Guidelines for Specifying & Procuring LED Lighting Products for Lighting Projects

Introduction

1. LED lighting is a combination of a solid state light source, a control gear for operation of the LED lighting and optics for light distribution. These component parts together will affect the performance of the LED lighting in respect of energy efficiency, colour quality, life and lumen maintenance.

2. This document highlights the key aspects to be taken into account in specifying and procuring LED lighting products to be used in lighting projects. For easy reference, the key aspects are grouped under the following sub-headings - LED lighting construction and light distribution, LED driver and lighting controls, thermal management, energy efficiency, colour quality, life and lumen maintenance, and performance and quality assurance.

3. Whilst this document gives some general guidelines relating to LED lighting for reference, project designers and owners should also take into account specific circumstances and operating requirements of their lighting projects, and consult relevant professionals where necessary, when specifying and procuring LED lighting products. In addition, all relevant legislative requirements applicable to the lighting projects shall be observed. However, this document is not intended to cover road lighting, which should comply with the Public Lighting Design Manual issued by Highways Department.

LED lighting construction and light distribution

4. LED lighting type required in the project

   Is it a LED lamp (self-ballasted or non-self-ballasted) or LED luminaire (self-ballasted or non-self-ballasted)?

   [Note: A LED luminaire consists of LED modules, ballast or driver where applicable, heat-sink for thermal management, fixture and optics assembly. A self-ballasted lamp or luminaire can be connected to the supply mains directly, whereas a non-self-ballasted lamp or luminaire is to be connected to the supply mains via a separate driver. Control gear for starting and operating LED lighting is often called a driver.]

5. LED module replacement possibility

Could the burnt out LED modules within the LED luminaire be replaced or upgraded, without replacing the whole luminaire?

[Note: Integral LED modules are not replaceable after integration into the LED luminaire whereas built-in LED modules could be exchanged without damaging the luminaire. Compatibility of new LED modules for replacing or upgrading built-in LED modules in existing LED lighting should be ascertained, e.g. use LED module products from the same LED manufacturer or consult the LED manufacturer for advice.]

6. Ingress protection class

Adequate ingress protection (IP) rating of the LED luminaire should be prescribed for the intended application under specific environmental conditions.

[Note: IEC 60529 specifies the degree of ingress protection by enclosure. IP54 or IP55 may be required for luminaires for general outdoor applications. Other weather specific factors (e.g. sunlight, temperature, rainwater) should also be considered for outdoor luminaires.]

7. Optics

How is the light output from the LEDs controlled and distributed?

[Note: Distribution of the light output could be either by lens, diffuser or reflector. Well-designed optics will reduce optical losses and help improve the luminaire efficacy.]

8. Glare control

How is glare, if any, from the LED luminaire controlled? What is the glare rating (GR) or unified glare rating (UGR)?

[Note: Reflectors, diffusers or other features may be incorporated to control glare. Glare rating GR and UGR could be used to evaluate quantitatively disability glare and discomfort glare respectively of lighting design schemes.]

9. Safety and environmental requirements

LED modules and luminaire should comply with relevant safety and environmental standards.

[Note: Key safety standards include IEC 62031 for LED modules, IEC 61347-2-13 for LED drivers, IEC 62471 for photo-biological safety, IEC 60598 for aspects similar to general luminaire, IEC 62560 for self-ballasted LED lamps (>50V). EC Directive 2002/95/EC and related Commission Regulations specify restriction of the use of certain hazardous substances (RoHS) in electrical and electronic equipment including lighting.]

10. Radio frequency interference and electromagnetic compatibility
    LED lighting and the associated control gear (i.e. the driver) are to comply with the Telecommunications (Control of Interference) Regulations (Cap 106B) and the CISPR 15 standard. The LED lighting and control gear should also comply with the relevant electromagnetic compatibility standards.

