

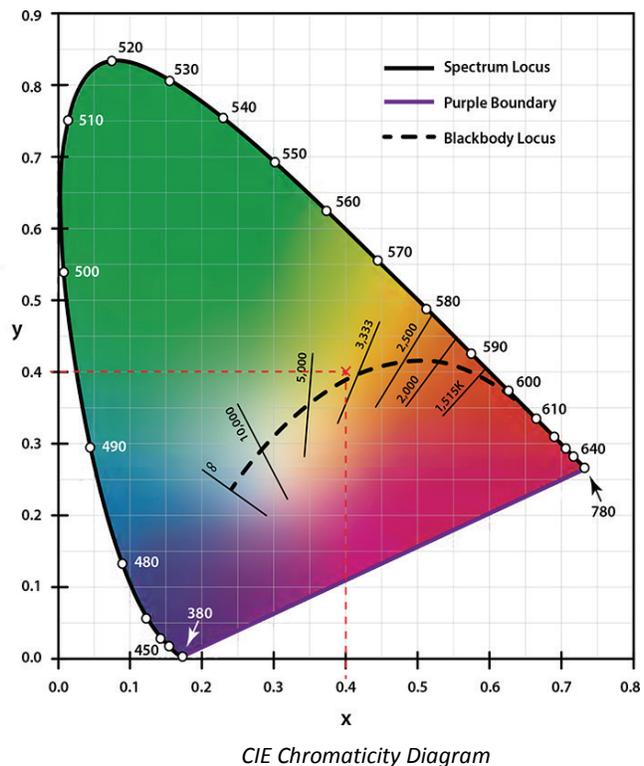
2 Holt Drive
Stony Point, NY 10980-1996
USA
+1 845 942-2800
+1 800 999-9574 (USA & Canada)
+1 845 942-2177 Fax

www.LightingServicesInc.com

TM-30: Shedding New Light on Color Rendering

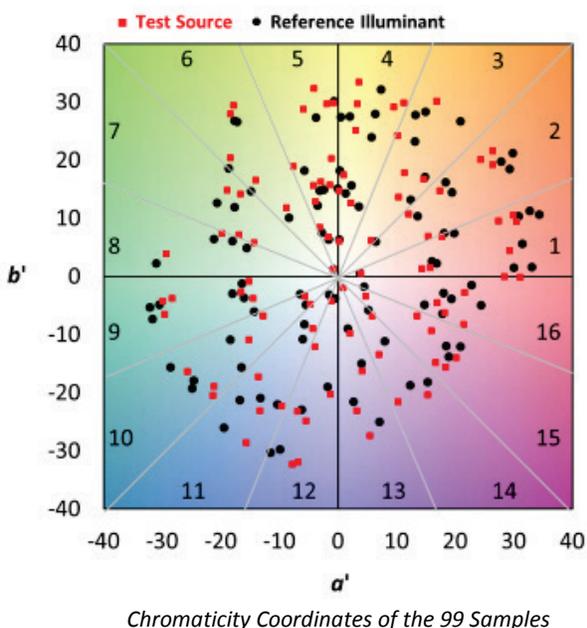
For the past 40 years, the color rendering of light sources has been measured using CRI (Color Rendering Index). For the most part, this has worked just fine – but what if, instead of grading a light source on only 8 color samples (CIE 1974), we could base it on 99 samples that actually represent colors we encounter in the real world. This is what the IES has done with its release of TM-30-15. Using more samples provides a more reliable metric for measuring color rendering of light sources. TM-30 not only evaluates a light source on its closeness to a reference light source, but also on its increase or decrease in chroma. What does this mean? Since this subject isn't exactly black and white, let's take a closer look.

When evaluating the color rendering properties of a light source, it is compared to a reference illuminant with the same correlated color temperature (CCT). With light sources that have a CCT lower or equal to 4500K, the reference illuminant is the black body locus (see right). This reference source portrays colors as they truly are, therefore, according to CIE 1974, its CRI is 100. As mentioned above, the CIE 1995 method for evaluating light sources relies on just 8 color samples. In TM-30, there are 99 color evaluation samples (CES). By comparing the chromaticity coordinates of the 99 samples when illuminated by the test source and the reference source, and calculating the average change, we can calculate the **fidelity index**, or **R_f**. The range of this value is from 0-100, with 100 indicating identical appearance.



