BILL CONNER ASSOCIATES LLC

LED Lighting

For years the lighting industry has been excited about the Light Emitting Diode as if it were the solution to all the energy and other ills of the venerable incandescent lamp. That feeling has not been completely misplaced; there are a lot of pros and some cons when using LED technology in a building. Many of the benefits of using LED lighting in a home or other commercial building do translate to performance venues; but there are other things to consider and the stakes are a much higher. Here we will discuss both fixed architectural and portable theatre lighting.

In the home there's little doubt that LED technology in lighting fixtures makes a lot of sense for some and is a great improvement over the Compact Fluorescent Lamp (CFL); those lights that look like a twisty ice cream cone. CFLs were not well received due to poor perceived light quality and they didn't dim as expected. They also get some knocks for containing mercury, making them difficult to responsibly dispose of. LED replacement lamps for the home seem to have better color rendering, can dim acceptably and are even more efficient than CFLs. LEDs are available in a lamp shape similar to incandescent. The prices have come down to the point where the return on investment, considering the long life and low energy use, is easy to accept. Finally of course there are energy codes that restrict the use of incandescent sources, which are frankly better heat producers than light emitters!

Theatres and other places of public assembly can take advantage of all this, though the fixtures and how they are built are different than residential lighting, which is a consumer commodity. For the most part, LED commercial lighting fixtures such as downlights, troffers and high bays don't necessarily have replaceable lamps as in the past. When you buy the fixture it is a finished piece including the enclosure, an integrated LED chip, power supply, all as a complete unit. With few exceptions, the LED chip can't be replaced. Since most LED fixtures have expected lives in the range of 50,000 hours before they reach a point called "Lumen Maintenance", it can be a long time before replacement is considered. At the end of that 50,000 hours the fixture likely hasn't quit working but the output of the LED starts to degrade beyond a specified level. Like other things that wear out gradually instead of failing catastrophically, one might not notice the lower or changed output until it becomes significant, probably well beyond 50,000 hours.

Dimming is the big issue with any lighting for the theatre. While a manufacturer's data sheet may indicate a product can dim, it is best to "trust but verify". What a manufacturer considers "dimming" may not meet your definition of an acceptable fade of house lighting in an assembly setting. In fact we've come to differentiate the capability to "dim" (to a set level) from the quality of the fade. For many architectural lighting fixtures no one really sees the dimming occur (perhaps run by photocells or other controls), so the fade quality is less important. Fade quality critical in a theatre. So buyer beware.

Another important detail in architectural lighting fixtures to be used in a performance space is the means of control. If the light can't be controlled well it should be avoided. Disregarding fixtures we can switch like backstage work lights, most LEDs must be controlled with either an analog DC circuit or a DMX-512 signal. Only in a few applications can an LED be controlled by a line voltage dimmer. We've been using 0-10VDC wiring for years in theatre, since the beginnings of remote control dimmers. We can't seem to get away from analog wiring. It is important to note that some analog-controlled LED lights do not fade to zero and may require the 120V power to the fixture to be switched to fully turn off the light. For fixtures that are DMX-512 capable, often we find they can fade to zero or at least near zero. Common now are fixtures that state they can dim to "<1%"; some do it better than others. This is another "trust but verify" concern. Quality is improving as the market matures, but a test will tell the story.

We like LED units for house lights in many cases due to the challenges of lamp replacement when the only option was quartz lights in a tall room. Fluorescent was never good enough and surely the dimming function of those fixtures disqualified them. We worried about the expense and ease of lamp replacement and spent a lot of time coming up with strategies to ensure the user could re-lamp their quartz fixtures. That meant catwalks, lowering systems or other retractable designs that permitted the light to be accessed for lamp replacement. There is some risk in putting LED fixtures out of reach, but for the most

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part the fixtures work well once they are installed and tested. It becomes another cost benefit analysis question; with quartz, each fixture must be accessed about once a year or so (depending on use). With LED the odd single failure requiring scaffolding or a lift seems like a fair bet. But these are issues which must be considered.

On the stage, the issues are somewhat different and the attitudes of users can be more passionate. While quality illumination of audience and backstage areas are really important, the rubber really meets the road on the stage. As lighting designers we care about the quality of the light; it's one of the central tenants of lighting design. Illumination is easy; quality is where the art comes in, and theatre lighting is an art. One of the major criticisms of LED lighting for the theatre has been color perception. Because most LEDs are made up of multiple, different color emitters, color is a big issue. Theatre lighting is sometimes used in some form of white, but also frequently uses every imaginable color from the lightest pastel to the most saturated colors. LED's ability to change the color is a great benefit but there are challenges.

Issues of color perception are beyond the scope of this paper, but here is a short synopsis. Daylight (from the sun), quartz or incandescent and even CFL are full or near "full-spectrum" emitters. They produce some form of "white" light, though there are apparent "color temperature" differences between each source. Incandescent seems warm while daylight seems more blue. But, for the sake of argument, each of these use all the parts of the visible spectrum to varying degrees. That's the ROYGBIV of the rainbow but also the colors between those 7 distinct colors. A 3-color mixing LED light (RGB) really only emits 3 very narrow parts of that spectrum. Because red and green are mixed to make yellow it doesn't quite work as well on yellow paint or fabric. Adding more LEDs, like amber or white help but there will never be enough colors to fill in all the gaps in the spectrum. Even an apparent white LED, regardless of the color temperature rating, use very narrow bands of the spectrum. The end result is that color under LED behaves differently than with quartz. Finally, LED lighting uses additive color mixing (adding the different colors together for mixing), while traditional theatre lights use gel for subtractive color mixing (filtering out the unwanted color). That is all a big deal in the theatre.

LEDs for the stage really seemed to take off with skydrop or cyclorama lighting. This makes sense because of the potential for energy savings and the fact that back drops are typically solid white(ish), so what you see is basically what you get. Use these same LEDs on a colorfully painted scenic drop and some adjustments may be needed to get the colors expected or desired. Next came useable wash lights and again it makes sense; a light that could easily change color without an old-style gel scroller for color wash purposes. It took manufacturers a long time to work through the optical design issues to make an ellipsoidal or profile light work, making sharp light that can throw a long distance. The optical issues are challenging. Current models aren't perfect but they are improving at every iteration. Even gobos (patterns) can be projected with most profile units. These LED sources aren't exactly like the quartz lights of old, but they improve with every new design. There is promise.

There are a lot of issues that must be considered when it comes to LED as a replacement for quartz. LEDs are expensive, they are heavy, they don't "amber shift" when dimming (perhaps a dubious concern), the fade quality varies among manufacturers, variation of color between models, color separation; we could go on. Quartz sources present problems too: heat, they are energy hogs, expense of lamp replacements, the light can only be a single color (save expensive add-ons like a scroller) and the need for a separate dimmer. If you think about it, neither source is perfect!

Lighting instruments are tools. Most people have many options in their tool box from which to choose. It seems like for lighting, LED is another tool to consider alongside quartz. We think the best approach is to weigh the needs and benefits of all this technology to determine the best way forward. Often that leads to what we call a "hybrid" approach, using both LED and quartz, each to their strengths. But regardless we are sure LEDs are here to stay. Quartz remains a useful tool, for a while anyway.