LED & LUMINAIRE LIFETIME

Dextra
GROUP PLC

When purchasing an LED luminaire customers understandably need to know the lifetime that the product will provide, both to understand maintenance and replacement schedules and also to ensure that they are purchasing a high quality product that will provide state of the art life expectancy. Accurately estimating luminaire lifetime requires consideration for several factors which are outlined in this article.

LED Lifetime, LM80, LM79 & TM21

LM80 and TM21 are commonly used by luminaire manufacturers to provide estimates for the lumen depreciation of LEDs over their lifetime, the following is a brief guide to these standards and how to interpret the data that is published:

LED Manufacturers undertake LM80 testing on their LEDs to establish the lumen depreciation of the LEDs over a specified test period. A batch of LEDs are tested in controlled conditions and the lumen output measured periodically to determine the rate of depreciation. LM80 tests must be undertaken for a minimum of 6,000 hours but can be extended further if the manufacturer desires.

TM21 is the accepted standard for extrapolating LED lifetime from LM80 test data. The majority of high quality chips on the market will have LM80 test data available to a minimum of 6,000 hours, and in many cases longer test periods have been performed. Few manufacturers however test further than 15,000 hours due to the high cost and time required for testing. TM21 provides formula to extrapolate lumen depreciation over lifetime for no more than six times the LM80 test duration, 6,000 hours of LM80 test data would therefore allow a TM21 lifetime extrapolation up to 36,000 hours.

At Dextra Group our supplier has provided 10,000 hours of test data for our LEDs and we therefore provide TM21 lifetime extrapolations to 60,000 hours. Whilst lifetime can be theoretically estimated beyond six times the LM80 test hours, any such extrapolations are not valid TM21 statements and should be viewed with caution. It is always sensible to challenge luminaire manufacturers to provide their LM80 test data, especially where lifetime extrapolations exceed six times the typical length of LM80 test periods undertaken by LED manufacturers.

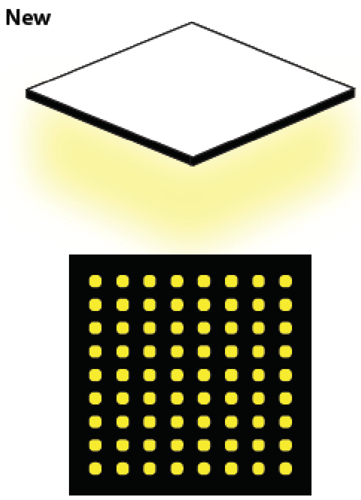
LM79 is a similar test to LM80 however it is undertaken at the luminaire level rather than chip level. A complete luminaire is tested under controlled conditions and the lumen output is measured periodically to determine the rate of depreciation. In reality such testing is rarely undertaken given it would be impractical to undertake such lengthy testing on the wide range of luminaire types available on the market. It is generally deemed to be acceptable to base luminaire lumen depreciation estimates on the LED LM80 testing and TM21 lifetime extrapolation. Luminaire manufacturers design their luminaires to ensure that the LEDs will not operate in excess of the temperatures and currents used during the LED LM80 test, allowing them to have confidence that the luminaire will offer similar depreciation to that published by the LED manufacturer.

TM21 LED lifetimes are then published with L, B and F values as follows:

