Guidelines for Specification of LED Lighting Products 2011

This Guide has been produced under the umbrella of the Lighting Industry Liaison Group and is endorsed by its member organisations:

HEMSA
Highway Electrical Manufacturers & Suppliers Association

PLDA
Professional Lighting Designers Association

Society of Light and Lighting

LA
The Lighting Association
The Lighting Associsation

ILP
Institution of Lighting Professionals

LIF
Lighting Industry Federation

IALD
International Association of Lighting Designers

June 2011

Introduction

With LED's emerging as a new functional light source there is a need to ensure performance claims are made in a consistent way. This is the second edition of the guidance notes, taking into account new IEC standards and the development of LED technology. These guidance notes are harmonised with these standards and provide a template for the basis of the specification of LED performance criteria. They have been produced under the umbrella of the Lighting Liaison Group, which is an informal group representing the major lighting organisations in the UK who have endorsed and added their names to this Guidelines document.

These criteria are designed to ensure that performance claims can be matched against traceable data. They are also designed to ensure that the performance data relate to the luminaire during operation and not just to the performance of the LED and LED module.

*A light engine may be a single of group of LED's and may have a remote phosphor plate. The light engine is considered as a light module whose performance is the combined effect of the different elements that make it up.

Summary

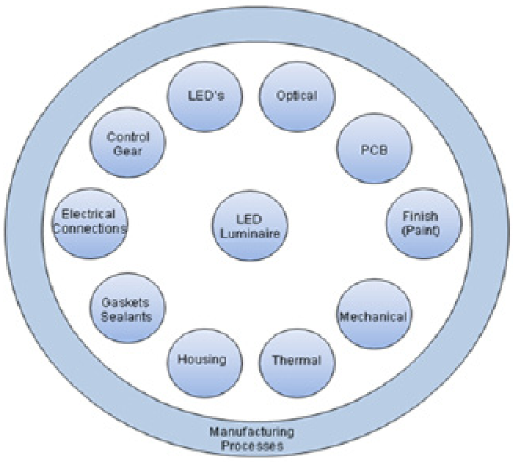
Typical questions a user should ask are shown below. More detail is given in further sections of this guide.

Question	Answer	Realistic Performance Indications	Evidence required
How is life defined	By a combination of lumen maintenance and failure fraction.	Life should always be stated as: 1. Light Loss - Usually either L90 or L70 (L50 for decorative luminaires) – no. of hours; and 2. Physical Failures - LED Life F10 – no. of hours E.G. If the rated life of a product is 50,000 hours, this means light loss of L70 and physical failures of Fx (where x is the percentage no. of failures) at the rated life of 50,000 hours. (Note: it should be assumed that the manufacturer has tested to a maximum of 6000 hrs and extrapolated beyond that – unless they explicitly state differently)	See section 3.0
What is the lumen depreciation	Rate and percentage of light loss	Light output > 90% of initial Cat 1 Light output > 80% of initial Cat 2 Light output > 70% of initial Cat 3	See section 3.0
What is the colour rendering index	The rated CRI should include any shift over life.	Initial CRI and CRI change.	See section 3.0
How stable is the Colour temperature	Defined by the colour shift through life	Within a 1-step ellipse Within a 3-step ellipse Within a 5-step ellipse Within a 7-step ellipse Greater than a 7-step ellipse	See section 3.0
What ambient temperature is the luminaire performance based on.	For indoor 25^{0}C for outdoor 15^0		
What is the photometric distribution	Measurement of the light intensities at various angles and may be absolute or relative	Candelas (cd) and degrees	See section 3.0
Driver current	The current at which the LED's are driven	Measured in mA	
Power Factor	The power factor for the whole circuit	0.85 or better.	

This guide is in 3 sections. A description of the parameters that affect system performance, the data and measurement required of the manufacturer and a specification list to ensure the user realises the claimed performance.

1.0 System Reliability

An LED luminaire is in many ways more complex than a traditional lighting fixture, in that many system components and operating conditions require tighter control to provide optimum performance. It is an electromechanical system that includes, in addition to the essential light-emitting source, provisions for heat transfer, electrical control, optical conditioning, mechanical support, and protection, as well as aesthetic design elements. Because the LEDs themselves are expected to have long life, all of these other components, adhesives, and other materials must be equally long-lived, or, to the extent they are not, they will limit the system lifetime.



Factors affecting the luminaire performance are:

LED performance
While LEDs do not radiate heat, with current products half or more of the input energy may be converted to heat that must be conducted away from the diodes.

