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Explanation of Various Light Sources and Their Use in Visual Color Matching Applications

Those becoming involved with the science and practice of visual color matching as well as seasoned veterans of the process, will need to determine which light sources are best to use for a specific color matching application. Although on the surface this may seem to be a fairly straightforward decision, due to the variety of sources now available on the market today, the actual decision can be rather difficult.

The easiest decisions will occur when a customer specifies which sources should be used. Companies such as Wal-Mart, Target, Sears, and Home Depot all have company-established specifications for sources to be used in color matching.

If you do not have the benefit of a pre-established standard or specification to work from, you will need to establish your own. Choosing the light sources will be an integral part of establishing the procedure. Typically, the evaluation needs to be performed with a predominantly blue source, a reddish yellow source, and a greenish source. This allows for the efficient visual detection of metamerism. Below is a listing of various commonly available light sources, a brief description of each, and their intended usage or application. Additionally, we provide a short list of definitions to help the reader understand the terminology used in describing the various light sources.

Definitions:

CIE Rating - Based on CIE Publication 51, it is a very strict rating of a light source's ability to reproduce daylight, in both the visible and ultraviolet spectrums. The first letter provides the rating for the visible spectrum and the second letter the rating for the UV spectrum. An "AA" rating is the highest and "EE" the lowest. A rating of "BC" or better is acceptable for color matching applications.

Color Rendering Index (CRI) - A rating of a light sources ability to reproduce a daylight source. Based on a scale of 0 to 100, a rating of 92 or higher is required for critical color evaluation applications.

Color Temperature (AKA Correlated Color Temperature) - A rating of a light sources color output. It is based on the Kelvin scale in which 0 degrees is at Absolute Zero (-273 C) where all motion in a molecule is deemed to stop. The lower the color temperature of the light source, the redder the source will be. Inversely, the higher the color temperature of the source, the bluer it will be. Some common color temperatures, common names associated with them and their associated colors are:

7500K (D75)	North Sky Daylight	Moderate to Deep Blue
6500K(D65)	Average Daylight	Moderate Blue
5000K (D50)	Equal Energy Daylight	White
4100K	Various fluorescent sources	Greenish
3000K	Various fluorescent sources	Orangish
200K	Tungsten A	Red/Yellow
2865K	Illuminant A	Yellowish Red
2300K	Horizon	Reddish

High Efficiency source - A light source that requires a reduced amount of energy (i.e., electricity) to power the lamp.

Phosphor - The powdered chemical that is coated on the inside of the glass envelope that will glow or "fluoresce" when excited. Different phosphors have different color and bandwidth emissions of light.

Light Source Descriptions:

D75 (7500K) - A bluish colored light source originally used for grading cotton and other evaluation applications. It has been replaced by D65 as the standard source for these applications. It accentuates blue and subdues green and red. It is derived from the light coming in a north facing window in the northern hemisphere at noon at various times throughout the year. It is commonly called "North Sky Daylight."

D65 (6500K) - A light bluish colored light source used in color matching applications of paints, plastics, textiles, raw inks, and other manufactured products. It is the only daylight source that was actually measured. The other daylight sources (D75 and D50) were mathematically derived from these measurements. It accentuates blue and subdues green and red. Commonly used as a primary light source in color measurement instrumentation. It is derived from the average of measurements made of light coming in a north facing window in the northern hemisphere on an overcast day at various times through the day at various times throughout the year.

D50 (5000K) - A near white light source used in the evaluation of graphic arts and imaging applications. It has similar amounts of red, green, and blue energy. It neither accentuates nor subdues color, a prime requirement when viewing press sheets and original images (i.e., photographs) since they usually have many colors within the product to be evaluated.

Ultra Violet - Light energy not normally visible to the human eye, but which is present in natural daylight. UV energy has the ability to excite certain substances (dyes/pigments/chemicals) within a sample causing them to emit light in the visible spectrum, usually in the blue region. These substances are used in various products to "brighten" colors, particularly whites. It is necessary to include correct amounts of UV energy in a color matching system to allow for optimum simulations of natural daylight.

Cool White Fluorescent (CWF) - A wide band single phosphor fluorescent source commonly used in commercial lighting applications in North America. It is characterized by emitting high amounts of green energy, with a color temperature of approximately 4100K. It has a CRI or approximately 62.

Warm White Fluorescent (WWF) - A wide band single phosphor fluorescent source used in commercial lighting applications in North America. It is characterized by emitting high amounts of yellow/red energy, with a color temperature of approximately 3000K. It has a CRI of approximately 53.

TL84 - A narrow band tri-phosphor fluorescent source originally designed for commercial lighting applications outside North America. It is characterized by emitting high amounts of green energy, with a color temperature of approximately 4100K. It has a CRI of approximately 86.

TL830 - A narrow band tri-phosphor fluorescent source originally designed for commercial lighting applications outside North America. It is characterized by emitting high amounts of yellowish red energy, with a color temperature of approximately 3000K. It has a CRI of approximately 86.

