High TLCI LEDs for Film, Live TV and Digital Creators

WHY TLCI IS MORE IMPORTANT THAN CRI WHEN CAMERAS ARE INVOLVED

Just like the human eye, a digital camera sensor has unique response curves for blue, green and red (see Figure 1). A camera's sensitivity is different from that of a human eye, so the way a camera perceives color also changes. The European Broadcasting Union (EBU) created the Television Lighting Consistency Index (TLCI-2012) to replace CRI for digital cameras.

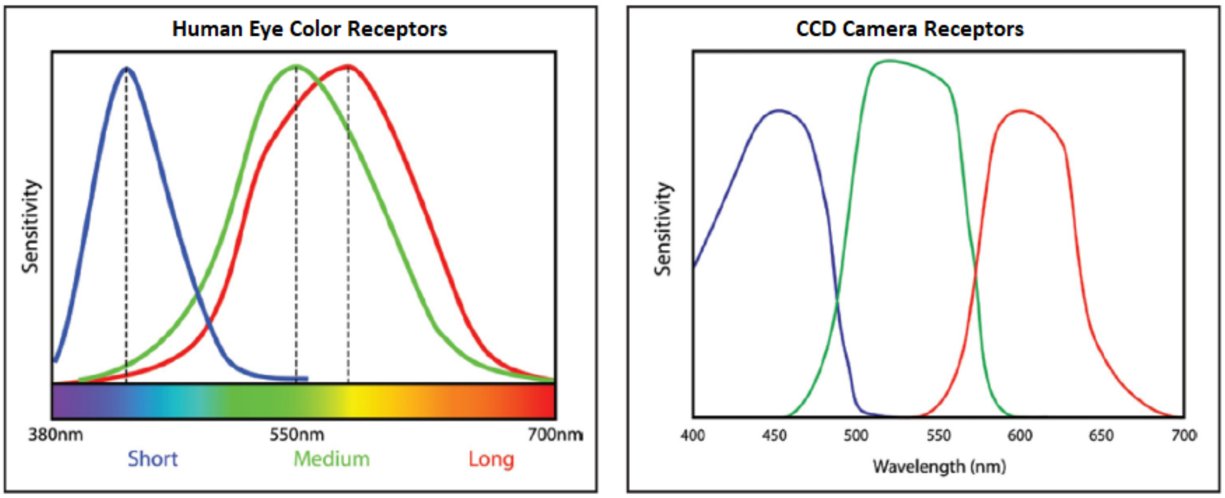

Figure 1: Color response curves of the human eye (left) and a CCD camera (right) [1]

LEDs with high TLCI help filmmakers, broadcasters, and digital creators capture scenes under consistent illumination to reduce or eliminate costly color corrections in post-processing. Figure 2 shows the effort that a professional colorist would need to apply to correct scenes shot under illumination at different TLCI levels. As can be seen, a scene shot with 90 TLCI LEDs would be easy for a professional to correct and a 95 TLCI LED should eliminate the need for color correction in all but the most demanding applications. Cree LED now has 90+ TLCI and 95+ TLCI binning to meet these needs.

Figure 2: The effort and skill needed (right) to properly color correct photography or videography illuminated by lights of a typical TLCI value of the scale on the left. [2]

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UNDERSTANDING THE TLCI CALCULATOR AND REPORT

The full TLCI-2012 documentation and downloadable calculator can be found on the EBU website. Figure 4 shows an example report from the XLamp® XP-L2 Broadcast Edition 95+TLCI LED. Compare it to the standard 90 CRI LED shown in Figure 3.

Each experimental ("Test") spectrum is compared to a Reference illuminant (inset lower right), which changes automatically based on the calculated CCT. The 18 color patches represent the 18 color samples in the TLCI calculation plus 6 grey levels, showing how each is rendered under the Test illuminant. The patches also contain a smaller inset square showing the color rendered under the Reference illuminant. If the inset square is not visible, the Test illuminant is accurate and little or no color correction is needed.

