inappropriate products and inadvertently disallowing appropriate products. In general, priority level is related to the likelihood that a design intent is achieved. It can also influence the availability and cost of products that meet the specification criteria, particularly if the tradeoff leans toward a higher priority level—although this is fluid as new products are developed.

Another basic consideration when establishing color rendition specification criteria is simplicity versus complexity. Using a single measure can be easier for users to understand and remember, but a more complex multi-measure approach can be more transparent and/or informative in some cases, allowing a better match with the intent.
E.3.2 Application-Specific Considerations

Beyond the basic considerations of intent and priority level, there are many application-specific factors that should be considered when establishing color rendition specification criteria for a specific use case. Indeed, application has been shown to influence what color rendition attributes are desirable. Application-specific factors can affect both the type of measures included and the threshold values that are set, refining what might otherwise have been determined based on intent and priority level alone. These factors include:

1. **Objects being illuminated:** If one or more specific objects of known hue are being illuminated, it is more appropriate to use a hue-specific local measure ($R_{c,s,h_j}$, $R_{m,s,h_j}$, or $R_{l,h_j}$) than an average measure ($R_l$ or $R_g$). The specific local measure can be determined based on the intent. Even if the environment is filled with many colors (i.e., a polychromatic environment), the nature of the objects can lead to changes in the most appropriate color shifts. Vibrant environments might call for color rendition that enhances chroma. In contrast, the presence of objects for which color is an essential element of the identity may dictate a need for limited hue shifts. Research has shown that certain hues, particularly red, are more particularly influential in color psychology.

2. **Illuminance level:** Color perception changes with luminance. One known characteristic, the Hunt effect, is that perception of colorfulness decreases as luminance decreases. In practical terms, colors look duller as lighting is dimmed. In contrast to this known behavior, existing measures of color rendition—including ANSI/IES TM-30-18—assume equal illuminance of the test source and reference illuminant. Many experiments have shown that increasing chroma (which is related to colorfulness) relative to the reference illuminant, particularly for red hues, improves subjective evaluations of preference and naturalness when the illuminance is typical of architectural interiors (approximately 200 to 700 lux). Recent research has shown that this effect is related to the illuminance, which suggests adjusting target color rendition criteria based on illuminance level if the aesthetics of the space is the primary design consideration. A gradient of criteria is not practical, but varying color rendition for light levels outside the range of 200 to 700 lux may be appropriate.

3. **Need for hue stability:** Because color shifts smoothly vary around the hue circle, chroma shifts are accompanied by hue shifts in nearby hue-angle bins. Thus, if preserving hue is an important consideration, large increases in chroma should be avoided. Hue shifts can be assessed by examining local hue shift values ($R_{m,s,h_j}$).

4. **Tolerance for uncertainty:** Measures of color rendition rely on standardized sets of color samples to represent colors in architectural environments. Depending on the characteristics of the light source SPD, the appearance predicted by color rendition measures can vary relative to the actual appearance of colors in an architectural space. Some SPDs render similar, or metameric, colors in similar ways (less uncertainty), while other can render such colors in very different ways (more uncertainty). A measure was recently proposed by a group of researchers
to capture this aspect of color rendition, the metameric uncertainty index ($R_t$).\textsuperscript{14} It is based on the same calculation framework as ANSI/IES TM-30-18, but it is not currently part of the ANSI/IES method. This characteristic is very important in certain situations, such as where color matching or metamerism are important, but may be less important in situations where the precise appearance of individual colors is not a consideration.

5. **Viewing population age:** As the human eye ages, lens transmission decreases, and the lens selectively absorbs more short-wavelength radiation (i.e., “blue light”).\textsuperscript{15-17} There is currently insufficient research on the effect of the aging eye on color perception to establish age-adjustment factors for color rendition specification criteria. However, those developing color rendition criteria for spaces whose occupants are elderly or “aging in place” should be aware of age-induced changes in the visual system.

