LED versus Neon:
Frequently Asked Questions (FAQs)

presented by:

The EGL Company
100 Industrial Road
Berkeley Heights, NJ 07922

Introduction:

Most anyone who has spent any time in the sign industry knows at least something about neon. Its use has been a major contributor to the sign world for 80 years. Comparatively, light emitting diodes (LEDs) are very new. For outdoor sign applications, they've only been around for a couple of years. As a result, there's yet much to be learned about them. We thought we'd share with you some of what we've discovered (as well as source materials)…

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What is an LED?

The abbreviation "LED" is short for "light emitting diode." It is essentially a semiconductor diode that emits visible light when charged with an electric current. LEDs have the characteristics of other diodes and semiconductors. Conductivity is affected by temperature and various chemical doping agents. The characteristics of their light output are dependent upon optical control by lens use.

LED design and manufacturing technology are considered by Wall Street to be "high tech." There are a handful of major manufacturers of LEDs, most being part of global conglomerates. They include: Agilent, Osram, Toshiba, GE/Emcore (in partnership), Nichia, Toyoda Gosei, Cree, Teledyne, and Uniroyal. With the exception of Osram, none have sign industry experience. The industry continues to experience rapid technological improvement. Through these advances, use of LEDs to produce "white" light is expected to have significant impact on use of conventional light sources in 5-15 years. Major funding has been directed towards LED research, not only by their manufacturers but also by the Federal Government.

LEDs are considered to be a high-efficiency light source since most of the energy used is converted to light, not heat. However, with today's technology, LEDs are only available in a limited color pallet: red, amber, yellow, green, blue, and white (essentially 6500 Kelvin).

How are they characterized and specified?

There are many, many types of LEDs manufactured for a wealth of applications. Most are unrelated to advertising displays, signs, etc. Some are designed to emit energy only in the non-visible portions of the spectrum, such as infrared or ultraviolet. LEDs are described by color, brightness, efficiency, viewing angle, and basic chemistry of which they are composed.

Color is expressed qualitatively (ie: "red"), and quantitatively by the emitted wavelength (ex: 650nm). Brightness is expressed qualitatively (ex: "super high") and quantitatively by lumens. Since lumen output is strongly dependent upon drive current, this factor is also frequently given (typically 20mA).

Efficiency is typically expressed in lumens per watt. However, this rating would always be related to drive current. Often, when LEDs are described, this current rating is omitted, the assumption being it is driven at "industry standard" for the device. Viewing angle is expressed in degrees.

What are their advantages/characteristics as a light source?

Light sources are typically evaluated for application suitability according to light output (lumens), efficiency (lumens per watt), hue (degrees Kelvin), Color Rendering Index (CRI), life expectancy, and cost. For sign applications, linear fluorescent lamps, metal halide HID, and cold cathode luminous tubes are most used. As a mainstream light source, LEDs are something rather new.

Think of an LED as a tiny little light bulb. But, unlike many other light sources such as fluorescent lamps used in signs or incandescent bulbs one might use at home, they are a very "directional" light source. They are more properly described as "narrow bandwidth light emitters." Due to their compact size, they are almost pinpoint.

The lumen output of a single "high brightness" LED is miniscule. It is typically around 3-5 lumens (at 20mA), with a range of one to twenty-five. Because they are extremely efficient in how they convert electricity to light output, their wattage ratings are extremely low. Typically, these are expressed in hundredths of watts (0.10 to 0.20).

While their efficiency is a tremendous advantage, one of the drawbacks of LEDs is their tiny output. It literally takes hundreds of LEDs to equal the lumen output of one 8-ft fluorescent lamp or a 15mm neon tube. It should be mentioned that much research is being addressed towards production of LEDs which produce as much as 10 times the output of existing diodes. To date, these newer components are designed to be driven at currents of 200-400mA.

What is their history in sign lighting or identification applications?