The table in the top right is the "Colorist's Advice Report." This guides a colorist through the post-processing color corrections needed. A zero value shows perfect color rendering, a single + or – sign means the error is very small (and the sign tells which way to apply correction); multiple + or – signs show that a higher magnitude of correction is needed.

XPG2 90 CRI Standard: CCT = D5539 (-0.5)

TLCI-2012 : 91 (D5539)

Television Lighting Consistency Index-2012

Sector	Lightness	Chroma	Hue
R	+	+	0
R/Y	0	0	- -
Y	0	0	-
Y/G	0	0	0
G	0	0	+
G/C	0	0	+
C	0	0	+
C/B	+	0	- -
B	0	-	0
B/M	+	0	++
M	+	0	++
M/R	++	0	++

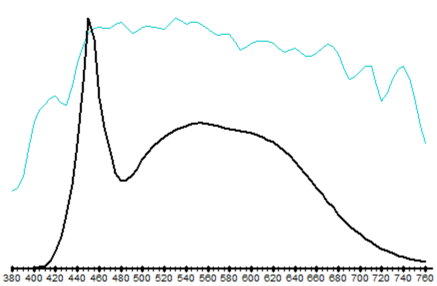
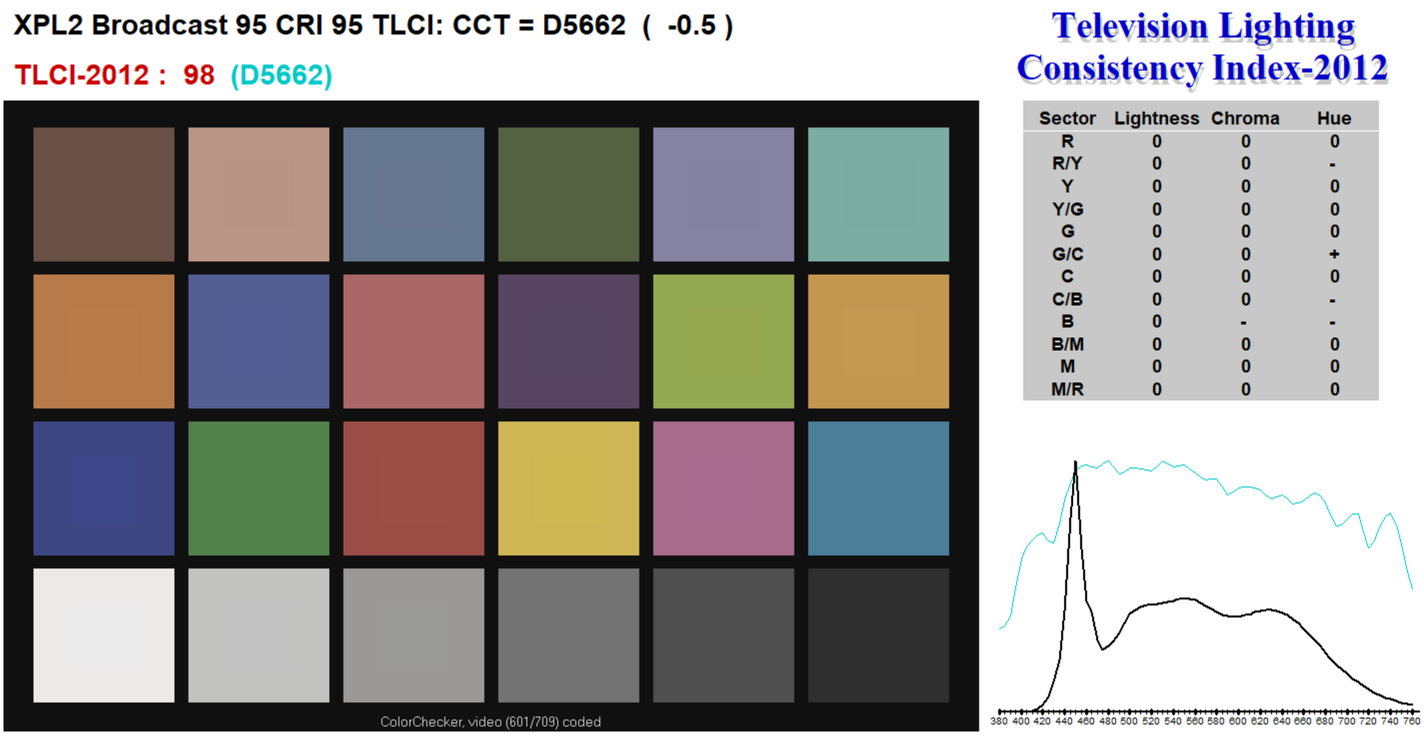


