

PHILIPS

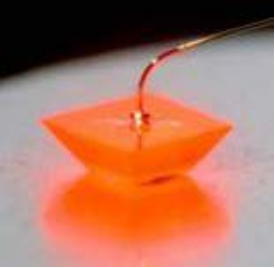

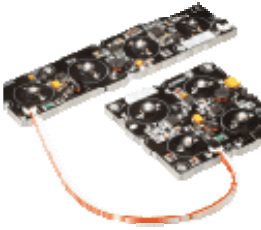


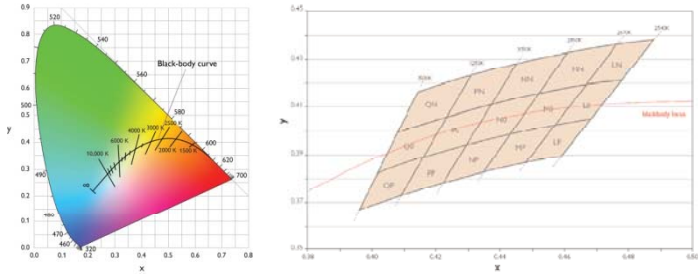
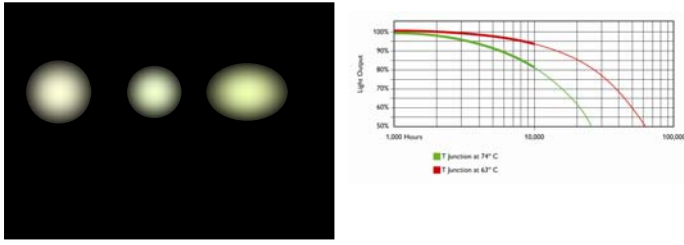
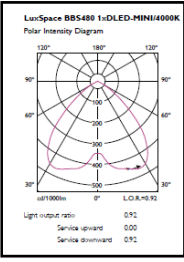
sense **and** simplicity

LED Lighting Standards *An Attempt*



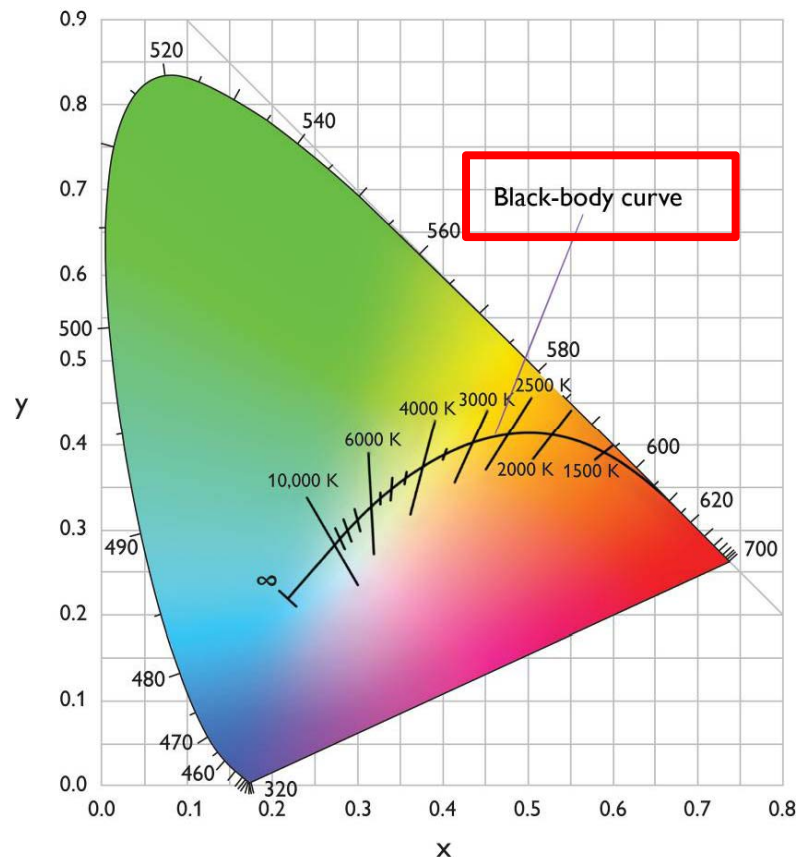
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Definitions of LED Levels

Level 0	Level 1	Level 2	Level 3	Level 4
				
LED Chip	LED	LED on PCB	LED Module	Luminaire
 <p data-bbox="149 1219 835 1273">Color Temperature & Binning</p>		 <p data-bbox="995 1219 1472 1338">Color Shift & Lumen Maintenance</p>		 <p data-bbox="1646 1219 1927 1273">Photometry</p>