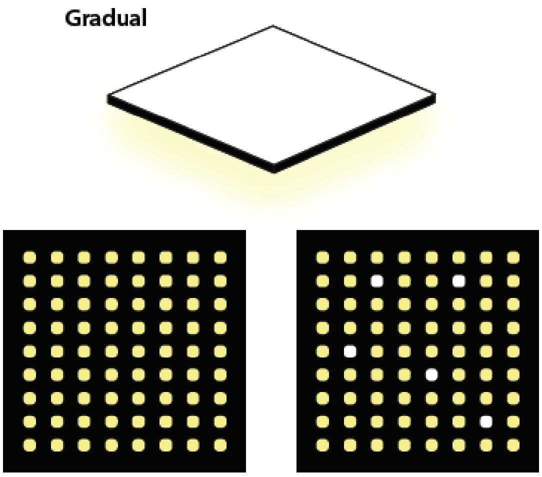
- The L value stipulates the lumen maintenance of the LED.
- The B value stipulates the percentage of LEDs which will not meet the published rate of lumen maintenance, this must be B50 for a valid TM21 lifetime extrapolation as TM21 is based on an average lumen depreciation.
- The F value stipulates the percentage of chips that will fail completely.
- The above values are then specified to the operating hours.
- For example L90 / B50 / F10 at 60,000 hours means that the LEDs will maintain 90% of their light output, 50% of the LEDs will have depreciated by more than the L value and 50% will have depreciated by less than the L value and 10% of the LEDs will have failed at 60,000 operating hours.

Of these the B value is most commonly misunderstood and is often incorrectly interpreted as an LED failure as the lumen depreciation exceeds the published rate. During LM80 testing the average lumen depreciation of the tested batch of LEDs is measured and a valid TM21 lifetime extrapolation requires that the lifetime extrapolation is based on an average lumen depreciation measurement.

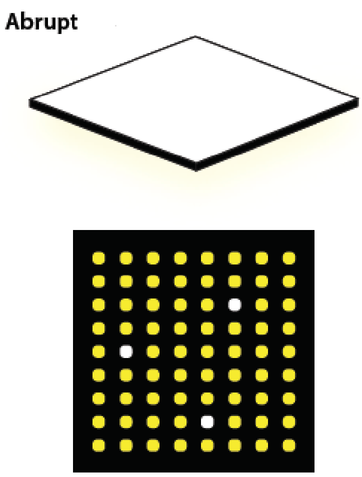
Any valid TM21 lifetime statement must therefore use B50, this simply means that an average lumen depreciation value has been taken from the LEDs tested during the LM80 process. The L value for lumen maintenance will always be attained despite 50% of the LEDs performing marginally under and 50% performing marginally over the L value.



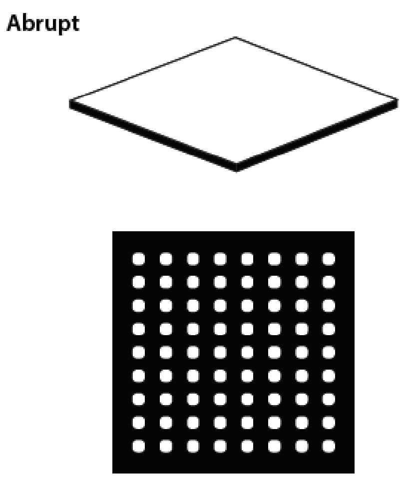
LED luminaire 100%



Light deviation of LEDs



Abrupt failure of individual LEDs

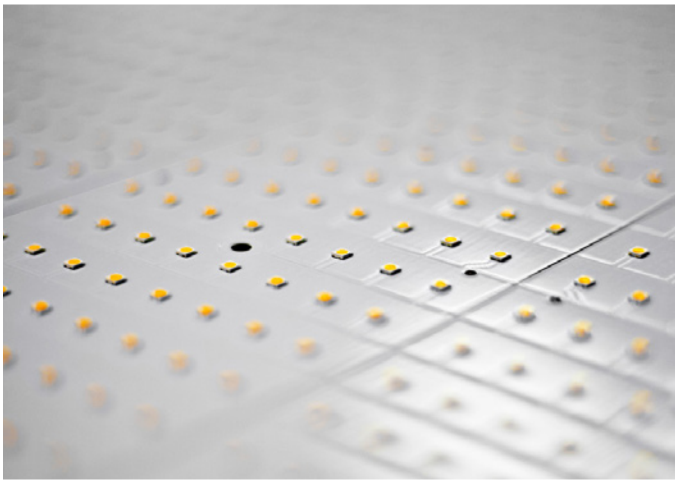


Abrupt failure of LED luminaire

Driver Lifetime

The driver is the other key electrical component when it comes to determining product lifetime. Driver lifetime is typically published in operating hours to a percentage failure rate. Many drivers on the market operate to 50,000 hours lifetime to 10% failure rate, however premium drivers from respected brands are now commonly offering 100,000 hours to 10% failure rate. It is also important to note that many of the lower cost drivers, especially those for far eastern and domestic markets may offer substantially lower lifetimes. At Dextra we only use drivers with 100,000 hour rated lifetimes.

