In Pursuit of Natural Lighting: How CRI and R Values Measure Light Quality

When we talk about light quality, whether it's of incandescent, fluorescent or LED lighting, we are really comparing it to daylight. Daylight is the original white light. Our eyes have evolved to interpret our surroundings under sunlight, where objects appear to have the best color and appearance. I'm going to go into a little detail about current metrics (and a few developing ones) that allow us to determine how well a light fixture stands up to natural light, and try to bring them out of the arcane world of lighting engineering into the one we live in, where there is a dizzying array of LED fixtures to navigate. The only reason for you to learn about these metrics is to separate high-end lighting that makes a space look beautiful from mediocre lighting. Knowing what kinds of metrics and values to look for will help you source great lighting.

For most of the history of artificial lighting, we tolerated the fact that incandescent light bulbs gave off a lot of heat and emitted an intensely yellowish glow, because that end of the spectrum is more pleasing to us and makes faces and objects look good. The introduction of fluorescent was a shock, especially in home lighting: suddenly everything turned green. At the same time, streetlights and other outdoor lighting cast a dead orange glow at night. The simple explanation is that each light source omits part of the spectrum, which means some colors are overemphasized in our perception.

It's becoming clear that we don't want fixtures that cast light that alters the way colors look naturally, and prefer lighting that makes everything look the way it does in daylight. In other words, we simply want natural lighting. Natural-looking lighting has become the challenge of both small and large manufacturers. Apple™, in a current example, is releasing its new iOS™ version 9.3 this month with a Night Shift™ feature that aims to prevent the sleep loss due to exposure to the highly artificial blue light used to brighten the displays of its devices.

One of the strengths of LED lighting is that it offers an unprecedented ability to control how light renders colors. Because LED lights have become not only more common and within reach to shoppers, being now in their third generation of development, a product can't simply be LED, it has to be above average.

CRI Is Not Really About Color Temperature

Color Rendering Index (CRI) is the current standard metric of a light source's ability to reveal the colors of objects faithfully in comparison with natural light. One thing to note first is that a white light's color temperature (or CCT, measured in Kelvins) is related to but doesn't solely determine light quality. Although sunlight seems "warm" in quality, it is actually that very cool 6500K color temperature at midday. It's the perfect CRI (100) of sunlight that makes it the standard for color rendering to which we compare all artificial light. (When we say "warm" we probably mean familiar.) So the holy grail of LED lighting is to create light that renders colors and whites perfectly no matter what the CCT. This lets you have the warm glow of incandescent (2700K for example) while having high CRI/light quality.

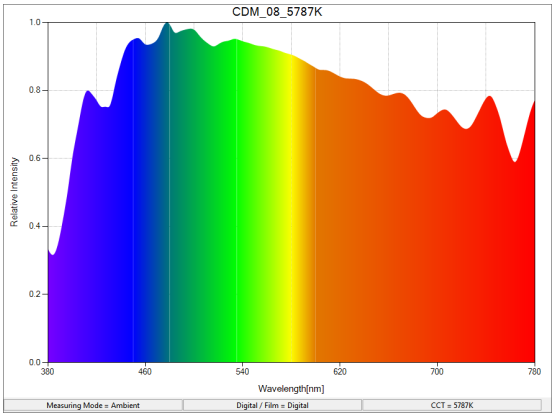

Figure 1 - Spectrograph of daylight

Measured Against Daylight

Natural daylight is the ideal light source because it contains high levels of every color in the spectrum (Figure 1, above), while inferior lighting either has low levels of some colors or is missing them entirely. The better balanced a light spectrum is, and the more each color is equally represented, the higher the CRI value. A good example of distribution of color is shown in Alloy LED's PrimaLine™ Tape Light spectrograph (indicated in the "wavelength" axis in Figure 2, below.)

