Evaluating performance of LED based luminaires

Guidance Paper

LIGHTINGEUROPE
THE VOICE OF THE LIGHTING INDUSTRY

Executive Summary

The intention of this paper is to provide guidance to users (like specifiers, lighting designers, technical engineers and policy makers) of LED based luminaires intended for lighting projects. It enables ‘apple-to-apple’ comparison and easy evaluation of manufacturers’ performance data when preparing lighting projects or tender specifications.

Emphasis will be put on explaining the “useful life” (useful lifetime) performance requirements. The paper recommends a fixed set of performance data for LED based luminaires. This data set is focused on the information which is necessary for lighting application design.

January 2018

Content of the document

1. Introduction: *evaluating performance of LED based luminaires*

In recent years, there has been a significant increase in the use of LED based luminaires. Initially, there were no universal standards available to measure or compare the performance of LED based lighting products. There is confusion among customers about which LED based luminaire to choose.

However, while the quality of LED technology has rapidly improved and the application considerations have not changed, the product data have remained unnecessarily complex. In this regard, the main challenge for the professional market is to improve the way users of LED based luminaires evaluate the performance data of different manufacturers when preparing lighting projects or tender specifications. Today they often compare – unwittingly – apples with pears.

Both 'initial' and 'useful lifetime' performance data have to be evaluated in order to have confidence in how LED based luminaires will perform and how long they will sustain their rated characteristics over their years of operation.

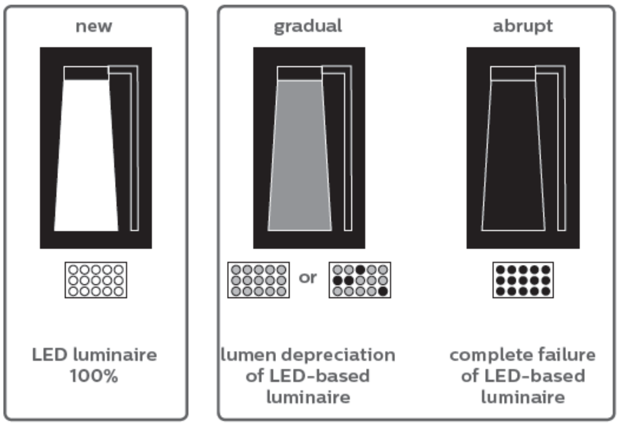


Fig 1 – *Evaluating 'initial' and 'useful lifetime' performance of LED based luminaires*

As things stand at present, evaluating LED based luminaires is complex because of two main reasons:

1. The use of different technical definitions and related parameters to describe the performance of products, thus making them difficult to compare (for example incorrect use of LED module or light source data instead of luminaire data);

2. The technical design choices made for a product can make a tremendous difference in terms of performance over the useful lifetime.

LightingEurope is of the opinion that the establishment of simplified performance metrics that support the needs of good lighting design and allow easy product to product comparisons to be made will add value to the professional market.

Confusion due to the use of different sets of definitions can be eased by following the latest IEC/EN standards on performance of LED based luminaires. These standards give guidance on 'what' (phenomena and metric) to publish and 'how' (measurement and/or calculation method) to arrive at a set of comparable product specifications.

2. Lighting requirements

Good lighting design calculations require different technical product parameters based on standardised and therefore comparable data. IEC 62722-2-1 Performance requirements for LED based luminaires, gives an overview of the relevant 'initial' and 'useful lifetime' product information parameters that should be used for the planning of lighting designs.

2.1 Luminaire performance parameters *(following IEC/CENELEC)*

Relevant product information parameters as described in IEC 62722-2-1:

1. Rated input power (*P* in W)
2. Rated luminous flux (Φ in lm)
3. Rated luminous efficacy (η in lm/W)
4. Rated luminous intensity distribution (in cd or cd/klm)
5. Rated correlated colour temperature (T_{cp} in K)
6. Rated colour rendering index (*CRI*)
7. Ambient temperature related to performance of the luminaire (t_q in ˚C)
8. Rated median useful life (L_x in hours with x for the associated rated luminous flux maintenance factor in %)
9. Rated abrupt failure value (in %)

In this context 'rated' means the value of the parameter for the LED based luminaire declared by the manufacturer when operated under specified conditions. It is reminded that the t_q value for which the performance data is declared shall always be reported even if this is 25˚C. Where applications require t_q temperatures other than 25˚C all performance data is required to reflect the actual performance for these specific t_q temperatures.

To enable apple-to-apple comparison LightingEurope recommends that performance data set should always be declared at a t_q of 25˚C. Manufacturers may declare additional performance data sets at different t_q values.

In this section, the initial luminaire performance parameters (1-7) are described that can be used as input for lighting design calculations. The useful lifetime luminaire performance parameters (8-9) are described in section 3. Lifetime considerations. Annex A provides the terms and definition, including a reference to standard for measurement methods, which is essentially for EN 13032-4

Common examples of misrepresentation of performance data are:

1) Luminous flux output for LED module being stated instead of the luminous flux output for the complete luminaire.

2) Data based on 25 °C operation temperature of the LED module or light source instead of data based on the actual operating temperature of the source inside the luminaire.

3) Operating power being based on just that of the LED module or light source instead of that consumed by the complete luminaire.

4) Incorrect comparison of power / efficiency between luminaires containing built in control gear and those using remote control gear.

