LED Lighting in the Museum Setting

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Overview

Every aspect of the museum experience has been enhanced with the use of LEDs (light-emitting diodes). LEDs create light by electroluminescence in a semiconductor material. Light is produced when positive and negatively charged electrons combine together within the material. The advent of the LED allows for new possibilities in manipulating the spectrum of light, enhancing vision, and slowing the degradation of light-sensitive materials.

Numerous benefits can be gained by mastering the complexities of this emerging technology. Benefits of LEDs include longer lamp life, reduced electric and HVAC bills, more easily controlled occupancy sensors and contribution to "green initiatives." This technical bulletin will provide an overview of the considerations around the use of LEDs on five controllable qualities of light: intensity, movement, angle, distribution, and color. The focus throughout is on LEDs within the museum setting due to its higher standard for lighting than other uses. If LED technology can generate positive results for a museum application, it can inspire other institutions to explore the potential of LEDs.

Intensity

The supplied chart [Fig. 1] explains the two factors of photochemical damage. Assessing the sensitivity of a material going on display can help determine the illuminance and the exposure it is capable of withstanding. To achieve the greatest benefit from energy savings and light damage, the exposure should be the primary focus. Illuminance is the measure of perceived light illuminating an object. Deciding on a proper illuminance requires a balance between providing sufficient light levels to accommodate the needs of visitors and restricting overall light exposure for the preservation of the artwork. For materials with a light sensitivity rated high or moderately high, a relatively low illuminance of 50-75 lux is recommended with limited exposure. Lux is the measure of intensity over a given surface area. Reducing the light level for an object could extend the display time allowing it to be seen by more visitors, however, it should be noted that light intensity, its duration and the quality of light in any amount will cause light damage to a work of art. High light intensity is often used if the lighting source is coming from a particularly high ceiling. Even with an increase in intensity, LEDs will still save on energy consumption.

Movement

The human eye is particularly attuned to movement, including the movement of light itself.

In the case of museum lighting, movement can either be subtle or obvious, depending on the type of light source and how far it is in its life cycle. To test a light's subtle movement, one can use a "flicker checker," a black and white checkered top that, when spun, either creates bands of several solid shades of grey, indicating that no flickering is present in the light source, or a hex pattern, indicating that flickering is present. A more noticeable case of movement can be seen when an LED bulb is coming to the end of its life cycle. It continuously flashes on and off, creating a strobe-like effect that is distracting to visitors. In a typical gallery setting where ceiling height is anywhere between twelve to fourteen feet, changing a bulb can be relatively simple. However, in the case where a museum has to light an indoor courtyard with a ceiling as high as eighty-five feet, curators might think carefully about installing an LED that has the potential to create noticeable light movement should it begin to burn out. If the museum staff is unable to immediately replace lights at that height within a short amount of time, they might choose to use incandescent bulbs instead. It is important to consider staff time and physical limitations when deciding what light source to use.

Angle

Of the five categories considered in this paper, light angle is the only one that takes into consideration the placement of the light rather than analyzing the mechanics within the lighting source itself. The choice of lighting angle influences every aspect of the museum experience, including the three-dimensionality of sculpture, where picture-frame shadows fall on the artworks, and the amount of reflective glare on a painted surface or glazing. The medium and dimensionality of an artwork dictates the best angle of the lighting source. A work of art with gold elements might be best displayed with a low light angle, for instance, to make the gold as reflective as possible while using the smallest amount of illumination. A piece that has transparent qualities might benefit from a light source coming from the back as well as the front. These considerations are all determined on a case-by-case basis. There is no one-size-fits-all solution for any given material. The typical museum has a fixed lighting track along the perimeter of each gallery and down each hallway. Converting to an LED system might entail adjustments, addition tracks or even removal of tracks entirely in favor of a system that allow for light placement specific to every artwork.

Figure 1

Typical Museum Lighting Requirements

Light Sensitivity of Material	Illuminance	Exposure
High	50–75 Lux	Very Limited
Moderate	50–75 Lux	Limited
Low	150–350 Lux	Permanent Display
Not Light Sensitive	No Limit	Permanent Display

Distribution

Distribution is a way of making a light plan work as a uniform scheme, with the ability to focus light where you want it and reduce it where you don't want it. When considering distribution, one must keep in mind what system allows for the most control. There are typically two options to create an ideal distribution, retrofit lamps and remote phosphor lamps. A retrofit lamp is an LED bulb fitted for use in a canister previously designed for an incandescent light. Retrofit lamps produce a low amount of glare and have the possibility to create either a diffuse wall wash or a controlled spotlight. Carefully matching the size of the beam to the size of the artwork reduces the amount of shadow and makes the art the focal-point in the room. Some users have noted that retrofit lamps generate more heat than remote phosphor lamps, due to the fact that the casing was not specifically made to handle LEDs. The casing that holds the bulb as well as museum cases can be drilled to ventilate the heat. In any case, the heat generated by LEDs is far less than incandescent bulbs produce.

