

THE LIGHT QUALITY OF LEDS | EAGLE LIGHTING AUSTRALIA



eaglelightingaustralia
Member of the Fagerhult Group

INTRODUCTION

Many factors affect the light quality of LED. Colour temperature, colour rendition and colour quality affect both how the light works and how it is perceived. Although the technological properties of LED's and

traditional light sources are not directly comparable, the user's demands for how the light from a good luminaire should behave, remains unchanged.



COLOUR RENDITION

Colour rendition of LED's is normally given as a Colour Rendering Index (CRI) or Ra. The Ra scale is from 1 to 100 and measures the capacity of the light source to render colours. A high Ra often produces a somewhat lower efficiency so an assessment must be made around what is more critical to the project.

The Colour Rendering Index (CRI) is given as an average value (Ra) across 8 or 14 colours. An 8 scale test features pastel colours and is a poor indicator of colour rendering ability, particularly saturated colour. A CRI (14) test is preferred, however, a CRI (14) test can still see an LED rendering thirteen colours well but not so good at the fourteenth. The diagram below is a good example where, despite the LED rendering red poorly, it still scores a CRI (8) of 85 and a CRI (14) of 80. Because of these flaws in the CRI system, there are currently other systems of measurement under investigation. One such system is the Colour Quality System (CQS) where scores are still given out of 100 but the colours used as a reference are

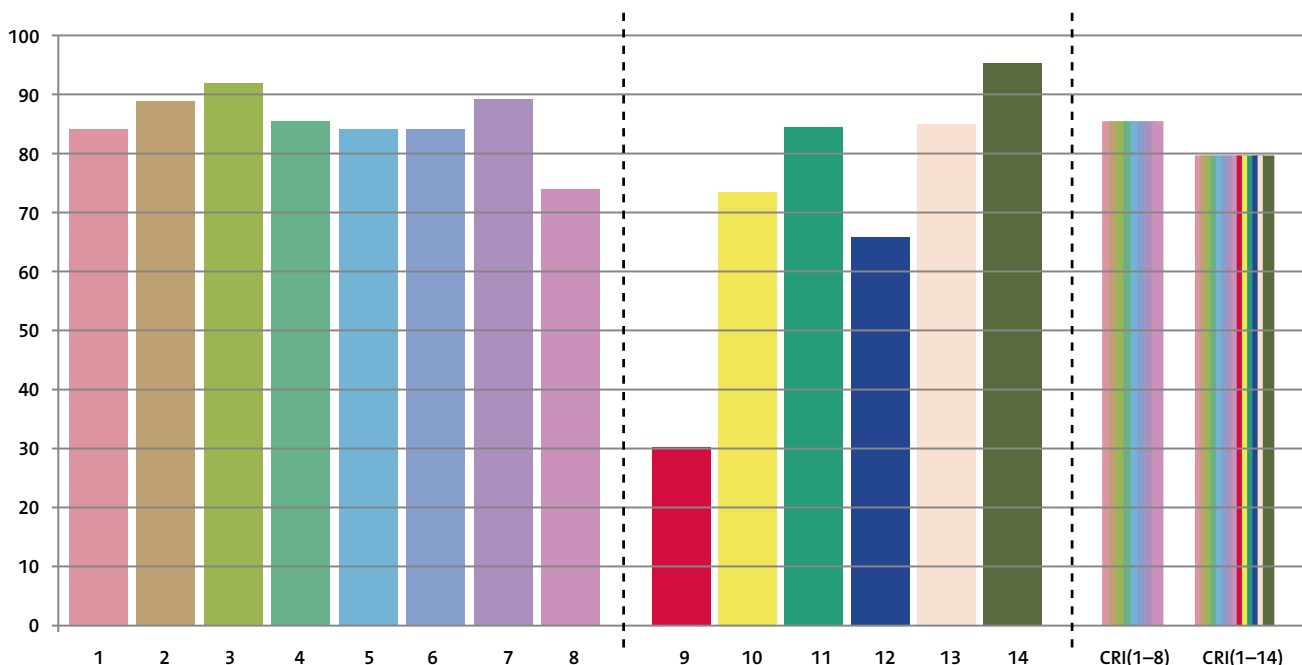
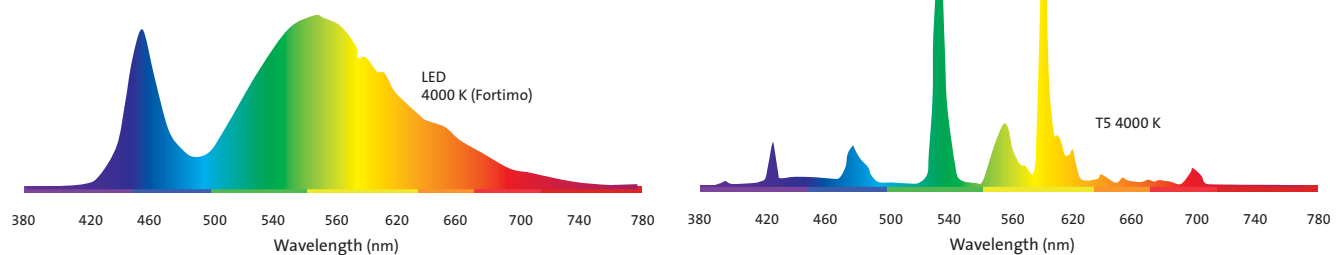
all saturated and the formula to derive at the figure more detailed.