5) A combination of incorrect input power and luminous flux output values resulting in inflated efficacy.

2.2 Lighting application requirements *(following CEN)*

When considering if a product is the best solution for an application we need to understand what should be calculated to ensure that the correct lit environment is created.

When requirements are specific to the given lighting solution within the application space, a lighting design needs to be performed. In that case the data requirements when considering a particular lighting product should be application driven and consider what information is required to ensure the lighting solution is correct for the application space. Any data that is not driven by the application requirements should be considered of secondary importance.

Table 1 shows, according to European standards, which product requirements are relevant for each application and which of these requirements can be fulfilled wholly by the product data and therefore can be specified on a product datasheet.

Annex B provides a detailed overview of application requirements specified in the different European (EN) application standards.

No	IEC 62722-2-1	EN 12464-1	EN 12464-2	EN 15193	EN 13201-2	EN 13201-5	EN 12193
1	Input power			x		x	
2	Luminous flux	x	x		x		x
3	Luminaire efficacy			x		x	
4	Luminous intensity distribution	x	x		x		x
5	Correlated Color Temperature	x	x		x		x
6	Color Rendering Index	x	x		x		x
7	Ambient temperature	This value is not directly required by the standards but the value is fundamentally necessary for a correct and comparable operation in the lighting application.					
8	Median Useful Life (depreciation)	x	x	x	x		x
9	Abrupt Failure Value (failures)	x	x		x		x

Table 1 – *Product data directly linked to lighting application standards*

Key to the standards

IEC 62722-2-1:2016 - Luminaire performance: Particular requirements for LED luminaires.

EN 12464-1:2011 - Light and lighting: Lighting of work places Part 1: Indoor work places.

EN 12464-2:2014 - Light and lighting: Lighting of work places Part 2: Outdoor work places.

EN 15193:2007 - Energy performance of buildings: Energy requirements for lighting.

EN 13201-2:2015 - Road lighting Part 2: Performance requirements

EN 13201-5:2016 - Road lighting Part 5: Energy performance indicators

EN 12193:2007 - Light and lighting: Sports lighting

3. Lifetime considerations

3.1 Overview

There are two relevant useful lifetime performance values to be considered related to 'gradual' and 'abrupt' luminous flux output degradation of a LED based luminaire.

Gradual luminous flux output degradation relates to the lumen maintenance of the light source in a luminaire. It describes how much of the initial luminous flux output of the light sources in the luminaire is available after a certain period of time. Luminous flux output depreciation can be a combination of individual LEDs giving less light and individual LEDs giving no light at all.

Note: There are currently no standards available for the assessment of the degradation of additional optical elements.

Abrupt luminous flux output degradation describes the situation where the LED based luminaire no longer gives any light at all because the system (or a critical component therein) has failed.

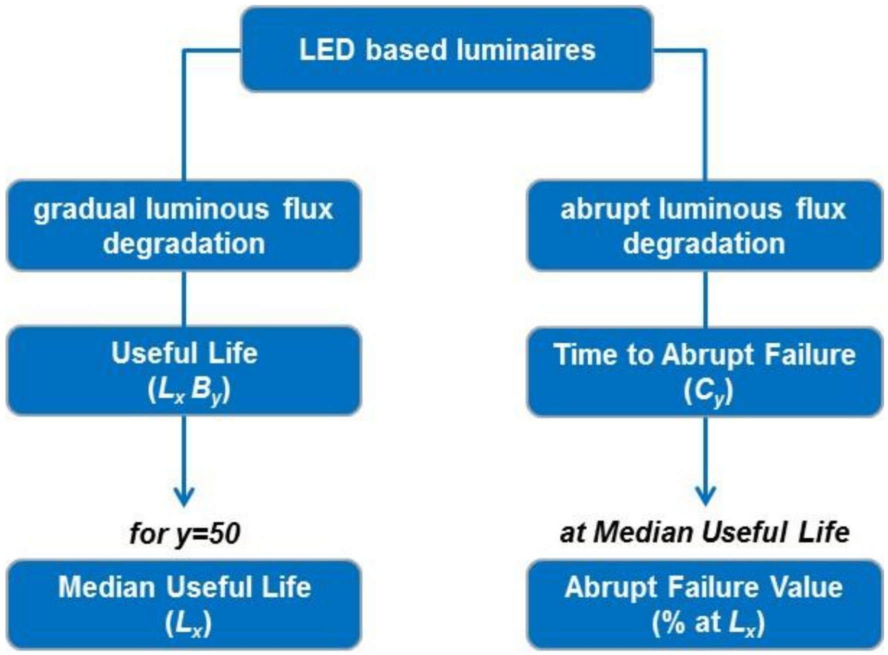


Fig 2 – *IEC lifetime metric*

Both 'gradual' and 'abrupt' luminous flux output degradations have been described in the IEC lifetime metric for LED based luminaires. IEC suggests applying a standard set of quantities for communication to the market: 'Median Useful Life' and the associated 'Abrupt Failure Value'.

As the Median Useful Life of LED based luminaires can be very long, it is important to understand that useful lifetime performance values are predictions rather than measurements. For manufacturers, it is not possible to measure the useful lifetime values with, for example, 50.000 h before launching new products. Instead, the manufacturers use shorter assessment periods and extrapolate the results to arrive at predictions.