In the early 1980s, LED technology had progressed enough to be used for indoor displays. Red, amber, and green LEDs were most effective and their most-common application were single-line scrolling displays. By 1988, new technology with Aluminum (Al) Gallium (Ga) Arsenide (As) chemistry offering 10 times brightness in red band spectrum allowed effective outdoor use.

By the early 1990s, more-durable, weather-resistant LEDs appeared (AlInGaP), new blues appeared. Larger, brighter, more cost-effective outdoor message boards were possible. By the late 1990s, there was strong growth in large outdoor boards and video-type displays, especially in Las Vegas and Manhattan. LED life expectancy increases, costs go down.

Visible light LEDs were first used for EXIT signs in 1985. As of today, there are many different types of LED EXIT signs produced by dozens of competitive manufacturers. While still potentially impacted by technological change, this LED market is relatively mature. Competition is fierce. There is a huge range in quality, life expectancy, and cost. Consequently, there have been some disappointments, especially when sign purchasers don't get product living up to their expectations. Worst case is when claims of 10 or 20 year life end up being more like 10-20 months of actual service. Some of the speculation regarding LED performance for outdoor sign applications have already become reality for the exit signs market.

The ISA Sign Expo of May 2000 saw the introduction of LEDs to mainstream electric sign application, including channel letters and outline lighting. Several companies previewed products, most-prominently LumiLEDS, a joint venture of Agilent and Philips.

Since then, there has been a great deal of trade promotion of LEDs for sign and identity use. Several end-user programs have tried them, and with mixed results. British Petroleum (BP) was lauded as being the first major program to specify LEDs, incorporating them into their new global identity program. After several early stumbles, widespread implementation has not yet taken place. Jack in the Box restaurants also tried LEDs resulting in significant frustration and disappointment. Experiences such as these give rise to contemplation of validity of LED claims.

From where do the claims of 100,000-hour life arise?

Today, there is no standard or accepted definition for LED lamp life. In contrast, "life" for traditional light sources is defined as the time at which 50% of the samples in a test batch have burned out. There is enough history for conventional light sources so as to reliably predict life. So, for example, a 1000 watt incandescent lamp is rated at 1000 hours. A linear fluorescent T8 or T12 is 20,000 hours. A high pressure sodium 400W lamp is 24,000 hours. Note also that these light sources tend to retain 70-90% of original lumen output at the end of rated life.

According to Narendan, LEDs typically do not fail catastrophically, rather their light output degrades with time. He recommends LED life be defined in terms of output degradation and color shift. One common way in which LED life is defined is the time it takes for light output to reach 50% of initial value. Different colors of LEDs reach this 50% point at different rates. Present technology indicates life (with this definition) for 5mm white LEDs as around 10,000 driven at 20mA in laboratory conditions. Red LEDs are much longer-lasting when similarly evaluated.

The current practice of LED manufacturers is to measure light output under laboratory conditions for a certain number of hours (for example 5000) and mathematically extrapolate to some point tens of thousands of hours into the future. There is no actual data available to the industry substantiating a 100,000-hour rating. Obviously, for outdoor sign applications, there is no more than a few years of actual field history with LEDs.

In contrast, there is documentable history for cold cathode and hot-cathode fluorescent tubes. There is also extensive field experience. It is the latter that is most significant. What is most important to the sign user is how long the light source will last in the real-world, perhaps under challenging conditions of heat, moisture, dirt, neglect, supply voltage variations, etc.

What factors might negatively impact LED lifespan?

Heat is the universal enemy of all sensitive electronic components. In order to achieve expected life, these components must be used within acceptable design parameters. With respect to heat, the two variables which must be controlled are ambient temperature and drive current. Most common LEDs are rated for use at 20-30 degrees C. Exposing them to temperatures of 50 C or more significantly shortens their life expectancy. Thus, sign users located in harsh climates such as the desert Southwest should take note.

