

As the phase-out of incandescent accelerates, the lighting community may find that trying to adapt screw-base LED products to existing recessed downlight fixtures is a lot like banging a square peg into a round hole



THE SOCKET- SHARE CONUNDRUM

BY DONALD PEIFER

No one knows quite what the future of general lighting will look like, but it is increasingly likely that solid-state lighting (SSL) will be instrumental in shaping it. Energy efficiency is a key driver today in most industries. It is estimated that by 2025, the energy demand for lighting will have been reduced by 50 percent thanks in large part to increasing efficiency of SSL.

Whether lighting emerges, as many suspect it will, as the consumer product type with the biggest potential for energy savings depends on many things. Will future SSL products highlight the strengths of the technology, or will they mimic past technologies in order to encourage quick acceptance? The prospect of new lighting technologies such as screw-base light emitting diode (SLED) products sharing sockets with the incandescent lamp is dangerous. Many fixtures that were built to accommodate incandescent lamps, while popular, are heat traps. Because LEDs are adversely affected by heat, both SLED lifetime and performance can be greatly compromised when used in these fixture types. Fortunately, there are other alternatives.

THE CHAMELEON EFFECT

Commercial success is largely a function of consumer acceptance. By mirroring existing technology products in form factor, a new technology may be seen as familiar and therefore more acceptable to consumers. This chameleon effect—creating new technologies in the image of a current/past technology—is a well-established practice in the lighting industry. While the wave of LED replacement lamps about to flood the market is certainly an example of this, the chameleon effect in lighting can be traced even farther back to the dawn of electric lighting.

Prior to the development of the incandescent lamp, popular light sources were well standardized. Sperm whale oil allowed for the cre-

ation of wax candles and oil lamps with predictable intensity and even burn time. Candles of the 19th century were so well standardized that they were used to tell time—either with hash marks or, most cleverly, in miner’s candles, which had weights placed at vertical integrals on the candle. As it burned down, a weight would drop into a metal bowl. The sound notified the miners of the passing of another hour.

Thomas Edison, who should be credited not so much with inventing the incandescent lamp as commercially developing it, understood well the value of mimicry as a path to consumer acceptance. The light source that the incandescent was meant to directly replace was the gas lamp. Gas lamps of the time were calibrated to deliver the same intensity as oil lamps. That intensity was the equivalent of 16 candles. Edison chose a voltage, 110 volts—the nominal household voltage still today—for his prototype incandescent lamp, which allowed it to burn with an equal intensity of 16 candles. Edison also utilized the existing infrastructure of gas lighting for his electric lighting. Electrical wires were routed through existing gas conduit into retrofit gas fixtures. Everything about the incandescent lamp was designed to be relatively familiar even down to the screw base which came from the common kerosene can caps of the time.

Edison utilized the chameleon effect to great success, and incandescent was by all accounts a superior technology. It was safer. It was more reliable. It was smoke free. There were no application issues

that compromised the effectiveness of incandescent lamps used in existing gas lighting platforms. As a result, incandescent lamps proliferated. They replaced gas lighting, and 140 years later, they are still a template for emerging lighting technologies and products.

HOSTILE ENVIRONMENTS

Incandescent lamps are not affected by heat. Stuffed in a ceiling can, enclosed in glass, in a sauna or a freezer, it’s all the same. The performance and lifetimes of newer technologies designed to replace incandescent lamps, on the other hand, are *greatly* affected by heat. At the same time, these newer technologies offer tremendous opportunities for energy savings over incandescent lamps. Strategies to proliferate newer technologies therefore need to consider heat buildup in common incandescent fixture types in order to be considered effective replacements in those fixtures. The strategy to roll out the screw-base compact fluorescent lamp (SCFL), for example, was compromised initially by several issues, not the least of which was heat buildup in common incandescent fixture types. In-situ testing shows ambient temperatures in many common fixtures well exceeding recommended operating temperatures for SCFL products. Fortunately, CFLs that use a mercury amalgam can withstand much higher ambient temperatures though at a higher cost and longer warm-up times.

The performance and lifetime of LED devices are also specifically affected by heat. Whereas CFLs have a solution to that heat, most LED de-

vices do not. LEDs exposed to high heat experience color shift, reduced output and disappointingly short lifetimes. Where it was believed that LED lifetime was reduced most by overdriving the die, studies have shown that increased ambient temperature is an even greater contributor—leading to *exponential* decrease in LED lifetime.

Riding piggy-back on all screw-base CFL and LED products are their power supplies, whose lifetime and performance are also adversely affected by high ambient temperatures. For every 10 deg C increase in ambient temperature over optimal 25 deg C (77 deg F), it is believed, the life of the power supply is halved. While maximum recommended operating temperature for the power supplies is usually 65 deg C (149 deg F), testing has revealed that at least half the ballasts’ operating temperatures exceeded 65 deg C in common fixture types. This is yet another hurdle that SLED products must overcome. Because of the chameleon effect, performance and lifetime are compromised. Let’s look at the type of fixture that the LED replacement lamp will be used in and the conditions that affect the lifetime and performance of the LEDs in this environment.