Note: Methods for accelerated lifetime assessments for LED based products are currently not available.
The IEC performance standards currently describe lifetime metrics for LED based products but not how to measure/calculate the parameter of the lifetime metrics. As a consequence, the quality of the lifetime predictions varies wildly and there is a significant risk of apple-to-pear comparison.

Reputable manufacturers will calculate Median Useful Life and associated Abrupt Failure Value based on historical design data and knowledge, component level testing and thermal design.
Lifetime data are normally specified together with a specific ambient temperature (t_q), the number of burning hours and the associated switching cycles.

3.2 Gradual luminous flux degradation – Useful Life and Median Useful Life

The gradual light output degradation of a population of LED based luminaires at a certain point in time is called Useful Life and expressed in general as L_xB_y. The population includes operating LED based luminaires only; non-operative products are excluded.

Useful Life expresses the age at which a given percentile of LED based luminaires (y) cannot meet the lumen maintenance factor x. Light output lower than the required luminous flux maintenance factor x called flux degraded because they produce less light but still operate.

In order to unambiguously compare manufacturers' lifetime data, IEC introduced Median Useful Life (L_x). Median Useful Life is the time at which 50 % (B_{50}) of a population of LED based luminaires are flux degraded. Median Useful Life is generally expressed as L_x so without the B_{50} notification.

Example: Median Useful Life L_{90} is understood as the length of time during which 50 % (B_{50}) of a population of operating LED based luminaires of the same type have flux degraded to less than 90 % (L_{90}) of their initial luminous flux but are still operating.

Besides the median value (B_{50}), in the market an apparent demand for B_{10} or even B_0 rated products exists. Although B_y is a defined performance characteristic, the standard IEC 62722-2-1 does not include any technical explanation for how this parameter should be verified or applied.

Also lighting application design standards give no guidance for how a B_y factor should be accounted for. Closer technical evaluation as to what this really means is required.

It can be expected that around a distribution of products there will be a proportion above and a proportion below the rated performance value. The graph below shows an example of the normal distribution for a L_{90} rated product, illustrating the difference of a B_{10} or B_{50} value.

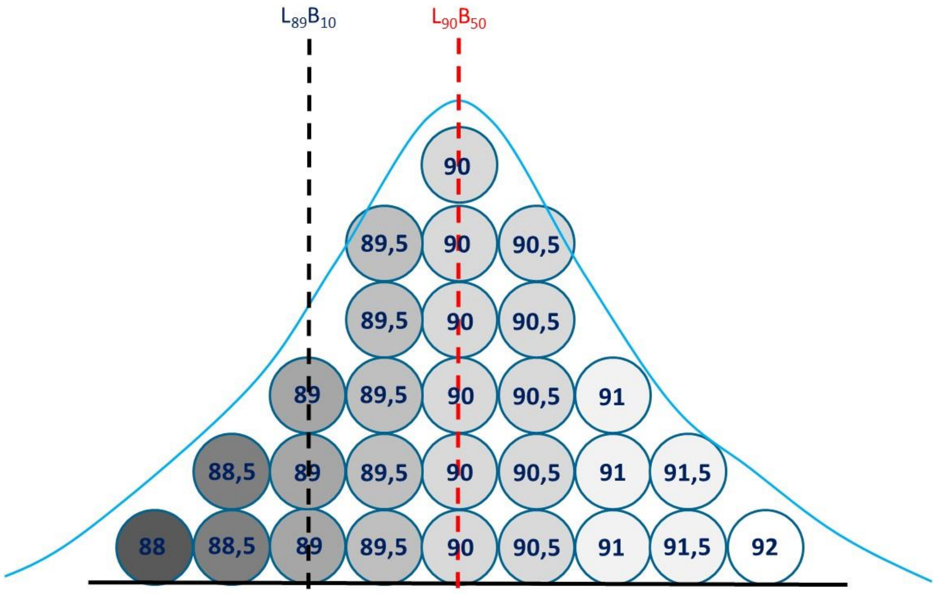


Fig 3 – Example of *normal distribution for a L_{90} rated product*

Detailed analysis from various manufacturers in LightingEurope of product data from LED based luminaires shows that, when projecting installation life up to 100.000 hours, the difference in flux degradation between B_{10} and B_{50} is about 1 %.

For the L_{90} example at 100.000 hours this means that an initial luminous flux of 10.000 lumen will be 9.000 lumen in the case of B_{50}. If the same luminaire is rated as B_{10}, the corresponding value would be 8910 lumen. . Bearing in mind that the rated light output data of both LED and traditional light sources are subject to a typical 10 % tolerance this practical differential can be regarded as negligible.

