LED Technology
Developments and Applications

CIBSE Conference
6th March 2012
Croke Park Conference Centre

Paddy Craven

Craven Lighting

LED

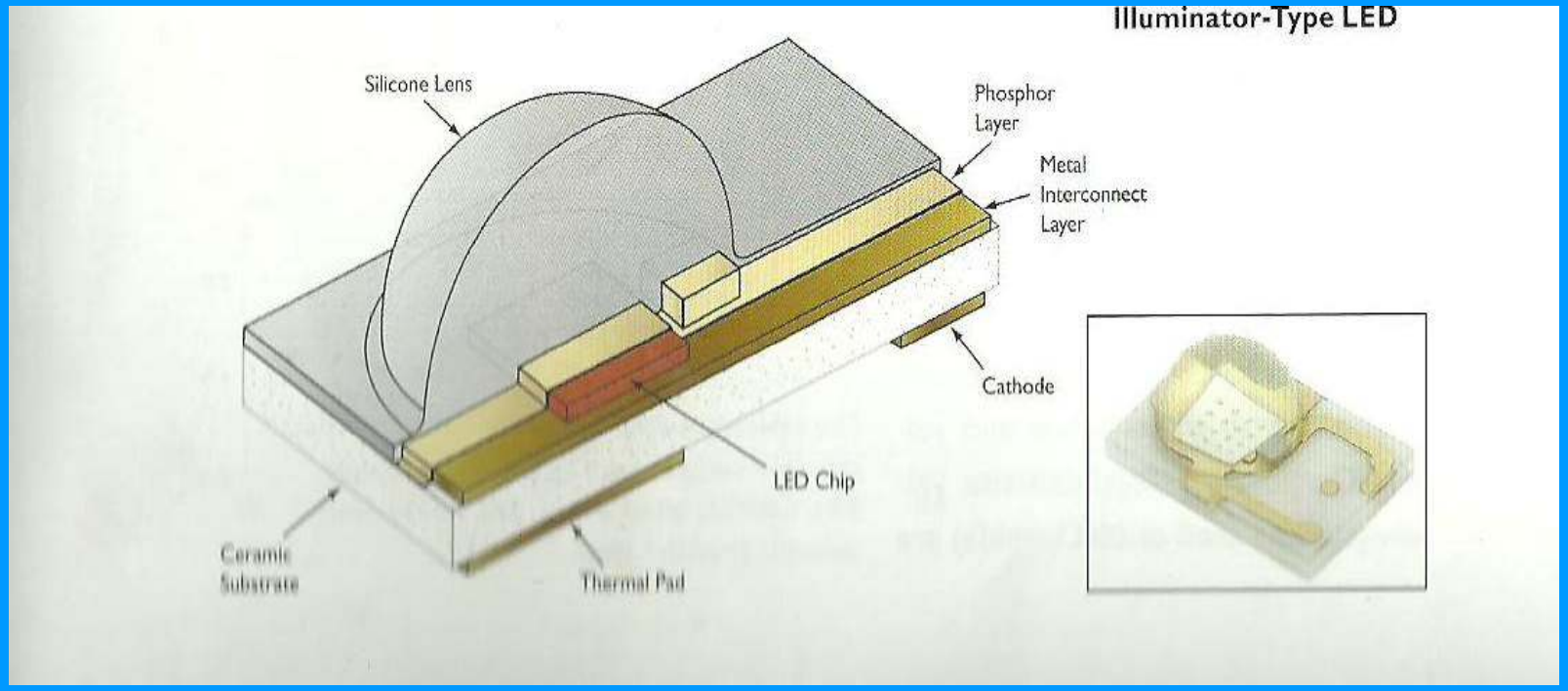
- History of LED
- Description of LED
- Materials
- Colour
- Binning
- CRI and CCT
- Efficacy and Efficiency
- Lumen Maintenance
- Luminaire Design
- Thermal Management
- Light output
- Applications
- London trials/Los Angeles/NewYork
- Future of LED

History of LED

•1960s	• First red LED developed at GE in 1962 • HP manufacture red indicator LEDs (.01 lumen) • First green and yellow LEDs
•1970s	• First blue LEDs in 1971 •1972 – 1 lumen red LEDs available • Applications in watches, calculators and exit signs
•1980s	• Advances in lumen output • First superbright red LEDs in 1984
•1990s	• 1993 High brightness blue LED at Nichia • 1995 High brightness green LED • 1996 First white LEDs •Ultrabright red and amber LEDs • Led replacing incandescent light in coloured sources •1998 RGB lighting applications
•2000s	• White light via RGB and via blue + phosphors • LEDs available in 1 to 100 lumens • 2003 acceptance in entertainment lighting • 2004 – viable for accent lighting • 2005 – 1000 lumen output via multichip packages • 2008 - viable for general illumination

Indicator and illuminator

Illuminator type LED



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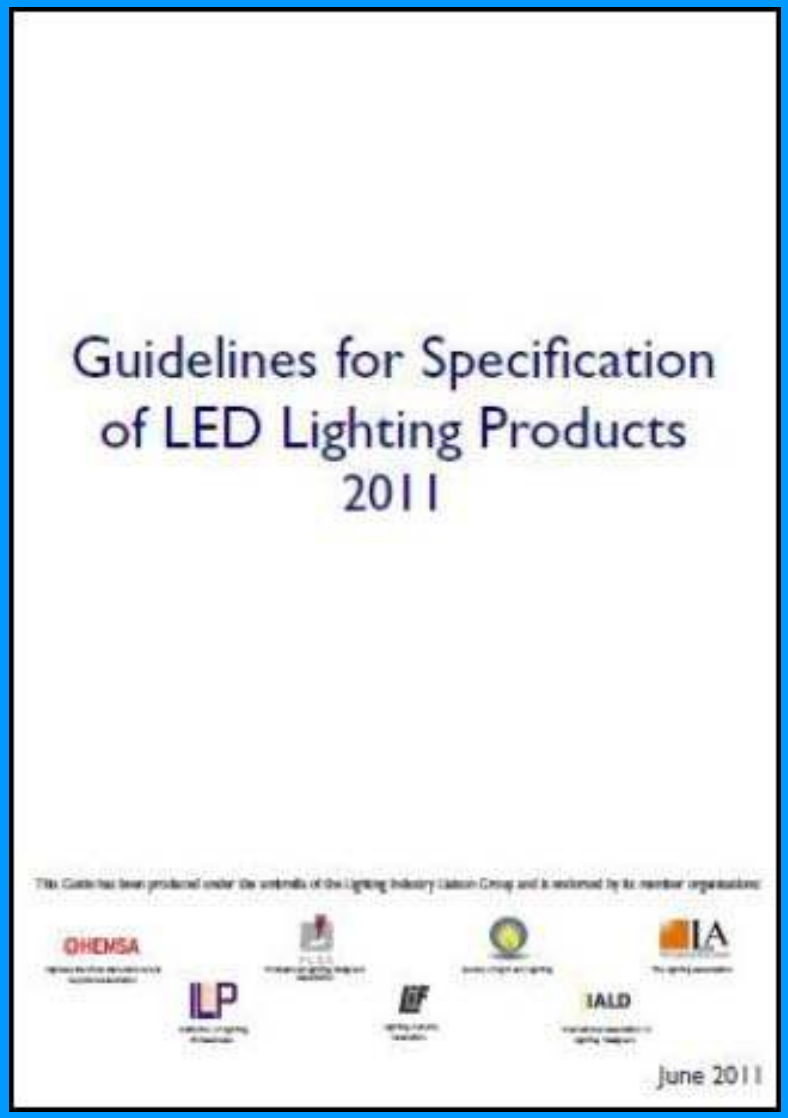

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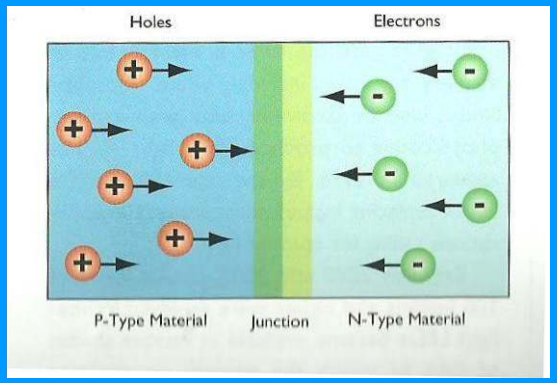
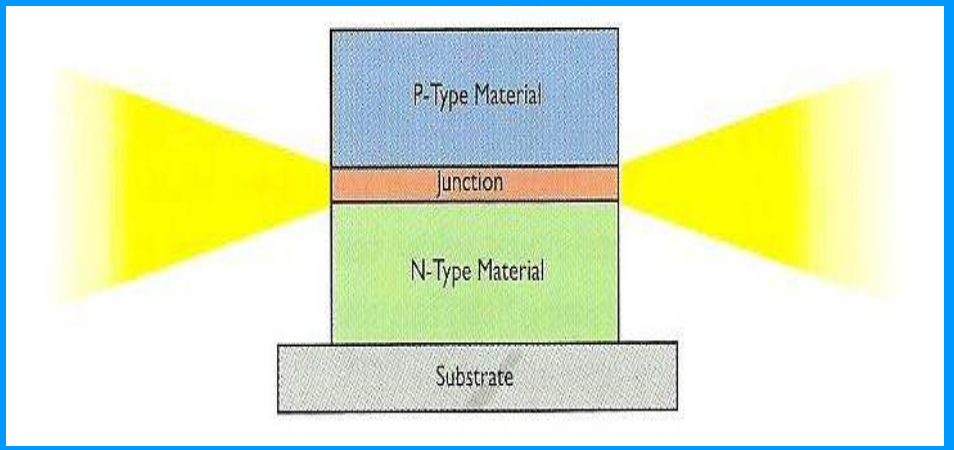
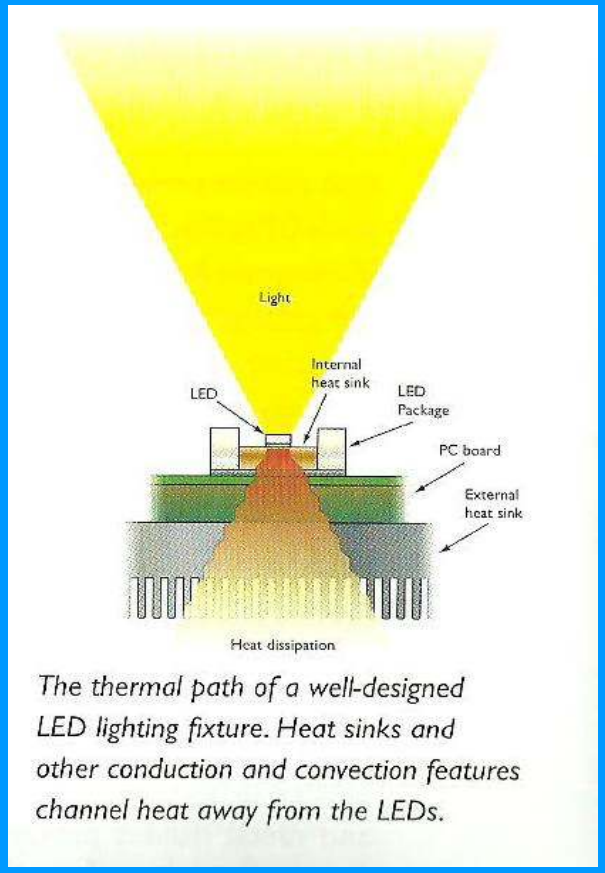
The Spire of Dublin - Lit by LED