Figure 3: TLCI report of standard 90 CRI 5700 K LED. The Colorist Advice Report inset top right shows several hue and lightness corrections are required.



Sector	Lightness	Chroma	Hue
R	0	0	0
R/Y	0	0	-
Y	0	0	0
Y/G	0	0	0
G	0	0	0
G/C	0	0	+
C	0	0	0
C/B	0	0	-
B	0	-	-
B/M	0	0	0
M	0	0	0
M/R	0	0	0

Figure 4: TLCI report of Cree LED's XP-L2 Broadcast Series 95 TLCI 5700 K LED. The actual measured TLCI is 98 and the Colorist Advice Report inset top right shows a nearly perfect color rendering. Also notice the changes in visibility of the inset squares in each color path.

CASE STUDY: SWITCHING FROM 90 CRI TO 95 TLCI XP-L2 BROADCAST LED

Using a simple HD camera and still life scene, we can digitally demonstrate the color rendering difference that can be expected from upgrading from 90 CRI to 95 TLCI. Figure 5 shows a scene illuminated at 1500 lux by a standard 90 CRI XP-L2 LED. Figure 6 shows the same scene illuminated by a 5700 K 95 TLCI 95 CRI XP-L2 Broadcast LED. It is easy to see the difference in the far-left fabric swatches having a much crisper white and more vivid cyan and light blues. As a comparison, Figure 7 shows the same scene illuminated by a standard 70 CRI LED at the same lux.

Figure 5: Scene illuminated by a standard 90 CRI XP-L2 LED

Figure 6: The same scene illuminated at the same lux by a 95 TLCI 95 CRI XP-L2 Broadcast LED

Figure 7: For reference, a standard 70 CRI LED illuminating the same scene at the same lux

Zooming into these fabric swatches with photo editing software (see Figure 8) reveals the digital RGB value differences between the 90 CRI and 95 TLCI illumination. Note that these are the minimum bin values. The actual measured values in this experiment are 92 CRI and 98 TLCI.

The RGB values in the white swatch are closer to pure white (255, 255, 255), especially in the blue component. This difference is visually apparent when you notice the 90 CRI white is warmer and the 95 TLCI white is more of a crisp true white.

In the cyan swatches the RGB values reveal better saturation in all three channels, but again the largest difference is in the blue component. This difference is expected because the 95 TLCI LED better fills the cyan gap than the standard 90 CRI LED. The red channel also shows a strong increase in saturation as a result of the wider and longer-wavelength red component of the 95 TLCI LED.

Figure 8: Comparison of digital RGB values on white (top) and cyan (bottom) fabric swatches. TLCI and CRI values of the illumination are inset in the zoom circles.

CONSIDERING PHOTODEGRADATION FOR INDOOR APPLICATIONS

When choosing a high-TLCI LED for indoor lighting, it is important to consider the potential for photodegradation (color fading) of artwork, textiles, paints and other pigmented objects in the room. Many 95+ TLCI LED manufacturers use a violet LED pump (~400-420 nm), while Cree LED uses a typical ~455 nm blue LED pump. Photons of 420 nm typically degrade pigments about 52% faster than photons at 455 nm, according to the CIE 157:2004 spectral weighting damage function. Researchers at PNNL calculated damage across the entire spectrum of typical commercial violet- and blue-pumped LEDs, finding that the violet-pumped LED had a 0.97 material damage risk score, 31% higher than the blue-pumped LED (0.74) [3]. Figure 9 below shows the CIE Spectral Damage Potential by CCT and CRI for LEDs, including a comparison of the blue- and violet-pumped LEDs at 3000 K. When illuminating subjects sensitive to photodegradation, Cree LED recommends avoiding violet-pumped LEDs.