Color and Color temperature for White Light

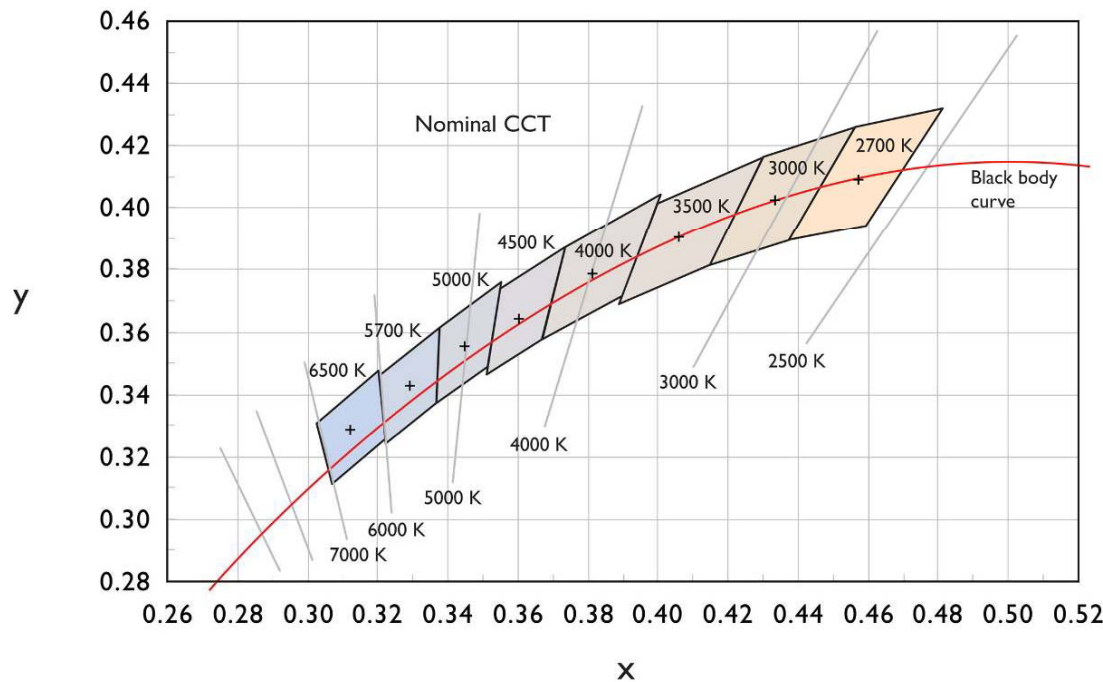
Correlated Color Temperature (CCT) describes white light



- CCT describes whether the light appears
 - warm (amber or reddish)
 - neutral or
 - cool (bluish)
- CCT is based on a reference (black body) source
 - As the black body gets hotter, it turns red, orange, yellow, white, and finally blue
- White LED Classification
 - Warm white = 2700K – 3500K
 - Neutral white = 3500K – 4500K
 - Cool white = 4500K+
- Cool White LEDs are more efficient than Warm white

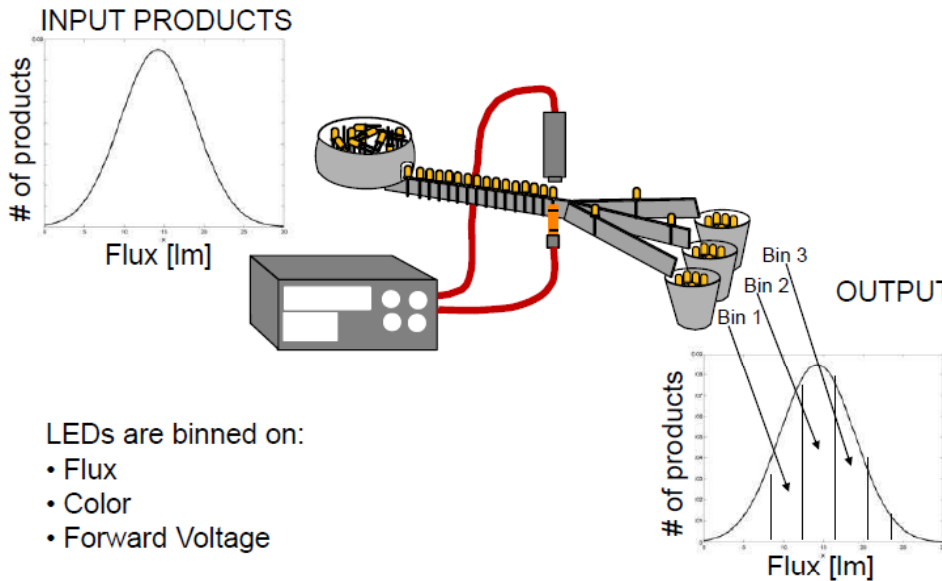
ANSI C78.337A CCT Standard

- ANSI standards have been established with regard to the allowed variation within which a white light source can claim to have certain CCT