    [Note: Disturbance voltage limits at the mains terminals and the radiated disturbance limits are specified in CISPR 15 issued by the International Special Committee on Radio Interference. EN 55015 is equivalent to CISPR 15. The Office of the Telecommunications Authority (OFTA) should be consulted for the latest requirements under Cap 106B for avoiding radio frequency interference caused by LED lighting equipment and associated power supplies. Electromagnetic compatibility refers to the ability of the LED lighting system and components to function satisfactorily under the electromagnetic environment without unduly affecting the environment. Key electromagnetic compatibility standards include IEC 61000-3-2 for limits on harmonic current emissions, IEC 61000-3-3 for limits on voltage changes, voltage fluctuations and flicker, and IEC 61547 for immunity requirements.]

LED driver and lighting controls

11. Type of driver to power and control LED lighting
    Is it an integral (i.e. as a part of the LED lighting), built-in (i.e. as a demountable part), or independent (i.e. separate) driver?

    [Note: IEC 62384 specifies performance requirements for electronic control gear for LED modules.]

12. Driver properties
    Are the drivers and LED compatible? For retrofit, can the control gears of existing lamps be re-used to drive the retrofitted LED lighting? What is the maximum case temperature of the driver? What are the driver losses?

[Note: A basic LED driver consists of two stages, i.e. a power supply for converting the alternating current in the supply mains into direct current for the LED and a current control unit for providing constant current supply for stable operation of the LED. Suppliers could be asked to provide substantiation or warranty on compatibility between the driver and the LED lighting. Dimmable drivers are designed for broader current range to suit the dimming operation of the LED lighting. LED drivers may also incorporate devices to handle power quality issues e.g. power factor correction, filter for harmonic distortion.]

13. Dimming provision

Is dimming provision required? If so, is dimming available for the LED lighting and by what means? Can the circuits (for multiple circuits) be switched or dimmed individually? Can common dimming devices be compatible with and used to dim the LED lighting?

[Note: Dimming could be of line voltage (e.g. phase control) or low voltage (e.g. 0-10V DC controls, digital lighting controls) type, and dimming controls could be integrated into a dimmable driver or provided by a separate dimmer. Dimmable drivers often use pulse width modulation (PWM) switching technique to dim the LED light output by regulating the total power and driving current supplied to the LED lighting. For retrofit projects, compatibility of new LED lighting with existing dimmer switches, if retained for use, should be ensured, and maximum load rating of the existing dimmers should not be exceeded. Some typical problems of incompatibility may include flicker, LED lighting not turned on, and even operational failure. Dimming of new lighting (with high initial light output) may be an energy saving opportunity.]

Thermal management

14. Thermal management provisions

LED lighting should have well-designed thermal management provisions that are maintainable throughout the life of the LED lighting to ensure LED junction temperature be maintained within design limit.

[Note: LED lighting performance is affected by the LED junction temperature. LED manufacturers test and sort their products with power pulses which are so short as to maintain the junction temperature at 25 deg C. Yet, actual operating temperature of the LED lighting may be at 60 deg C or above and the life of the LED lighting could be much shortened due to accelerated lumen depreciation in addition to colour shift and reduced light output under higher operating temperature condition. Good heat sink design for LED lighting is essential to dissipate heat from the LED junction and LED driver to maintain a low operating temperature.]

15. Maximum allowable ambient temperature

Maximum allowable ambient temperature for the LED lighting should be considered so that the LED lighting can operate without adversely affecting its life or colour stability.

[Note: This is to ensure that the maximum case temperature of the driver and the design LED junction temperature not be exceeded. Typical ambient temperature for continuous service of the lighting to be up to around 35 to 40 deg C depending on the environmental condition for the lighting.]

16. Operating temperature data

Operating temperature data (at a verifiable temperature measurement point on the LED lighting/module) should be available together with an indication on how they are related to the junction temperature, the expected light output and lumen depreciation.

[Note: The operating temperature is correlated to the LED junction temperature and could be used to estimate the life of the LED lighting under the operating temperature condition.]

Energy efficiency

17. Luminous efficacy (lumens/watt) of the LED lighting

For LED lamp, what is the system efficacy (i.e. including the driver)? For LED luminaire, what is the luminaire efficacy? How is the luminous efficacy compared to that of other lighting technologies?

[Note: Luminous efficacy is a measure of energy performance of the lighting. Luminaire efficacy also accounts for driver, thermal and luminaire optical losses, in addition to the efficacy of the LED modules. In general, luminaire efficacy = LED efficacy x driver efficiency x optical efficiency x thermal efficiency. As an example, US Energy Star Program for Solid State Lighting Luminaire specifies minimum luminaire efficacy values for different types of LED lighting.]