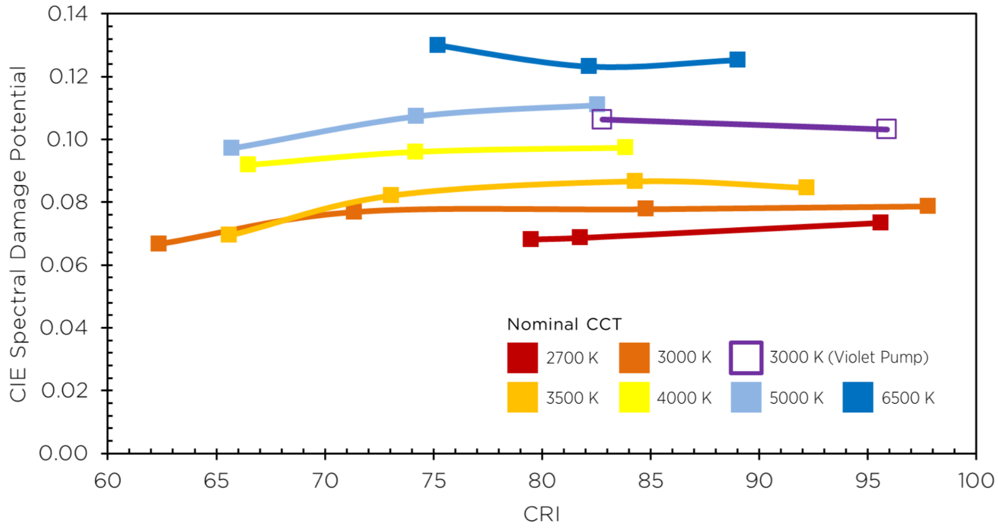


Figure 9: CIE Spectral Damage Potential of blue-pumped LEDs (solid squares) and violet-pumped LEDs (open squares) by typical CRI. There is no strong trend by CRI, but cooler CCTs and violet-pumped LEDs show a strong increase in damage potential. [3]

CHOOSING A HIGH-TLCI LED

Cree LED now offers several products with high-TLCI binning and will add more options in the future. Visit https://www.cree-led.com/products/applications/broadcast/ or find a distributor in your region: https://cree-led.com/where-to-buy.

REFERENCES

[1] Wood, Mike. *Television Lighting Consistency Index–TLCI, Protocol* Fall 2013 issue https://www.mikewoodconsulting.com/articles/Protocol%20Fall%202013%20-%20TLCI.pdf

[2] R 137: TELEVISION LIGHTING CONSISTENCY INDEX-2012 AND TELEVISION LUMINAIRE MATCHING FACTOR-2013, August 2016 https://tech.ebu.ch/docs/r/r137.pdf

[3] Royer, Michael P. TRUE COLORS: LEDS AND THE RELATIONSHIP BETWEEN CCT, CRI, OPTICAL SAFETY, MATERIAL DEGRADATION, AND PHOTOBIOLOGICAL STIMULATION. United States: N. p., 2014. Web. doi:10.2172/1165332. https://doi.org/10.2172/1165332

Other related references:

[4] EBU Tech 3355: Method for the Assessment of the colorimetric properties of luminaires, the Television Lighting Consistency Index (TLCI-2012), October 2012 https://tech.ebu.ch/docs/tech/tech3355.pdf

[5] EBU Tech 3353: DEVELOPMENT OF A "STANDARD" TELEVISION CAMERA MODEL IMPLEMENTED IN THE TLCI-2012, November 2012 https://tech.ebu.ch/docs/tech/tech3353.pdf