ANSI C78.377A CCT Standard	
Nominal CCT	CCT Range (K)
2700 K	2725 ± 145
3000 K	3045 ± 175
3500 K	3465 ± 245
4000 K	3985 ± 275
4500 K	4503 ± 243
5000 K	5028 ± 283
5700 K	5665 ± 355
6500 K	6530 ± 510

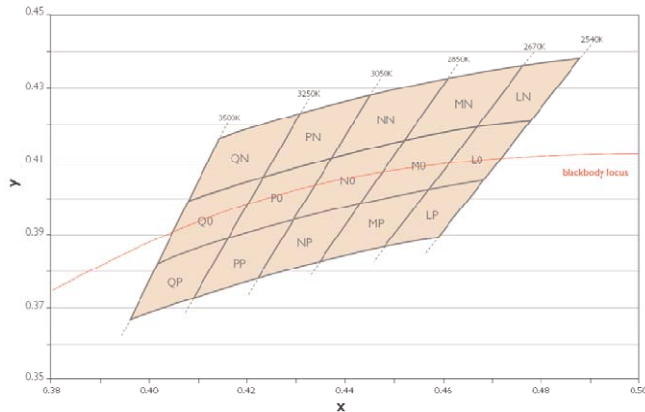
Binning



LEDs are binned on:

- Flux
- Color
- Forward Voltage

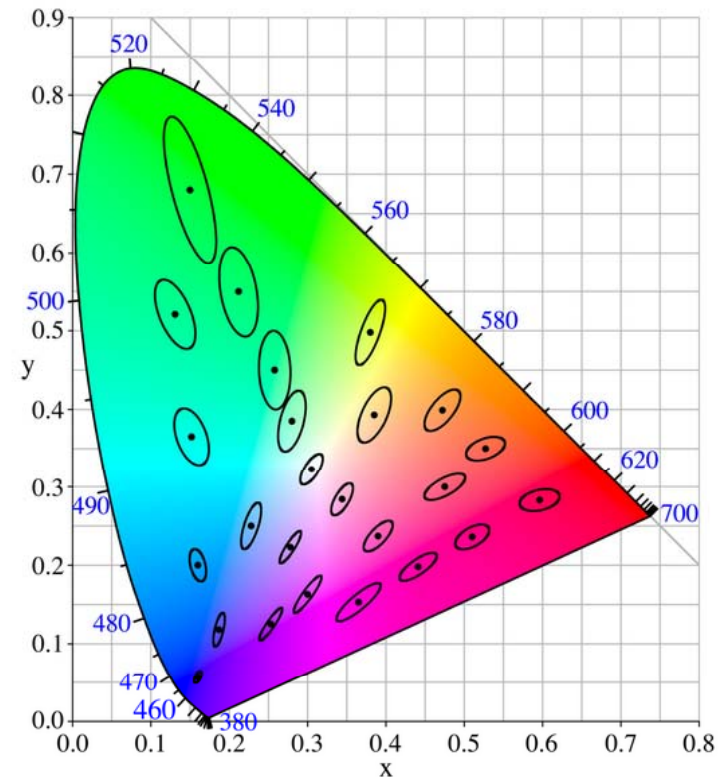
- LEDs are produced from a large semiconductor wafer
- All LEDs in a product batch are different
- Those with similar performance are grouped together by manufacturers into bins
- LED devices are typically binned separately by flux and color
- The tighter the bin, or the higher the flux, the higher the cost (can be a factor of 2X-3X)
- Each LED manufacturer has its own unique bin parameters



15 color bins for Warm White (Rebel)

MacAdam ellipses

- Threshold at which color difference becomes perceptible is defined by a **MacAdam ellipse**
- Scale of a macadam ellipse is determined by the **SDMC** (standard deviation of color matching)
 - 1 SDMC “step” is not visible
 - 2 to 4 is barely visible
 - 5 or more is readily noticeable
- The 8 CCTs as defined by ANSI have each with a color range defined by boxes surrounding 7-step MacAdam ellipses



MacAdam ellipses for one of MacAdam's test participants, plotted on the CIE 1931 xy chromaticity diagram. The ellipses are ten times their actual size, as depicted in MacAdam's paper.