Whilst colour rendition will vary among different LEDs, it is directly linked to the spectral distribution of the LED. Therefore, an analysis of the spectral distribution can give us more information about the LED's ability to reproduce colours. The more a particular colour is present in the spectral distribution, the better the LED at rendering that colour. It is also worth noting that colour rendition can differ between a new LED and one that has been in use for several thousand hours.

COLOUR RENDERING CHECKLIST

- ✓ Always make sure the quoted Ra is from a CRI(14) test.
- ✓ Look at the spectral distribution when colour rendering is important. Are the colours you are trying to illuminate present in the LED?

SPECTRAL DISTRIBUTION GRAPHS



COLOUR TEMPERATURE AND QUALITY

The colour temperature of a white light source is given in Kelvin (K). Originally, Kelvin was a measure of the colour of a heated (and therefore glowing) black body.

For lamps with a filament, this measure is easy to apply, as the colour temperature in Kelvin is the same as the actual temperature of the filament. For light sources with no filament– such as fluorescent tubes, gas discharge lamps and LEDs – we must calculate a correlated colour temperature (CCT) in Kelvin.

Colour temperature may vary from one manufacturer to another, even if they report the same measurement. In addition, the colour temperature of an LED can change over time, which means that the value after several thousand hours of use will not be the same as that of a new

LED- see the chromaticity section for more information.

LED manufacturers sort their products into 'bins' according to their performance. As highlighted on the ANSI standard binning chart diagram, there are 16 bins around 3500K.

A 3500K LED taken from the top left quadrant will appear greenish when compared to one from the bottom right quadrant that will have a pinkish hue. Interestingly, we often see manufacturers using LED's with a greenish hue as these are often more efficient.

Even though there is an ANSI standard, two opposite corners within a bin can also appear to be different. For this reason, many manufacturers will sub categorise into smaller bins again to improve

the colour consistency. The fewer bins your LEDs are selected from, the more stable the quality of the product.

One of the emerging trends to deal with colour temperature issues is remote phosphor technology. By using naturally grown blue LEDs and mixing the light in a chamber before it reaches the phosphor, manufacturers can produce LEDs of consistent colour. This reduces many of the issues of colour shift over time that are associated with traditional phosphor covered LED's.

There are also constant tuning LED solutions, where constant feedback from the LED board sees the LEDs adjusted accordingly to keep the colour temperature stable, not just initially, but for the life of the LED board. This type of solution does require the use of additional built in