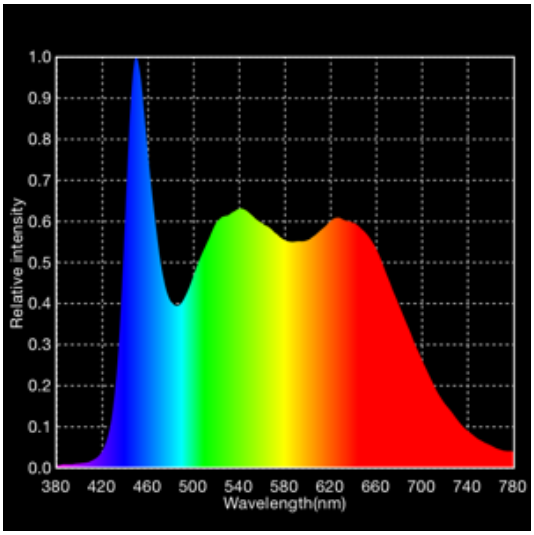

Figure 2 – 95 CRI PrimaLine tape light spectrograph

The higher the CRI values of the light are, the more seamlessly it blends with daylight. Since we live in and move back and forth between the indoors and outdoors, and because most spaces have both natural light from windows and artificial light from fixtures, it's important that the latter resemble daylight as closely as possible.

It is also important to note what LED lighting's spectrum does not include: harmful ultraviolet or infrared light. LED light provides the color rendering qualities of the sun without including light frequencies that can fade furniture and art and be harmful to humans.

Don't Ignore R Values

CRI is not the only factor in light quality, because it only contains measurements for R1-R8 values, which are pastel colors (see Figure 3 on the next page), and does not measure red, for example, which is present in skin tones and wood finishes. A light also needs to have solid "R" values from R9-R15 that measure how well the light brings out saturated colors. The example below shows Alloy's 95 CRI PrimaLine Tape Light vs. an 85 CRI competitor. The most popular indicators of high upper "R" values are R9 (red) and R13 (light pink). Out of a possible 100, 90 and 98 are very high marks; low values for these would indicate that a light is showing the color of an object or person to be lacking in color and dull-looking.

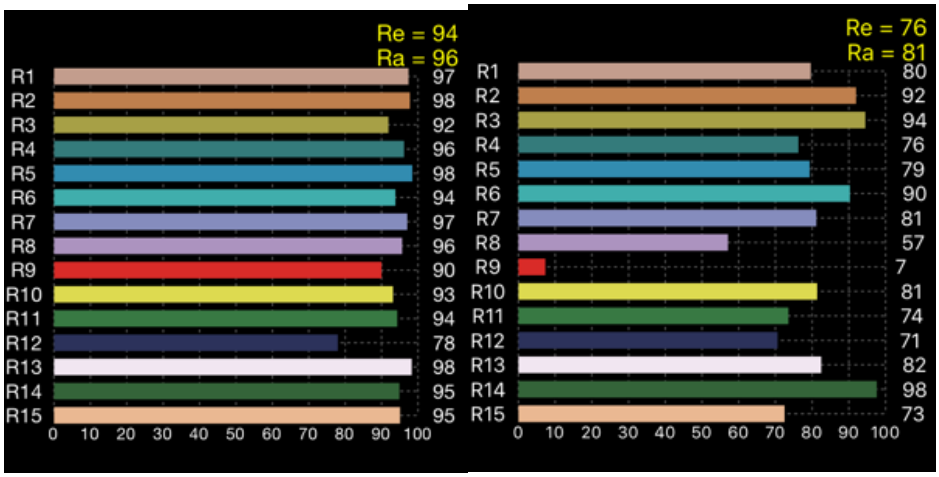

Figure 3 - "R" values for 95 CRI PrimaLine tape light (left) and a competitor's 85 CRI tape light (right).

R1-R8 represent CRI, with the additional R9-R15 values showing saturated colors.

CRI Is Not Enough

On the right side of Figure 3, you can see that even a tape light with a nominal CRI of 85, which is fair, can still have poor R9-R15 values, which means it will dull down saturated colors. If you see a supplier advertising their R9 and R13 values, not only is it easy for you to assess them, but it shows they are conscious of the importance of R values, which is half the battle in finding the right supplier for your needs.