As for the other operational parameter, most LEDs are designed for drive currents of 20-30mA. It is understood, as a result of both experience and extensive testing, that LED life expectancy is seriously impacted by higher drive currents. More importantly, it should be understood that once such a device is exposed to damaging current/temperature, it is not recoverable. The damage is done.

Since brightness of an LED can be significantly enhanced by increasing drive current, there may be a tendency to overdrive them. The brightness difference between 20 and 70mA is dramatic. The user should be cautioned, that with current technology, one cannot have both life and brightness. Not without using thousands of LEDs. To more effectively compete economically with conventional sign light sources, LED applications will either be dimmer or they will sacrifice useful life.

Water is also extremely damaging to electronic components. Obviously, the presence of moisture creates inadvertent conductive circumstances. Additionally, humidity impacts lumen depreciation. Dust and dirt, would be expected to have similar sorts of impact to varying degrees. The presence of foreign materials may affect light output by either obstructing or absorbing light.

How are LEDs actually installed in signs?

Presently, there are many varying recommendations for how LEDs should be used to illuminate channel letters or accent lighting. There are at least a half-dozen competitive offerings, each with its own instructions for use. There is no standard for how they should be installed, which LEDs to use, which operating voltage, which power supply, or other “givens” taken for granted in general practice of using neon.

Most systems gang up individual LEDs onto a small circuit board termed a “module.” At least two systems require the connection of modules using many short leads of insulated wire. The LED modules are fastened to a letter back using adhesive pads requiring their protective covering to be removed. Other systems can be purchased in reels of pre-wired modules with connectors of fixed length. These are fastened mechanically and with adhesive pads. The circuit of LEDs must be connected to a power supply, typically a 12 or 24-volt driver. Some can be adjusted (“tuned”) for output (brightness).

It should be noted that these installation recommendations require the LEDs to be installed in a series circuit driven by forward voltage. The different systems also typically include resistors somewhere either in the modules or power supply. This is significant because they tend to diminish the effective light output from what would be expected from the individual LEDs themselves (per specced output).

It should also be noted that the physical positioning of the LED module within a channel letter is critical. Since LEDs are an extremely directional light source, if not positioned properly, hot and/or dim spots will result. Further, one system requires the LED modules to be affixed to the channel letter returns rather than the backs. This design is more dependent upon the reflectivity of the return and letter back materials for even illumination. If these reflective surfaces are dirty, they will not be as effective in projecting light.

In sign applications, what happens when LEDs fail?

Should an LED fail, there will expectedly be a dark spot in the channel letter or light strip. Its visual impact will be more or less noticeable depending upon its placement as well as its beam angle and brightness. More significantly, it’s very possible that if one LED fails, many will.

For first consideration is whether the individual failed LED was exposed to either damaging heat or current. If so, chances are others in the application have been as well. That means more than one will have shortened life expectancy. Also, it should be recalled that LED applications are series wired. What this means is that failure of one LED in “open” mode restricts current from getting to those downstream. So, an entire string may go out, similar to what is observed with inexpensive Christmas tree lights.

What else might go wrong which requires service?

Mounting adhesives fail. The manufacturers’ instruction manuals all include cautions against applying mounting pads to surfaces which are damp, dusty, dirty, etc. Adhesives give way when exposed to excessive heat or cold as well. Already there have been observances of mounting pad failure even prior to installation. It is then up to the serviceman to glue things back together. Probably, it will not be simple.

Also note that LEDs can be damaged in handling. They are sensitive electronic components. They’re packed in special non-conductive materials. Is there some question that these semi-conductors can be damaged through exposure to static charge?

Besides the LED modules themselves, the power supply which drives them must be considered. How durable will it be in rigorous-use conditions in heat, moisture, dust, etc? What happens when they are overloaded? What happens if not supplied with adequate input voltage? These are all questions for which there are no acceptable answers supported by field experience.