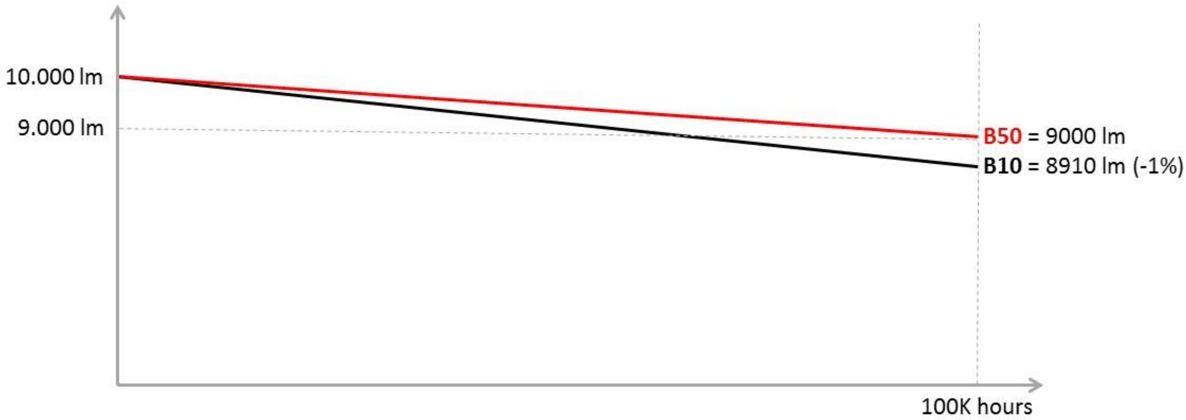


Fig 4 – *Product data analysis of an example of a LED based luminaire*

As B_{10} and B_{50} are so close together, the spread due to depreciation is low and the median (B_{50}) value represents with a sufficient degree of accuracy the lumen deprecation behavior of a number of products at the projected lifetime (in this example 100.000 hours). The measurement process for B_{50} is standardized and more widely accepted than any other By. Therefore, for reasons of accuracy and consistency between manufacturers the use of any other By cannot be recommended over the use of B_{50}.

This indicates that for the commonly used L_{70}, L_{80} or L_{90} values the B_y factor is not as significant as may be thought (or promoted) by some manufacturers and users. Consequently, LightingEurope sees little benefit in the continued promotion of B_y as a significant factor for making product to product performance comparisons. Therefore, LightingEurope recommends promoting only the Median Useful Life generally expressed as L_x without the B_{50} notification.

Statistically the median (B_{50}) value represents with a sufficient degree of accuracy the lumen deprecation behavior of a population of LED based luminaires at the projected lifetime. Therefore, LightingEurope recommends promoting and expressing Median Useful Life as L_x without B_{50} notification.

3.3 Abrupt luminous flux degradation – Time to Abrupt Failure and Abrupt Failure Value

An important parameter that should be considered with expected long life is system reliability. A LED based luminaire will last as long as the component used with the shortest life. There are several critical components of a LED based luminaire that influence the system reliability.

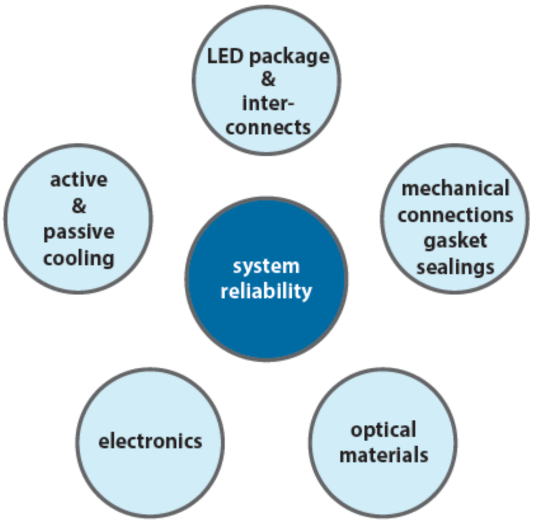


Fig 5 – *Principal components of a LED based luminaire*

Degradation of optical material may cause a reduction of luminous flux rather than an abrupt degradation. Failure of one of the remaining principal components generally leads to complete failure of the LED based luminaire. This is not taken into account when indicating the rated Median Useful Life. For that reason, abrupt failures have to be considered separately so it can be taken into account at time of lighting engineering and planning. This is why the IEC lifetime metric also specifies time to abrupt failure, which takes into account failure modes of principal components in the LED based luminaire design.

The abrupt light output degradation of a population of LED luminaires at a certain point in time is called Time to Abrupt Failure and expressed in general as C_y. Time to Abrupt Failure expresses the age at which a given percentage (y) of LED based luminaires have failed abruptly.

To facilitate easy evaluation of manufacturers' performance data, IEC introduced the Abrupt Failure Value (AFV) of a population of LED based luminaires. Abrupt Failure Value is the percentage of LED based luminaires failing to operate at Median Useful Life (L_x).

Example: Abrupt Failure Value of 10 % represents 10 % of the population of initially operating LED based luminaires fail to produce any luminous flux at Median Useful Life.

The current IEC standards do not describe completely what failure modes of principal components to include in the Abrupt Failure Value (AFV) calculations. Since most of the abrupt failures in practice occur in relation to the LED control gear, LightingEurope recommends specifying the expected control gear failure rate of the device as the AFV indicated for the Median Useful Life of the LED-based luminaire.

3.4 Why lifetime is not always a critical factor

Looking at common practice, lifetime data for LED based luminaires seems to be a race for the highest number of hours belonging to the Median Useful Life $L_{80}B_{50}$. We have to be aware that in the professional market, requirements are specific to the lighting solution within the application and a lighting design needs to be performed.

As input to the lighting design the average installation life is often given, so one could argue the highest number of hours is not a relevant discriminator when selecting a LED based luminaire.

LightingEurope believes that this justifies the question what is the best recommended value for comparing the useful life of LED based luminaires?

1. Fixing of the 'x' (lumen depreciation) from Median Useful Life L_x as a comparison value for different luminaires. In this case the 'time' is not fixed and can have a variation from luminaire to luminaire.