LEDs - How they work





Junction Temperature

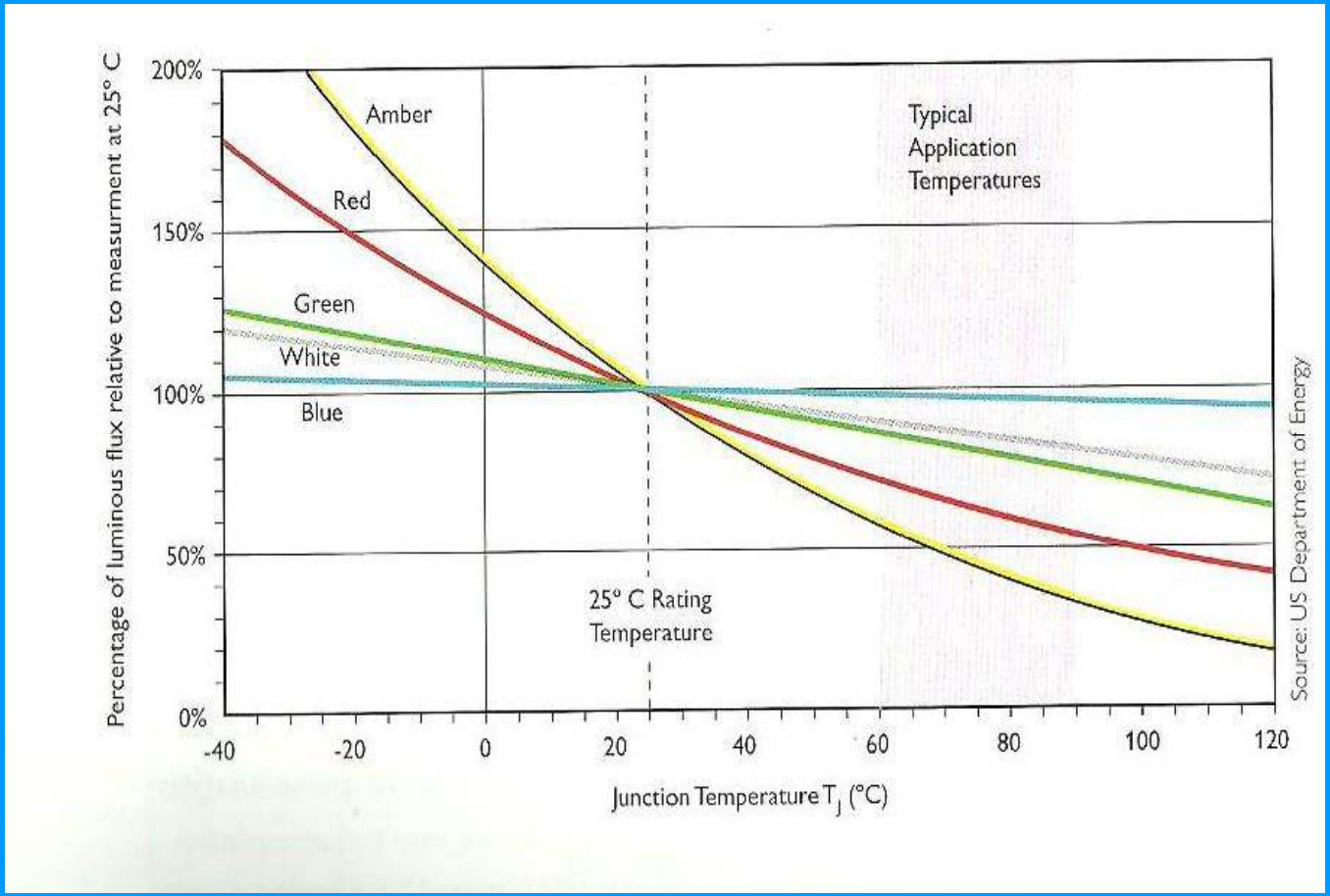


The thermal path of a well-designed LED lighting fixture. Heat sinks and other conduction and convection features channel heat away from the LEDs.

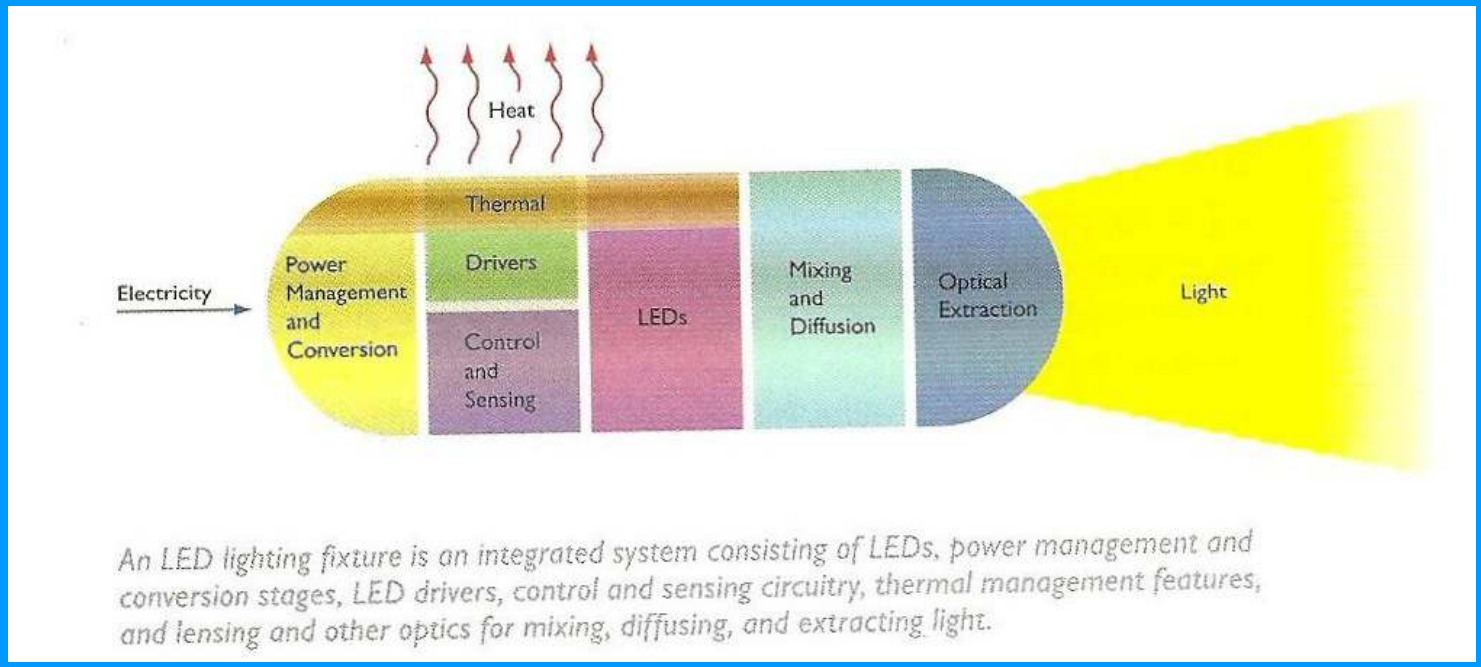
Junction Temperature

- Three Factors
- Drive current
- Thermal Path
- Ambient Temperature

Junction Temperature

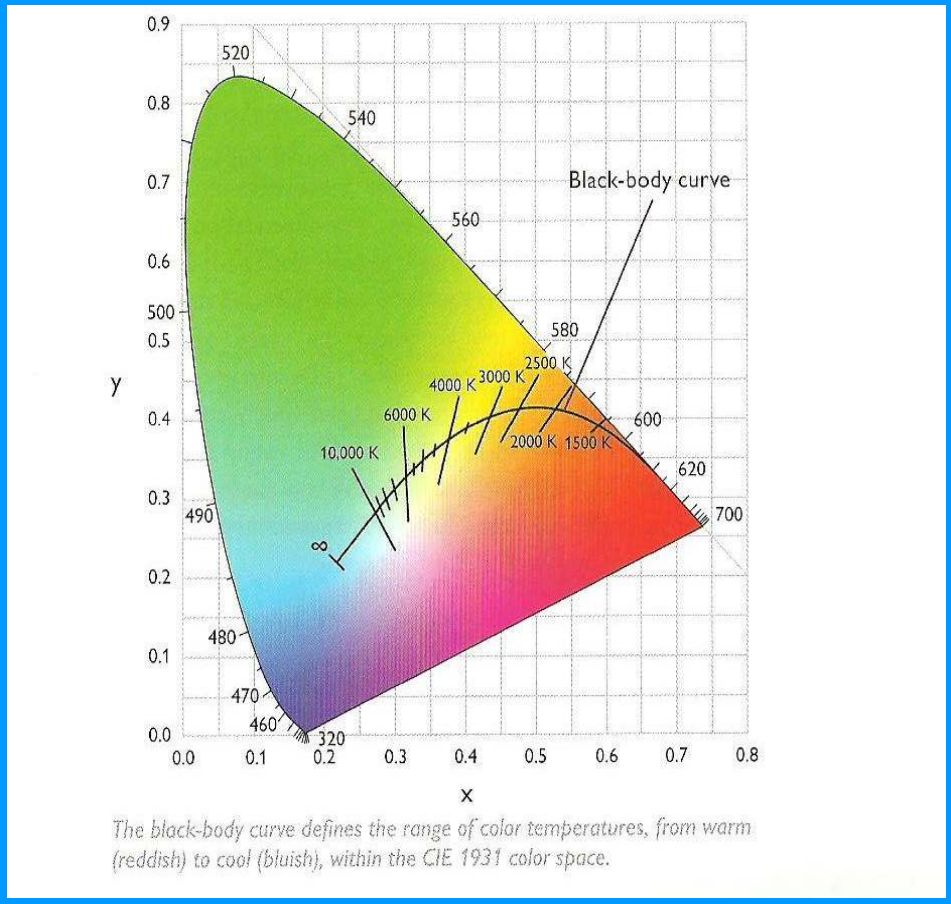


LED FIXTURE ANATOMY



An LED lighting fixture is an integrated system consisting of LEDs, power management and conversion stages, LED drivers, control and sensing circuitry, thermal management features, and lensing and other optics for mixing, diffusing, and extracting light.