And what happens when a component fails? With what does the serviceman replace it? Which brand of LED system is it? Which power supply? What about changes to product offerings? Last year’s system may be obsolete compared to this year’s. Then what? LED components aren’t “plug and play.” Are the proper brand of replacement parts on the service truck? Does the local distributor carry that brand? So, service work with LED sign lighting may be complicated. And we haven't even begun to consider the differences in appearance of LED modules after several years of service.

What about color matching?

Variations in the manufacturing process occur often enough that LEDs are typically "binned," meaning they are inspected for dominant wavelength and saturation, then segmented by similarity. The differences in color are often noticeable to the human eye. It should be noted that this is less of an issue with red, more with other hues.

A greater issue would be the changes in character of light output under use. Virtually all LEDs experience a degradation of both lumen output and hue with age. They also decay at varying rates. This can be observed in traffic signal applications where, after a time, variances in brightness between individual LEDS can be noticed.

Studies published by the Lighting Research Center demonstrate that light and color degradation are accelerated with increased heat. At 50 degrees C, the red LEDs diminished by 10% after 5000 hours. Blues diminished 30%. With higher ambient conditions or drive current, the situation worsens.

In contrast, neon-filled tubes, when properly processed, do not deteriorate significantly. There is even empirical evidence that tube brightness may actually increase with age. Additionally, most fluorescent tubes show much less degradation of output and hue compared to the LEDs posed to substitute for them. There are many technical studies to support this.

What about claims of great savings?

Much of the body of technical work on LEDs agrees that fluorescent tube light sources are unmatched for value. Lumen output for fluorescent tubes is usually upwards to 100 lumens/watt. Plus, a typical F32T8, for examples is rated at almost 3000 lumens. Its rated life is 20,000 hours, meaning 50% last even longer. And it costs just over $3. That's a lot of value for money. As a result, even the LED technologists admit a competitive LED for general lighting may be a decade or more away.

Cold cathode tubes show similar output and efficiency ratings, albeit at higher cost per tube due to their custom nature. For the additional cost, one also should expect higher quality and longevity. 50,000-hour life expectancy is not an exaggeration.

In contrast, the highest-efficiency LEDs for sign use are less than half the lumen/watt rating of fluorescents. And, $3 won't even buy one sign-application LED module. So, based on either operating cost or installed costs, LED technology cannot yet compete with fluorescent tube technology.

As for red LEDs compared to clear neon tubes, there are still differences but they are not as great. If one considers the output of each light source under ideal conditions, LEDs are measured at around 20 l/w and clear neon at 10-12 l/w. But that doesn't take into consideration any losses when wired to the power supplies presently used in the sign system. There can be a dramatic difference.

Several technical studies (Greenberg, Masi, etc.) have already been completed comparing the resulting outputs of LEDs and neon tubes using recommended power supplies in real-life channel letters. In those comparisons, using components procured through sign supply distribution, the LEDs don't even match the lumen output or lumens per watt efficiency of clear neon. And, when enough LEDs are used to create comparative brightness, the installed cost of the LED channel letter skyrockets.

Summary:

Does all of this leave you a bit confused? If so, you are not alone. There are many inconsistencies between what sign-application LED marketers claim and what we've found. As a result of fairly extensive investigation of technical source materials as well as some real-world testing, we're uncomfortable. Not with the performance integrity of luminous tubes.

What we'd like to see are the features, functions, and benefits of both lighting systems fairly compared. Neon is a wonderfully versatile and effective light source used by many around the world. LEDs will most-likely have a major place in the future of lighting. There may even be some existing applications for which LEDs are more suitable than neon. But why the hype? Wouldn't you rather have a straight story?

Source Materials:

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The Promise and Challenge of Solid-State Lighting" by Bergh, Craford, Duggal, and Haitz in Physics Today Online, December 2001, http://www.physicstoday.org/pt/vol-54/iss-12/p42.html

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Prepared by D. Eric Johnson, Identity Marketing Services
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