ICAT RATING

There are an estimated 500 million recessed downlights in U.S. homes alone, making it far and away the most popular fixture type. The average new home has over 23 recessed cans installed. Because of mandates for these fixtures to be

Insulated Ceiling Air Tight (ICAT) rated, many of the SLED replacement lamps entering the market are inappropriate for this, the most popular fixture type.

ICAT began as a Washington State code, but it has been adopted both nationally and internationally. Currently 39 states require that

While energy efficiency is a nice ancillary benefit, ICAT was not designed around this at all. The code was designed to ensure cold roofs in residential construction. It is necessary during cold weather months for a roof to remain cold. Heat escaping through the tops of light fixtures and gaps in insula-



While old habits die hard, ultimately, the question to be asked is: why continue developing LED products in the image of a past technology—especially when it is fraught with so many application issues?

all recessed fixtures installed in homes be ICAT rated. ICAT rating is part of a general construction mandate to assure tight construction in homes. The code seeks to minimize air leaks in buildings through windows, doors, duct work and light fixtures. Trapping warm air during the cool months obviously reduces the burden on heating and saves energy.

tion allow warm air to infiltrate an attic space causing condensation. In cathedral ceilings, where there is no attic, gaps in insulation allow warm air to escape directly through the roof. This will, in turn, melt snow, which can refreeze at night. The cycle of melting and freezing—contraction and expansion—allows water to trespass beneath shingles onto the plywood

sheathing and framing lumber of the building. Ice dams will form near the eaves. This will in short order destroy the roof and compromise the structure of the home. What the ICAT rating ensures is that no warm air can leak through the tops of the light fixture. Additionally, it ensures that builders can insulate directly over the top of these fixtures and eliminate places where warm air can escape.

While the mandate for ICAT-rated fixtures is great for roofs and homes in general, it is bad for heat-sensitive lighting technologies. As a function of convection, any lamp—whether incandescent, CFL or LED—will generate warm air in a recessed can. Warm air will rise, and in an ICAT fixture will get trapped. This will lead to an escalation in ambient temperature within the fixture well above those recommended for LEDs. SLED products are especially at danger here since LEDs conduct most of their heat upwards instead of radiating outwards like SCFL and incandescent lamps. Ambient temperatures in ICAT fixtures can regularly exceed 60 deg C (140 deg F), which corresponds to LED junction temperatures over 70 deg C (158 deg F)—well above recommended operating temperatures. While ICAT fixtures are the most popular fixture type, there are a host of other common fixtures which are much worse from the perspective of high ambient temperatures. Glass enclosed fixtures commonly used in kitchens and bathrooms have ambient temperatures that can exceed 90 deg C (194 deg F).

LED “socket share” in these hostile thermal environments is, in no uncertain terms, a misapplication of the technology. The thermal management strategy for any LED device is to establish a thermal path from the LED junction to the outside environment. That is great if the outside environment is room temperature with air flow. What if it is not though? What if your outside environment is the inside of an airtight can or an enclosed glass fixture? The proliferation of SSL may be jeopardized if we are not prepared to answer that question.

CONCLUSIONS

Edison used the chameleon effect to great success—introducing a new technology in the image of a past technology with no ill effect. Creating LEDs in the image of incandescent is dangerous, however, if the SLED replacement lamps will be subjected to high ambient temperatures which will compromise performance and lifetime.

Because of the mandate for ICAT-rated fixtures in over 75 percent of the country, it must be assumed that any SLED product will be used in an ICAT-rated fixture. Application testing in ICAT-rated fixtures for all SLED products should be recommended. Consumer education is also important regarding the potential dangers of using SLED products not just in ICAT-rated cans but in common incandescent fixtures where heat can be trapped. (“Let it Breathe” could be the public service message that accompanies the push for consumers to change to more efficient and sustainable

SLED products.) Finally, dedicated recessed can housings should be developed that mitigate the issues of heat while allowing the larger building codes to be met.

The incandescent is soon to be a staple of the past; SSL is, no doubt, the future. While old habits die hard, ultimately, the question to be asked is: why continue developing LED products in the image of a past technology—especially when it is fraught with so many application issues? Do we really want to keep the screw base around? Without its legacy, a similar electrical format developed today would never pass code. For a technology with so much potential to promote change, it is important to invest our future in products that cater to the strengths of SSL and resist the 19th century temptation to screw in and burn out. 🔧



About the Author: Donald Peifer, Member IES (2007), began his career designing the lighting for such famed photographers as Annie Leibovitz and Steven Klein. Architectural lighting projects include the flagship Nike Media Store in New York City. He holds a Masters of Science degree from the Lighting Research Center at RPI and has developed dozens of fixtures for use in a variety of applications. Mr. Peifer is the co-founder and chief technology officer of Lunera Lighting, a solid-state lighting fixture manufacturer and lighting solutions provider.

**make your voice
HEARD!**

Join an IES committee:
Fax: 212-248-5017