Life Expectancy of LED Modules

LED SYSTEMS FOR LIGHTING

Guideline for determining the life expectancy of LED modules

Contents

1. Introduction

In February 2003, the Zentralverband der Elektrotechnik- und Elektronikindustrie e.V. (the German electrical and electronic manufacturers' association) published a report on the subject of the life expectancies of LED modules [1].
This paper is based mainly on work conducted by OSRAM GmbH and OSRAM Opto Semiconductors GmbH. It therefore provides the basis for this application paper. The information which follows refers specifically to the LED modules of OSRAM GmbH.

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2. Test conditions during the qualification of LED modules

During the process of developing a new LED and LED module, extensive tests are undertaken for the qualification of the products. In this respect the development process at OSRAM GmbH and OSRAM Opto Semiconductors GmbH differs to other manufacturers of LED modules who do not have extensive systems of quality assurance.

The qualification of new LED chips, new packages and LED modules involves for example the following tests:

• Operation in 85% humidity and 85°C ambient temperature for 1000 h (temperature & humidity bias – T& HB)

• Operation at minimum and maximum temperatures (- 40° and 85°C) for 5 mins each for 1000 h operation (power temp cycling - PTC)

• Light flux degradation at maximum ambient temperatures (steady state life test – SSLT)

and a whole range of other tests. Only when these tests have been passed successfully products such as LED or LED modules are released for production and sale to customers. OSRAM Opto Semiconductors GmbH and OSRAM GmbH would be pleased to give you further details on these tests.

3. Interpretation of the limits in the data sheets for the LED modules

The data sheets for the LED modules include not only limits as e.g. supply voltage but temperature limits as well:

a) Storage temperatures

The storage temperature limits were introduced in order to define material-related limits for the ambient temperature during storage of the LED modules. These limits also apply when an LED module is fitted to a luminaire which is exposed to a high thermal load, e.g. from sunlight, even when not switched on.

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b) Operating temperature at the Tc point

The limits for the Tc point apply to the LED module when switched on.
We recommend that the operating temperature should be tested in all new designs. These measurements can be used to determine the loads to which LED modules in temperature-critical applications are exposed.
When the temperature limits are exceeded the LED may reach a state at which the temperature limits of the LED (package, chip, potting materials) are reached.

4. Determination of the life expectancy of LED modules

With the increasing use of LED in applications with longer service lives such as in lighting systems and in light advertising, the way in which the technical light-related data change during the service life becomes extremely important for customers. LED solutions are equated with long life expectancies and our customers rightly expect clear answers on this issue.
In recent years OSRAM Opto Semiconductors GmbH has undertaken extensive life expectancy tests and we can now give you the first results in the form of concrete data. The data base will be continuously expanded. This refers to blue and green LED in particular.

The life expectancy data are based on the following principles:

4.1 Life expectancy of LED modules as defined by the LED dictionary of the ZVEI

Life expectancy ***T50*** This gives the time elapsed before the measured photometric parameters fall below 50% of the original value at zero hours, subject to the value of *Tc*. Measurement unit: h

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The 50% value is the standard value used in the semiconductor industry. With the increasing use of LED for applications with standardized illumination conditions, there will be increasing demand in the future for values at 70% (outdoor lighting) and 80% (indoor lighting). We keep this in mind and we will update the application note in the future.

4.2 Measurement methods for determing life expectancies

The life expectancy of an LED solution is strongly dependent on the temperature inside the luminaire during operation. As a consequence, information on life expectancy can only be given if the luminaire-related temperature influences on the LED solution integrated in the luminaire have been determined beforehand. Depending on the design of the luminaire, cooling or thermal isolation may be the result.

4.3 Measurement of the temperature at the reference measurement point

Before the life expectancy of an LED module in a luminaire can be calculated, the temperature at the reference measurement point of the LED module must be measured. All our data sheets for our LED modules include reference measurement points in the drawings. The diagram shows the position of the measurement point on the LINEARlight LM01A.