CIE CHROMATICITY CHART



The black-body curve defines the range of color temperatures, from warm (reddish) to cool (bluish), within the CIE 1931 color space.

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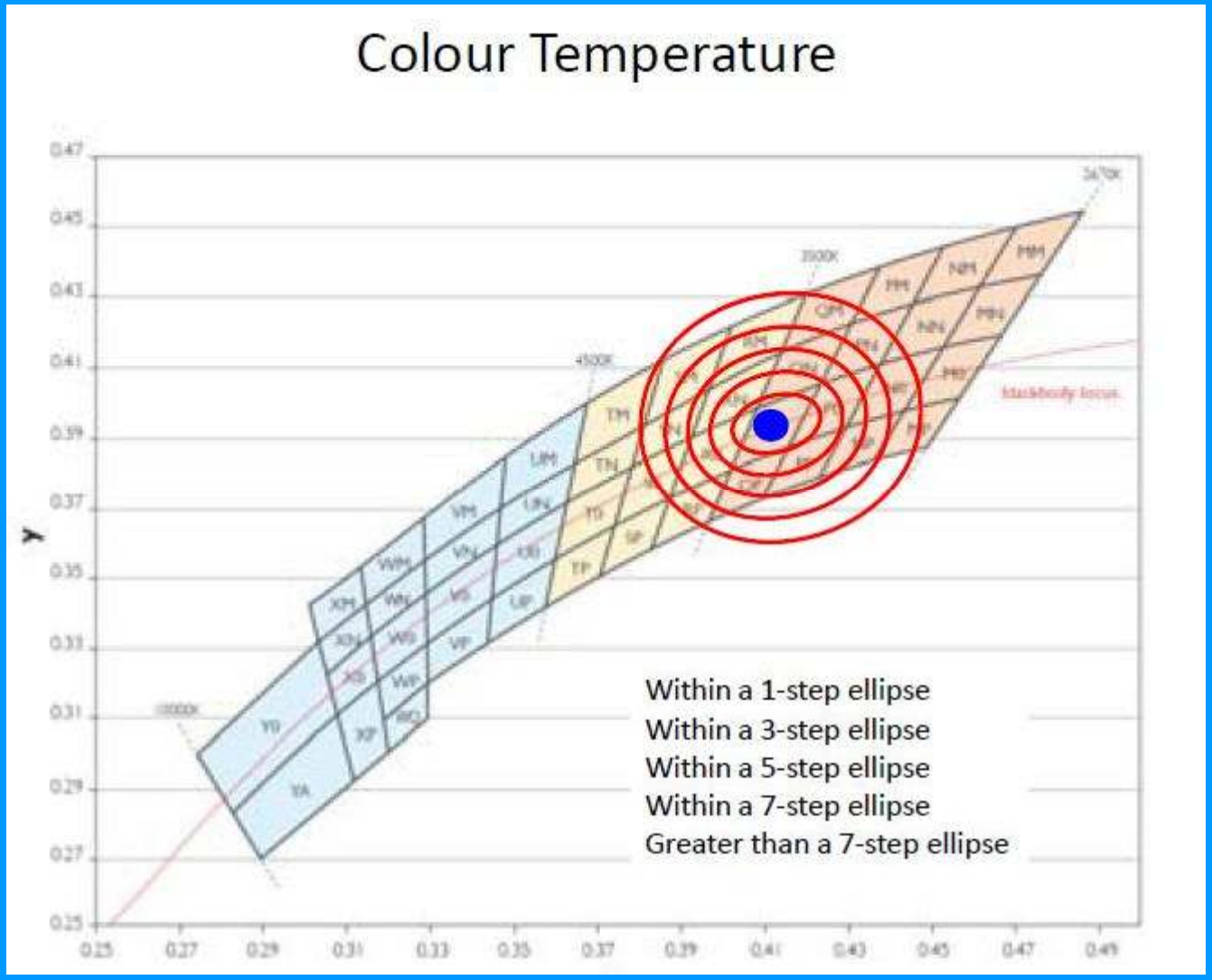
Colour Temperature



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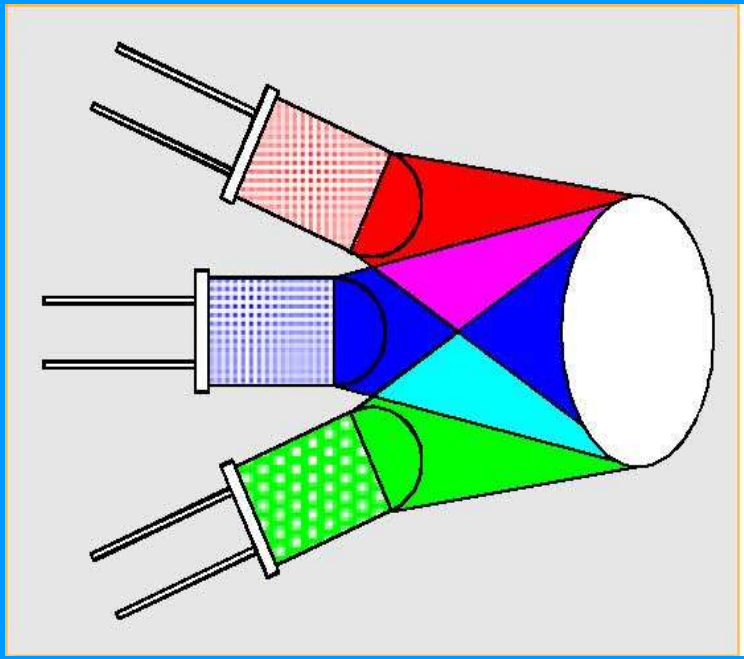
Effect of Colour Temperature

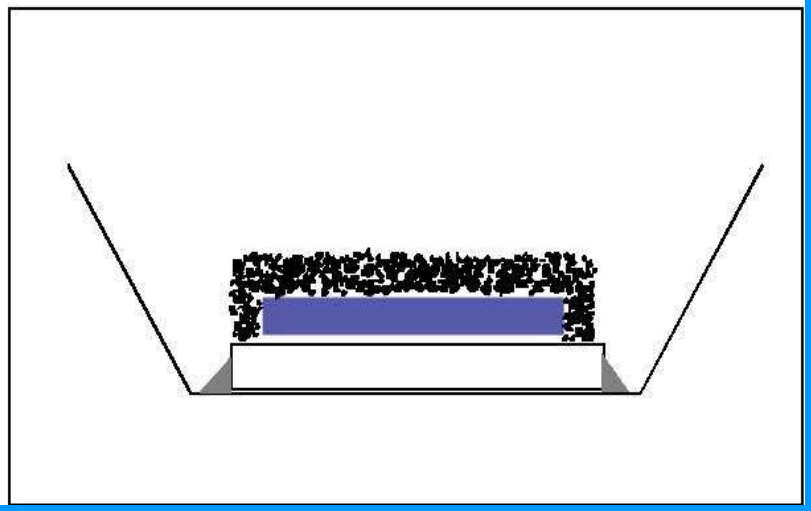
Effect, Mood, and Application by Color Temperature

Color Temperature	Warm 2700 K	White 3000 K	Neutral 3500 K	Cool 4100 K	Daylight 5000 K – 6500 K
Effects and Moods	Warm Cozy Open	Friendly Intimate Personal Exclusive	Friendly Inviting Non-threatening	Neat Clean Efficient	Bright Alert Exacting coloration
Applications	Restaurants Hotel lobbies Boutiques Homes	Libraries Office areas Retail stores	Showrooms Bookstores Office areas	Office areas Classrooms Mass merchandisers Hospitals	Galleries Museums Jewelry stores Medical exam areas

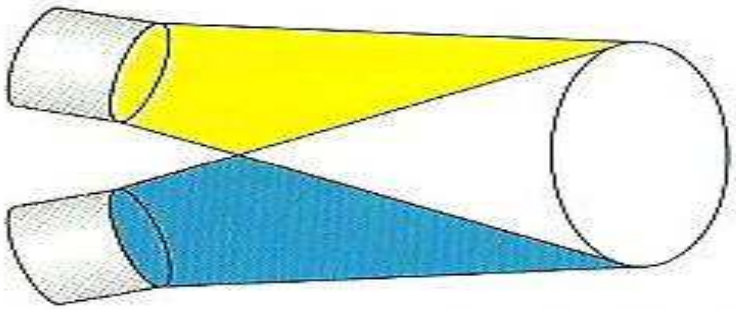
White Light

- RGB

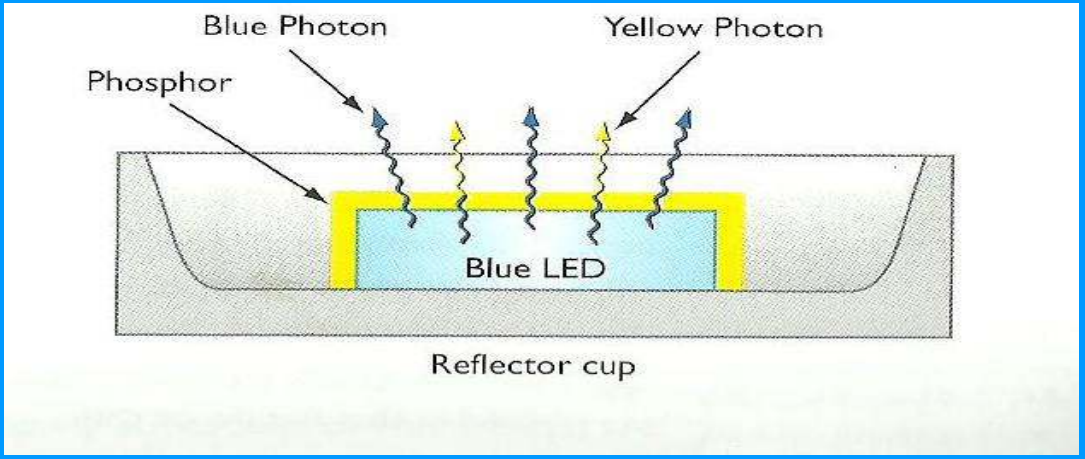




White Light - Blue/Yellow



White light can be produced by combining the wavelengths of yellow and blue light only. Sir Isaac Newton discovered this effect when performing color-matching experiments in the early 1700s.



