Photo credit: Philips SSL Solutions

LED Application Series:

Using LEDs to Their Best Advantage

LEDs are often touted for energy efficiency and long life. While these are important considerations, lighting selection is based on many other factors as well. This fact sheet explores some of the unique attributes of LEDs, which may make them the right choice for some applications.

How do building owners, facility managers, and lighting specifiers choose lighting products? Purchase price and operating costs (energy and maintenance) are usually the top concerns but a host of other aspects may come into play, depending on the application. Here are some unique LED characteristics:

- Directional light emission – directing light where it is needed.
- Size advantage – can be very compact and low-profile.
- Breakage resistance – no breakable glass or filaments.
- Cold temperature operation – performance improves in the cold.
- Instant on – require no "warm up" time.
- Rapid cycling capability – lifetime not affected by frequent switching.
- Controllability – compatible with electronic controls to change light levels and color characteristics.
- No IR or UV emissions - LEDs intended for lighting do not emit infrared or ultraviolet radiation.

Background

What makes LEDs different from other light sources? LEDs are semiconductor devices, while incandescent, fluorescent, and high-intensity discharge (HID) lamps are all based on glass enclosures containing a filament or electrodes, with fill gases and coatings of various types.

LED lighting starts with a tiny chip (most commonly about 1 mm^2) comprising layers of semi-conducting material. LED packages may contain just one chip or multiple chips, mounted on heat-conducting material and usually enclosed in a lens or encapsulant. The resulting device, typically around 7 to 9 mm on a side, can produce 30 to 150 lumens each, and can be used separately or in arrays. LED devices are mounted on a circuit board and attached to a lighting fixture, architectural structure, or even a "light bulb" package.

Directional light emission

Traditional light sources emit light in all directions. For many applications, this results in some portion of the light generated by the lamp being wasted. Special optics and reflectors can be used to make directional light sources, but they cause light losses. Because LEDs are mounted on a flat surface, they emit light hemispherically, rather than spherically. For task lighting and other directional applications, this reduces wasted light.

Examples of LED Lighting Applications

General illumination applications that may most benefit from the LED attributes described in this document including the following:

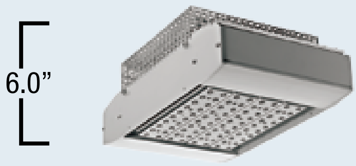
- Undercabinet lighting
- In-cabinet accent lighting
- Adjustable task lighting
- Refrigerated case lighting
- Outdoor area lighting
- Elevator lighting
- Recessed downlights
- Accent lights
- Step and path lighting
- Cove lighting
- Spaces with occupancy sensors
- Food preparation areas
- Retail display cases
- Art display lighting.

Example of directional task lamp using LEDs. Photo credit: Finelite.

Low profile/compact size

The small size and directional light emission of LEDs offer the potential for innovative, low-profile, compact lighting design. However, achieving a low-profile requires careful design. To produce illuminance levels equivalent to high output traditional luminaires requires grouping multiple LEDs, each of which increases the heat sinking needed to maintain light output and useful life. Even "large" LED fixtures producing thousands of lumens can be lower-profile than their HID counterparts.

The LED parking structure light shown here is only 6 inches high, compared to a common metal halide parking garage fixture almost 12 inches high. In parking garages with low ceilings, that six-inch difference can be valuable. For directed light applications with lower luminous flux requirements, the low profile benefit of LEDs can be exploited to a greater extent. Under-, over-, and in-cabinet LED lighting can be very low-profile, in some cases little more than the LED devices on a circuit board attached unobtrusively to the cabinetry.



LED Fixture	
Dimensions	6” high by 17” long
Watts	118
Initial lumens	6,400

Photo credit: Beta Lighting

Metal Halide Fixture	
Dimensions	11.5” high by 15” wide
Watts	175
Initial lumens	10,400

Photo credit: Lithonia

Breakage resistance

LEDs are largely impervious to vibration because they do not have filaments or glass enclosures. Standard incandescent and discharge lamps may be affected by vibration when operated in vehicular and industrial applications, and specialized vibration-resistant lamps are needed in applications with excessive vibration. LED's inherent vibration resistance may be beneficial in applications such as transportation (planes, trains, automobiles), lighting on and near industrial equipment, elevators and escalators, and ceiling fan light kits.

Photo credit: Sea Gull Lighting

Traditional light sources are all based on glass or quartz envelopes. Product breakage is a fact of life in electric lamp transport, storage, handling, and installation. LED devices usually do not use any glass. LED devices mounted on a circuit board are connected with soldered leads that may be vulnerable to direct impact, but no more so than cell phones and other electronic devices. LED light fixtures may be especially appropriate in applications with a high likelihood of lamp breakage, such as sports facilities or where vandalism is likely. LED durability may provide added value in applications where broken lamps present a hazard to occupants, such as children's rooms, assisted living facilities, or food preparation industries.