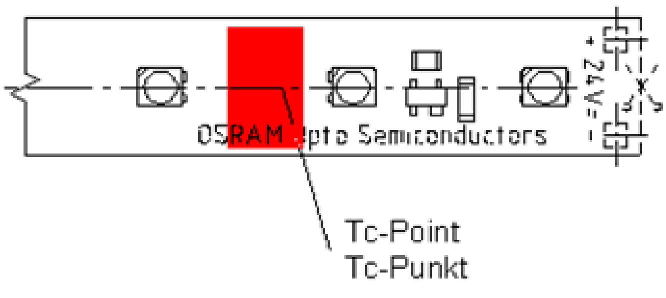

Fig. 1 LINEARlight with Tc-point indicated

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4.4 Selection of temperature sensors

Temperature sensors should cause minimum heat discharge from the measurement point. In the EN 60598 part 1 sensors and the use of them are described. Convenient sensors are thermoelements and irreversible, temperature-sensitive adhesive strips (e.g. ML4C from OMEGA).

4.5 Ambient temperature of the luminaire

First the temperature sensor has to be attached at the Tc point of the LED module while fitted to the luminaire.
Luminaires for indoor use are then stabilized at an ambient temperature of 25°C. Any deviations to the situation, when the LED luminaire is used in practice and which are known in advance should be taken into account.
For outdoor use it must be assumed that the ambient temperature will fluctuate considerably, with major variations depending on regional location. Reference should be made to regional weather maps for details.

4.6 Measurement of the temperature at Tc and derivation of the life expectancy

In [1] the measurement conditions and measurement methods are explained with illustration of a concrete example. No further explanation is therefore given here.
The temperature measurements provide a concrete temperature at the measurement point. To translate this into a clear indication of the life expectancy, a correlation is required between the measured temperature and the life expectancies specified by us for two measurement points.
For this you will find the life expectancy information for all key LED modules presented in table form for two measurement points in the Appendix.

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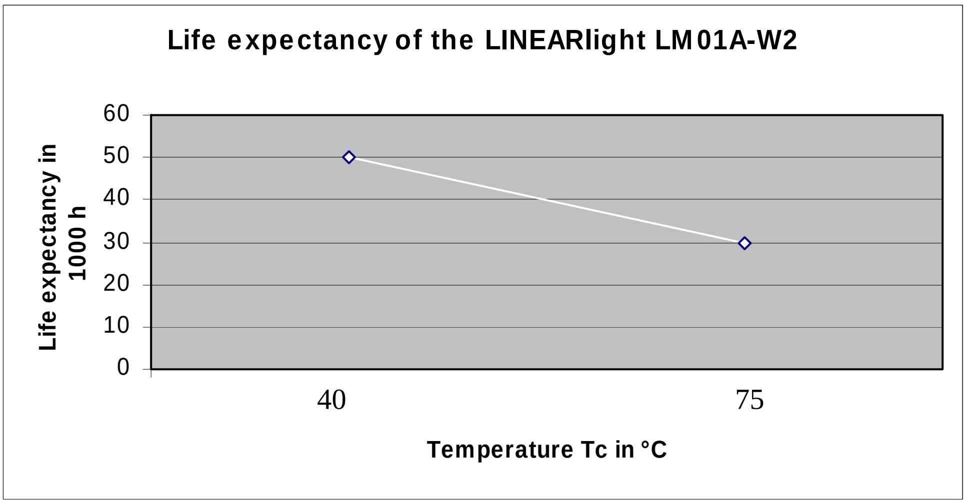

Fig. 2 Life expectancy of the LINEARlight LM01A-W2 in dependency on the temperature at the Tc

Notes on interpretation of the table and determination of intermediate values:

- Intermediate values of sufficient accuracy can be determined with a linear interpolation between the two measurement points. The temperature difference between the ambient temperature during measurement and during the later use of your luminaire should be added to/subtracted from the measured temperature at the Tc beforehand.
- In case the measured temperature is outside the data range, the extrapolation of the data does not provide sufficient accuracy. In this case you should seek additional information from OSRAM GmbH through your OSRAM representative.
- The life expectancy data were given for data up to 50,000 hours. In our opinion this represents the life expectancy of a luminaire under normal conditions of use. With the data limited to 50,000 h, both measurement points produced life expectancies for the colors yellow, orange, red and super red of ≥ 50,000 h.
- If the service life of your application should be well in excess of 50,000 h, please request further information from us.