Optical performance
LEDs are directional light sources, giving the lamp or luminaire designer new challenges when compared to existing lamp technology. The use of reflectors, lenses and diffusers, or a combination there of, allows a designer to direct light in many different ways. The efficiency of the optical system must be considered and factored into the overall efficiency value of the lamp or luminaire

PCB
A PCB is the interface between an LED and heat-sink and carries with it a thermal resistance value. The higher the resistance the less efficient the system is at soaking away heat from the LED, this may well impact on the LED lumen output performance and ultimately the life, lumen maintenance and/or catastrophic failure of the LED

Finish
The paint finish/colour may affect the heat dissipation from the luminaire

Mechanical
The mechanical integrity of a luminaire is important in several different areas including: IPxx rating to suit the application, heat-sinking that will not become compromised with time and or lack of maintenance, vibration resistance, specifically so that the heat-sink does not become detached from the LED PCB, bonding mechanisms are suitable for the life of the lamp or luminaire

Thermal
The performance of an LED is dependent on its temperature during operation. The design of the luminaire will influence its operating temperature and hence published characteristics.

Housing
LEDs allow new design freedom and housings can be used both for styling and heat-sinking purposes. Consideration should be made for maintenance and/or cleaning of the heat-sink, so that the overall thermal performance of the lamp or luminaire remains within specification

Gaskets
Many LEDs and specifically phosphor can react to different chemicals; some gaskets can out-gas chemicals that can affect the performance of some LEDs. A luminaire manufacturer should work with the LED supplier and qualify any new gasket materials

Sealants
Many LEDs and specifically phosphor can react to different chemicals; some sealants can out-gas chemicals that can affect the performance of some LEDs. A luminaire manufacturer should work with the LED supplier and qualify any new sealants materials

Electrical
Electrical overstress is now a well known cause of catastrophic failure of LEDs. Some LEDs contain an on board Transient Voltage Suppression chip (TVS), which provides some level of protection. A well designed lamp or luminaire will feature the necessary design or protection in order to minimize damage at installation or power-up

Control Gear (Driver) For proper operation, the power supply and electronics must provide a well-controlled DC drive current and possibly other control features, and must not fail for the life of the product. Failure rate of the external control gear **shall be included in the overall assessment of total life / failure rate**

Drive Current
Drive current affects LED operating temperature and thus life and output. Normally around 350mA is quoted but this can be higher, the higher the LED is driven the brighter it will be but it may have a shorter operation lifetime and be less efficient. Some of the new multi die led are designed to operate and perform at higher drive currents.

Manufacturing
There are many process variables during any manufacturing process. Experience, track record and a traceability system are a vital part of providing a user or specifier with confidence and a route to tracking any issues

Operational Environments
There are many different types of environments luminaires will be required to operate. Humidity can be higher in certain applications and can cause rapid degradation of materials used within the luminaire. Temperature can be higher in certain applications and can cause rapid degradation of materials used within the luminaire. The luminaire manufacturer should work with the material suppliers and qualify any new materials if the application requires operating in high humidity and/or high temperature conditions.

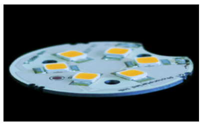
The reliability of the luminaire will be a combination of all of the above.

2.0 Life

For clarity, 3 systems are defined

LED Light Source
The LED die (or chip) is contained in a suitable package allowing simplified electrical connection or assembly

LED module
This is the LED together with mechanical and optical components making a replaceable item for use in a luminaire



LED Luminaire
This is the complete system consisting of all elements described in Section 1.

2.1 Lifetime Lx

Life is the length of time during which a LED Light source*, LED Module or LED Luminaire provides more than claimed percentage x of the initial luminous flux, under standard conditions. A LED product has thus reached its end of life when it no longer provides the claimed percentage of the initial luminous flux, Lx. Life is always published as combination of life at claimed lumen maintenance and failure fraction, Fy applying at the time of reaching the claimed percentage of the initial luminous flux. Lx

* For LED Light Sources this is designated in LM-80 Lifetime (Lp)

There is no validated way to translate the lumen maintenance curve of an individual LED Light source into a curve for the LED Module or LED luminaire. Life testing of the LED light source is carried out according to LM-80 up to 6000h or 10,000h. Beyond these values statistical

predictions are made. see. Fig 1
A reliable luminaire manufacturer will indicate the basis of these projections. It should be noted that if a product contains a good quality LED light source that has LM-80 data available and the LED Module or Luminaire maker calculates lifetime data based upon the LM-80 data this represents an extremely good start in ensuring the LED Module or Luminaire could be reliable.

