

LUNERA THERMAL IQ

HID LED Lamp Gen 3 Thermal Management



What is the HID Retrofit Thermal Challenge?

When legacy HID lamp sources such as Metal Halide, Mercury Vapor and High Pressure Sodium (HPS) are retrofitted with LUNERA HID LED Lamps in the existing fixture, thermal management is of paramount concern. LEDs improve the efficiency of legacy HID light sources from approx. 10% to 25% allowing the input power to be reduced by 60-80% - however LEDs still turn 75% of their input power into heat.

There are three ways to address heat management – conduction, convection and radiation (fig 1). HID sources generate most of their heat at very high temperatures – the operating temperature of the gas discharge portion of HID lamps are between 1000°C and 3000°C; this allows HID lamps to disperse their waste heat out as infrared radiation. LEDs operate below 105°C, as radiation is a function of temperature delta to the 4th power (fig. 1), this means that LEDs can only radiate about 1 / 1000th of the energy of an HID source. As a result heat must be conducted and convected off the LED lamp.

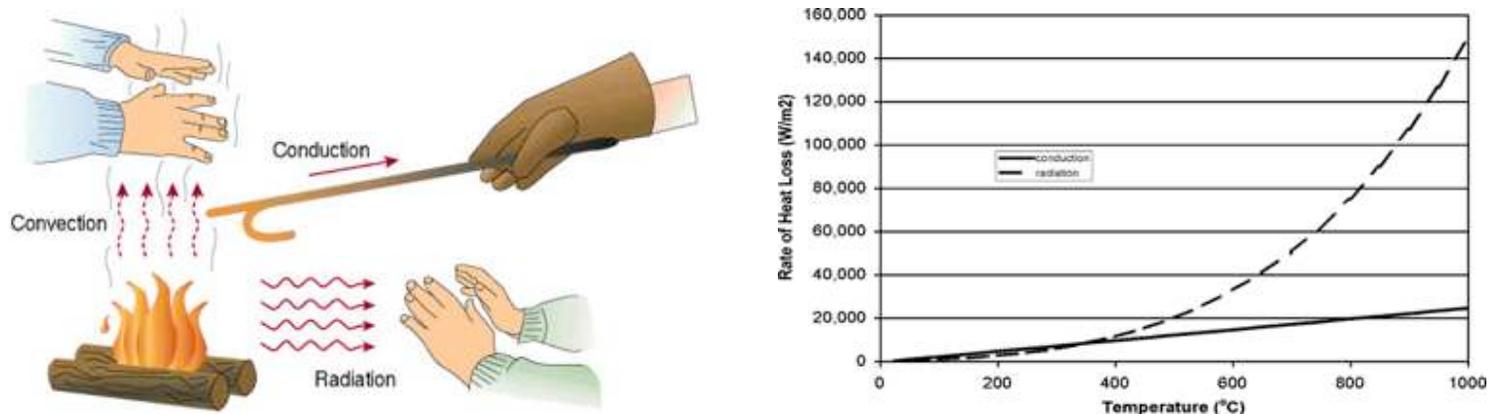


Fig 1. Three forms of addressing waste heat – conduction, convection and radiation. Conduction and convection grow linearly with the temperature difference, radiation grows at the 4th power of the temperature difference.

HID fixtures were not designed with LED retrofits in mind, so airflow for conduction and convection are often limited. In addition, HID fixtures are installed in harsh environments such as the top of a non-air conditioned warehouse or in an exterior wallpack where ambient temperatures can reach 150°F / 65°C. Lunera thus takes several measures to ensure the safety and longevity of our HID LED retrofits.

Thermal Management Techniques

Four thermal management techniques are employed by Lunera's HID LED lamps which we call Thermal IQ.

1. Passive Convection in open fixture environments

a. A heatsink with sufficient airflow and surface area is designed to support heat dissipation through heat conduction to the surrounding air and resulting heating and convection of that air.

2. Forced air in High Thermal Environments (fully enclosed fixtures or ambient temperatures above 100°F)

a. Using forced air can improve the efficiency of a heatsink by 5x; however it has three (3) issues.

- i. Noise – fans can generate moderate additional amounts of noise
- ii. Fan Reliability – Lunera uses magnetic levitation (maglev) fans rated at 70k hrs or more; these have no bearings that can dry out causing premature failure
- iii. Dust Accumulation – in an open fixture there is an unlimited quantity of dust that could clog up the fan vents; in a sealed fixture there is a finite amount. It is important to understand if the lamp will be installed in a high dust environment such as a paper factory and use a fully sealed fixture in that case.