18. Rated power and measured input power

What are the design rated current, voltage and power of the LED lighting? What is the measured total input power (W) of the LED lighting (i.e. upstream of the driver)? What is the power factor of the LED lighting?

[Note: There is optimized driving current for different LEDs. Overdriving (i.e. driving beyond the rated current) may increase lumen output but would be at the expense of lamp life due to increased junction temperature. Lighting manufacturers may choose driving current ranges for their LED lighting taking into account different luminaire design factors, e.g. thermal management, ambient temperature condition, service life, light output and power consumption. For LED lighting with dimming operation, design may need to be compromised so that the LED driver could deliver broader range of driving current to meet the design light output range. It is desirable to have a high power factor for LED lighting as a low power factor load will draw more current for the same amount of real power in the electrical circuit. The power utility companies' Supply Rules specify minimum power factor requirement for connected loads.]

19. Light output available

Does the light output (lumens) from the LED lighting (at the specified correlated colour temperature (CCT)) meet the intended application?

[Note: In general, the warmer the colour temperature, the lower the lumen output is from the LED of same power. For general lighting application, luminous flux (lumens) is a common parameter for light output performance whereas for accent & display lighting application, luminous intensity (Cd) needs to be considered, e.g. how is the luminous intensity of the LED lighting at specified beam angle compared to other spot light technologies?]

Colour quality

20. Correlated colour temperature

Correlated colour temperature (CCT) of the LED light source should be considered.

[Note: CCT describes the colour appearance of a light source. In general, CCT for warm white light ranges from around 2600K to 3500K and that for cool white light is over around 5000K. LEDs with higher CCT are generally more energy efficient. It is noted that perception of colour consistency may be affected by the viewing angle.]

21. Colour rendering index
Colour rendering index (CRI) of the LED light source should be considered.

[Note: CRI describes the degree of change in colour appearance of an object when illuminated by LED light source as compared with that when illuminated by a reference light source. LEDs with CRI > 90 are available on the market. For general applications such as in offices, CRI of 80 or above is good enough. LEDs with higher CRI normally have lower efficacy.]

22. Chromaticity and colour shift
Colour stability of LED lighting as reflected by stability of chromaticity and colour shift over the useful life of the LED should be ascertained from test results.

[Note: Colour stability may be affected by quality of LED and/or poor thermal management design. Chromaticity refers to perception of colour of light and is specified by colour coordinates on CIE Chromaticity Diagram. For example, the US Energy Star Program for Solid State Lighting Luminінaire specifies the tolerance limits for CCT and the limit on change in colour coordinates on chromaticity quadrangles (similar to MacAdam ellipses) per ANSI C78.377 over the 6,000-hour lumen maintenance test period.]

Life and lumen maintenance

23. Estimated useful life of LED lighting
From lumen maintenance perspective, estimated useful life of LED lighting is normally based on lumen depreciation to 70% of the initial lumen output. For LED lighting as a whole, conventional electrical failure (e.g. lights out due to failure of parts other than the LED) should also be considered by referring to the failure rate under the claimed life.

[Note: Life claims are to be supported by lumen maintenance testing (up to 6,000 hours) for LED lighting samples per IESNA LM-79-08, IEC/PAS 62612, IEC/PAS 62717, IEC/PAS 62722 or other equivalent standards. Electrical failure rate refers to the respective percentage of the population that has experienced conventional lights out failure. It is desirable that lifetime of LED lighting be reported in terms of both lumen maintenance and failure rate; for example, B50 (for L70) and F10, i.e. lumen maintenance lifetime when lumen output of 50% of the LED lighting drops below 70% of the initial lumen output, and failure time when 10% of the LED lighting had conventional lights out failure. IESNA TM-21-11 provides an extrapolation method for lifetime estimation based on performance data collected from IESNA LM-80-08.]

24. Estimated life of the LED driver
Consideration should also be given to the estimated life of the LED driver and the failure rate that it is based on.