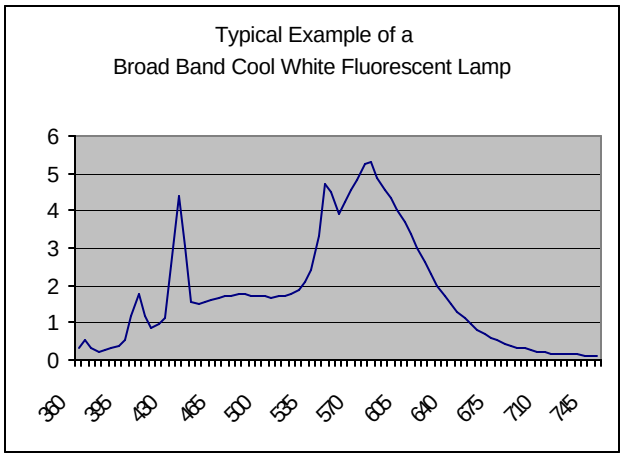
TL835 - A narrow band tri-phosphor fluorescent source originally designed for commercial lighting applications outside North America. It is characterized by emitting high amounts of reddish yellow energy, with a color temperature of approximately 3500K. It has a CRI of approximately 86.

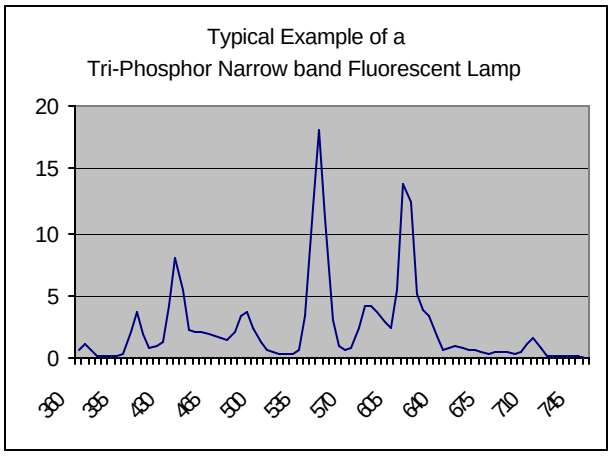
Ultralume 30 (U30 or 30U) - A narrow band tri-phosphor fluorescent source originally designed for commercial lighting applications in North America where energy savings is required. It is characterized by emitting high amounts of yellowish red energy with a color temperature of approximately 3000K. It has a CRI of approximately 85.

Ultralume 35 (U35 or 35U) - A narrow band tri-phosphor fluorescent source originally designed for commercial lighting applications in North America where energy savings is required. It is characterized by emitting high amounts of reddish yellow energy with a color temperature of approximately 3500K. It has a CRI of approximately 85.

It must be understood that not all fluorescent sources are available in all lamp sizes. Additionally, as was stated previously, certain retailers will specify which light sources or fluorescent lamps must be used for color matching applications if product is to be supplied to their stores. Your GTI representative will be happy to assist in the process of choosing the right compliment of sources and lamps for your applications. Please contact GTI or your local representative for further information.

Daylight source lamps supplied by GTI are specifically designed to provide the necessary light output, at the various visible and non-visible wavelengths and maintain the proper viewing environment within the GTI fixtures and color matching systems. If commonly available commercial lamps are used, even lamps from another standardized lighting manufacturer, the viewing system may *not* conform to specified standards. To assure consistent quality, *always* replace GTI lamps with GTI replacement lamps.





Incandescent and Tungsten Illumination

A typical light bulb found in the home is an incandescent tungsten lamp. It uses a tungsten filament that will glow when electricity is passed through it. A quartz halogen lamp is also a tungsten incandescent lamp, but has special characteristics to give the lamp a more even output over its life cycle. These lamps are very common and are used in color match applications where a yellowish to red source is required. The most common tungsten filament sources available, with their applications, are given below:

3200K	Tungsten A	Red/Yellow	Photographic imaging applications.
2865K	Illuminant A	Yellowish Red	Standardized source and illuminant for color matching.
2300K	Horizon	Reddish	Source described in older specifications and used for color matching applications. Replaced by Illuminant A.

Tungsten A - is used primarily in the photographic, film and video industries where a "whiteish" source and continuous light output are required. It is not commonly used for color matching applications.

Illuminant A - is a standardized illuminant described in the international standard, CIE Publication 15.2 and specified for use in color matching applications in ASTM D1729-96. It is used where a yellowish-red source is required. It is the predominant source/illuminant used for both instrumental and visual color matching applications. Another source described as Horizon in an outdated standard as an "Incandescent illumination of low correlated color temperature…" is not used in instrumental color matching applications.

Both overall light output and color temperature of a tungsten lamp will vary greatly with the voltage. Even a change of three volts in a 110 volt lamp will produce a measurable change in both output and color temperature. Color matching systems using these lamps must employ voltage stabilization circuits to make certain the color temperature remains stable. Even with this circuitry, it is very difficult to maintain the overall stability of light output and color temperature for a reasonable amount of time with tungsten lamps. In addition, as a tungsten lamp heats up, its color temperature and light output will change, sometimes quite drastically.

As a group, they produce very little blue energy. When used to imitate daylight, the overall light output must be increased substantially and special glass filters used that can take the heat energy produced by these lamps. Since a filter by its nature *removes* something (a water filter does not produce water, it removes sediment), an optical filter used in color matching to imitate daylight will remove or filter out some of the yellow and red portions of the spectrum. Although the daylight simulation produced by these systems is good, there are many disadvantages to using this type of source for daylight simulation. These include excessive heat from the high wattage lamps (as much as 3000 degrees Fahrenheit) that must be dissipated into the room environment, the electrical power needed to power them (as much as 18 amps for a typical application), and the high cost of the special filters.