Even More Metrics: CQS and GAI

As a testament to how difficult it is to replicate nature, there are even newer additional metrics. The good news is they've only been created, again, to help separate the superior from the average. Now that you've gotten used to R values, it's time to talk about efforts to replace this inadequate metric.

One new metric, as early as 2012, is the Color Quality Scale (CQS). CQS is meant to replace CRI (which was developed in the '50s and is now outdated), and adds chromatic discrimination (aka contrast between colors) and observer preferences. This means that it gives more weight to how our subjectivity influences our perception of colors. As you can see below, the colors of the CQS scale are more saturated than the CRI color scale (Figure 3, above), and more representative of the actual color spectrum. At the same time, it still has only 15 colors in the scale, making it no more nuanced than the R1-R15 values.

Figure 4 - The CQS scale, which has 15 saturated colors

It makes sense that CQS should take into account our visceral response to how much a color pops: dyes are added to food, chemicals to plastics, and gloss to finishes, all to enhance the saturation of colors. CQS is offered on top of how accurately a color is portrayed, which is what the CRI metric should give us, but CRI is an incomplete picture. In other words, whereas a 95 CRI says "this is the real color", a high CQS value says "check out how vibrant, accurate, and appealing this color is!"

Another similar metric called Gamut Area Index (GAI) has been in development, but we haven't heard as much about it as about CQS. It has the same goal as CQS, which is giving more weight to subjective perceptions of vividness and natural quality. GAI is meant be paired with, rather than replace, CRI, since

GAI and CRI use different sets of metrics. Ultimately, though, GAI has the same flaw as CRI, which is that it uses the same incomplete, pastel-based color scale as CRI.

You may also run across the FCI (Feeling of Contrast Index) that, again, is another way of measuring the elusive perception of the vividness of color.

TM-30

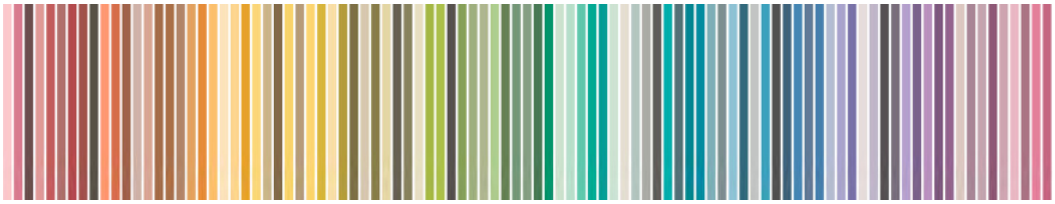

Figure 5 - TM-30 Color Scale

It only takes a glance at the color scale for the TM-30 lighting metric (Figure 5) to see that it is vastly more sophisticated than any of the others. The range of colors is a more accurate reflection of the real world, showing the kinds of colors you see in skin tones, plants, food, clothing, and furnishings. The team that developed TM-30 hopes it will be approved by the IES to replace CRI and CQS entirely. Though the information offered on its scale of 99 colors will be a lot to digest, it should also include an averaged figure, as CRI does. It's hard to imagine a more accurate metric. TM-30 has gotten a lot of coverage over the past year, so stay tuned.

Takeaway

As LED lighting and lighting metrics get ever more sophisticated, there's no reason to settle for anything less than fantastic. When you are sourcing LED lights for most indoor applications, like residential, retail display, and hospitality lighting, be sure to get the CRI and R value figures from the supplier before purchasing, these are currently the best widely available metric. However, not all applications call for the highest quality lighting: there is no need to spend more money to illuminate a warehouse, a street, a storage facility, etc. with high CRI lighting. Also look to LED manufacturers and suppliers to lead the way in producing the highest-quality and most natural lighting, using the metrics of the future as their guide.

Sources:

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