6. **Viewing population culture:** Cultural preferences related to subjective aspects of color rendition have been examined to a limited extent, with mixed results.\textsuperscript{18-21} The most comprehensive of these studies found that cross-cultural geographic variability did not exceed the within-culture variability.

7. **Viewing conditions:** Methods for evaluating light source color rendition, such as ANSI/IES TM-30-18, rely on underlying assumptions embedded in the color appearance models used in the calculation framework. One of the most important considerations is chromatic adaptation, or the ability of the human visual system to maintain white balance. Color rendition measures assume the viewer has adapted to the chromaticity of the light being emitted. In cases where a single space is illuminated with multiple chromaticities, complete chromatic adaptation may not be possible, and the color appearance of objects may not match what is predicted by color appearance models. This can introduce uncertainty to color rendition specification criteria. No research has been conducted to address this issue.

8. **Practitioner’s discretion:** Lighting design is art and science, and the opinion and experience of the lighting practitioner is an important part of the decision-making process. Experience can help practitioners bridge the gap between science and application.

There are also many lighting design factors that are independent of color rendition. These include but are not limited to: chromaticity, correlated color temperature (CCT), circadian and other photobiological effects, glare, flicker, whiteness rendition, luminous intensity distribution, distribution of light within a space, physical luminaire aesthetics, and luminaire profile. As used here, *independent* means that these factors can be changed without any influence on color rendition; said another way, there is no tradeoff between color rendition and these factors. As such, these factors were not considered in the determination of the criteria presented in this Annex.

### E.4 Recommended Color Rendition Specification Criteria

Table E-2 provides a set of recommended color rendition specification criteria based on ANSI/IES TM-30-18 that were developed using empirical data and consensus-based decision making. They are intended to guide lighting
practitioners and others who implement such criteria. They represent current best practices for the identified intents, but adjustments may be warranted to better align the criteria with their specific end use, given the many factors that can influence color rendition specification criteria. In practice, these specification criteria form qualification boundaries, but they do not guarantee an outcome—neither appropriateness of qualified products or inappropriateness of not-qualified products.

Table E-2. Recommended Specification Criteria.

<table>
<thead>
<tr>
<th>Priority Level</th>
<th>Design Intent</th>
<th>Preference (P)</th>
<th>Vividness (V)</th>
<th>Fidelity (F)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(The desired effect of color rendition on the illuminated environment)</td>
<td>$R_t \geq 78$</td>
<td>$R_t \geq 95$</td>
<td>$R_t \geq 75$</td>
</tr>
<tr>
<td>1</td>
<td>P1</td>
<td>$R_g \geq 95$</td>
<td>$R_g \geq 118$</td>
<td>$R_g \geq 110$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$-1% \leq R_{cs,h1} \leq 15%$</td>
<td>$R_{cs,h1} \geq 15%$</td>
<td>$R_{cs,h1} \geq 6%$</td>
</tr>
<tr>
<td>2</td>
<td>P2</td>
<td>$R_g \geq 92$</td>
<td>$R_g \geq 100$</td>
<td>$R_g \geq 100$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$-7% \leq R_{cs,h1} \leq 19%$</td>
<td>$R_{cs,h1} \geq 6%$</td>
<td>$R_{cs,h1} \geq 0%$</td>
</tr>
<tr>
<td>3</td>
<td>P3</td>
<td>$R_g \geq 89$</td>
<td>$R_g \geq 100$</td>
<td>$R_g \geq 100$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$-12% \leq R_{cs,h1} \leq 23%$</td>
<td>$R_{cs,h1} \geq 0%$</td>
<td>$R_{cs,h1} \geq 0%$</td>
</tr>
</tbody>
</table>

Table note: All criteria assume a polychromatic environment with average horizontal illuminance between 200 and 700 lux and uniform chromaticity.