For LED Modules and LED Luminaires the lumen maintenance curve can also be affected by the combined effect of all components of a Light source/luminaire as described in Section 1. LED Modules and LED Luminaires have life testing carried out to 6000h if there is no LED Light source data. If LED Light source data from tests carried out to 6000h is available, LED Modules and LED Luminaires may have life testing carried out to 2000h.

For general lighting applications, it is recommended to define Life as the length of time it takes an LED Module or LED Luminaire to reach (depending on the application) 90% or 70% of its initial light output (L90 or L70). For decorative lighting applications, it is recommended to define useful life as the length of time it takes to reach 50% of its initial output.

Lifetime (Lx) is published in combination with the failure fraction, (Fx)

2.2 Failure Fraction (Fy)

This is the percentage y of a number of LED Light sources* of the same type that have reached the end of their individual lives where y designates the percentage (fraction) of failures.

* For LED Light Sources this is designated in LM-80 Lifetime (Bp)

For LED Modules this failure fraction expresses the combined effect of all components of a Light source/luminaire as described in Section 1
Failure Fraction should be declared at the Lifetime Lx and can only be based on testing up to 6000h together with statistical predictions. For general lighting applications this should be less than 10% (F10).

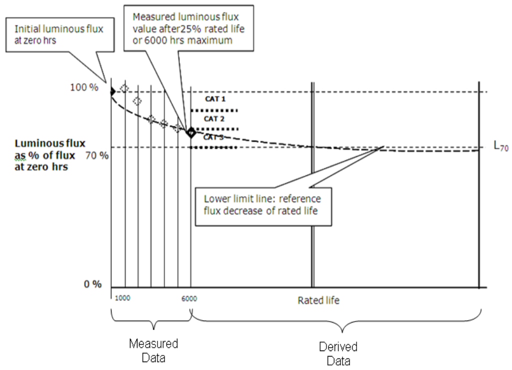


Fig1

3.0 Luminaire manufacturers design data, made available for traceability

3.1 LED Light source data

The following data for the LED light source must be measured at a junction temperature of 25°C

Drive current/voltage/power for the LED

Life Lx
See section 2.1
Failure Fraction
Fy. See section 2.2

Colour Temperature LED
The initial colour point (x & y) of the LED and the colour temperature derived from it.

CRI for the LED
The initial Colour Rendering Index (CRI) of the LED. The preferred measure of CRI is Ra14 as the additional test colours compared to Ra8 will give a more accurate representation of the LEDs ability to reproduce colours.

3.2 Measured LED Module data

This is principally the same as that for the 'Measured Luminaire Data' (see 3.3 below)

3.3 Measured Luminaire data

The following measured data for the luminaire data should be presented for an ambient temperature of 25°C. (15°C for Exterior luminaires)

Note: Where a declared ambient air temperature other than 25 °C is advised by the manufacturer a correction factor will need to be established to correct the measured luminous flux value at 25 °C to the luminous flux value at the declared ambient. This shall be done using relative photometry in a temperature controlled cabinet.

Rated Power
Total luminaire power including drivers should be measured under standard conditions and expressed in Watts

Power Factor
The power factor should be clearly stated in all cases. Although product standards may not require this below 26W, it should be noted that some clients, and in particular contractors and local authorities working with un-metered supplies (the majority of public lighting in the UK), will require power factor correction of 0.85 or better.

Rated Lumen Output
The initial luminous flux shall be measured after thermal stabilisation of the LED luminaire.

Light Loss Maintenance Factor (LLMF)
This will be the light lost at rated life.

Rated Luminaire Efficacy
Properly measured, Luminaire Efficacy combines both the light source system efficacy and luminaire efficiency, allowing for a true comparison of a luminaire regardless of the light source. Luminaire efficacy is the preferred metric for LEDs because it measures the net light output from the luminaire divided by power into the system, accounting for driver, optical, and thermal losses.

The board temperature Tboard of the LED package installed in the luminaire,

Lumen depreciation
The lumen depreciation rate is judged by the light output at 25% of rated life (with a maximum duration of 6000 h) compared to the initial output. The depreciation classification is:

Light output > 90% of initial	Cat 1
Light output > 80% of initial	Cat 2
Light output > 70% of initial	Cat 3

Life Lx
See section 2.1

Failure Fraction
Fy. See section 2.2

Colour Temperature
The initial colour point (x & y) of the LED and the colour temperature derived from it or bin class related to C78.377-2008 where colour temperature values are recommended as 2700K, 3000K, 3500K, 4000K, 5000K, 6500K

Colour Maintenance
The colour shift is judged by the colour point shift at 6,000 hours compared to the initial colour point (x & y) of the luminaire.