Cold temperature operation

Photo credit: GE Lumination

Cold temperatures present a challenge for fluorescent lamps. At low temperatures, higher voltage is required to start fluorescent lamps, and luminous flux is decreased. A non-amalgam CFL, for example, will drop to 50% of full light output at 0°C. The use of amalgam (an alloy of mercury and other metals, used to stabilize and control mercury pressure in the lamp) in CFLs largely addresses this problem, allowing the CFL to maintain light output over a wide temperature range (-17°C to 65°C). The trade-off is that amalgam lamps have a noticeably longer "run-up" time to full brightness, compared to non-amalgam lamps. In contrast, LED performance inherently increases as operating temperatures drop. This makes LEDs a natural fit for grocery store refrigerated and freezer cases, cold storage facilities, and outdoor applications. In fact, DOE testing of an LED refrigerated case light measured 5% higher efficacy at -5°C, compared to operation at 25°C.

Instant on

Close up of refrigerated case lighting.
Photo credit: GE Lumination.

Fluorescent lamps, especially those containing amalgam, do not provide full brightness immediately upon being turned on. Fluorescents using amalgam can take three minutes or more to reach their full light output. HID lamps have longer warm up times, from several minutes for metal halide to 10 minutes or more for sodium lamps. HID lamps also have a "re-strike" time delay; if turned off they must be allowed to cool down before turning on again, usually for 10-20 minutes. Newer pulse-start HID ballasts provide faster restrike times of 2-8 minutes. LEDs, in contrast, come on at full brightness almost instantly, with no re-strike delay. This characteristic of LEDs is notable in vehicle brake lights, where they come on 170 to 200 milliseconds faster than standard incandescent lamps, providing an estimated 19 feet of additional stopping distance at highway speeds (65 mph). In general illumination applications, instant on can be desirable for safety and convenience.

Rapid cycling

Traditional light sources will burn out sooner if switched on and off frequently. In incandescent lamps, the tungsten filament degrades with each hour of operation, with the final break (causing the lamp to "burn out") usually occurring as the lamp is switched on and the electric current rushes through the weakened filament. In fluorescent and HID lamps, the high starting voltage erodes the emitter material coating the electrodes. In fact, linear fluorescent lamps are rated for different expected lifetimes, depending on the on-off frequency, achieving longer total operating hours on 12-hour starts (i.e., turned on and left on for 12 hours) compared to shorter cycles. HID lamps also have long warm up times and are unable to re-start until cooled off, so rapid cycling is not an option. LED life and lumen maintenance is unaffected by rapid cycling. In addition to flashing light displays, this rapid cycling capability makes LEDs well-suited to use with occupancy sensors or daylight sensors.

Controllability/tunability

Traditional, efficient light sources (fluorescent and HID) present a number of challenges with regard to lighting controls. Dimming of commercial (specification)-grade fluorescent systems is readily available and effective, although at a substantial price premium. For CFLs used in residential applications, dimming is more problematic. Unlike incandescent lamps, which are universally dimmable with inexpensive controls, only CFLs with a dimming ballast may be operated on a dimming circuit. Further, CFLs usually do not have a continuous (1% to 100% light output) dimming range like incandescents. Often CFLs will dim down to about 30% of full light output.

LEDs may offer potential benefits in terms of controlling light levels (dimming) and color appearance. However, not all LED devices are compatible with all dimmers, so manufacturer guidelines should be followed. As LED driver and control technology continues to evolve, this is expected to be an area of great innovation in lighting. Dimming, color control, and integration with occupancy and photoelectric controls offer potential for increased energy efficiency and user satisfaction.

No IR or UV emissions

Photo credit: Scott Rosenfeld

Incandescent lamps convert most of the power they draw into infrared (IR) or radiated heat; less than 10% of the power they use is actually converted to visible light. Fluorescent lamps convert a higher proportion of power into visible light, around 20%. HID lamps can emit significant ultraviolet radiation (UV), requiring special shielding and diffusing to avoid occupant exposure. LEDs emit virtually no IR or UV. Excessive heat (IR) from lighting presents a burn hazard to people and materials. UV is extremely damaging to artwork, artifacts, and fabrics, and can cause skin and eye burns in people exposed to unshielded sources.

Summary

LEDs are available in an ever-increasing number of general lighting products. In addition to attributes typically considered before buying a new light source, such as color quality, energy efficiency, and operating costs, decision makers should also consider the unique attributes described in this document, as appropriate to the intended application:

- Directional lighting
- Size advantage
- Breakage resistance
- Cold temperature operation
- Instant on
- Rapid cycling capability
- Controllability
- No IR or UV emissions

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