Operating temperature is key to achieving the rated driver lifetime, a small increase in temperature above the drivers maximum rating may substantially reduce lifetime, conversely a small reduction in the operating temperature of the driver will significantly extend lifetime. For this reason it is important to both understand the peak ambient temperatures of your installation, and also consider the inclusion of controls in your lighting installation. The use of presence detection and daylight regulation controls will not only provide substantial reductions in operating costs through energy savings, but will also extend product lifetime by dimming or switching the luminaire during periods of absence or when daylight contribution is high therefore reducing the operating temperature and extending product lifetime.



LED Circuit Design

The design of the LED circuit can also be crucial to ensuring the longevity of the luminaire. All LED circuits should be designed with the LEDs in a number of parallel strings of series wired LEDs, this ensures that if a single LED fails open circuit it will only cause the other LEDs within the string to lose power. If the circuit were laid out entirely in series any one open circuit LED failure would cause the entire circuit to lose power.

One benefit of LED luminaires is that when individual LEDs fail in this manner the driver continues to supply the same power to the remaining operational LEDs, there is no loss of light output as the other LEDs will simply operate at slightly higher output to offset the failed LED. The downside of this however can be that if a significant number of LEDs fail the increase in power to the remaining LEDs and therefore increased operating temperature may cause the them to fail more rapidly.

Environmental conditions

As mentioned previously, temperature is the key consideration when attempting to understand luminaire lifetime as high temperatures will adversely affect the electronics. Other environmental conditions can however also impact electronics, housings and diffusers and should be considered as part of any lifetime estimate.

Industrial applications which are particularly wet, dirty or use chemicals which may attack metals, plastics or paint finishes, external applications where luminaires are exposed to harsh weather, especially coastal applications where high levels of atmospheric salt may cause corrosion and exposure to sunlight which can cause some plastics to discolour and become brittle are all examples of environments which may reduce life expectancy. Some chemicals, especially Volatile Organic Compounds (VOCs), can attack LEDs causing discolouration and reduced light output.

It is important to understand the environment that your luminaire must tolerate and specify the product accordingly to ensure it is designed to withstand these conditions.

At what point should my luminaire be replaced?

A luminaire has reached end of life when it no longer provides an adequate lux level, where component failures are so commonplace it no longer makes commercial sense to spot repair individual failures or where the housing has degraded to the extent that it is no longer fit for purpose.

The lighting design for your installation should have included a reasonable maintenance factor to ensure that the installation was over lit at the outset allowing a level of depreciation to occur without compromising the lux level of your installation which will in part dictate when replacement is required. Assuming that a reasonable maintenance factor has been applied and that you have purchased a quality luminaire with long life components and that is operated in a reasonable environment that does not place undue strain on components or excessive wear on the housing it is generally reasonable to assume that after 100,000 operating hours the luminaire will likely need to be replaced as the drivers and LEDs will be approaching end of life. This equates to a little over ten years if the luminaires are operated 24 hours per day 365 days per year.

At end of life it makes commercial and environmental sense to consider methods by which the luminaires might be upgraded rather than replaced in full, for example by seeing if manufacturers can provide replacement gear trays to replace and upgrade all of the key components with a single part whilst retaining the old housing.

When purchasing luminaires it is sensible to ensure that they are easily maintained and repaired and that key components are easily accessible and replacement parts can be easily sourced.

For further details on product design which encompasses the principles of TM66 and the circular economy please see our article "TM66 Circular Economy".