PHILIPS

LED Luminaires

White paper

Evaluating performance of LED based luminaires

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1. Why standardization of performance requirements for LED luminaires is important?

There has been a significant increase in the use of LED based luminaires in recent years. The absence of universal standards available to measure or compare the performance of LED based lighting products has created a lot of confusion among customers about which LED products to choose.

In this regard, the main challenge for the professional market is to improve the way users of LED based luminaires evaluate the performance claims of different LED luminaire manufacturers when preparing lighting projects or tender specifications.

To start with, our recommended approach when evaluating performance claims from different manufacturers is the following:
1. Apply a standardized set of quality criteria for comparison;
2. Only evaluate products that have been measured in compliance with appropriate IEC standards (January 2018, Evaluating performance of LED based luminaires).

This approach will allow you to judge comparison claims on an equal, like-for-like basis – apples with apples, so to speak, rather than apples with pears.

In this paper, we would like to bring more light to some of the critical values and expressions used in discussions relating to lifetime and performance related data. Among others we will cover initial and over time performance, useful life and abrupt failure.

1.1 Performance criteria as defined by the International Electrotechnical Commission (IEC)

Both "initial" and "over time" performance must be evaluated to have confidence in how LED based luminaires will perform and how long they will sustain their rated characteristics over their years of operation. The initial product specifications will typically be **measured**, whereas performance over time will be **calculated** using the IEC lifetime metric for LED based lighting products.

In line with the recommended approach and guidance given by IEC, initial performance specifications for all for all LED based Philips professional lighting luminaires are measured in compliance with the appropriate IEC performance standards:

1. Initial rated input power (in W)
2. Initial rated luminous system flux (in lm)
3. Initial LED luminaire efficacy (in lm/W)
4. Luminous intensity distribution
5. Initial Correlated Color Temperature (CCT) in K
6. Initial rated Color Rendering Index (CRI)
7. Initial rated chromaticity co-ordinate value and expected tolerance (x,y) < x SDCM

Initial specifications of all LED based luminaires are specified at an performance ambient temperature Tq of 25^{0}C (depending application performance data at additional Tq can be published).

1.2 Over time performance criteria as defined by the International Electrotechnical Commission (IEC)

There are two relevant 'over time' performance values to be considered related to the output degradation of a LED based luminaires:

Gradual luminous flux degradation relates to the lumen maintenance of a luminaire over time. 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.

Abrupt luminous flux 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. The IEC lifetime metric for LED based luminaires specifies Useful Life and Time to Abrupt Failure.

2. Useful Life and Median Useful Life

The gradual light output degradation of a population of LED based lighting products at a certain point in time is called useful life and is generally expressed as LxBy. Useful life describes the lumen maintenance of an LED based luminaire over time. To compare lifetime data unambiguously, IEC introduced Median Useful Life (Lx). Median Useful Life is the time at which 50% (B50) of a population of LED based luminaires are flux degraded.

For example, Median Useful Life L90 is understood as the length of time during which 50% (B50) of a population of operating LED based luminaires of the same type have flux degraded to less than 90% (L90) of their initial, luminous flux but are still operating.

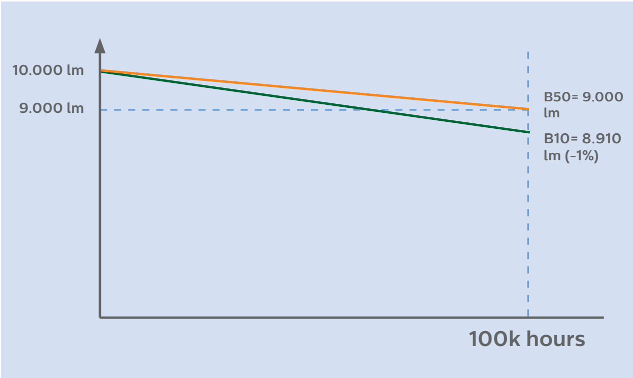

Figure 1 – Product data analysis of an example of a LED based luminaire

What this means in practice, for the L90 example at 100,000 hours, is that an initial luminous flux of 10,000 lumen will be 9,000 lumen in the case of B50. If the same luminaire is rated as B10, 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 typical tolerances of up to 10%, this practical differential can be regarded as negligible.

2.1 Abrupt failure value

Another important parameter to be considered in regard to expected long life is system reliability. In short, a LED based luminaire will last as long as the component used with the shortest life. Below is the list of the most critical components of a LED based luminaire that influence system reliability.

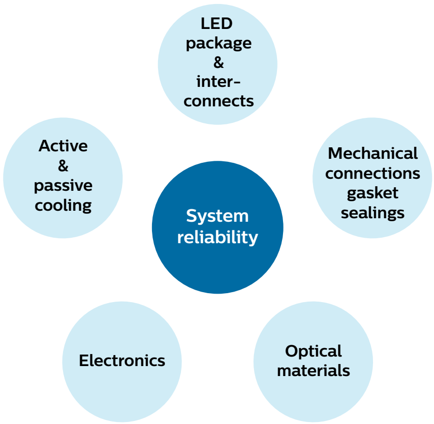

Figure 2 – Critical components LED based luminaire

Degradation of optical material may cause luminous flux to reduce rather than abruptly degrade. Failure of one of the remaining principal components generally leads to complete failure of the LED based luminaire. This is not taken into account in the rated Median Useful Life. Consequently, abrupt failures should be considered separately during lighting engineering and planning. This is why the IEC lifetime metric also specifies time to abrupt failure, as this 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 time is called Time to Abrupt Failure and is generally expressed as Cy. It expresses the age at which a given percentage (y) of LED based luminaires have failed abruptly.

What we publish on performance over time

The 'over time' performance specifications of Philips LED based luminaires are calculated using the IEC lifetime metric for LED based lighting products and in accordance with the LightingEurope guidance paper on "Evaluating performance of LED based luminaires". Over time life claims are specified at a performance ambient temperature Tq of 25°C.

For **indoor** LED based luminaires we will publish two IEC-compliant quality criteria:

1. Lumen maintenance at median useful life:
   - for all products at 50k hours
   - for Industry products in addition also at 100k hours
2. Control gear abrupt failure rate (%) at median useful life.

For **outdoor** LED based luminaires we will publish two IEC-compliant quality criteria:

1. Lumen maintenance at median useful life:
   - for most products at 100k hours
   - depending application (e.g. sports) for some products a lower number of hours (35k, 50k or 75k hours) is published
2. Control gear abrupt failure rate (%) at median useful life.

3. Why lifetime is not always a critical factor

In actual practice, lifetime data for LED based luminaires is often a race for the highest number of hours for the Median Useful Life L80B50. 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. The input is often the average installation life, which suggests that the highest number of hours is not a relevant discriminator when selecting a LED based luminaire. To investigate this further, we've calculated the average installation life for different indoor and outdoor applications, based on the annual operating hours and the average time to refurbishment for a product in a specific application. It should be noted that these values may not be realistic in every situation. An example would be 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 1 – 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 2 – Possible examples of average installation life for different outdoor applications

In short, for products used in most indoor applications, the average installation life will not exceed 50,000 hours. For products used in most outdoor applications, the average installation life will not exceed 100,000 hours. Moreover, we believe 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. In accordance with the LightingEurope guidance paper, we recommend 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, the "time" value for Median Useful Life to 35K, 50K, 75K and/or 100K should be fixed and the "x" from Lx (lumen depreciation) expressed for time value(s) related to the applications where the product may be used. We publish this Lx:
- on a product family level: (up to) Lx
- on specific product level: Lx

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