[Note: The life of LED lighting also depends on other components of the LED lighting (e.g. electronic components on the printed circuit board, solder joint/connector, driver) in addition to the estimated life of the LED itself. If possible, LED driver should be chosen to have lifetime compatible with that of the LED.]

25. Estimated lumen maintenance curve
The estimated lumen maintenance curve for the LED lighting should be considered.

[Note: The lumen maintenance curve should Include initial lumen output and the lumen depreciation pattern during the useful life of the LED lighting under the design operating temperature condition.]

26. Warranty
Warranty on useful life of LED lighting should be considered.

[Note: Warranty (in terms of number of years or hours, depending on the claimed lifetime, from date of purchase against failure & performance) may be negotiated with the supplier in order to cover any repair or replacement of the LED lamp or luminaire against failure or deficiency in performance (e.g. excessive lumen depreciation compared with lumen-lifetime curve, colour shift).]

Performance and quality assurance

27. Photometric data and test reports
Photometric data and test reports of the LED lighting from qualified independent or manufacturer-based laboratories should be available to ascertain the overall performance claims of the LED lighting.

[Note: Photometric measurement data per IESNA LM-79-08, EN 13032-1 & 2, IEC/PAS 62612, IEC/PAS 62717, IEC/PAS 62722 or equivalent test procedures may include: total luminous flux (lumens), luminaire power (Watt), luminous intensity (candela) distribution in one or more directions, chromaticity coordinates, CCT and CRI etc.. Annex A lists the key supporting information on LED lighting performance.

Annex B lists the lighting related standards referred in this document.]

28. Quality assurance

Does the LED lighting comply with or get registered under any LED lighting performance certification, recognition or labelling scheme administered by reputable, independent organizations?

[Note: Compliance with a LED quality scheme may provide an indication on quality level of the LED lighting. The Hong Kong Voluntary Energy Efficiency Labelling Scheme for LED Lamp, US Energy Star Program for Solid State Lighting Luminaire, and UK Energy Saving Trust are some typical examples of a LED quality scheme. Mock-up test of LED lighting samples in controlled environment to verify actual performance versus performance claims could be considered before bulk purchase. Checking out how the concerned LED lighting products perform in local job references may also be useful.]

Energy Efficiency Office, EMSD
January 2012

Annex A: Supporting information on LED lighting performance# to ascertain suitability of the LED lighting for the intended application

	Description	Supporting Information	Remark
(i)	LED driver	Type: integral, built-in or independent driver? Driver efficiency (%): Maximum case temperature of driver (deg C): Estimated life (hour): Dimming arrangement, if any:	Driver performance standard: IEC 62384
(ii)	Rating of LED lighting (lamp* / luminaire*)	Ambient temperature (deg C) for the rating: Rated current (mA): Rated voltage (V): Rated input power (W): Power factor: Initial lumen output (lumens):	
(iii)	Temperature of LED lighting	Maximum allowable ambient temperature for LED lighting (deg C): Operating temperature for LED lighting (deg C): Correlation between operating temperature and junction temperature: Thermal management provisions:	Supported by test data at reference temperature measurement point for operating temperature
(iv)	Luminous efficacy of LED lighting (lamp* / luminaire*)	Lumen output (lumens): Input power (include driver) (W): Efficacy (lumens/W) :	Supported by photometric measurement data; testing per IEC/PAS 62612, IESNA LM-79-08,

	Description	Supporting Information	Remark
			EN 13032-1&2 or equivalent standard
(v)	Correlated colour temperature (CCT)	Nominal CCT (K): CCT shift (K):	Ditto
(vi)	Colour rendering index (CRI)	General CRI (Ra):	Ditto
(vii)	Chromaticity	Colour coordinates (x,y or u,v): Coordinates shift:	Ditto
(viii)	Luminous intensity distribution (lamp* / luminaire*)	Normalised luminous intensity (cd/lumen): (in form of tables or plots)	Ditto
(ix)	Estimated life of LED lighting (lamp* / luminaire*) (at 70% lumen maintenance)	Lumen maintenance testing standard adopted: Estimated life L70: (supported by lumen depreciation curve) Failure rate: Warranty on life, if any:	Life claims based on lumen maintenance testing per IESNA LM-79-08, IEC/PAS 62612, IEC/PAS 62717, IEC/PAS 62722 or equivalent standard
(x)	LED lighting construction	Thermal management feature: Ingress protection class (IP): Glare control feature: Glare rating (UGR/GR): Optics feature:	
(xi)	LED quality assurance	Compliance with LED recognition/ certification scheme, if any:	

Annex A covers only the lighting performance aspects. Other aspects e.g. safety and electromagnetic compatibility as stipulated in the Guidelines should also be

taken into account in specifying and procuring LED lighting products.