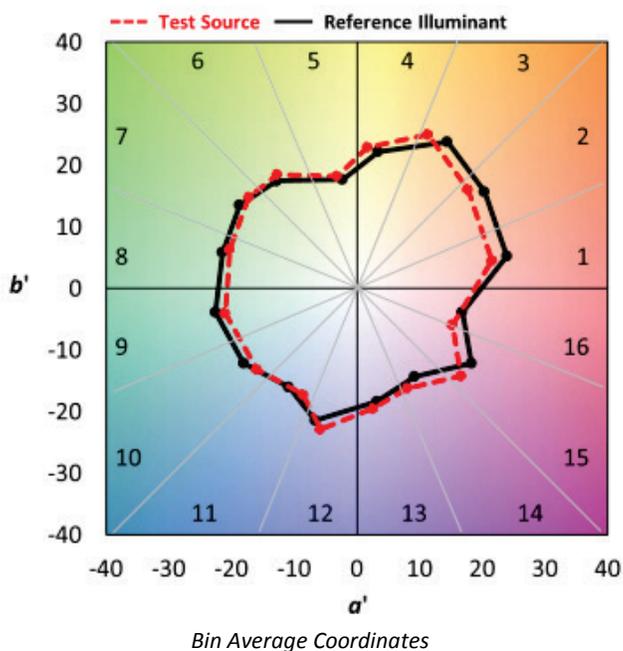


It is important to note that some sources may have lower or higher Rf values than CRI values. For example, a light source could have been previously optimized to portray the 8 color samples only so it scored high with CRI. However, when tested with 99 samples, the light source could score less because its spectral power distribution (SPD) curve does not allow the additional samples to be accurately represented.



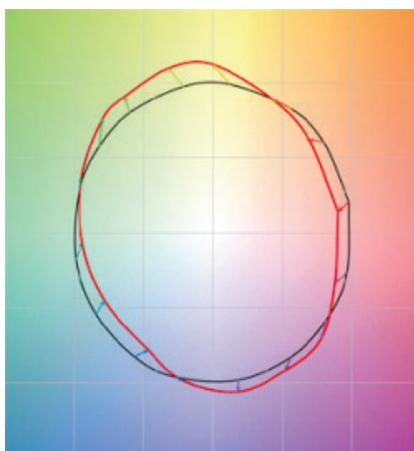
The second measurement used in the TM-30 is the **gamut index, Rg**, which determines the increase or decrease in chroma for the given light source. It compares the 99 CES under the test and reference illuminants. In the graph to the left, each CES is represented by both black and red dots. The black dots are each CES under the reference illuminant. The red dots are each CES under the test light source. You can see that with some areas, the black and red dots are very close which means that sample looks almost the same under the reference illuminant and the test light source. The further apart the two dots are, the higher the shift in color between the two.

But the question still remains, how is the Rg value calculated? The (a', b') plane above is cut into 16 sections (numbered on graph). The arithmetic mean of the a' and b' coordinates of all the samples in each section for both the reference source and test source result in 32

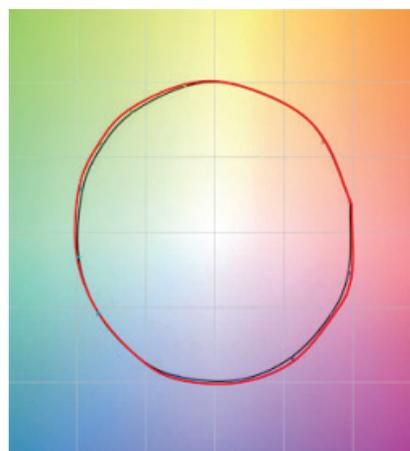


coordinate pairs. The 16 pairs for the reference source and the 16 pairs for the test source are plotted on the same graph and each make up a similar polygon (see right). Rg is calculated as 100 times the ratio of the area of the two polygons. It is important to keep in mind that this calculation determines the *average* gamut area for all of the CES and not the largest possible area defined by the most saturated samples only. This is how the calculation is performed because it is better to represent all colors rather than just a subset of the most saturated colors.