COLOUR TEMPERATURE AND QUALITY

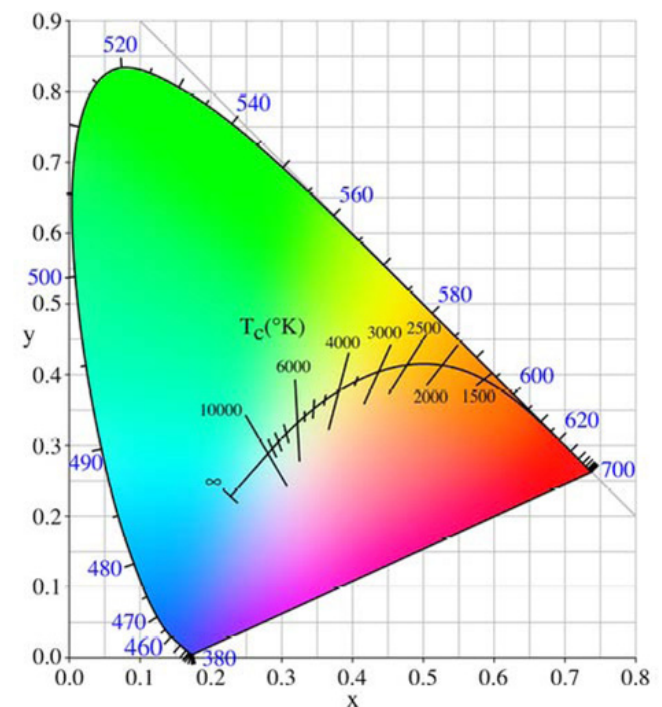
electronic components, however, and hence can be prone to higher failure rates.

Remember, there is no substitute for looking at the LED itself and making your own assessment of it's colour temperature and colour quality.