2. Fixing of the 'time' value from Median Useful Life L_x as a comparison value for different luminaires. In this case the 'x' from L_x (lumen depreciation) is not fixed and can have a variation from luminaire to luminaire.

To investigate the importance, the average installation life for different indoor- and outdoor applications have been calculated, based on the annual operating hours and the average time to refurbishment for a product in a specific application.

We also need to be aware that these values may not be realistic in all situations (e.g. in case of the use of automatic lighting controls or application requiring 24/7 illumination).

Indoor applications	Default annual operating hours (EN15193)	Average time to refurbishment	Average installation life
	t_o	years	hours
Offices	2500	20	50.000
Education	2000	25	50.000
Hospitals	5000	10	50.000
Hotels	5000	10	50.000
Restaurants	2500	10	25.000
Sports	4000	25	100.000
Retail	5000	10	50.000
Manufacturing	4000	25	100.000

Table 2 – Possible examples of *average installation life for different indoor applications*

Outdoor applications	Default annual operating hours (EN13201-5)	Average time to refurbishment	Average installation life
	t_o	years	hours
Street	4000	25	100.000
Tunnel (entrance)	4000	25	100.000
Tunnel (interior)	8760	12	100.000
Sport (recreational)	1250	20	25.000
Area	4000	25	100.000

Table 3 - *Possible examples of average installation life for different outdoor applications*

It can be concluded that for products used in the majority of indoor applications the average installation life will not exceed 50.000 hours. For products used in the majority of outdoor applications the average installation life will not exceed 100.000 hours.

LightingEurope believes that ‘number of hours’ should not be a dominant discriminator when selecting LED based luminaires for professional applications. For the lighting design, the maintained luminous flux at the average installation life for a specific application is much more relevant and may support energy saving through the reduction in over-design to account for losses through life.

LightingEurope recommends not to specify or declare lifetime claims exceeding 100.000 hours, unless it is clearly required by specific lighting applications and verified by an appropriate life test period.

To enable apple-to-apple comparison LightingEurope recommends to fix of the ‘time’ value for Median Useful Life to 35k, 50k, 75k and/or 100k and express the ‘x’ from L_x *(lumen depreciation) for time value(s) related to the applications where the product may be used.*

3.5 Maintenance factor consideration in different applications

With LEDs rapidly becoming the new standard in (functional) lighting design for both indoor and outdoor installations, the need has arisen to provide more clarity on how the existing CIE maintenance factor (MF) determination methods can be applied to this technology.

Clarification is needed to prevent unsafe and uncomfortable situations during the lifetime of the installation. Current CIE technical reports describing the MF determination methodology contain detailed explanations with respect to conventional luminaires and light sources, but lack detail to accommodate LED-based lighting designs. However, the core of the CIE methodology - which is based on the same principles for both indoor and outdoor- is still accurate.

ISO/TC 274 is currently developing a Technical Specification that will provide a standardized way of working for determining the maintenance factor for both indoor and outdoor installations using the methodology as described in CIE 154:2003 & CIE 97:2005. Insights from recently published product performance standards such as IEC 62722-2-1, will be combined with the existing determination methodology from CIE technical reports.

By using the overall MF determination methodology and the content on the impact of the environment on luminaires in combination with the product performance metrics, a robust way of working can be established. This will allow for the determination of the maintenance factor of installations including the latest light source technologies. This will create a level playing field with respect to comparison of lighting designs in the market, provide clarity to all involved parties (from end-users to policy makers), and ensure safety and comfort over the lifetime of the installation.

4. LightingEurope recommendations

LightingEurope recommends manufacturers of LED based luminaires publish apple-to-apple comparable product information following the parameters given in 4.1 and as described in IEC 62722-2-1.

4.1 Recommended initial performance values to be provided

1. Input power (*P* in W)
2. Luminous flux (*Φ* in lm)
3. Luminous efficacy (*η* in lm/W)
4. Luminous intensity distribution (in cd or cd/klm)
5. Correlated colour temperature (T_{cp} in K)
6. Colour rendering index (*CRI*)
7. Ambient temperature (t_q) related to performance of the luminaire (in ˚C)

4.2 Recommended over time performance values to be provided

1. Lumen maintenance factor ‘x’ (in %) at the associated median useful life L_x (in hours) (see 3.2)
2. Abrupt failure value (in %) at the same associated median useful life L_x (in hours) (see 3.3)

Lumen maintenance factor groups (buckets) should be introduced to enable initial product comparison. Separate product specific lumen maintenance factor values for input to lighting designs may also be published.

Lumen maintenance factor groups						
Group value	≥70	≥75	≥80	≥85	≥90	≥95
Group range	70-74	75-79	80-84	85-89	90-94	95-100

Table 4 – - *Lumen maintenance factor groups*

LightingEurope recommends the publication of:

1. *Initial performance data set as detailed in 4.1;*
2. *The lumen maintenance factor ‘x’ (in %) at Median Useful Life (L_x) values of 35k, 50k, 75k and/or 100k hours, related to the applications where the product may be used;*
3. *The expected ‘control gear failure rate’ at the same number of hours specified in the Median Useful Life(s).*

Note:

The data and information presented in this guide should not be taken as forming a basis of warranty conditions which are the responsibility of individual manufacturers.