If the test source does not increase or decrease in saturation compared to the reference source, the Rg value will be 100. If the value is over 100, this indicates an overall increase in saturation. If the Rg value is less than 100, there is an overall decrease in saturation. There is no maximum value for Rg but the possible range does increase as Rf decreases. For example, if the Rf value of a light source is 80, the Rg value is bound to a possible range of approximately 80 to 120.



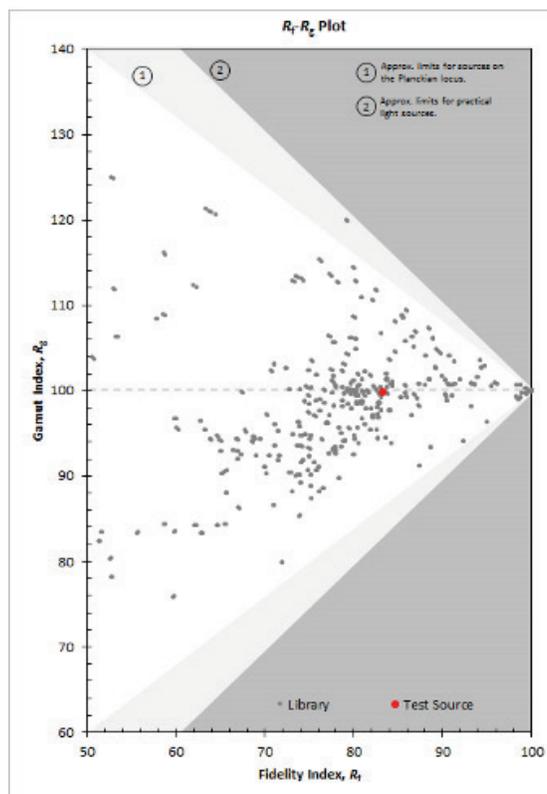
Color Vector Graphic (Xicato Standard)



Color Vector Graphic (Xicato Artist)

Now that we have values for both R_f and R_g , it is easier to see how it works through graphical representations. The color vector graphic (shown above) shows which colors are saturated or desaturated and which colors undergo a hue shift. The reference illuminant is normalized to a black circle and the gamut of the test source is plotted relative to the circle. Arrows that point into the black circle indicate areas of decreased saturation while areas that point out of the black circle indicate areas of increased saturation. Arrows that do not point directly to the center of the circle or directly away from the center of the circle are representing hue shift.

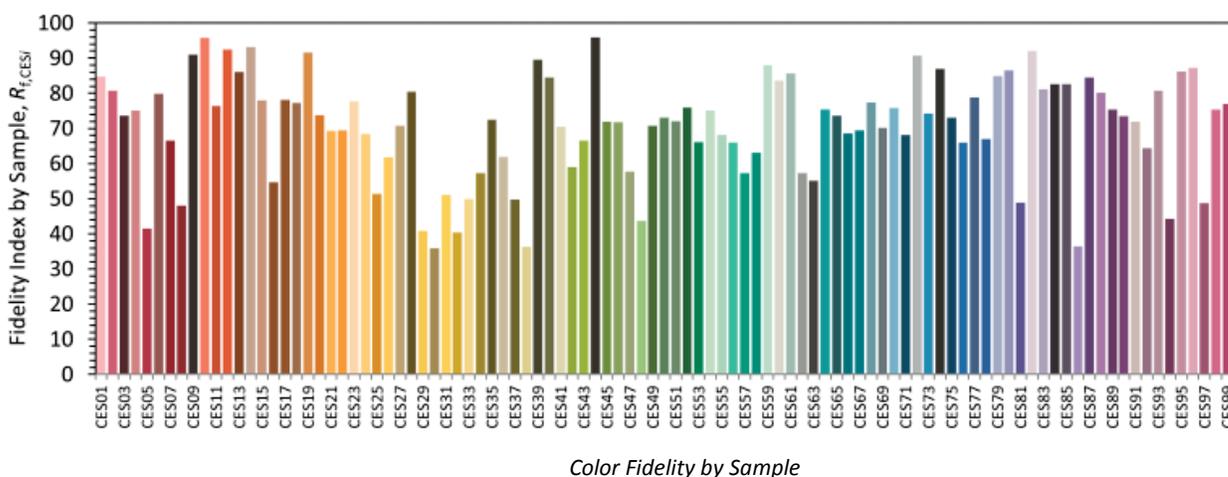
The graph to the right shows the relationship between R_g and R_f . The light grey area (labeled area 1) denotes approximate limits for light sources on the black body locus. The dark grey area (labeled area 2) denotes approximate limits for practical light sources. As the test point gets higher on the gamut index axis, it gets more saturated. The lower it is, the less saturated. As the test point gets lower on the fidelity index axis (closer to 50), the hue shift for that source increases. The R_f vs. R_g plot is mainly used as a visual reference which helps to compare different light sources.