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Materials Used

LEDs produce different colours by using *different material systems which produce photons of different wavelengths which appear as light of different colours*.

Oldest technologies used gallium phosphide (GaP), aluminium gallium arsenide (AlGaAs) and gallium arsenide phosphide (GaAsP) to produce wavelengths from red to yellowish green.

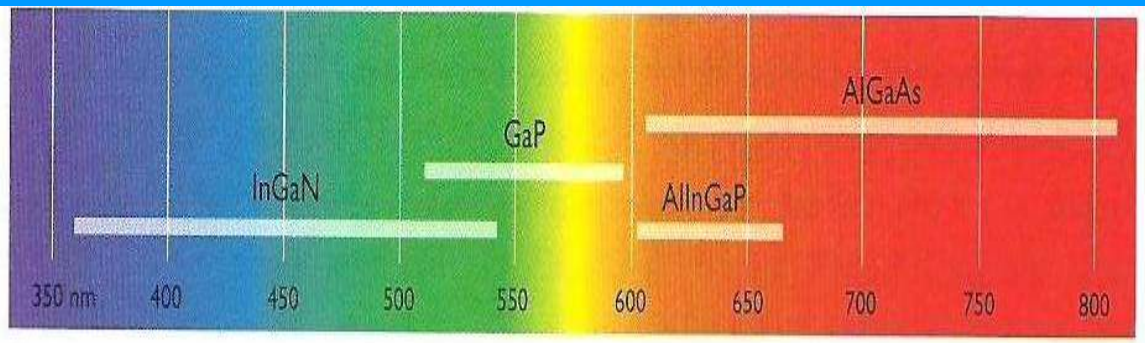
Nowadays GaP, AlGaAs and GaAsp used almost exclusively in indicator type LEDs.

Illuminator type LEDs typically use newer materials which can handle the current and temperature required.

HB red and amber use aluminium indium gallium phosphide (AlInGaP)

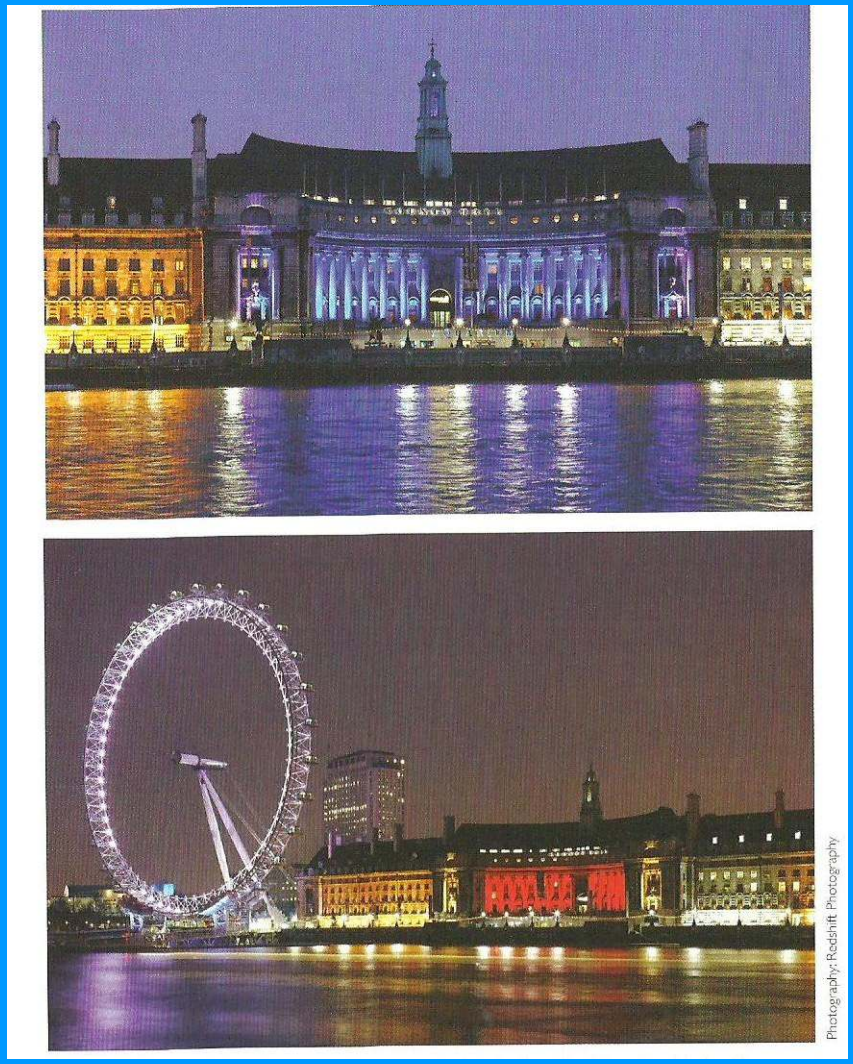
Blue,green and cyan use indium gallium nitride system (InGaN)

Different colours



The main material systems for producing monochrome LEDs. AlInGaP and InGaN cover almost the entire spectrum for high-intensity LEDs, except for green-yellow and yellow at wavelengths between 550 nanometers (nm) and 585 nm. Colors in this gap can be achieved by mixing green and red LEDs.

Colour change with LED



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Millions of colours

- No filters or gels required so reducing loss of light output by the ability of LEDs to natively produce millions of colours
- Now have a real energy efficient and versatile alternative to conventional sources for effect lighting on large structures

Royal Military Academy

- Note that some blue and red filters can block more than 96% of the output from a conventional light source