3. Thermal Dimming

a. At extreme temperatures, once passive and active cooling options have been exhausted, the only remaining option is to reduce lamp power to ensure key components including the LEDs are not overheated. The minimum thermal dimming level is 50% of maximum output.

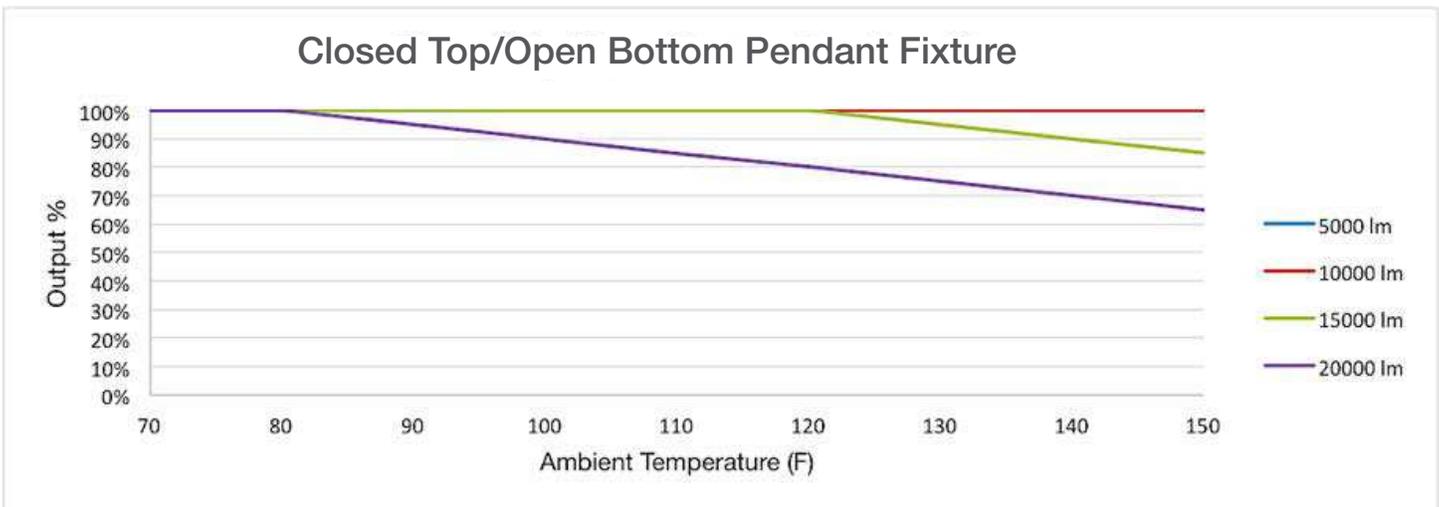
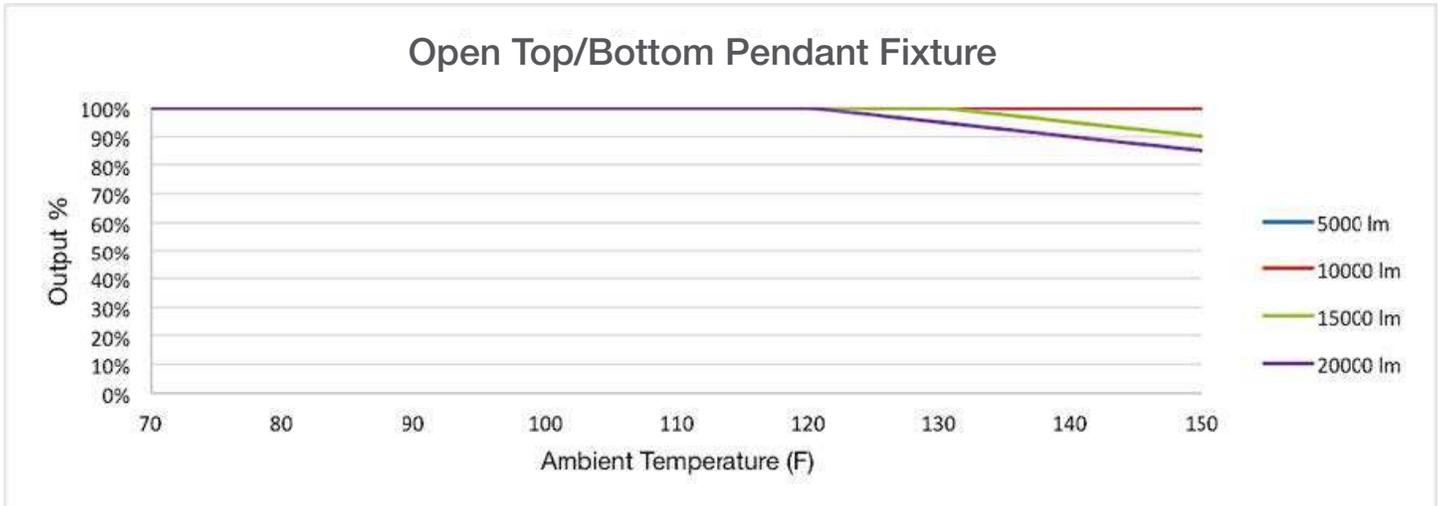
4. Thermal Shutdown