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5. Thermomanagement of LED modules based on the High-Flux LED Golden DRAGON ®

In principle the method for the modules based on the High-Flux LED Golden DRAGON®
is the same as described so far. However the higher wattage of the LED leads to a concentration of heat, which has to be dissipated to the ambient air by means of suitable metallic
heat sinks. Without this the LED‘s life expectancy will be inevitably reduced, or the LED may even be permanently damaged. Unlike the PowerTOPLED® which is used on our LINEARlight, BACKlight and LINEARlight Flex, for example, the LED Golden DRAGON® has a solid, built-in heat sink, which is thermically connected to a suitable substrate during soldering.

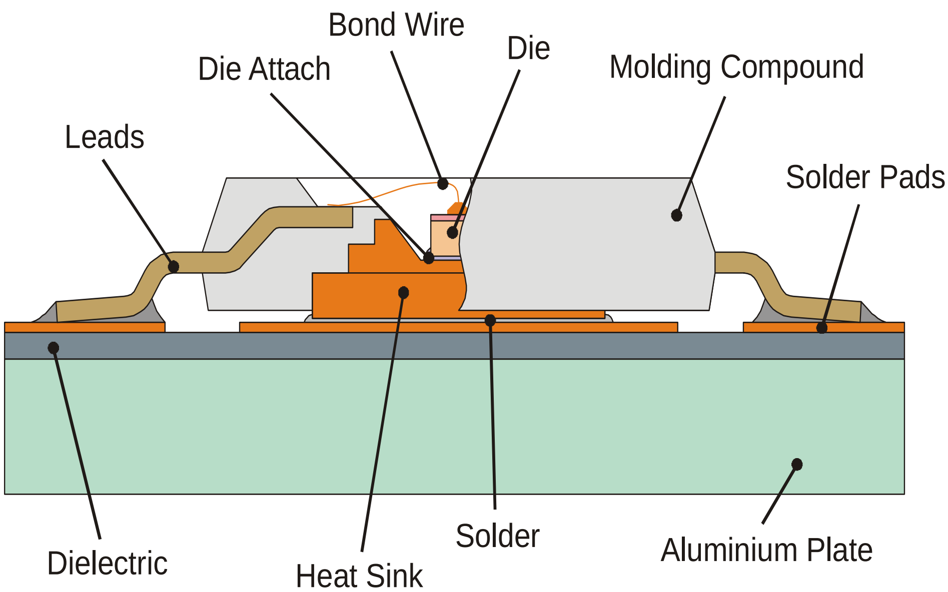

Fig. 3 Cross section of a Golden DRAGON® LED

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Of critical importance for heat dissipation are the thermal resistance R_{th} between the LED chip and the heat sink of the LED Golden DRAGON®, the resistance of the PCB substrate and the thermal resistance then over the structural elements of the luminaire to ambient air. The poorer the thermal resistance of the individual components, the poorer is the heat dissipation from the LED chip. The thermal resistance of the LED is defined by the manufacturer of the LED. The thermal resistance of the substrate technology and a part of the cooling system is defined by the material selected by the manufacturer of the LED module.
The user of an LED module can only influence the thermal resistance $R_{th\ BA}$ between the LED module and the ambient air. For further information about the Golden DRAGON® LED, please refer to the application note "Thermal Management of Golden DRAGON®" at the OSRAM Opto Semiconductors GmbH web site at http://www.osram-os.com.