* *For LED lamp or luminaire as applicable [Note: For LED luminaire, rating and photometric data should refer to the complete LED luminaire assembly.]*

Annex B: Lighting related standards referred in this document

	Standard	Year	Title
	International		
(1)	IEC 60529	2009	Degrees of Protection Provided by Enclosures (IP code)
(2)	IEC 60598-1	2008	Luminaires- Part 1: General Requirements and Tests
(3)	IEC 61347-2-13	2006	Lamp Controlgear- Part 2-13: Particular Requirements for D.C. or A.C. Supplied Electronic Controlgear for LED Modules
(4)	IEC 62031	2008	LED Modules for General Lighting- Safety Specifications
(5)	IEC 62384	2009	D.C. or A.C. Supplied Electronic Control Gear for LED Modules- Performance Requirements
(6)	IEC 62471	2006	Photobiological Safety of Lamps and Lamp Systems
(7)	IEC/PAS 62612	2009	Self-ballasted LED Lamps for General Lighting Services- Performance Requirements
(8)	IEC 61000-3-2	2009	Electromagnetic Compatibility (EMC)) Limits- Limits for Harmonic Current Emissions (Equipment Input Current Less Than or Equal to 16A per Phase)
(9)	IEC 61000-3-3	2008	Electromagnetic Compatibility (EMC)) Limits- Limitation of Voltage Changes, Voltage Fluctuations and Flicker in Public Low-Voltage Supply Systems, for Equipment with Rated Current (Less Than or Equal to 16A per Phase
(10)	IEC 61547	2010	Equipment for General Lighting Purposes- EMC Immunity Requirements
(11)	IEC 62560	2011	Self-ballasted LED Lamps for General Lighting Services by Voltage > 50V- Safety Specifications
(12)	IEC/PAS 62717	2011	LED Modules for General Lighting- Performance Requirements
(13)	IEC/PAS 62722-1	2011	Luminaires Performance- Part 1: General Requirements
(14)	IEC/PAS 62722-2-1	2011	Luminaires Performance- Part 2.1: Particular Requirements for LED Luminaires
(15)	CISPR 15	2009	Limits and Methods of Measurement of Radio Disturbance Characteristics of Electrical Lighting and Similar Equipment
	Regional/National		
(16)	EN 13032-1	2005	Light and Lighting- Measurement and Presentation of Photometric Data of Lamps and Luminaires- Part 1:

			Measurement and File Format
(17)	EN 13032-2	2007	Light and Lighting- Measurement and Presentation of Photometric Data of Lamps and Luminaires- Part 2: Presentation of Data for Indoor and Outdoor Work Places
(18)	EN 55015	2009	Limits and Methods of Measurement of Radio Disturbance Characteristics of Electrical Lighting and Similar Equipment
(19)	LM-79-08	2008	IESNA Approved Method for the Electrical and Photometric Measurements of Solid-State Lighting Products
(20)	LM-80-08	2008	IESNA Approved Method for Measuring Lumen Maintenance of LED Light Sources
(21)	TM-21-11	2011	IESNA Projecting Long Term Lumen Maintenance of LED Light Sources
(22)	ANSI C78.377	2008	Specification for the Chromaticity of Solid State Lighting Products
(23)	EC Directive 2002/95/EC	2003	EC Directives on the Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment

Note:

1. As mentioned in IEC/TR 62471-2: Photobiological Safety of Lamps and Lamp Systems- Part 2: Guidance on Manufacturing Requirements Relating to Non-laser Optical Safety, IEC 62471 is currently being revised by IEC and will be published as IEC 62471-1.