Annex A: Terms, definitions and references

Term	*Definition*	*Standard references*
Rated input power (in W)	**input power** ***P*** electrical power from the mains supply consumed by the luminaire including the operation of all electrical components necessary for its intended functioning Unit : W **rated value** quantitative value for a characteristic of a product for specific operating conditions specified in this standard, or in applicable standards, or assigned by the manufacturer or responsible vendor *Source: IEC 62722-1:2014*	**IEC 62722-1:2014-09;** **IEC 62722-2-1:2014-11:** The provisions of Clause 7 of IEC 62717 apply to the LED luminaire. **IEC 62717:2014-12 — Performance standard for LED modules:** The initial power consumed by each individual LED module in the measured sample shall not exceed the rated power by more than 10%.
Rated luminous flux (in lm)	**luminous flux** ***Φ*v, *Φ*** quantity derived from radiant flux, Φe, by evaluating the radiation according to its action upon the CIE standard photometric observer Unit: lm NOTE 1 For photopic vision $\Phi_v = K_m \int_0^\infty \frac{d\Phi_e(\lambda)}{d\lambda} V(\lambda)\, d\lambda$ where $\frac{d\Phi_e(\lambda)}{d\lambda}$ is the spectral distribution of the radiant flux and *V*(λ) is the spectral luminous efficiency. NOTE 2 For the values of *K*m (photopic vision) and *K'*m (scotopic vision), see IEC 60050-845, 845-01-56. NOTE 3 The luminous flux of LED dies is usually expressed in groups into which they are sorted. *Source*: IEC 62504	**IEC 62722-1:2014-09;** **IEC 62722-2-1:2014-11:** The provisions of 8.1 of IEC 62717 apply to the LED luminaire. In addition the provisions in Clause A.1, paragraph 2 of IEC 62722-2-1 apply where a rated ambient temperature related to performance other than 25 °C is advised by the manufacturer. **IEC 62717:2014-12 — Performance standard for LED modules:** The initial luminous flux of each individual LED module in the measured sample shall not be less than the rated luminous flux by more than 10%.
LED luminaire efficacy (in lm/W)	**Luminaire efficacy** ***η*v, *η*** ratio of the luminaires total luminous flux versus its rated input power at rated supply voltages, excluding any emergency lighting charging power NOTE 1 Luminaire efficacy is expressed in lumen per watt. Unit: $lm .W^{-1}$ *Source: IEC 62722-1:2014*	**IEC 62722-1:2014-09;** **IEC 62722-2-1:2014-11:** The provisions of Clause 8.1 of IEC 62717 apply to the LED luminaire. **IEC 62717:2014-12 — Performance standard for LED modules:** LED module (luminaire) efficacy shall be calculated from the measured initial luminous flux of the individual LED module (luminaire) divided by the measured initial input power of the same individual LED module (luminaire). For measurement of luminous flux see Annex A.3.2.

Term	*Definition*	*Standard references*
Luminous intensity distribution	**luminous intensity** (of a source, in a given direction) ***I_V*; *I*** quotient of the luminous flux dΦ_V leaving the source and propagated in the element of solid angle dΩ containing the given direction, by the element of solid angle $I_V = d\Phi_V/d\Omega$ Unit: cd=lm. sr^{-1} NOTE 1 The definition holds strictly only a point of source. NOTE 2 The luminous intensity of LED is expressed according to CIE 127:2007 measurement procedure. [IEC 60050-845:1987, 845-01-31] and [CIE S 017/E:2011 ILV, 17-739 modified] *Source: IEC 62504:2014*	**IEC 62722-1:2014-09;** **IEC 62722-2-1:2014-11:** The provisions of Clause 8.2.3 of IEC 62717 apply to the LED luminaire. **IEC 62717:2014-12 — Performance standard for LED modules:** The distribution of luminous intensity shall be in accordance with that declared by the manufacturer. The measurement is conducted according to A.3.3.
Correlated Colour Temperature (CCT in K)	**correlated colour temperature** ***T_{cp}*** temperature of the Planckian radiator having the chromaticity nearest the chromaticity associated with the given spectral distribution on a diagram where the (CIE 1931 standard observer based) $u', \frac{2}{3}v'$ coordinates of the Planckian locus and the test stimulus are depicted Unit: K NOTE 1 The concept of correlated colour temperature should not be used if the chromaticity of the test source differs more than $\Delta C = \left[(u'_t - u'_p)^2 + \frac{4}{9}(v'_t - v'_p)^2 \right]^{1/2} = 5 \times 10^{-2}$ from the Planckian radiator, where u'_t, v'_t refer to the test source, u'_p, v'_p to the Planckian radiator. NOTE 2 Correlated colour temperature can be calculated by a simple minimum search computer program that searches for that Planckian temperature that provides the smallest chromaticity difference between the test chromaticity and the Planckian locus, or e.g. by a method recommended by Robertson, A. R. "Computation of correlated colour temperature and distribution temperature", *J. Opt. Soc. Am.* **58**, 1528-1535, 1968. (Note that the values in some of the tables in this reference are not up-to-date). Abbreviation: "**CCT**" *Source: ISO 11664*	**IEC 62722-1:2014-09;** **IEC 62722-2-1:2014-11:** The provisions of Clause 9.2. of IEC 62717 apply to the LED luminaire. **IEC 62717:2014-12 — Performance standard for LED modules:** Preferred values to ensure interchangeability are under consideration. The four-digit CCT value is divided by 100 and the resulting figure is rounded off to the next integer number, when using the photometric code in Annex D.