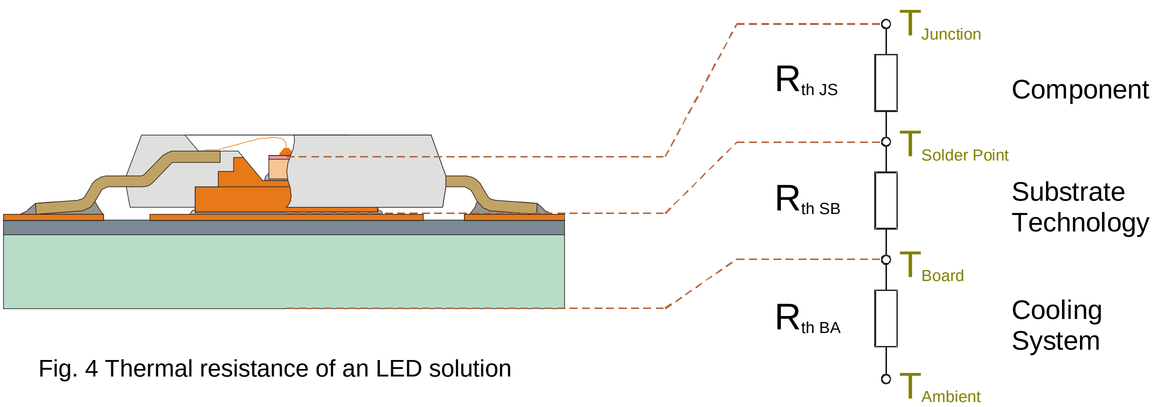

Fig. 4 Thermal resistance of an LED solution

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The manufacturer of the luminaire is responsible for ensuring an adequate heat transfer between the LED module and the ambient air via the luminaire by designing the luminaire accordingly. For the initial design calculations of the required cooling surfaces for the white, blue and green LED Golden DRAGON®, the chart in figure 5 can be used. For the red and yellow LED a cooling surface of 7 cm² is sufficent, regardless of the target life expectancy. Once the desired life expectancy has been selected, the chart can be used to determine the required cooling surface. Of course the guideline in figure 5 is only valid when the LED module is driven according to the data-sheet.

The following points should be taken into account when using the chart:

1. The curve relates to a single LED only. Where more than one LED is used in the module, the cooling surface size has to be multiplied by the number of LED.

2. The base material used was bare aluminium with a thickness of 2 mm. The determined cooling area must be available for free convection on both sides. As an example, if a cooling surface of 18 cm² was determined for a white Golden DRAGON® LED with a life expectancy of 30,000 hours, the total cooling surface available for convection must be 18 cm².

3. A greater material thickness and a metal with a higher coefficient of thermal conductivity improves the heat distribution in the heat sink resulting in an improved heat transfer from the LED to the peripheral areas of the heat sink. The temperature of the active layer in the LED decreases, resulting in a longer life expectancy.

4. Coatings generally lead to improved heat dissipation.

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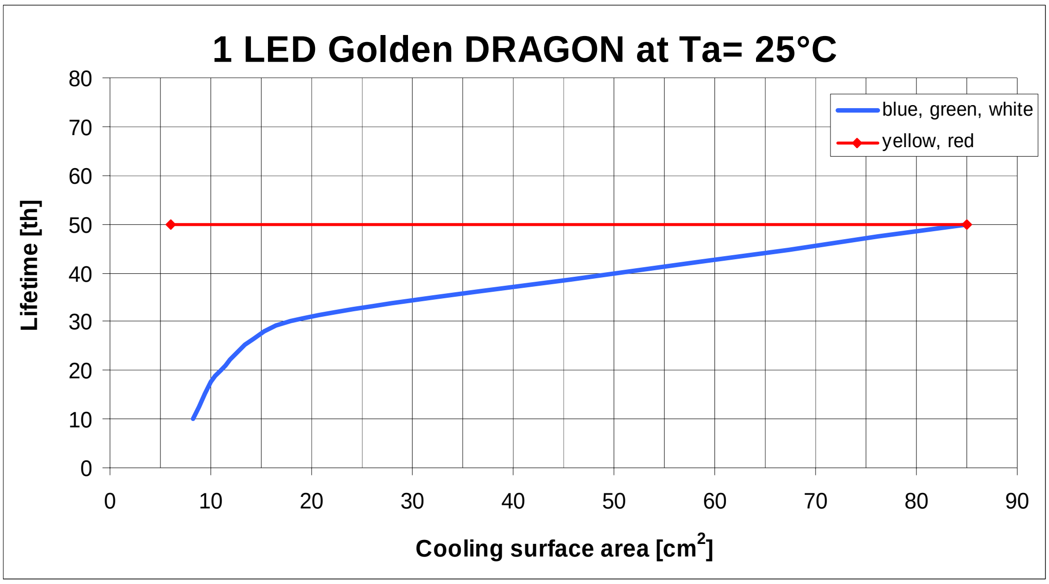

