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What you need to know about light sources and color evaluation

The perceived color of any object is significantly influenced by the light source and the environment in which it is viewed. As the light source changes, the color of an object may also change. To ensure consistency in color decisions, it is therefore essential that everyone evaluating color in a supply chain evaluates samples under similar lighting conditions. A basic understanding of lighting technology will be invaluable to those tasked with making the decision to implement a new light source.

Understanding Color Temperature and CIE Standards

Before embarking on the light source selection process, it's important to understand some basics regarding how light sources are described. International standards for light sources are established by the International Commission on Illumination (CIE), and lighting suppliers use these standards in their manufacturing processes. While each lighting supplier may choose their own brand and model names for their lighting, they will also provide information on the "color temperature" of their products. The color temperature, expressed in degrees Kelvin (K), gives the end-user a general sense of the "color" of the light source. The lower the color temperature of the light source, the warmer or redder the source will be. Inversely, the higher the color temperature of the source, the cooler or bluer it will be.

The most common color temperatures, names, and their associated colors are:

Color Temperature	Name	Color
7500K (D75)	North Sky Daylight	Moderate to Deep Blue
6500K (D65)	Average Daylight	Moderate Blue
5000K (D50)	Noon Sky Daylight	White
4100K	Various Fluorescent & LED Sources	Green
3500K	Various Fluorescent & LED Sources	Redder / Yellow
3000K	Various Fluorescent & LED Sources	Red / Yellow
2856K	Illuminant A / Incandescent / Tungsten Halogen	Yellow / Red
2300K	Horizon	Red

A number of fluorescent light sources have been used in retail lighting environments, and these have historically been described using generic names rather than their color temperatures. However modern designs are typically driven by energy regulations in various regions rather than by attempts to correspond to specific CIE standards, with naming transitioning to use of color temperature rather than the former generic names. See appendix for a chart of generic names to their corresponding color temperature.

Understanding Types of Light Sources

A variety of lighting products are available in the market today, and each product will produce visible light energy by one of several methods.

- **Incandescent and Tungsten Filament:** Historically, the typical light bulb found in the home has been an incandescent tungsten lamp. This type of lamp utilizes a tungsten filament that will glow when electricity is passed through it. But this process generates wasted energy in the form of heat, so in the interest of energy conservation many lamps of this type have been discontinued. As a result, today we are seeing a greater number of compact fluorescents and LED lamps used in the home environment.

  A quartz halogen lamp is a specific type of incandescent tungsten lamp with special characteristics to give the lamp a more uniform output over its life cycle. These lamps are used when a yellowish to red source is required.

- **Fluorescent:** Fluorescent light sources produce light when electrical energy is applied to a glass tube containing mercury together with fluorescent compounds called “phosphors”. By adjusting the types of phosphors in the lamp, lighting manufacturers can produce fluorescent tubes in a variety of styles and color temperatures. “Wide band” fluorescent tubes such as Cool White Fluorescent (CWF) have been largely replaced by more energy efficient “tri-phosphor” fluorescent tubes.
- **LED:** Light-emitting diodes (LEDs) have been used in electronics for over 50 years, but it wasn’t until the relatively recent introduction of white LEDs that they have become increasingly important in retail and consumer lighting. LEDs offer significantly improved energy efficiency compared to other types of lighting and are becoming the light source of choice for many retail, office, and home environments. To ensure a positive consumer experience when products are viewed in LED lighting, it is essential that product color is developed and evaluated in comparable LED viewing conditions.
- **Ultra-Violet:** Ultra-violet (UV) light energy is not visible to the human eye but is present in natural daylight. UV energy is used to excite optical brightening agents (OBAs) and fluorescent dyes and pigments within a sample, causing them to emit visible light. The “extra” visible light makes white materials appear whiter and brighter than they would without the OBAs, and fluorescent colors exhibit the classic “neon” affect.

