Light Emitting Diodes vs. Neon/Cold Cathode

Report on the use of LEDs vs. Neon or Cold Cathode Lighting Systems

Introduction

LED
Light Emitting Diode. A solid state light source.

Neon
A linear light source, usually based on fluorescence technology. Most people refer to cold cathode lamps with less than 15 mm diameter as “neon”.

Cold Cathode
The umbrella term for all light sources which rely on “cold” hollow cathodes for their operation. This is in contrast to hot cathode technology which is commonly referred to as fluorescent lamps. It includes neon signs and Cold Cathode Lighting.

Cold Cathode Lighting
Most people refer to larger diameter (20 or 25 mm), higher current (100 mA or greater) Cold Cathode lamps as Cold Cathode Lighting. They are often used for architectural secondary lighting.

Efficiency and Efficacy
Efficiency is energy in versus energy out (Watt per Watt). However, we are interested in efficacy or Lumens per Watt. This measures the amount of light being created per input watt into the drive gear. If we compare efficacies, we are comparing useful light versus energy consumption in a meaningful way. Below is a table of features comparing LED and Neon or Cold Cathode.

Feature	LED	Cold Cathode
Geometry	Point Source	Linear Source
Efficacy	Good at about 20 Lumens per watt.	Very good at 130 Lumens per watt.
Color Range	Red, blue, green, amber, range of whites	Various shades of red, orange, yellow, green, blue, purple, range of whites.
Color Quality	Colors have a very narrow bandwidth emission.	Range of bandwidths and saturation. Full range of whites from cold to warm.
Lifetime/Reliability	Stated as 60,000 hours plus. See below.	Typically 30,000 hours. Good reliability if made to European standards EN50107.
Temperature Sensitivity	Light output drops as temperature rises.	Not good below -5 degrees Celsius. Maximum efficacy at 40 degrees Celsius.
Voltage	Less than 24 V	Low (less than 1000 volts) or High (up to 15000 Volts)
Track Record	Limited in the sign industry	Decades in the sign and lighting industries.
Hazard Rating	Low if correctly installed.	Low if correctly installed to European or US standards.
Fire Hazard	Low voltage does not mean no fire hazard.	Low if correctly installed to European or US standards.
Flexibility in Light Output	Can be dimmed.	Light level can be set by selecting running current and can be dimmed.

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Lighting And Display Applications

There is no doubt that LEDs have a tremendous potential in the lighting and display industries. In fact they are perfect for message centres, displays and giant TV screens. They can be used to produce very compact and energy efficient lamps to replace incandescent bulbs and their color changing ability has many decorative applications. However, they are a point source. Modifying their output with diffusers to produce linear light sources must greatly reduce their efficacy.

Cold cathode lighting, on the other hand, is a linear source by definition and, with the correct design will create stunning secondary lighting installations in ceiling coves and wall washes, for example. It is second to none in this type of application.

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Lifetime and Reliability

The lifetime data about LEDs is complex. The simple statements often seen of 60,000 or 100,000 hours are misleading, in the writers opinion. Reputable manufacturers use two methods for describing lifetimes. One is based on the percentage of LEDs surviving, and the other on the percentage of the original light output. The latter is less important, in the writer's opinion, because, in general, the light output of LEDs (whether that be high or low) remains reasonably constant over quite long periods of time.

However, there is nothing worse than seeing a series of LEDs where a significant number are no longer functioning. And what can you do about it? Very little. The cost of replacing a few LEDs (if it were even feasible given module designs) is prohibitive.

Compare the above with neon or cold cathode. Well processed lamps under normal operating conditions can certainly last 30,000 hours or more. I know of lamps running more than 80,000 hours, but the light output had substantially dropped. In a similar way to LEDs these lamps both drop in light output and occasionally cease to function. Here there is considerable justification for replacing a single failed lamp and returning the installation to a fully functioning state.

Temperature Sensitivity

It is well known that LEDs operate very well in low temperatures. However, they do suffer a drop in light output as temperatures rise. Reliability can also be affected. It has been very difficult to establish meaningful data correlating ambient temperature and LED light output, or even LED junction temperature, which is the real measure of an LED's life expectancy.

We need to consider three temperatures:

1) Ambient – the temperature of the surroundings of the LED module. Nominally, ambient room temperature is usually quoted as 25 Degrees C.

2) Board temperature – the temperature of the most accessible point adjacent to the LED proper on the module.

3) Junction temperature – the critical temperature inside the LED.

Unfortunately, the relationship between these three figures is complex. The following is an oversimplification, but is supported by articles in the literature. In one reported experiment the differences between ambient and board temperatures varied from 3 to 24 Degrees C. This variation was entirely due to the design of the mounting used by the various manufacturers involved.

In many references the junction temperatures are 10 to 15 Degrees above the board temperatures. So, the junction temperature of an LED can be approximately 15 to 40 Degrees C. above ambient. Sign boxes, particularly south facing, can achieve temperatures in excess of 50 Degrees C. The board temperatures of the LEDs in the sign box will be 55 to 75 Degrees C.

One study has shown that LED life dropped from the expected 50,000 hours to less than 10,000 hours when the board temperature was varied from 40 to 57 Degrees C., temperatures easily achieved in a sign box.

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The junction temperature of the LEDs in that sign box will therefore be at least 65 to 90 degrees C, depending on the quality of the mounting. A Cree XR-E power LED has an expected lifetime (lumen maintenance of greater than 70 % of original) of 50,000 hours as long as the junction temperature does not exceed 80 Degrees C. In a poor fitting, the Cree will not last 50,000 hours in a sign box running at 50 Degrees C.

Contrast this with neon and cold cathode where the optimum running temperature is 40 Degrees C., and the drop off in light output (as temperatures rise) is small (and depends on the phosphor in question). Note modern Cold Cathode Lighting lamps use the same phosphors as CCFL and compact fluorescent lamps that run at considerably more than 50 degrees C.

Voltage

LEDs are driven by low voltage, up to 24 V. However, this does not mean they are risk free. There has been at least one fire caused by an LED installation in the UK (in a petrol station!). Low voltage means high current to achieve a reasonable wattage. High current means high temperatures if things go wrong, and hence the cause of fires. Appropriate protection is essential for safe use. As far as the writer is aware, there is no National or International standard to work to with LED installations.

Neon signs and cold cathode lighting can be either high voltage (1000V to 5,000 volts relative to earth (in Europe, higher voltages elsewhere in the world)), or low voltage (less than 1000V). Low voltage installations rarely incur problems. There have been standards for neon sign installations for many years in many countries. The introduction of an international European Norm involving the requirement for earth leakage protection on the secondary side of the high voltage transformers in 1998 has reduced the already low incidence of fires to zero. Whether high or low voltage, neon and cold cathode, correctly installed is safe and reliable especially if the International Standards that exist are worked to.

Track Record

LEDs in signs and lighting have only recently become commercially viable. They have little track record. Neon and cold cathode installations have been carried out since the 1920s. There is much in the way of instruction and standards to work with and to.

Conclusions

LEDs certainly have their place in displays, message centres and giant TV screens, and as replacements for incandescent lamps in lighting applications. Their use as an alternative to neon or Cold Cathode Lighting is less clear. Light output, efficacy and lifetimes can be compromised by inadequate design and installation. The environmental conditions can actually preclude their use in extremes of temperature. (e.g South facing installations in hot climates.) LEDs are point sources which have plenty of significant applications. When a linear source is required, such as in architectural lighting, then there is still nothing better than neon or Cold Cathode Lighting.

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