The recommended criteria of Table E-2 feature three design intents and three priority levels. 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. Each intent is described further in Section E.4.3. Additional design intents could be added in the future. The three priority levels (1, 2, 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. All priority levels are nested, so that qualifying for a higher level ensures qualification for all lower levels.
**Important:** The recommendations are subject to two key assumptions, which address some of the application-specific factors listed in Section E.2.2: 1) average illuminance is approximately 200 to 700 lux (19 to 65 fc); and 2) the environment is polychromatic—that is, rendition of all colors is a consideration, not just certain ones.

**Important:** The design intents are distinct, but the qualification ranges are not mutually exclusive. It is possible to meet one of the three levels for each design intent, although it is not possible to meet Priority Level 1 for all three design intents. The regions of overlap between the specification ranges are shown in Figure E-1 and described further in Annex F.

If color rendition needs are complex or specialized, i.e., falling outside the intents and assumptions of Table E-2, full consideration of all factors influencing choice of color rendition specification criteria (see Section E.3) is warranted, resulting in the development of a customized solution. Some situations that may not meet these assumptions include roadway lighting (low illuminance levels), single-material architectural facades (not polychromatic), dimly lit interior architectural environments (low illuminance levels), and some storage spaces (color rendition not a priority).

If color rendition is of low priority relative to other design considerations, such that meeting any of the basic design intents identified in Table E-2 is not important, alternatives with more lenient criteria may be appropriate. Benchmarking is one method that may be appropriate in certain situations where color rendition is of low priority. For example, approximation of $R_a \geq 70$ for LED products is $R_i \geq 70$, $R_g \geq 90$, and $R_{cs,h}\geq -18\%$. This is explained further in Annex F.

**Important:** Simply converting existing minimum values used with CIE $R_a$ to the same values for $R_i$ is not recommended. There are considerable differences between the CIE General Color Rendering Index ($R_a$; colloquially, CRI) and $R_i$, despite both being measures of average color fidelity. Furthermore, the design intent behind existing specifications based on CIE $R_a$ is generally unclear, and has not been supported by empirical data. This is demonstrated further in Annex F.
Figure E-1. Illustration of overlap between specifications. Overlapping areas represent a possible combination. The areas are not to scale.

E.4.1 Nomenclature

Each set of specification values in Table E-2 is assigned an abbreviation based on the first letter of the design intent (P, V, or F) and the priority level (1, 2, or 3). For example, the color preference specification with the highest priority level is given the code P1. These codes are suggested for use where concise communication is needed, either within a specification or in relation to the performance of a lighting product.

E.4.2 Transitions

It is acknowledged that some existing specifications rely on the combination of $R_a$ and $R_9$ from CIE 13.3-1995. The transition to new specifications can be a challenge because products that meet existing specifications may not meet new specifications. To address this practical consideration, a phased approach is recommended, with dual paths to qualification for a limited time while the market transitions.36

E.4.3 Tolerances

The recommended values are minimum and maximum specifications, not design targets. Therefore, tolerances are not specified. Where measurement and manufacturing tolerances are relevant, users should establish appropriate targets at their own discretion.
**E.4.4 Description of the Three Design Intents**

This section describes the function, meaning, and limitations of the three design intents. (For additional explanation of how the specific values were derived, see Annex F.)

**E.4.4.1 Color Preference**

This design intent captures subjective evaluations of preference, pleasantness, naturalness, acceptability, and related qualities. These sets of criteria utilize three ANSI/IES TM-30-18 measures: \( R_{cs,h1}, R_{f}, \) and \( R_{g} \). With increasing priority level, the recommended lower limit of \( R_{cs,h1} \) increases from -12% to -7% to -1%, reducing the desaturation of reds. The upper limit also decreases, limiting oversaturation of reds. The use of \( R_{cs,h1} \) as a central component for this design intent aligns with experimental and experiential evidence about the importance of red.