Colour Temperature Tolerance
Tolerance (categories) on nominal x & y values measured for both initial and at 25% of rated life (with a maximum duration of 6000 h)

All measured x & y's within a 1-step ellipse
All measured x & y's within a 3-step ellipse
All measured x & y's within a 5-step ellipse
All measured x & y's within a 7-step ellipse
All measured x & y's > 7-step ellipse

Tolerances beyond a 4-step ellipse are considered unacceptable for general illumination purposes.

Colour Rendering Index for the Luminaire
The initial Colour Rendering Index (CRI) of a luminaire is measured. A second measurement is made after a total operation time of 25% of rated life (with a maximum duration of 6000 h). The measured CRI values shall not have decreased by more than 3 points from the rated CRI value for initial CRI values and 5 points from the rated CRI value for maintained CRI values. The preferred measure of CRI is Ra14 as the additional test colours compared to Ra8 will give a more accurate representation of the LEDs ability to reproduce colours.

Intensity Distribution*

*Applicable for luminaires which modify the distribution of the light source.

Photometric data is available in two formats. Absolute Photometry does not require the use of a separate lumen output for the light source. Relative Photometry requires the LED package flux to be quoted. Both methods produce the same result. The manufacturer should state the format in which the photometric data is supplied. Absolute photometry of LED luminaires should be conducted according to IES LM-79-08 Photometric Measurements of Solid-State Lighting Products. Relative photometry should be conducted according to EN13032-1 (2004) Light and lighting - Measurement and presentation of photometric data of lamps and luminaires - Part 1: Measurement and file format

These standards contain advice on measurement uncertainty. Luminaire performance data to be quoted at operating temperature Tboard

Photometric results that are calculated by deviation from the tested sample by the use, for example of higher or lower drive currents or dies from bins other than the bin used for the tested device are to be clearly identified as such. Correction factors used are to be provided with the results.

Temperature cycling shock test:

The non-energised LED luminaire shall be stored firstly at – 20 °C for 1 hour. The luminaire is then immediately moved into a cabinet having a temperature of + 35 °C (see 1.2) and stored for 1 hour. Five such cycles shall be carried out. At the end of the test the LED luminaire shall operate and remain alight for 15 min.

Supply voltage switching test:
At test voltage the luminaire shall be switched on and off for 30 seconds. The cycling shall be repeated for a number equal to half the rated luminaire life in hours (example: 10K cycles if rated luminaire life is 20 000 hours). At the end of the test the LED luminaire shall operate and remain alight for 15 min.

Thermal Endurance Test

The LED luminaire shall be operated at nominal voltage and at an ambient temperature of + 35 ° C for outdoor luminaires, + 25 ° C for indoor luminaires and + 35 ° C for recessed luminaires until a test period equal to 25 % of the rated luminaire life (with a maximum of 6 000 hours) has passed. At the end of this time, and after cooling down to room temperature, the luminaire shall remain alight for at least 15 min.
(NOTE: Higher temperature for testing as only testing to 25% life)

4.0 Data required for specification

Initial Luminaire Lumen Output L100

Light Output Depreciation Category (1, 2 or 3)
Luminaire life L(x) (where x is the percentage of L100 at the declared life)

Failure Fraction F(x) (where x is the percentage of failures at L(x))

Colour Temperature Category at initial and 25% of rated life (with a maximum duration of 6000 h)

Colour Rendering Index Value

Colour Rendering Index Value Shift

Luminaire Electrical Characteristics
Total power consumed
Initial power factor
Power Factor @ at initial and 25% of rated life (with a maximum duration of 6000 h)

Appendix A References

Product type	Safety Standard	Performance Standard
Self-ballasted LED-lamps for general lighting services >50V - Safety specifications	IEC 62560 Edition 1 Publication expected 2010	IEC 62612/PAS Publicly Avalable Specification
Control gear for LED modules	IEC 61347-2-13 Published 2006	IEC 62384 Published 2006
LED Modules for general lighting - Safety specifications	IEC 62031 Edition 1 Publication 2008	Draft under preparation
LED Luminaires	IEC 60598-1	IEC/PAS 62722-2-1 Ed. 1: Luminaire performance - Part 2-1: Particular requirements for LED
LED's and LED modules	IEC TS 62504 Terms and Definitions for LED's and LED modules in general lighting	
CIE Technical Committees	TC2-46 CIE/ISO standards on LED intensity measurements	
	TC2-50 Measurement of the optical properties of LED clusters and arrays	
	TC2-58 Measurement of LED radiance and luminance	
	TC2-63 Optical measurement of High-Power LEDs	
	TC2-64 High speed testing methods for LEDs	

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