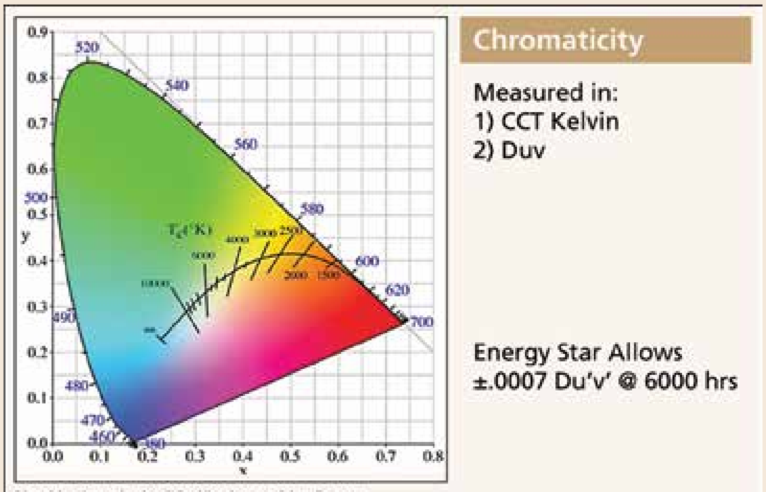
Remote phosphor lamps are canisters made specifically for LEDs and installed on their own track fixture. Since the casing is specifically made for an LED system, they tend to offer better control of heat output. Phosphor lamps also deliver a more color-stable light source over time. LED lights have been noted to have a slight color change over an extended period. Both retrofit and remote phosphor lamps produce the same amount of color shift. Most manufacturers of remote phosphor lamps provide warranties for color shifts with their products. Since converting to LEDs comes with a considerable increase in per-bulb price, it is best to work with a company that provides such warranty protection.

Color

Determining the proper color of light involves three criteria; chromaticity, color rendering, and damage factor.

Chromaticity can be seen when shining a light source onto a white substrate. The color reflected indicates the warm (yellow) or cool (blue) nature of the light. Kelvin temperature measures how yellow to blue a lighting source is, while Duv temperature measures how pink to green it is. Even though measurements are typically taken in Kelvin, humans are more sensitive to Duv changes on the pink to green scale, as indicated in the chromaticity graph. [Fig. 2]. The diagram represents the mapping of human color perception in regards to the spectral colors, or the visible spectrum.

Figure 2



Planckian locus in the CIE 1931 chromaticity diagram

Color rendering indicates the colors that a light source is capable of reflecting back. Shining a light source at a color chart will help determine which light source—natural, incandescent, LED, etc —would be best paired with a particular work of art. Adjustments can be made to the LED using phosphor filters to create the precise color rendering the museum or gallery desires.

Damage factor measures how an emitted spectrum of light might affect the potential for light damage to an object. One method of determining the color output of a light source is to measure it with the use of a spectrometer. A spectrometer measures a wide range of energies given off by light and calculates color indexes as well as damage factor. The decision of which light source to use should not be made solely by the data achieved with the use of a spectrometer, however. Experienced observation in actual lighting simulations within the gallery is also valuable and necessary. A proper lighting scheme is a balance between objective data and a subjective sense of how the lights look in actual use.

Conclusion

In order to achieve the best results from LEDs, there are several aspects to take into consideration:

- See the lighting source installed beforehand.
- Require that the light source be tested for total flux (light output), electrical power, efficacy, chromaticity, and intensity distribution. One such performance test is the LM-79.
- Test all aspects of the device to be sure they work together to create a uniform lighting system capable of the lighting effects your gallery requires (spotlight, wall wash, dimmers, etc.)
- Buy from companies you trust with documented support history, as a safeguard in the event there is a failure in one of the lighting sources and you need a replacement or refund.
- Diversify your lighting source based on the types of art. Keep a record of positive and negative performances from different brands.

Though all visible light is potentially damaging to works of art, without it we cannot have a satisfactory museum experience. It is vital that we balance the aesthetic presentation against the light exposure and safety levels. LEDs are still a new technology in terms of mainstream applications, especially in the art world. While the technology continues to improve at a rapid pace, the decision to convert now, later, or if at all should take into consideration whether improvements over previous technologies justify the cost.

Information in this article was gathered from source material written and presented by Steven Weintraub, Consultant at Art Preservation Services, and Gordon Anson, Deputy Chief of Design at the National Gallery of Art in Washington, DC. Both provide lighting consultation services.

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