The \( R_{f} \) values for the Color Preference intent are lower than for the Color Fidelity intent, at 70, 74, and 78 for the three priority levels. This is a response to the fact that increases in red chroma lead to lower color fidelity. Lower average color fidelity values allow for higher theoretical maximum energy efficiency but also allow for lower metamerism uncertainty—though neither is a guaranteed outcome of these sets of specification criteria, as there is substantial variability among SPDs meeting the criteria. The criteria for this design intent encompass a larger area within the range of possible color rendition characteristics than the other two design intents.

The Color Preference criteria do not ensure hue stability, and considerable hue shift can occur if red chroma is substantially increased—especially if gamut area is not increased simultaneously. Rather, they prioritize red chroma enhancement relative to the reference illuminant. Increasing red chroma relative to the reference illuminant (at equal illuminance, by definition) helps counteract the Hunt Effect, making reds appear more similar to their perceived appearance under a reference illuminant at high illuminance levels.

Majorities of currently available white phosphor-converted LED, fluorescent, and ceramic metal halide products that are intended for interior use fall into the P3 specification. Some products are available in the P2 and P1 specifications. Both standard and neodymium incandescent lamps typically fall in the P1 specification, providing a reasonable demonstration of the range of color rendition characteristics for P1 products.

Color Preference may be the dominant color rendition design intent in retail, office, hospitality, and residential lighting applications. As with all design intents, this is at the discretion of the lighting specifier, in consultation with other members of the design team.

**E.4.4.2 Color Fidelity**

This design intent captures the objective quantification of color fidelity. Average color fidelity measures, such as ANSI/IES TM-30-18 \( R_{f} \) (or CIE \( R_{a} \)), quantify the average color shift in comparison to a reference illuminant; in the ANSI/IES TM-30-18 method, this is always a broadband illuminant. High levels of color fidelity minimize all types of color shifts relative to the appearance under a reference illuminant, which may be important for object identification.
Because measures of average color fidelity, such as \( R_t \), do not indicate color fidelity of any particular hue region or color evaluation sample, a minimum \( R_{f,h1} \) (equal to the specified \( R_t \) criterion) is also specified for Priority Levels 2 and 3. This is the conceptual equivalent of supplementing CIE \( R_\alpha \) with \( R_\circ \). It is not specified for Priority Level 1, because the range of \( R_{f,h1} \) is already reasonably constrained by the very high \( R_t \) criterion. Due to the cohesive underlying system of ANSI/IES TM-30-18, \( R_{f,h1} \geq 85 \) is approximately equivalent to \(-9\% \leq R_{cs,h1} \leq 9\%\), and \( R_{f,h1} \geq 90 \) is approximately equivalent to \(-6\% \leq R_{cs,h1} \leq 6\%\). It would be reasonable to employ these \( R_{cs,h1} \) criteria in lieu of an \( R_{f,h1} \) criterion.

While high color fidelity implies only small differences from the reference condition, it also reduces metameric uncertainty. Increasing color fidelity increases the need for a broad distribution of spectral power, avoiding peaks and valleys that can interact with the reflectance characteristics of specific objects. High color fidelity improves the predictability of the color appearance of objects that are not included in the 99 standardized color evaluation samples.

The Color Fidelity intent, treating all color shifts equally, contrasts with the Color Preference intent, which prioritizes preservation of colorfulness over preservation of hue. However, there is strong overlap between the two. It is possible to simultaneously achieve Priority Level 1 for both intents.

Majorities of currently available white phosphor-converted LED and fluorescent lighting fall outside of the Color Fidelity specifications, but products in all three priority levels do exist. A standard incandescent or tungsten-halogen lamp meets the F1 specification, whereas a neodymium incandescent lamp would typically meet the F3 specification. The neodymium incandescent lamp has lower color fidelity because it intentionally shifts colors relative to the reference illuminant in order to increase color preference.