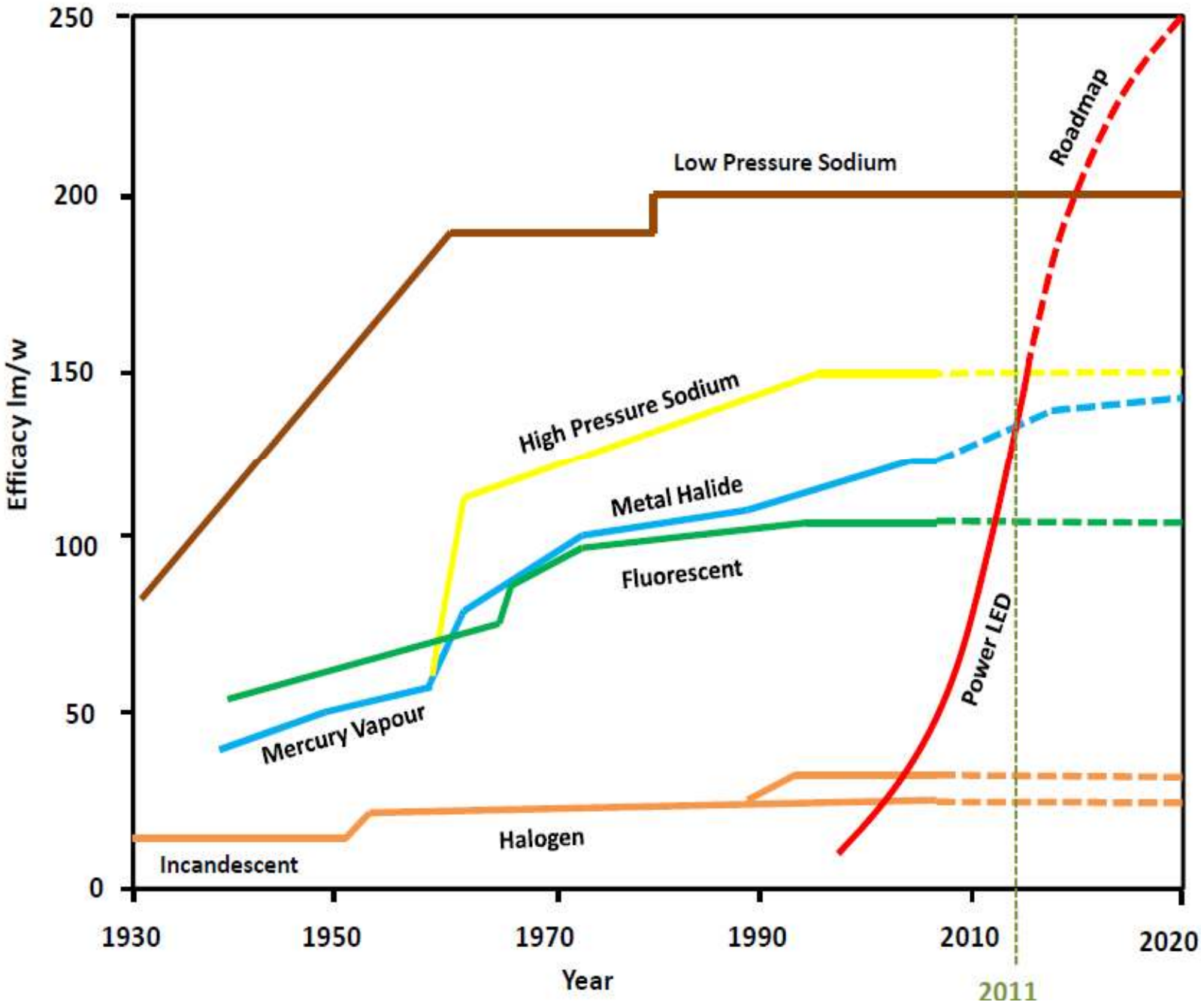
EFFICACY and EFFICIENCY

Not to be confused

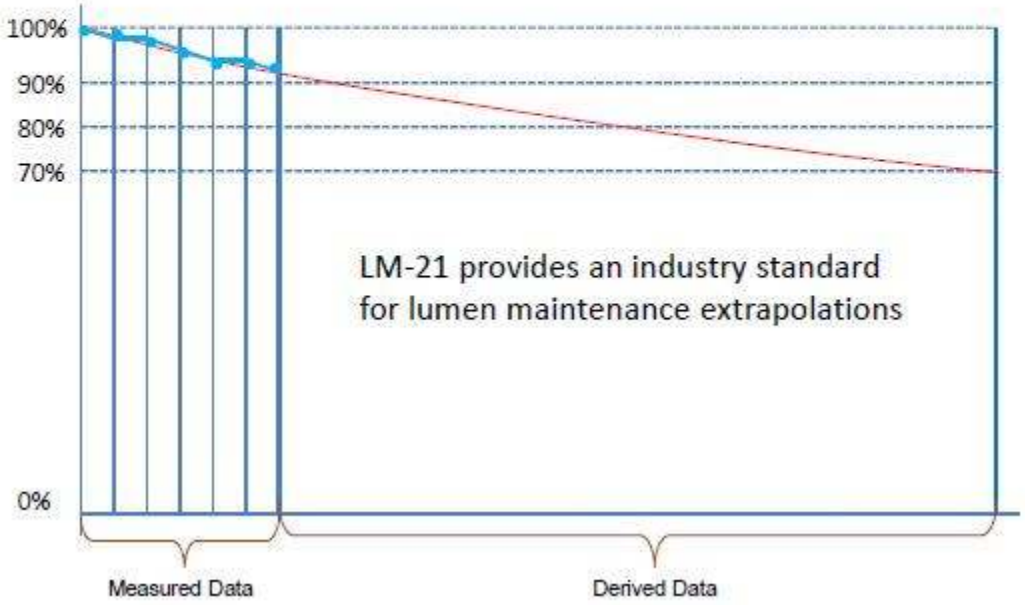
Efficiency is the ratio of lamp lumens to fixture lumens for a given light fixture

Efficacy is light output in lumens per unit of input energy in watts (lm/W)

LAMP EFFICACY



Lumen Maintenance L_x of LED



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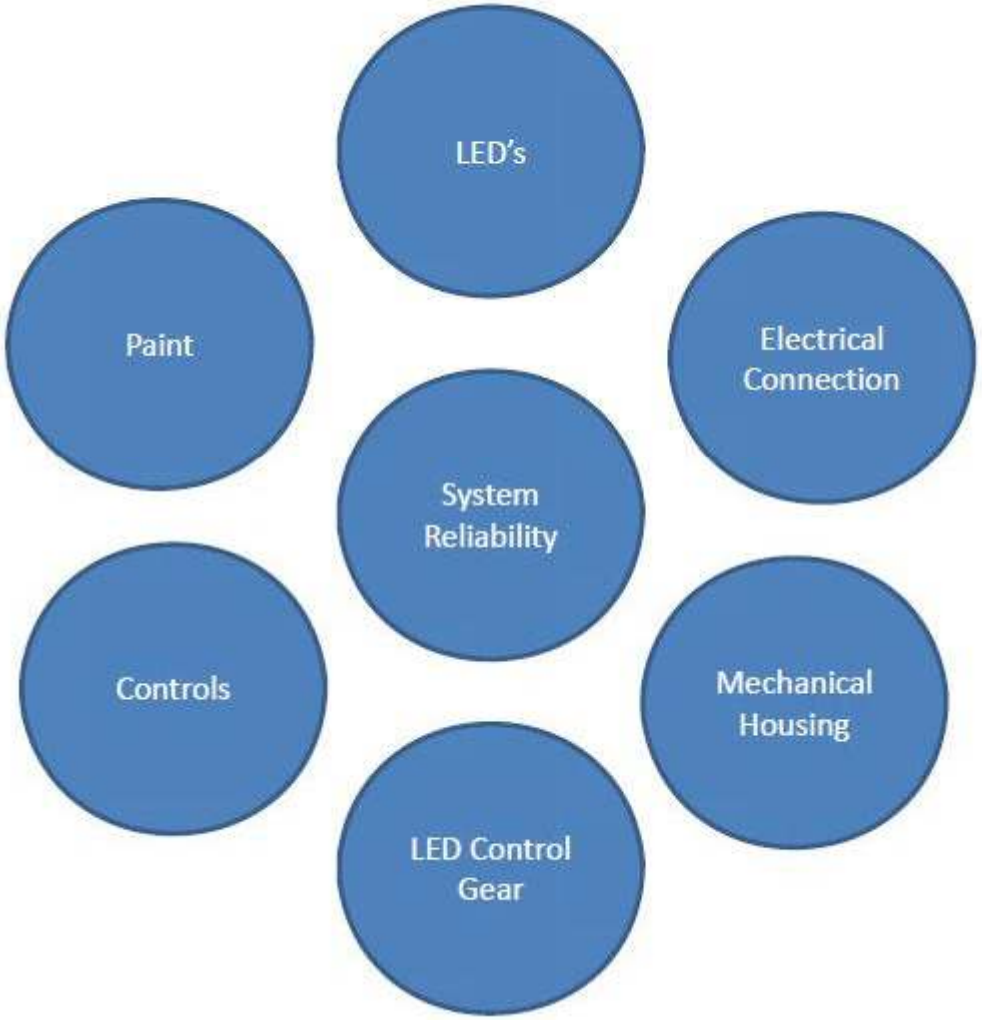
Lumen Maintenance L_x of Luminaire



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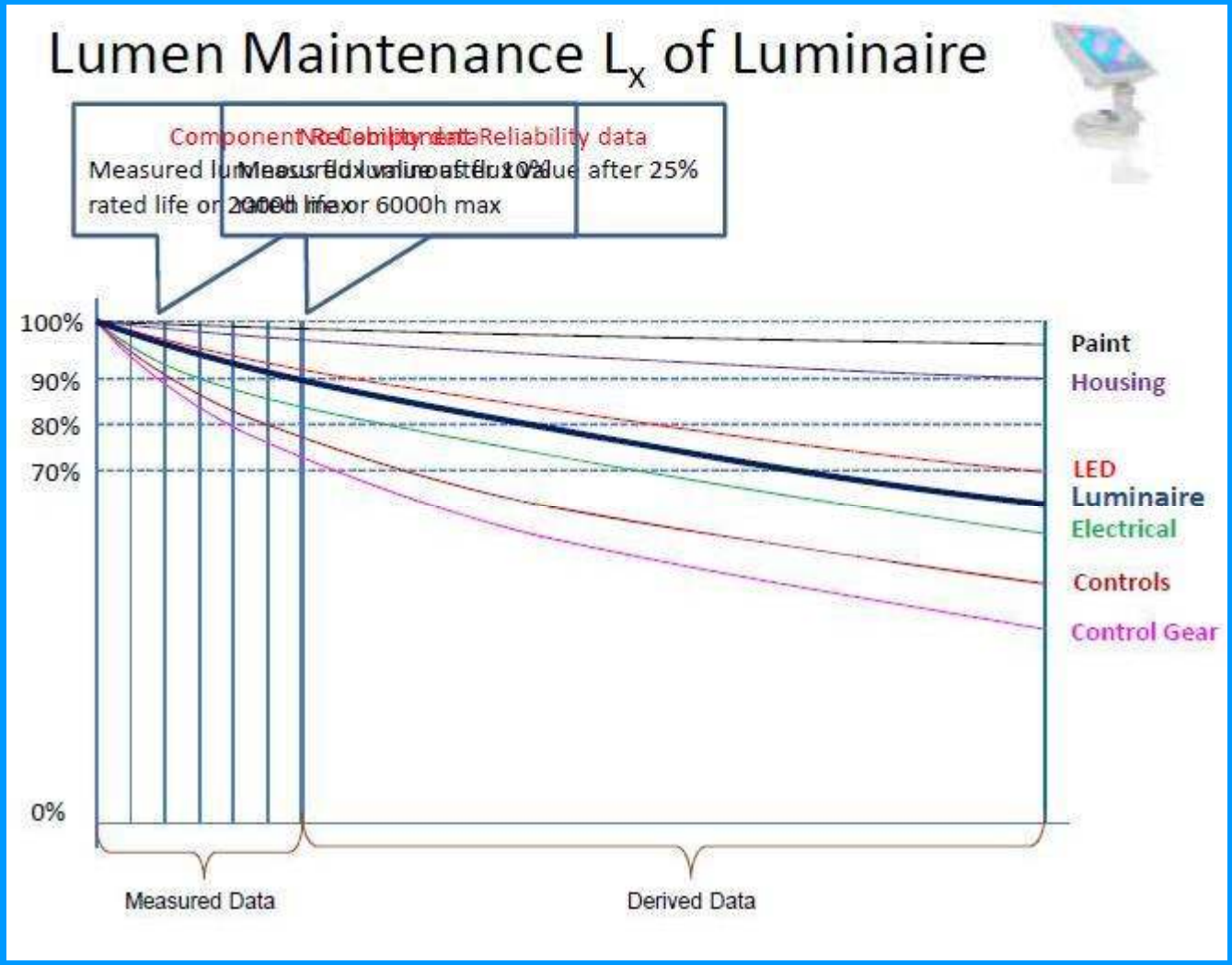