- a. In the case of an exception or misapplication, the lamp has multiple thermal shutdowns that will engage prior to thermal failure to minimize safety risk.
- b. In the case of thermal shutdown being reached; the lamp needs to be power cycled with an off time of approximately 25 seconds to reset.

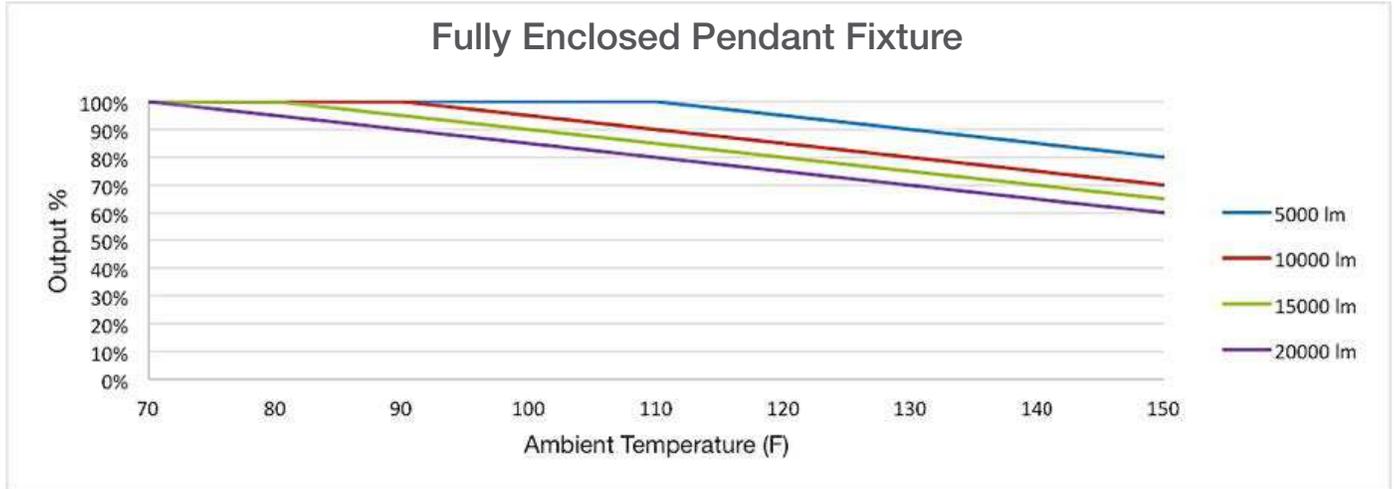
Thermal Dimming Curves Performance

Thermal Dimming reduces the power consumption, heat and also the light output of the lamp in question. The conditions under which thermal dimming is required are a function of the power level, lamp design, fixture design and ambient temperature outside the fixture.

Three (3) common fixture types were investigated with various powers of Lunera HID LED products.



LUNERA HID LED GEN 3



Conclusions

Reliable and safe LED lamp operation requires careful thermal and mechanical design. When retrofitting legacy HID fixtures with relatively high power lamps this is particularly critical.

Lunera uses four (4) techniques for thermal management that we collectively call Thermal IQ:

- passive cooling
- active cooling
- thermal dimming
- thermal shutdown

When used as intended, these enable safe and reliable operation of Lunera HID lamps in fixtures through their 50,000+ hrs rated lifetime.