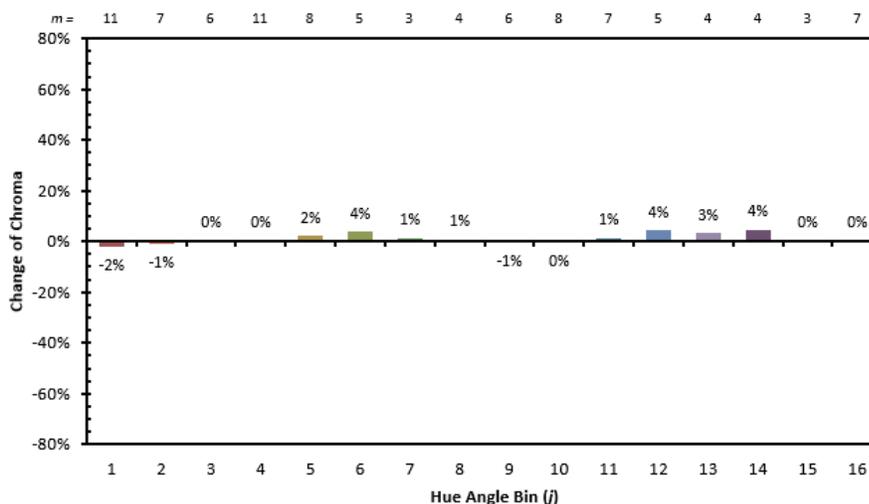
TM-30 is an improved color metric that will help to more accurately measure the color rendering of many light sources, especially LEDs. With more color samples, a more accurate assessment of color fidelity can be made. More color samples also suggests more detailed information about the rendition of specific objects. For example, CES 15 and CES 18 represent human skin tones. In an application where the color rendering of skin is important, the $R_{f,skin}$ fidelity score (average of CES 15 and CES 18) can be calculated and can help with choosing the most appropriate light source. Below is a graph showing the fidelity scores of each individual sample for a given light source, as well as a graph showing color rendition by hue bin.



With CRI, the higher score was usually considered better. With TM-30, the best light source depends on what application it will be used in. TM-30 provides its users with enough detailed information to accurately make that decision. At the end of the day, TM-30 is a great tool that will tremendously help the lighting community with understanding and applying color rendering metrics



Color Fidelity by Sample





Sources:

IES TM-30-15:

<https://www.ies.org/store/product/ies-method-for-evaluating-light-source-color-rendition-3368.cfm>

DOE:

http://energy.gov/sites/prod/files/2015/12/f27/tm-30_fact-sheet.pdf

Xicato:

<http://www.xicato.com/sites/default/files/documents/Xicato%20XIM%20and%20XTM%20TM-30-15%20Metrics%20White%20Paper.pdf>

Eye Lighting International:

<http://www.eyelighting.com/resources/lighting-technology-education/general-lighting-basics/correlated-color-temperature/>

Lighting Passport:

<http://www.lightingpassport.com/ies-tm30-15-standard.html>