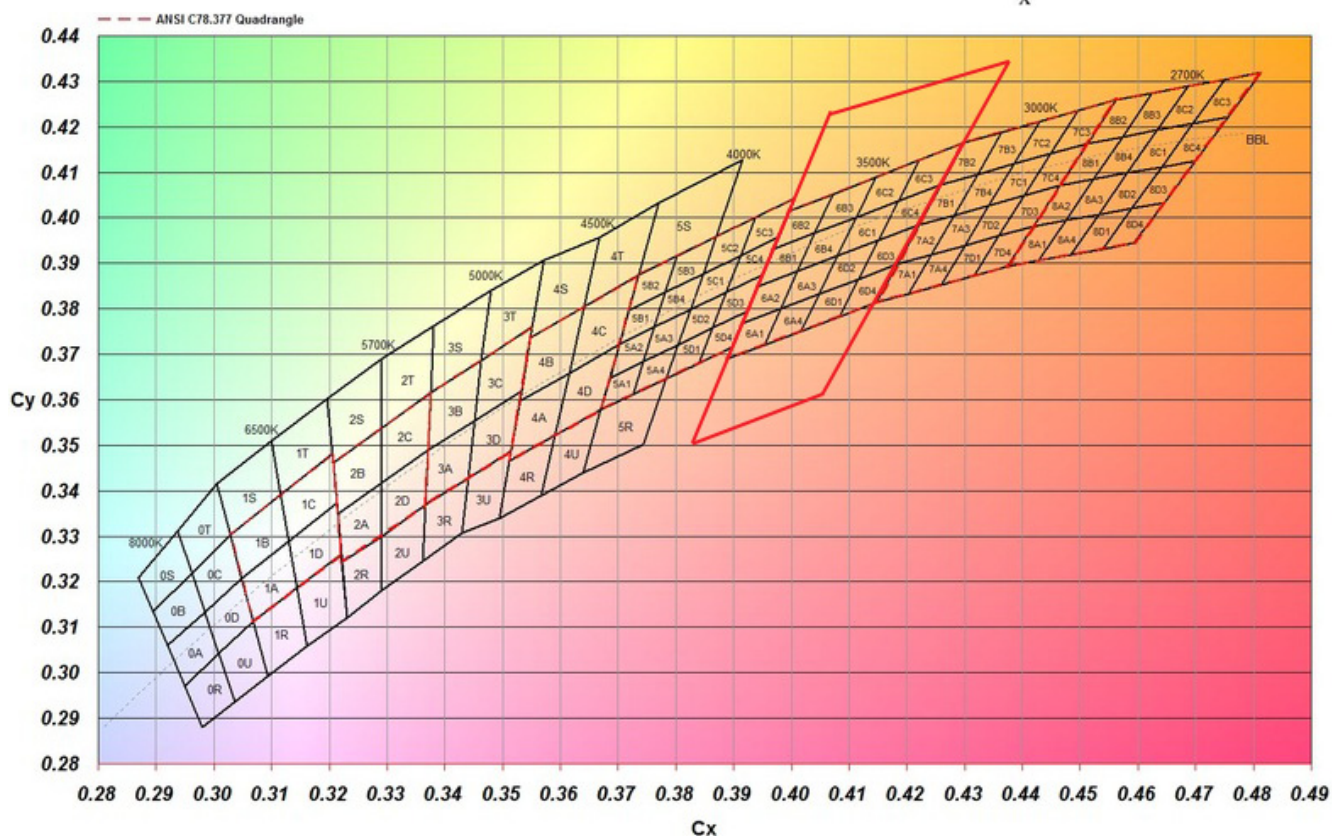
COLOUR TEMPERATURE CHECKLIST

- ☒ LED's that are as close to the Black Body Locus as possible will produce a more natural feel. Are the LED's centered to the BBL?
- ☒ Is the LED from a quality manufacturer who utilises 'sub' binning or other quality control measures?

BLACK BODY LOCUS (BBL)



ANSI WHITE



CHROMATICITY

Chromaticity needs to be considered when the LED colour is easily referenced. For instance, lighting a white surface, or placing an LED strip very close to a white wall.

The chromaticity of an LED product – that is, the degree of deviation of its colour point – can be defined in MacAdam ellipses in Standard Deviation of Colour Matching (SDCM) as per the CIE 1964 standard.

The MacAdam system originates from the United States and ranks colour consistency on a scale of 0 to 10. The image to the right shows what MacAdam ellipses look like at 3000K. The image below shows what value variation that equates to in terms of colour temperature and chromaticity co-ordinates.

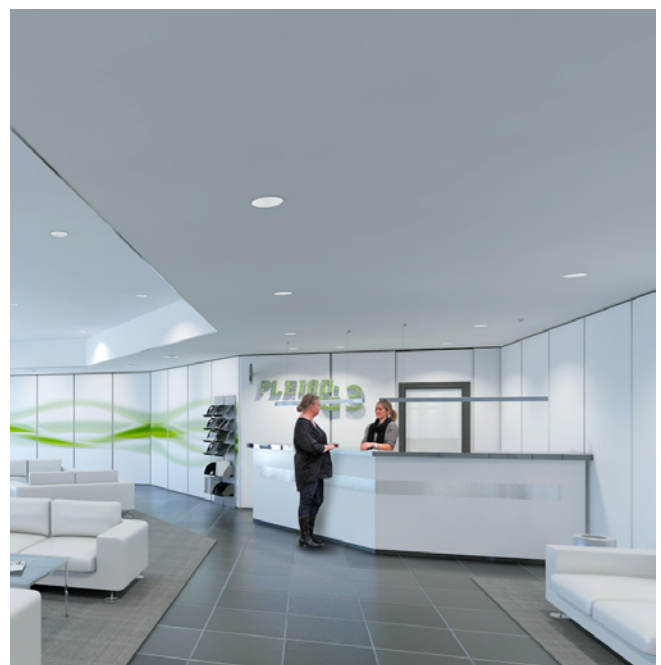
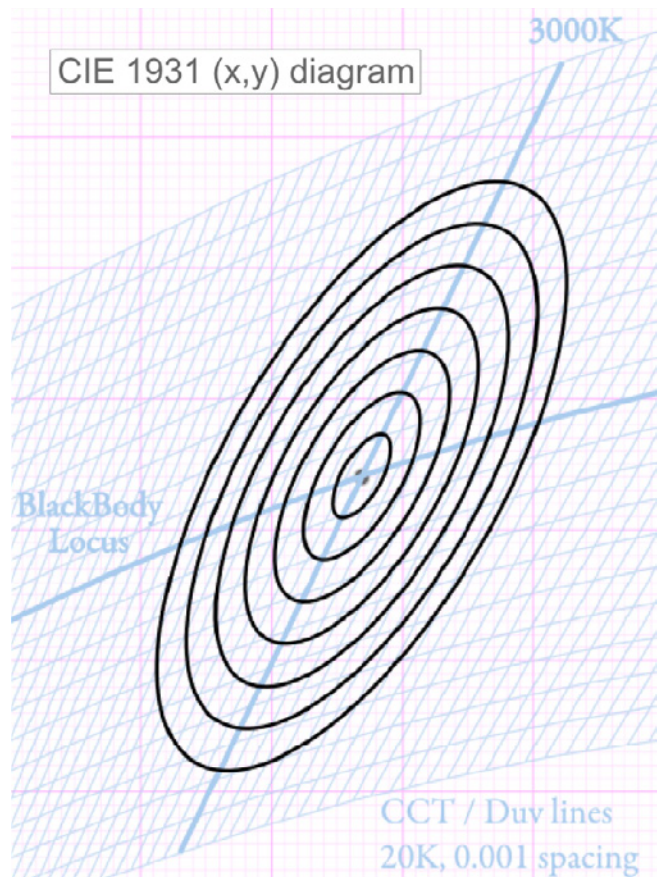
One other consideration is how the colour quality of a product changes throughout its lifespan. Most SDCM values are initial values and the quality of the LED plays a huge part in how much deviation will be experienced over the life of the LED.