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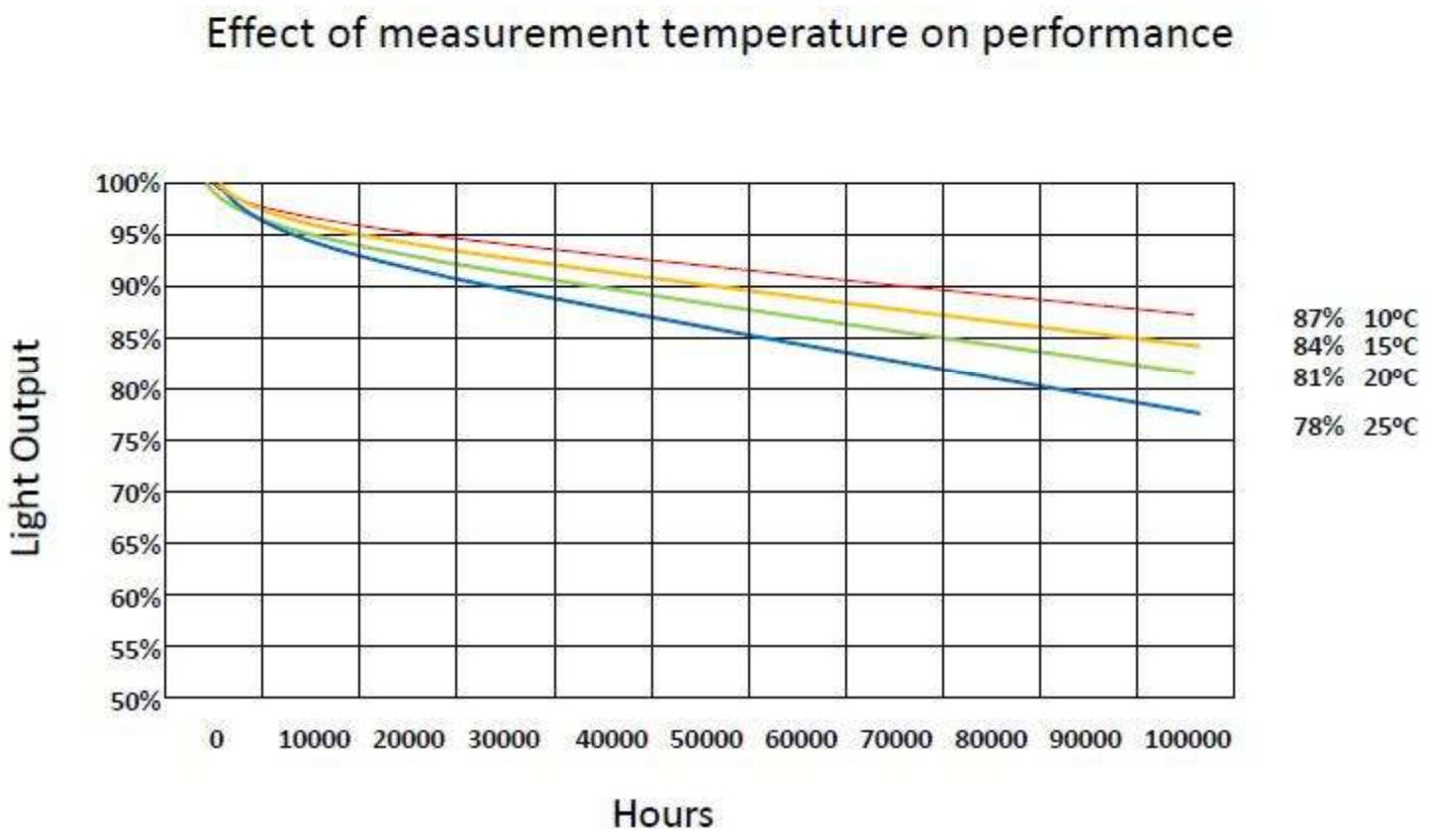
Lumen Maintenance L_x

Lumen maintenance	Code
>= 90	9
>=80	8
>= 70	7

Ambient temperature



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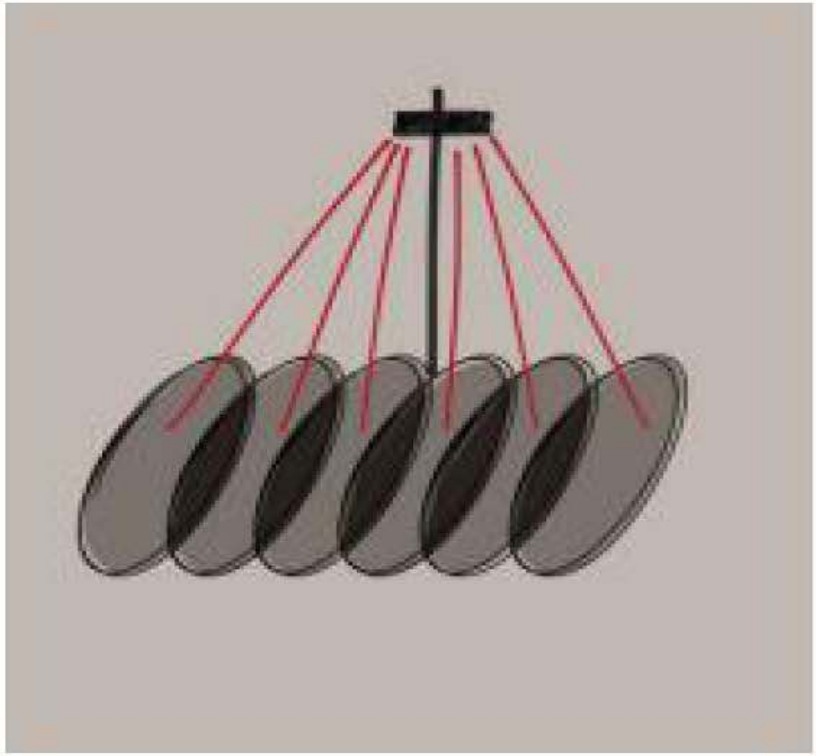

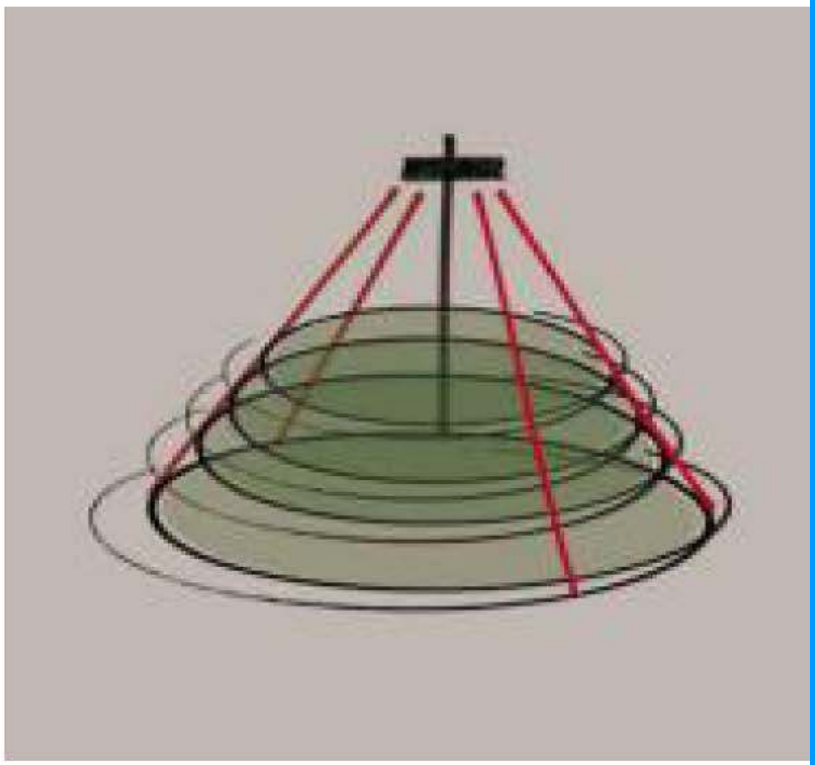

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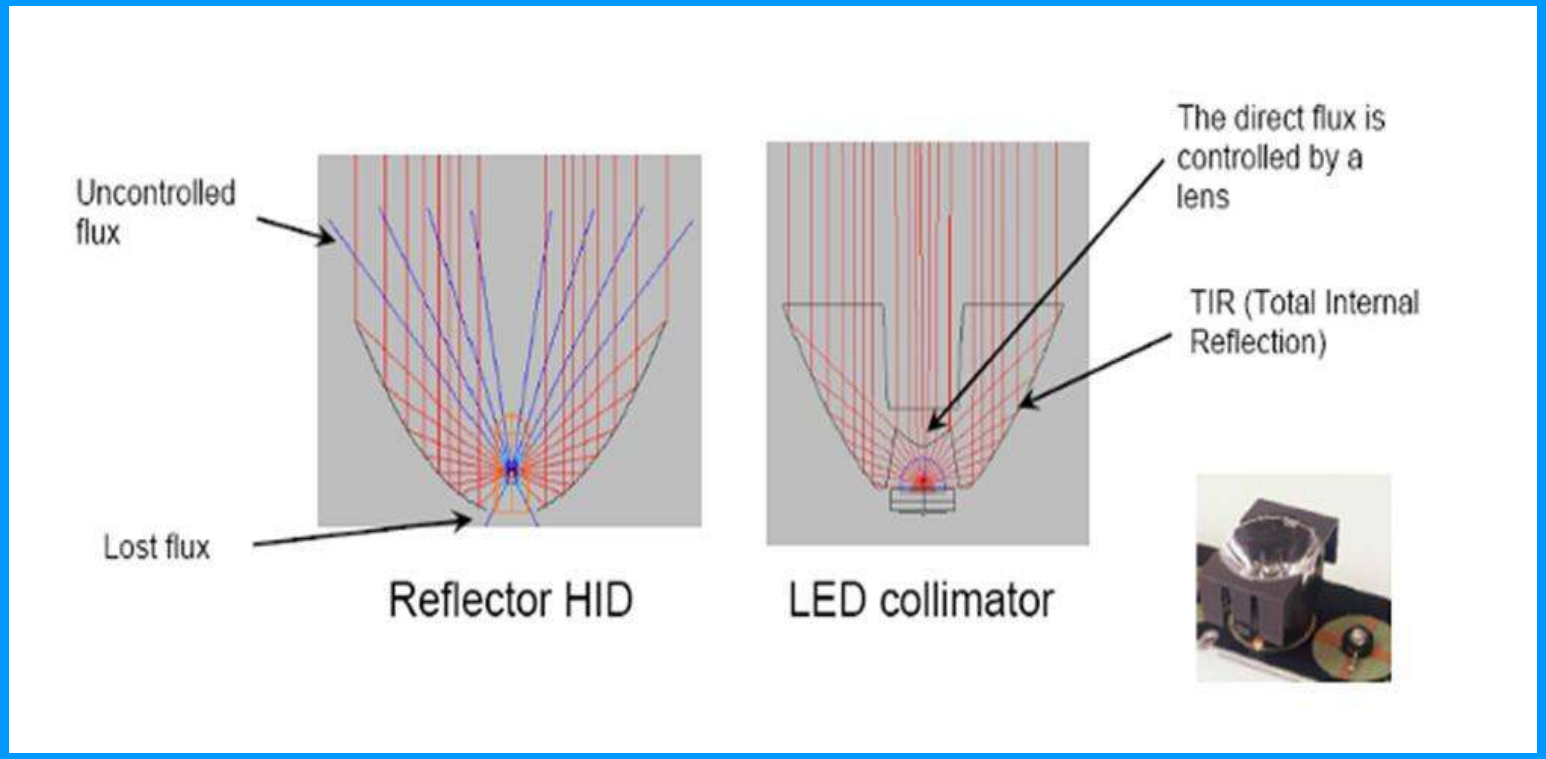