Term	*Definition*	*Standard references*
Rated Colour Rendering Index (CRI)	**colour rendering index** ***R*** measure of the degree to which the psychophysical colour of an object illuminated by the test illuminant conforms to that of the same object illuminated by the reference illuminant, suitable allowance having been made for the state of chromatic adaptation See also CIE 13 *Method of Measuring and Specifying Colour Rendering of Light Sources* Abbreviation: "**CRI**" *Source: CIE 13*	**IEC 62722-1:2014-09;** **IEC 62722-2-1:2014-11:** The provisions of Clause 9.3. of IEC 62717 apply to the LED luminaire. Where suitable component reliability data is available the test duration may be reduced from 6 000 h to 2 000 h. **IEC 62717:2014-12 — Performance standard for LED modules:** The initial Colour Rendering Index (CRI) of a LED module is measured. A second measurement is made at an operational time as stated in 6.1. (= 6000 h / 25% rated life) *Compliance*: *For all tested items in a sample the measured CRI values shall not have decreased by more than* *- 3 points from the rated CRI value (see Table 1) for initial CRI values and* *- 5 points from the rated CRI value (see Table 1) for maintained CRI values.*
Ambient temperature (t_q) for a luminaire	**temperature, rated ambient performance** (rated ambient performance temperature) t_q highest ambient temperature around the luminaire related to a rated performance of the luminaire under normal operating conditions, both as declared by the manufacturer or responsible vendor Unit: °C NOTE 1 Rated ambient performance temperature is expressed in °C. NOTE 2 For a given life time, the t_q temperature is a fixed value, not a variable. NOTE 3 There can be more than one t_q temperature, depending on the life time data, .3.4. *Source: IEC 62722-2-1:2014* NOTE 4 Measurement: According EN 60598-1 Annex D and K	**IEC 62722-1:2014-09;** **IEC 62722-2-1:2014-11:** **General** The provisions of Subclause A.1 of IEC 62717 apply to the LED luminaire. Where a rated ambient performance temperature tq 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.
Useful life (of LED modules and Luminaires	**useful life (of LED modules)** L_xB_y length of time until a percentage *y* of a population of operating LED modules of the same type have parametrically failed to provide at least percentage *x* of the initial luminous flux Note 1 The useful life includes operating LED modules only. *Source: 34A/1864/DC – planned as a second amendment to IEC 62717*	**IEC 62722-1:2014-09;** **IEC 62722-2-1:2014-11:** **General** The provisions of 10.1 of IEC 62717 apply to the LED luminaire. The length of time until a percentage *y* of a population of operating LED modules reaches gradual light output degradation of a percentage *x* is called the useful life (or "*B*y life") and expressed in general as L_xB_y. Light output lower than the lumen maintenance factor *x* is called a parametric failure because the product produces less light but still operates. "B_{10}" life is the age at which 10 % of products have failed parametrically. The age at which 50 % of the LED modules parametric fail, the "B_{50} life", is called median

Term	*Definition*	*Standard references*
		useful life. The population includes operating LED modules only; non-operative modules are excluded.
Median useful life (of LED modules and Luminaires)	**median useful life (of LED modules)** ***L_x*** length of time during which 50 % (B_{50}) of a population of operating LED modules of the same type have parametrically failed to provide at least percentage *x* of the initial luminous flux Note The median useful life includes operating LED modules only. Note In common language the expression "life of LED modules" without any modifiers is understood to mean the median useful life. [SOURCE: IEC 60050-845:1987, 845-07-61, modified – new definition] *Source: 34A/1864/DC – planned as a second amendment to IEC 62717*	**IEC 62722-1:2014-09;** **IEC 62722-2-1:2014-11:** **General** The provisions of 10.1 of IEC 62717 apply to the LED luminaire. The length of time until a percentage *y* of a population of operating LED modules reaches gradual light output degradation of a percentage *x* is called the useful life (or "*B*y life") and expressed in general as L_xB_y. Light output lower than the lumen maintenance factor *x* is called a parametric failure because the product produces less light but still operates. "B_{10}" life is the age at which 10 % of products have failed parametrically. The age at which 50 % of the LED modules parametric fail, the "B_{50} life", is called median useful life. The population includes operating LED modules only; non-operative modules are excluded.
Abrupt failure fraction of LED-module and LED-Luminaire	**abrupt failure** failure of a LED product to operate or to produce luminous flux NOTE 1 For the purpose of this standard, the LED product is a LED module NOTE 2 The term "complete Failure" is commonly used for the same purpose. *Source: IEC 62717:2014*	**IEC 62717:2014** **Life time specification for abrupt light output degradation:** The abrupt light output degradation of a population of LED Luminaires at a certain point in time is called time to abrupt failure and expressed as C_y. The recommended life time metrics for specifying LED module life is explained in Annex C of IEC 62717 and appley to the LED luminaire. For compliance criteria see 10.2 of the standard.
Time to abrupt failure of LED-module and LED-Luminaire	**time to abrupt failure** ***C_y*** length of time during which y % of a population of initially operating LED modules of the same type fail to produce any luminous flux Unit: h NOTE 1 The time to abrupt failure includes inoperative LED modules only. NOTE 2 $C_{AFV} = L_x$. *Source: IEC 62717:2014*	**IEC 62717:2014** **Life time specification for abrupt light output degradation:** The abrupt light output degradation of a population of LED Luminaires at a certain point in time is called time to abrupt failure and expressed as C_y. The recommended life time metrics for specifying LED module life is explained in Annex C of IEC 62717 and appley to the LED luminaire. For compliance criteria see 10.2 of the standard.
Abrupt failure value, corresponding to the median useful file of LED modules and luminaires	**abrupt failure value** ***AFV*** percentile of LED modules failing to operate at median useful life, L_x Note $AFV = F(L_x) \times 100$ %; $LSF(L_x) = 1 – F(L_x)$ Note Example: Given L_x=20 000 h and *AFV* = *F*(20 000 h) × 100 % = 7 % results in *LSF*(20 000 h) = 1 – 0,07 = 0,93. *Source: IEC 62717:2014*	**IEC 62717:2014** **Life time specification for abrupt light output degradation:** The abrupt light output degradation of a population of LED Luminaires at a certain point in time is called time to abrupt failure and expressed as C_y. The recommended life time metrics for specifying LED module life is explained in Annex C of IEC 62717 and appley to the LED luminaire. For compliance criteria see 10.2 of the standard.