CHROMATICITY CHECKLIST

- ☒ Will the LED be in a high reference area
i.e. along a white wall, gallery area where
consistency is imperative?
1-2 SDCM's
- ☒ Is this an area where reference is possible,
but not critical i.e. Most indoor environments.
3- 5 SDCM's
- ☒ Will the area offer very low chance of reference?
i.e. Outdoor environments, brick walls.
5- 7 SDCM's

CCT RANGE		
SDCM	3000K	ΔUV
1x	$\pm 30K$	± 0.0007
2x	$\pm 60K$	± 0.0010
4x	$\pm 100K$	± 0.0020
7-8x (1)	$\pm 175K$	0.0060

(1) Ansi-Nema C78.37377-2008



LED LIFETIME

An LED luminaire can have a very long life span – assuming that it is well-designed and has high-quality components. An LED very rarely breaks although, as with any electronic products, there is a normal failure rate. Rather than breaking, an LED generates reduced light flow over time. Life expectancy is normally defined as the point in time when the lumen output from the LED goes down to 70% of the initial value. 70%, or 30% depreciation, is the normal point where the human eye will start to notice a difference in the lighting levels.

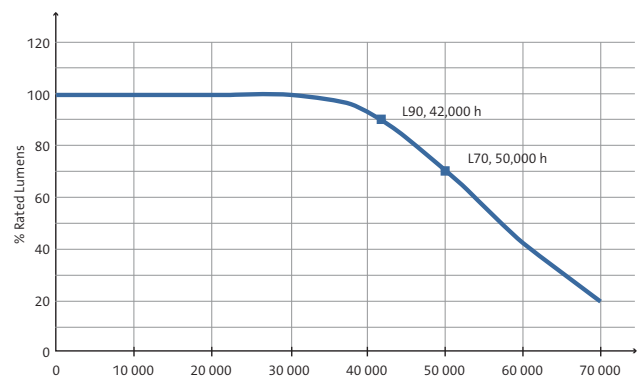
The life span is expressed as L70, followed by the number of hours, i.e. L70 32,000 h. The expected life span is affected by several factors including the choice of LED (manufacturer and type), how hard the chosen LED is run and the luminaire's ability to manage the thermal properties of the LED.

It is important to note that at the point in time when an LED luminaire does reach its rated life the LED will not stop working; it will just continue to depreciate in output. For this reason, maintenance and re-lamping periods should be carefully considered and stated. In some instances, it may make sense to quote a shorter maintenance period. For instance, retail fit-outs often get upgraded every 5 to 8 years. We can choose to run the LED harder to obtain more light output or efficiency, resulting in a shorter lifetime. This will enable us to choose a different lumen depreciation figure, meaning we use less luminaires to achieve our desired lighting levels.

To give an example, if we design with 50,000 hours in mind with the LED in the diagram, we must apply a 0.7 lamp lumen maintenance factor to our design – L70 50,000h. However, if we decided we only required 42,000 hours for our particular project we could use a 0.9 LLMF and state our design as L90 42,000h. This method can only be employed where the luminaire manufacturer's life time data is available, and is tested to LM-79 standards.

Whatever the stated life and maintenance, we must remember the LED is only one part of the equation. LED drivers and other electronics parts are still commonly rated to only 50,000 hours at 10% failures. In many cases this will primarily drive the ultimate life of the LED luminaire.

LUMEN MAINTENANCE



LED LIFETIME CHECKLIST

- ☒ Is the lifetime data from the luminaire itself, not just the LED?
- ☒ Does the Lamp Lumen Maintenance Factor being employed in the design correspond to the quoted life of the LED luminaire?
- ☒ Are adequate maintenance documents in place to ensure the LEDs are replaced at the end of life (when the lumens fall below what the project requires)?



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