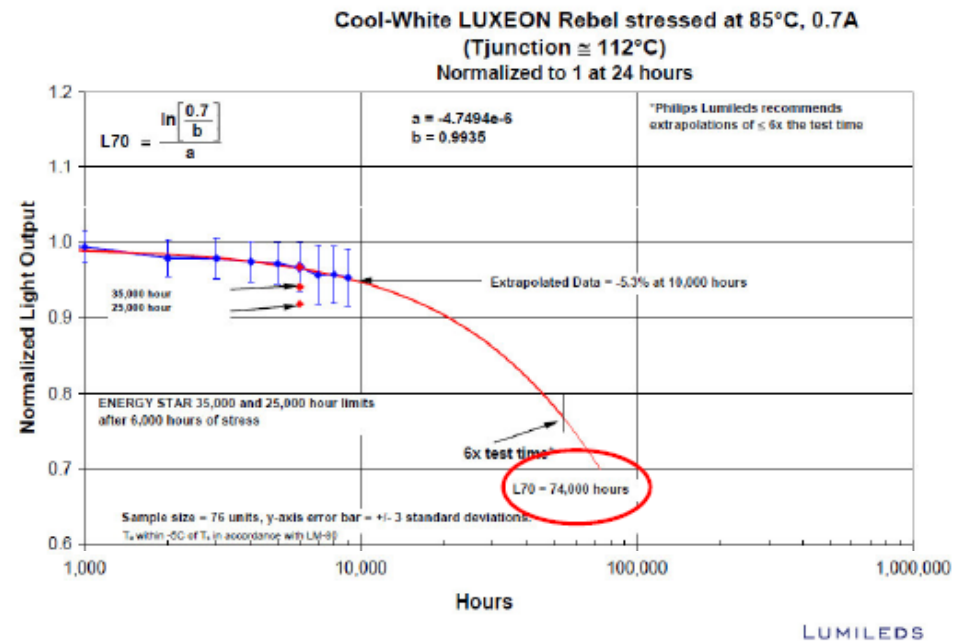
White Point Stability Standard

- LM80-08 Test Method
 - LEDs are tested at high ambient temperature (85°C) for 6000 hours and shift in CCT is recorded.
 - The drift has to be within 7 Macadam steps.
- LED sources can exhibit color shift over life which increases with higher junction temperatures



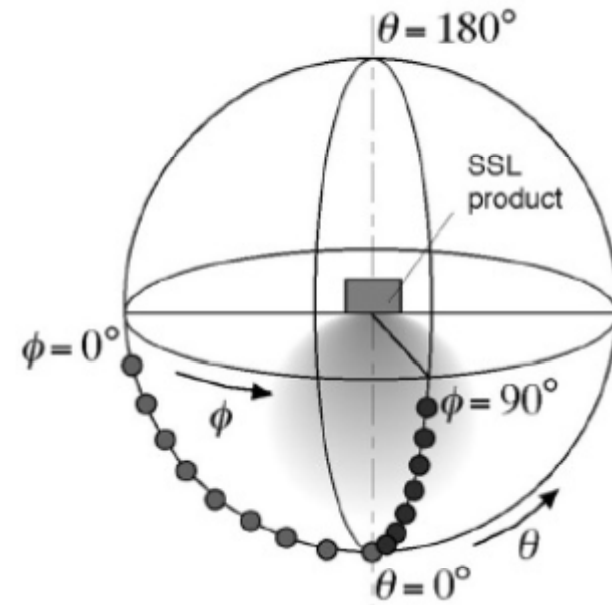
Lumen Maintenance

- LM80-08 Test Method
 - LEDs are tested at high ambient temperature (85°C) for 6000 hours and lumen output is recorded.
 - The graph is further extra polated upto 6x the test period and depreciation upto 70% from intial value is plotted.
 - This is termed as LifeSpan of the LED
- This is common platform for LED suppliers to show their reliability.



Photometry of LED Luminaire

- LM79-08 Test Method
 - Approved method describing procedures and precautions in performing reproducible measurement of LEDs
 - Total Flux (lm)
 - Electrical Power (W)
 - Efficacy (lm/W)
 - Chromacity



Color Rendering Index – CRI

only relevant for white light !



The 8 color samples used in the calculation of CRI

- CRI indicates the ability of a light source to reproduce the colors of various objects faithfully in reference to an ideal light source
 - “Ideal Light Source” = the sun or an incandescent lamp
 - 8 color samples at a minimum are included in the CRI metric
- CRI requirements differ by lighting application
 - CRI 90 – 100: Retail (merchandise, artwork) and work spaces (design) where faithful color rendering is critical
 - CRI 70 – 90: Most office, retail, school, educational, medical, and other work and residential spaces
 - CRI as low as 50: Industrial, security, and storage lighting where color fidelity is not important
- Increasing the CRI of a phosphor converted LED source reduces its efficiency

Other Standards

- IEC62471 – Photo-biological safety of lamps
- UL1598 – Luminaire Rain Test
- IEC 61347-2-13 & IEC 61547 – Drivers
- IEC 60598 – Luminaire Standard
- ANSI C136.21 - Street Light Luminaire Vibration Specs