Annex B: Application requirements from EN standards

Tables B1 and B2 show application requirements as specified in European EN standards. Country specific national standards may have additional requirements, for example the use of the colour rendering or colour temperature in road lighting applications. In addition, for specialist sports lighting applications additional requirements may be specified by the sport's governing bodies.

Note: red boxes indicate stated requirements whilst cream boxes indicate implied requirements.

Requirements linked to the product	EN 12464-1	EN 12464-2	EN 12193	EN 1837	EN 13201-2	EN 15193	EN 1838
Colour rendering (Ra)	red	red	red				red
Colour temperature (CCT)	red		cream				
Flicker / stroboscopic effects (no metric)	cream	cream		cream			red
Luminaire emergency lighting charging power						red	
Luminaire parasitic power						red	
Luminaire power						red	
Luminaire intensity		cream	cream				red
Luminance limits for DSE	red						
Luminance of facade / sign		cream					red
Maintenance factor (*this by default includes lifetime*)	cream	cream	cream	cream	cream	cream	cream
Shielding angles	cream						
Television lighting consistency index			red	*prEN 12193*			
Illuminance after 5s (switch to batteries)							red
Illuminance after 60s (switch to batteries)							red
UGR	red						
Upward light ratio		cream	cream				

Table B.1 - *Key requirements linked to products*

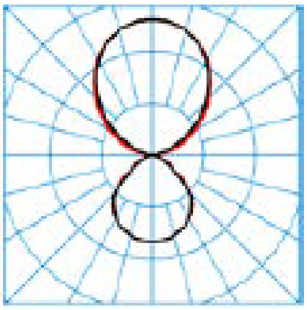
Requirements linked to the lighting design	EN 12464-1	EN 12464-2	EN 12193	EN 1837	EN 13201-2	EN 15193	EN 1838
Diversity (min/max)	red	red	red		red		red
Diversity (camera, min/max)			cream				
Edge illuminance ratio					red		
Flicker / stroboscopic effects (no metric)	cream	cream		cream			red
Glare rating (GR)		red					
Hemispherical illuminance					red		
Horizontal to vertical illuminance ratio			red				
Horizontal to vertical illuminance ratio (camera)			cream				
Illuminance on the background area	red						
Illuminance on the immediate surroundings	red	red		red			
Illuminance on surfaces	cream		red		red		red
Illuminance on the task area	red	red		red			
Luminance (average)					red		
Maintenance factor (*this by default includes lifetime*)	cream	cream	cream	cream	cream	cream	cream
Mean cylindrical illuminance	cream						
Modelling index	cream						
Semi-cylindrical illuminance					red		
Threshold Increment		cream	cream		red		
UGR	red						
Uniformity (min/avg)	red	red		red	red		
Upward light ratio		cream	cream				
Vertical illuminance		cream	cream		red		
Vertical illuminance (camera)			cream				
Vertical illuminance uniformity (min/max)			red				
Vertical illuminance uniformity (camera, min/max)			cream				
Vertical illuminance on properties		cream	cream				

Table B.2 - *Key requirements linked to lighting applications*

Annex C EXAMPLE DATA SHEET – LED LUMINAIRE PERFORMANCE DATA

This example reflects the LED performance data that would be expected to be provided by luminaire manufacturers. They should be part of the data sheet of an LED-luminaire. The complete content and the volume of information of a luminaire data sheet and its style will vary depending on the 'house style' of the manufacturer and type/application of the particular luminaire. To allow direct comparison between manufacturers data is normally provided based on t_q = 25°C. Data sets for other values of t_q may be provided (e.g. for special applications) at the discretion of the manufacturer.

Product data sheet xxxxxxxx 0000 xxx 01



Ambient temperature of luminaire (t_q)	25°C	40°C
Input power	48W	48W
Luminous flux	6000 lm	5600 lm
Luminous efficacy	125 lm/W	116 lm/W
Correlated colour temperature (CCT)	3000 K	3000 K
Colour rendering index (CRI)	≥80	≥80
Rated median useful life Lx (h) and the associated rated lumen maintenance factor (x)	L_{85}: 35,000 hrs L_{80}: 50,000 hrs	L_{80}: 35,000 hrs L_{75}: 50,000 hrs
Abrupt failure value (%) at Median useful life	5% @ 35,000 hrs 10% @ 50,000 hrs	10% @ 35,000 hrs 15% @ 50,000 hrs