Fig. 5 Design calculations for the cooling surfaces for 1 Golden DRAGON® LED in white, blue or green

Final certainty about the life expectancy, however, only comes with the measurement of the temperature at the Tc point in the luminaire prototypes.
The method of measurement for the LED modules based on Golden DRAGON® LED is the same as described in section 4. The positions of the Tc points are indicated in the data sheets for the modules (http://www.osram.com).
The precise life expectancy data are given in the table on page 13.
The life expectancy values for the red and yellow LED were limited to 50,000 hours.

The data will be revised in late 2005.

Further references:

[1] Methods for determining the life expectancy of LED modules in luminaires
http://www.zvei.org/Publikationen Electric Lamps Division
[2] Thermal Management of Golden DRAGON® http://www.osram-os.com
[3] Data sheets of the LED modules http://www.osram.com/products/led-systems/
[4] Data sheets of OPTOTRONIC® http://www.osram.com

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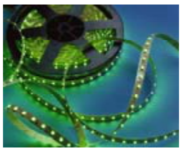
Attachment

Modules		Life expectancy in 1000 h at Tc = 40°C	Life expectancy in 1000 h at Tc = 75°C
LINEARlight 	LM01A-A1	>50	50
	LM01A-B1	in preparation	in preparation
	LM01A-T2	in preparation	in preparation
	LM01A-O1	> 50	50
	LM01A-S1	> 50	50
	LM01A-W2-865	50	30
	LM01A-W2-854	50	30
	LM01A-W2-847	50	30
	LM01A-Y1	> 50	50
LINEARlight Flex TOPLED 	LM10A-A1	> 50	50
	LM10A-B1	in preparation	in preparation
	LM10A-T1	in preparation	in preparation
	LM10A-W2-865		
	LM10A-W2-854		
	LM10A-W2-847	50	30
	LM10A-Y1	> 50	50
LINEARlight Flex SIDELED 	LM11A-A	> 50	50
	LM11A-B	in preparation	in preparation
	LM11A-T	in preparation	in preparation
	LM11A-Y1	> 50	50

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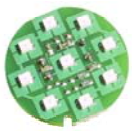
Modules		Life expectancy in 1000 h at Tc = 40°C	Life expectancy in 1000 h at Tc = 75°C
BACKlight 	LM03A-S1	> 50	50
	LM03A-A	> 50	50
	LM03A-Y1	> 50	50
	LM03A-O1	> 50	50
	LM03A-B1	in preparation	in preparation
	LM03A-T2	in preparation	in preparation
	LM03A-W2-865		
	LM03A-W2-854	50	30
EFFECTlight 	OS-WL01A-A1	> 50	50
	OS-WL01A-Y1	> 50	50
	OS-WL01A-V1	in preparation	in preparation
	OS-WL01A-B1	in preparation	in preparation
COINlight 	OS-CM01E-A1	> 50	50
	OS-CM01E-W2-854	50	30
	OS-CM01E-B1	in preparation	in preparation
	OS-CM01E-T1	in preparation	in preparation
	OS-CM01E-Y1	> 50	50

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Modules		Life expectancy in 1000 h at Tc = 40°C	Life expectany in 1000 h at Tc = 80°C
DRAGONtape®	DT6-A1	>50	>50
	DT6-B1	50	15
	DT6-V1	50	15
	DT6-W2-847	50	15
	DT6-W2-854	50	15
	DT6-W2-865	50	15
	DT6-Y1	> 50	> 50
DRAGONpuck®	DP3-A1	>50	>50
	DP3-B1	50	15
	DP3-V1	50	15
	DP3-W2-847	50	15
	DP3-W2-854	50	15
	DP3-W2-865	50	15
	DP3-Y1	> 50	> 50