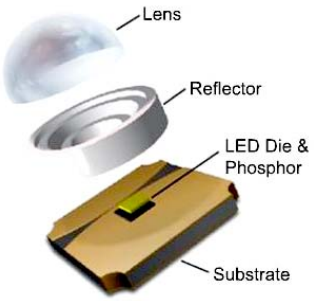
LED Fundamentals

Components, Life Expectancy & Thermal Principals

Components

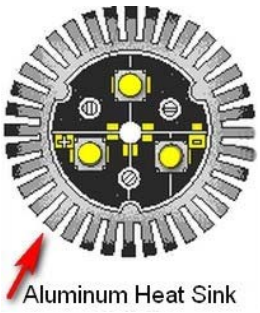
PCB - Printed Circuit Board:



This is the LED light engine itself. A series of high-output LEDs are mounted on a metal clad substrate and powered through a network of low-voltage circuits.

The diodes are enclosed in a secondary optical lens designed to shape the emitted light in a manner best suited for the application.

Heat Sink:



The heat sink is a thermally conductive medium (usually aluminum) on which the PCB is mounted. The heat sink is designed to draw the heat away from the susceptible electronic inner workings of the LED and is critical for preserving life and light output.

The effectiveness of the heat sink is determined by measuring the junction temperature (Tj). Most LED chip manufacturers publish lumen depreciation and life expectancy data as a function of the junction temperature.

Driver:

The driver is the electronic device which accepts AC power supplied to the fixture and converts it to the DC power required to drive the LED circuitry.

The driver is critical to overall efficiency and service life. Special consideration should be given to driver life expectancy as it is regarded as the weakest link of any LED system.

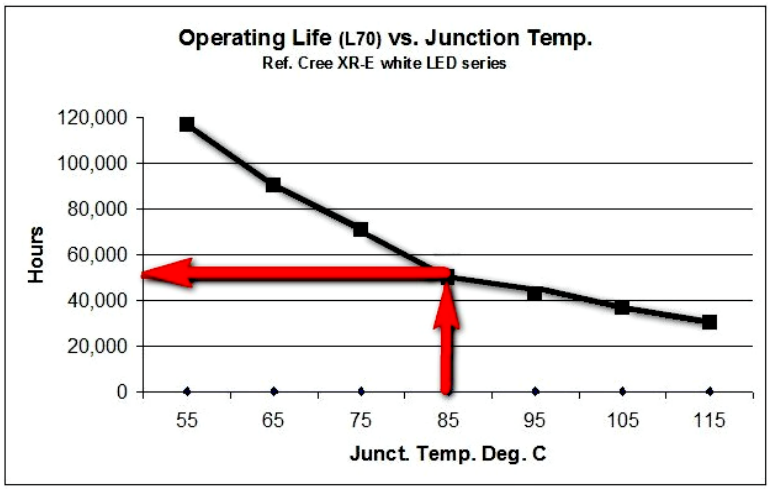
Life Expectancy LED Chips:

The expected life of the LED components is a direct function of how hot or cool they operate. The ambient temperature of the environment in which the fixtures operate must also be carefully considered, as it will also impact the overall temperature of the components.

The critical measurement is the Junction Temperature or (Tj)

The term "life expectancy" is defined as the point at which the LED source diminishes to 70% of its initial light output. Conversely, HID sources are rated at mean time to failure (10k - 20k hrs) at which 50% of lamp sources are expected to fail.

Most manufacturers are currently claiming 70% lumen maintenance at 50,000 hours of operation, given that the junction temperature is held at or below the published limit (usually 80°C).



Driver

The expected life of the LED driver is also a function of their operating temperature. Special provisions may also be required to ensure the LED drivers operate below their temperature limit (usually 60°C).

Unlike LEDs, drivers are rated in hours in "mean time to failure" which represents the time at which 50% of the drivers are expected to fail. This makes it even more critical to thermally protect and electronically isolate LED drivers in order to ensure they are operational for the expected life of the LED product.

Thermal Principles Drive Current (Generally Lower is Better)

Usually between 350ma to 1000ma.

Most chip manufacturers describe 350mA as optimal for highest efficacy.

Higher drive current delivers more overall light (per chip), increases power consumption and the junction temperature but decreases the overall efficacy. Higher drive current may reduce the initial cost-per-lumen produced by using fewer LED chips to deliver higher levels of light output.

Careful thermal considerations must be made to LED components driven at higher drive currents to ensure the additional heat created does not adversely affect the life expectancy of the LEDs.

Conversely, lower drive current delivers less overall light for the same number of LEDs, but delivers more lumens per watt and consumes less energy at a somewhat higher system cost (per lumen).

High Drive Current
light output (increase)
power consumption (increase)
junction temperature (increase)
heat sink requirements (increase)
overall efficacy (lm/W decrease)
cost per lumen (decrease)

Low Drive Current
light output (decrease)
power consumption (decrease)
junction temperature (decrease)
heat sink requirements (decrease)
overall efficacy (lm/W increase)
cost per lumen (increase)

Heat Sink - (Larger surface area = lower temperatures)

The heat sink is made of a thermally conductive material (usually aluminum) and is designed to draw the heat away from the PCB and the large (usually finned) surface area of the heat sink exchanges the heat with the air.

Ambient temperatures play an instrumental role in LED component temperature and therefore must be considered when designing a heat sink.

LED Quantity (Generally, More is Better)

Since heat is a function of wattage, the more wattage at which the LED chip is driven, the more heat is generated around the LED, diminishing both its performance and its lifetime.

Examples:

10 watt / 10 LEDs = *(1 watt each)* lower temperature and longer life

10 watt / 5 LEDs = *(2 watt each)* higher temperature and shorter life