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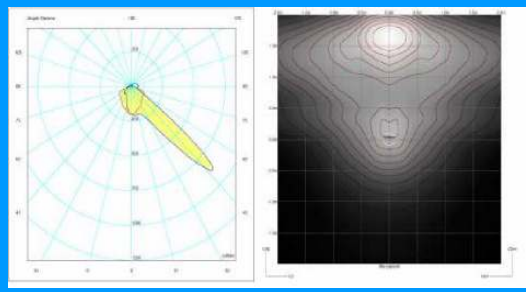
Optical Studies

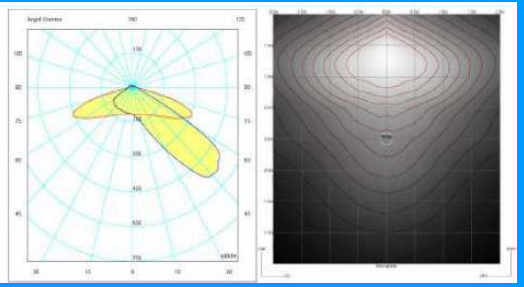
NLG-11

Streets – Classes ME

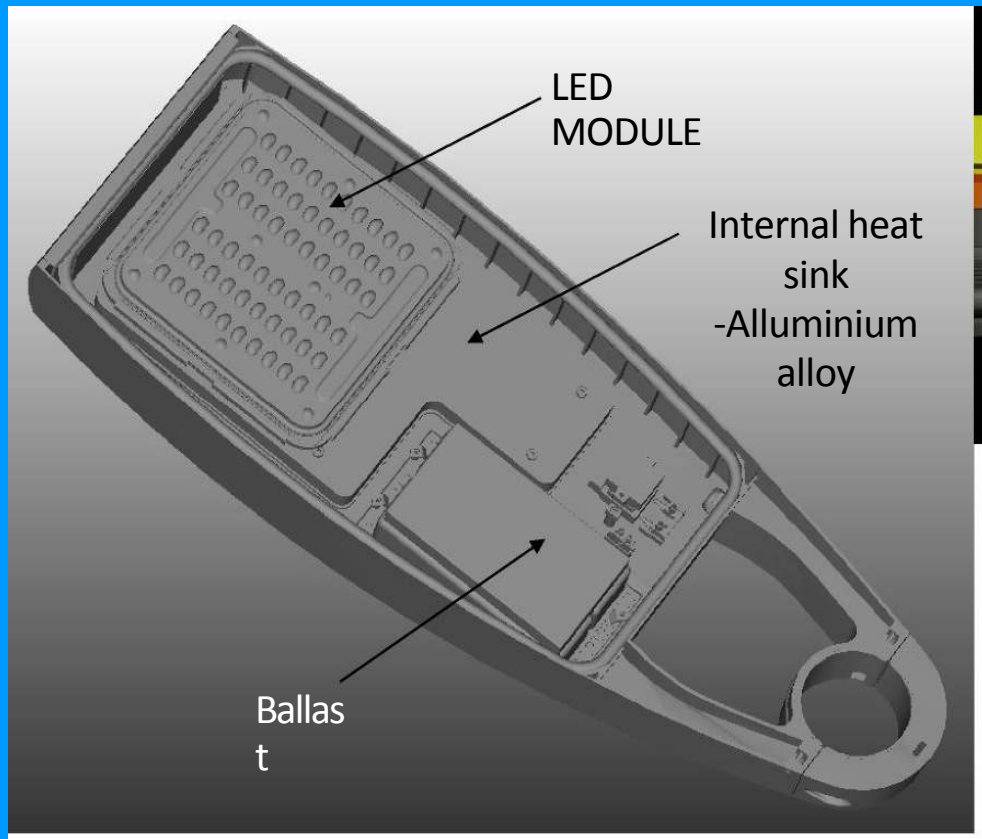


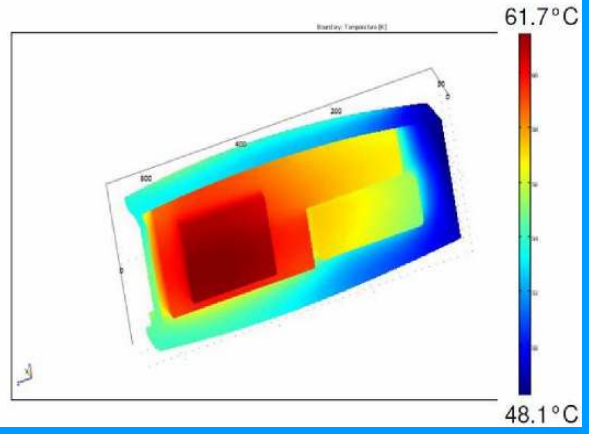
NLG-12

Streets –Rounabouts – Parking Areas – Classes CE



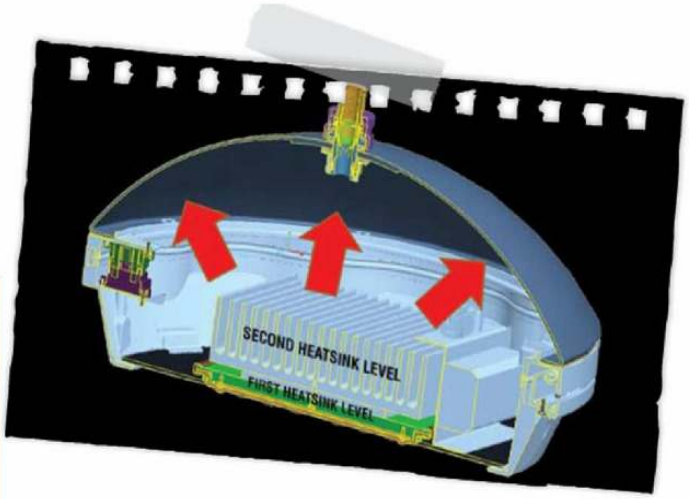
Thermal Studies

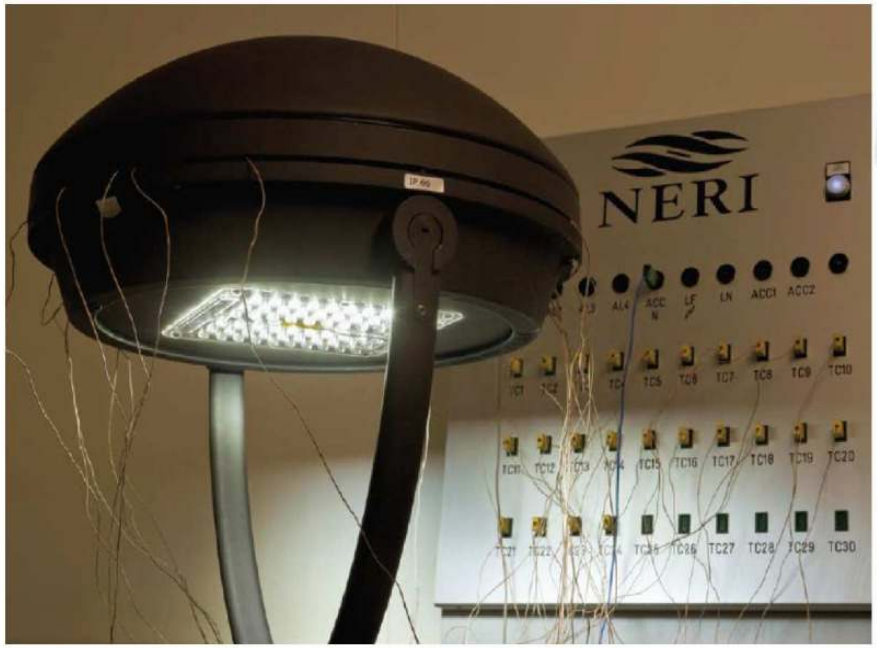




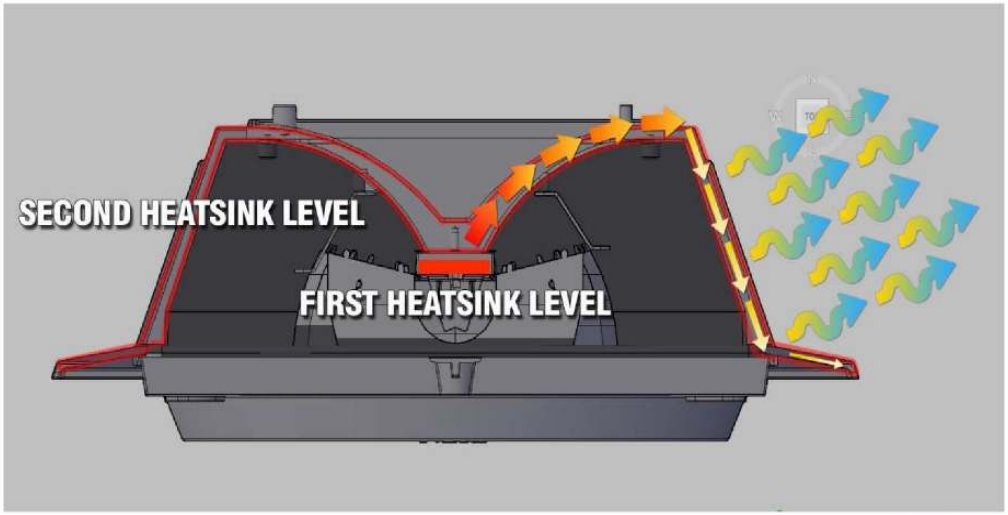
Thermal Studies

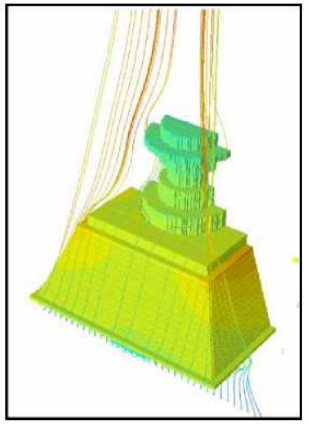
2 LEVEL SYSTEM





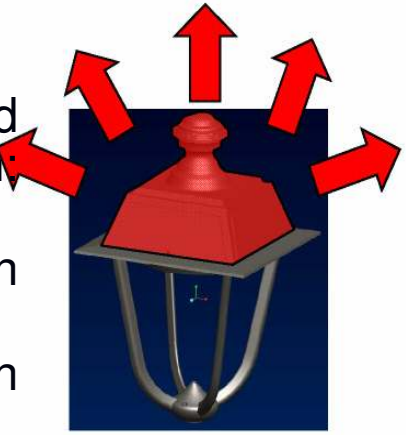
Thermal Studies

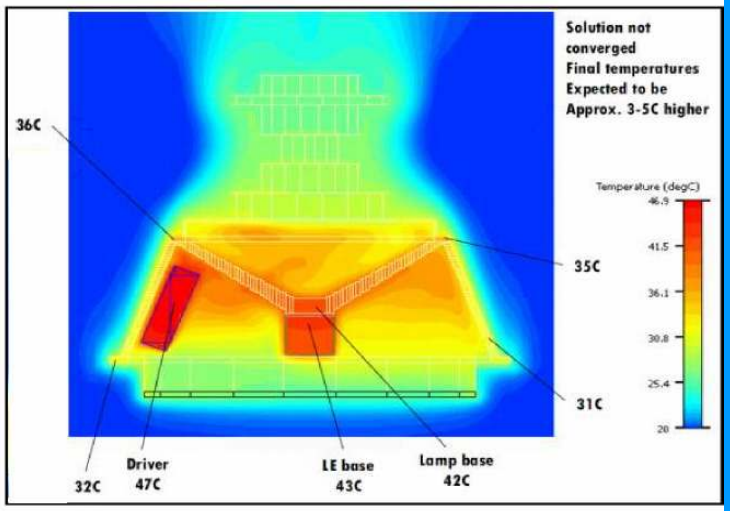




Heat Sink based on:

- Conduction
- Radiation





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Transport for London

TfL are currently undertaking some controlled trials on London's strategic road network. Investigating opportunities to reduce their carbon footprint.

A40 Western Avenue SON