Understanding Key Stakeholders in the Lighting Decision Process

Prior to implementing a new light source, companies must evaluate what impact the change will have on the perceived color of their color standards and existing products, and then decide what (if any) corrective actions are required. Color change will fall into two categories: flare, and metamerism. Flare refers to a change in color of a material when it is viewed in different light sources. Metamerism occurs when two samples match under one lighting condition but not under another. Changing light sources can result in noticeable differences in both flare and metamerism, but the severity of the impact may be different depending on who is evaluating the products, so key stakeholders must be considered in the evaluation process:

- **Designers:** The colors designers select for their designs may look different in a new light source, impacting the overall aesthetic of the product
- **Merchandisers:** The seasonal color palette must be evaluated in the new light source to ensure that individual colors do not flare in an unacceptable direction
- **Color office:** Communication is key, and the retail/apparel color office is often responsible for implementing the global color management workflow, so their input is essential
- **Suppliers:** It’s important to ensure that existing colors match standards under a new light source, and that on-going production matches the standard as well
- **Everyone who evaluates color:** Color evaluation will require light booths equipped with the proper light source, and software must be updated to calculate color differences
- **The customer:** Ultimately, you’ll want to select a light source that leads to a positive customer experience and supports ongoing sales of products

How to Build a Light Source Implementation Plan

The key to avoiding surprises when implementing a new light source into the color development process is to start with a well-defined plan. A plan ensures that specific problems can be addressed proactively within the organization, rather than having to react to any product issues in the store. The following steps will guide you in successful implementation of a new light source:

1. Consider when the transition to LED needs to be complete, as timing determines the urgency of each step
2. Who will be impacted by the transition to a new light source, and how will their concerns be considered in the evaluation and transition?
3. Select a standard CIE illuminant for color development and quality control that matches as closely as possible the light source used in the environment where the products will be sold
4. Equip light booths internally and in the supply chain with matching light sources
5. Ensure that matching light source data is available in color management software internally and in the supply chain
6. Evaluate standards to determine the impact on flare, then review with stakeholders (see above)
7. Evaluate samples to determine the impact on metamerism, then review with stakeholders (see above)
8. Based on the results of flare and metamerism evaluation, take one of three approaches for implementation in the global color development supply chain

Three Approaches to Implementation

Based on the results of the sample analysis, your organization may choose to take one of three approaches to implementing a new light source in your global color development supply chain:

1. Pick a light source for color development that is the same as the source used in store and require its use by vendors and suppliers. This approach may require additional color development as well as additional equipment.
2. Pick a light source that is as close as possible to the one being replaced, then continue using the original light source for color development. No additional color development work is required, but it may be difficult to find a new light source that matches the original one.
3. Adjust color standards to minimize issues due to flare. Changing the dyes used has the potential to produce “color constant” standards that will look the same regardless of light source, but a significant amount of color development rework may be required.

A Final Word

Industry standards for color viewing booths have been established for color quality, light intensity, evenness of illumination, viewing/illumination geometry, and surrounding conditions. Differences in any of these conditions can affect color appearance and result in inaccurate color quality decisions. The best way to ensure accuracy and repeatability in sample color evaluation is to use a color viewing booth that meets industry specifications. Datacolor’s industry-compliant viewing systems range from small desktop viewers to floor stand models to luminaires for complete color harmony rooms.

Lamps are the key component of any viewing environment. Lamps for Datacolor lighting products are designed for use in critical color viewing stations and deliver the tightest match to the industry standard curves. The lamps are manufactured with a unique blend of fluorescent phosphors or LEDs and produce a true full spectrum white light that renders colors with the highest degree of accuracy and efficiency. These lamps provide greater color fidelity and tighter compliance to the viewing standard than competitive lamps.

Appendix:

Common generic fluorescent light source names in retail lighting environments:

Name	CIE Standard	Color Temperature	Notes
CWF	F2	4150K	Not available in lengths <4 feet
WWF	F4	3000K	
TL84	F11	4100K	
TL83	F12	3000K	
TL835	--	3500K	Similar to SPX35
SPX35	--	3500K	Popular in retail applications
U30	--	3000K	Energy efficient, but discontinued
U35	--	3500K	Energy efficient, often replaced by SPX35