Color fidelity may be the most important design intent in manufacturing, medical, color matching, or color reproduction applications. As with all design intents, this is at the discretion of the lighting specifier, in consultation with other members of the design team.

E.4.4.3 Color Vividness

This design intent captures subjective evaluations of color vividness, which may alternatively be referred to as vibrancy or saturation. \( R_{cs,h1} \) is a key criterion for this design intent. It is augmented with \( R_\circ \) to prevent focused optimizations for a specific hue. The Color Vividness specifications have no upper limits on \( R_{cs,h1} \) or \( R_\circ \). Very large increases in vividness may not be viewed as natural or preferred and should be reserved for specific applications where these considerations are not important. Strong increases in \( R_{cs,h1} \) and/or \( R_\circ \) induce hue shifts and reduce color fidelity.

There is some overlap between the performance characteristics of the Color Preference and Color Vividness design intents, although Priority Level 1 cannot be achieved simultaneously for both. In short, color preference is maximized at an intermediate, above-average level of color vividness, where colors are neither dull nor too vivid. This design intent focuses only on increasing color vividness, and targets above-average performance. It is possible to simultaneously achieve any level of Color Preference and Color Fidelity at Priority Level 3 for Color Vividness (e.g., P1, V3, F1). Likewise, it is possible to achieve V2, F3, and P1. These are important regions of overlap but do not necessarily represent performance that is suitable for all situations, given tradeoffs with other
lighting characteristics. Some other possible combinations are illustrated with examples in Section E.5.

Majorities of currently available white phosphor-converted LED and fluorescent lighting fall outside of the Color Vividness specifications, although some products achieving up to V2 exist. At present, the V1 specification is most readily achieved using color-mixed LEDs. Color vividness may be the dominant color rendition design intent in some entertainment, display, or retail applications. As with all design intents, this is at the discretion of the lighting specifier, in consultation with other members of the design team.

E.5 Performance of Select Spectral Power Distributions

The performance of SPDs representative of currently available products is shown in the following series of graphics. It should be noted that identified product categories are not homogeneous in terms of color rendition; these are examples only and should not be used for any other purpose. Categorization according to the recommended color rendition specification criteria is shown in the upper-right corner, using the defined nomenclature (see Section E.4.1). A dash is used to indicate that none of the priority levels are met for the specific design intent.
<table>
<thead>
<tr>
<th>Phosphor-Converted White LED 1</th>
<th>P3</th>
<th>V-</th>
<th>F-</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Graph" /></td>
<td><img src="image2.png" alt="ColorRendering" /></td>
<td>$R_{cs,h1} = -9%$</td>
<td>$R_{f,h1} = 83$</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Phosphor-Converted White LED 2</th>
<th>P1</th>
<th>V-</th>
<th>F2</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image3.png" alt="Graph" /></td>
<td><img src="image4.png" alt="ColorRendering" /></td>
<td>$R_{cs,h1} = 0%$</td>
<td>$R_{f,h1} = 96$</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Phosphor-Converted White LED 3</th>
<th>P2</th>
<th>V-</th>
<th>F2</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image5.png" alt="Graph" /></td>
<td><img src="image6.png" alt="ColorRendering" /></td>
<td>$R_{cs,h1} = -3%$</td>
<td>$R_{f,h1} = 92$</td>
</tr>
</tbody>
</table>
741 Fluorescent

Radiant Power (Equal Luminous Flux)

Wavelength (nm)

Reference  Test

CCT 4664 K

Duv 0.0167

Rcs,-23% Rth,58%

835 Fluorescent

Radiant Power (Equal Luminous Flux)

Wavelength (nm)

Reference  Test

CCT 3483 K

Duv 0.0008

Rcs,-8% Rth,81%

930 Fluorescent

Radiant Power (Equal Luminous Flux)

Wavelength (nm)

Reference  Test

CCT 2910 K

Duv -0.0022

Rcs,-3% Rth,92%
References for Annex E