A40 Western Avenue LED

"Initial impressions are of excellent light Control, uniformity and colour rendering

Trial measurements show generally compliance with BS 5489 and BS EN 13201 ..."

Case Study
Start01

Installation of 9 light Fixtures inaugurated on the 13th May 2011

Sansepolcro (AR)
Italy
P.zza della Repubblica

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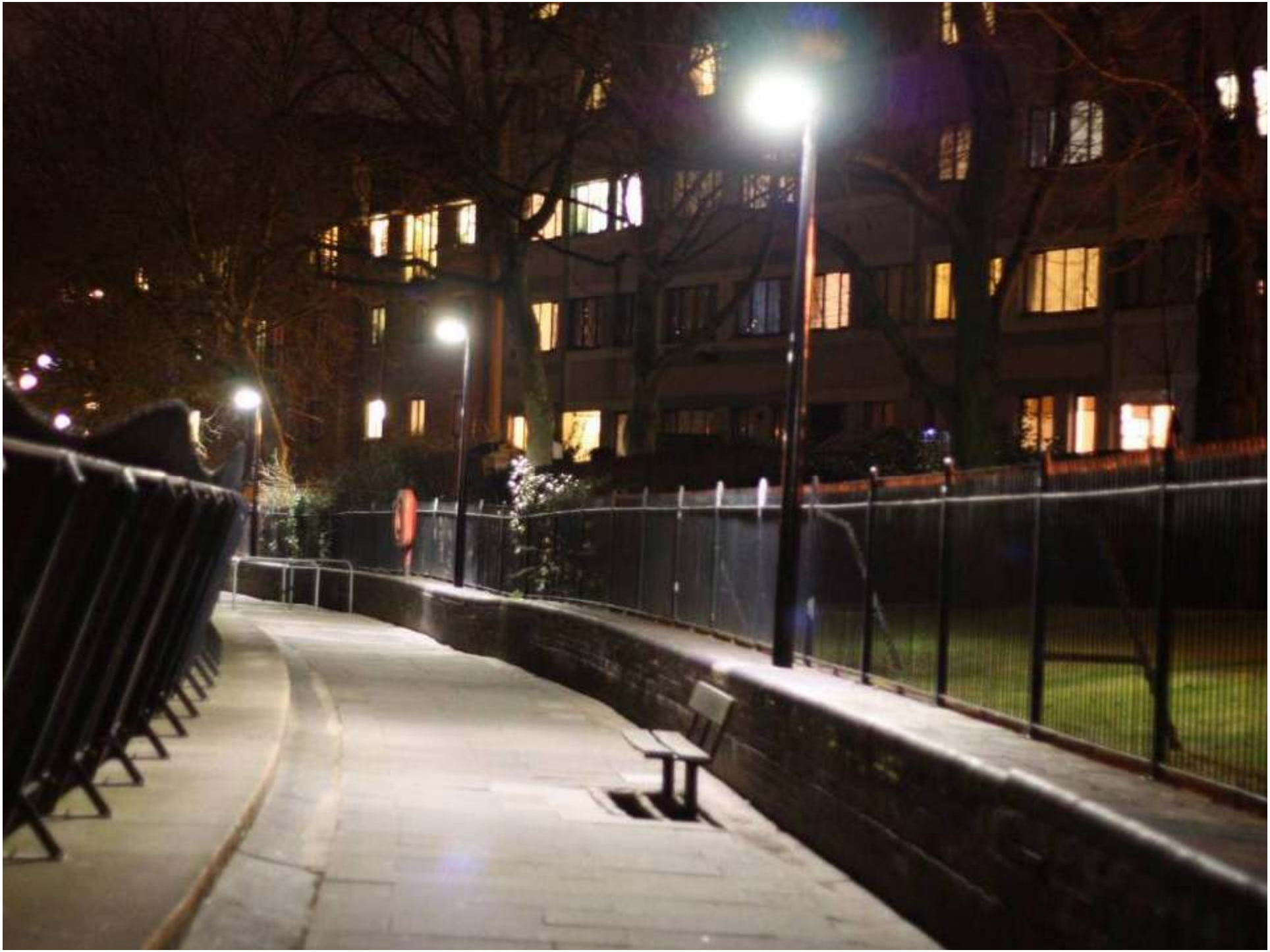

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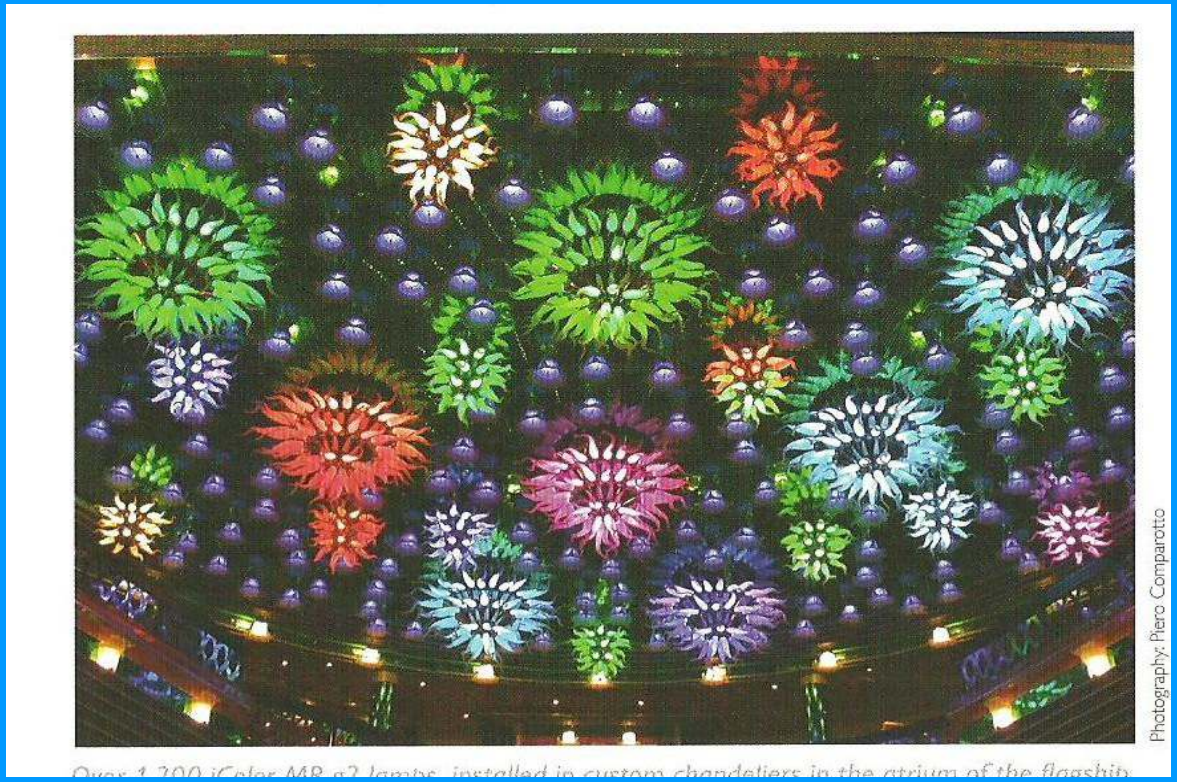
Useful websites

- www. ledlightingexplained.com
- www. theilp.org.uk
- www. philipslighting.com
- www.colorkinetics.com

Acknowledgements

- Mike Simpson Philips Lighting
- Dave Franks Westminster City Council
- Institution of Lighting Professionals
- Brian Bradley Bradgate Neri
- Chiara D’Agostino Neri Lighting
- John Craven IT

Costa Lotta Money



Photography: Piero Comparotto

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Thank You