BULBWORKS
SPECIALTY LIGHTBULBS AND SOCKETS

Color Temperature Of Light

Color Temperature is an important characteristic of Visible Light with regards to Microscopy. The Color Temperature of Thermal Light Sources such as Incandescent, Halogen, expressed in Degrees Kelvin (Degrees K or °K) is derived from comparing the hue of the light emitted from the light source to the hue emitted from a theoretical standard called a Black Body Radiator (black metal) when it is heated to various temperatures.

The temperature at which all molecular motion has stopped is Absolute Zero = 0°K= Minus 273 Degrees Celsius. A Black Body Radiator at 0°K would emit no energy and no light. The next several paragraphs describe the changes of the hues of color present in the light energy emitted from the Radiator (black metal) if it were heated from 0°K to progressively higher temperatures.

As you began to heat the Radiator, it would begin to give off visible light energy as a glow as it became hotter. The first light energy, appearing as a Reddish glow, would occur when the Radiator reached about 900 °K. If you were to continue to apply heat, the hue of the light emitted would remain almost exclusively Red until the temperature reached around 1400°K at which time the energy emitted, while still predominately Red, would also have hues of Yellow present. The amount of hues of Yellow would continue to increase and the amount of hues of Red would decrease as the temperature increased. The hues present in the light energy would move from less Red to more dominantly and completely Yellow as the temperature moved towards 3600 °K.

The hue would remain almost exclusively Yellow until the temperature of the Radiator reached around 3700 °K at which time the light, while still predominately remaining Yellow, would begin to also have very small hints of hues of White present. The amount of hues of White present would continue to increase and the amount of hues of Yellow would decrease as the temperature of the Radiator increased. The hues would move from less Yellow to more dominantly and completely White as the temperature of the Radiator increased and moved towards 5000°K.

The hue of the light would remain almost exclusively White until the temperature of the Radiator reached around 4600 °K at which time the light, while still predominately White, would begin to also have very small hints of hues of Blue present. The amount of hues of Blue would continue to increase and the amount of hues of White would decrease as the temperature of the Radiator increased. The hues would move from less White to more dominantly and completely Blue as the temperature of the Radiator increased and moved towards 5300°K and higher.

The Black Body Radiator is used as a basis to determine Color Temperature only for light sources that emit heat or Thermal Energy. Since the Black Body Radiator emits heat or Thermal Radiation in various colors at specific temperatures, the colors it emits are used to compare the hues of color present in light sources producing Thermal Energy such as Incandescent and Halogen light sources, and Flame. The color emitted from Thermal Light Sources is compared directly to the color emitted from the Black Body Radiator to assign the Color Temperature. The color temperature is assigned by comparing the actual temperature of the Black Body Radiator to the color of the light source. The Black Body Radiator approach cannot be used as a basis to determine Color Temperature for light sources that do not produce Thermal Radiation.

The Color Temperature for Non Thermal producing light sources such as Fluorescent, Mercury, Metal Halide, Xenon, and LEDs, is assigned by matching their brightness and hue to the brightness and hue of the Black Body Radiator when heated to specific temperatures, but the value assigned is an approximation or comparison determined by Human visual perception and not precise actual thermal matching. Because the value is determined by Human perception, when Color Temperature is determined by this method, the value is referred to as the Correlated Color Temperature or CCT sometimes also referred to as "apparent color temperature" since it is derived using other values. Both Color Temperature and Correlated Color Temperature, no matter what the derivation, are expressed as °K.

Color Temperature is an important attribute of the visual appearance of any light source. It should be noted that the Color Temperature of a light source will affect results in Microscopy and in Photographs and Digital images In addition to the Color Temperature, the Spectral Output of each type of light source will affect the results during Microscope Viewing, along with Photographic and Digital results as well. These issues become relevant when determining the correct compensatory filter needed to make color balance corrections for Microscope Viewing, Photography or Digital Imagery. The selection of a filter to compensate for Color Temperature is easier with Incandescent and Halogen light whose Color Temperature is derived from a more literal comparison to the Black Body Radiator because the hue of the light is defined. The selection of a compensatory filter needed to make color balance correction for Fluorescent, Mercury, Metal Halide, Xenon and LED light is made more difficult because it must be taken into account that they have a Color Temperature that has already been adjusted – a Correlated Color Temperature – because the Spectral Output of the light was considered when the Color Temperature was assigned. For Microscope Viewing, Photography or Digital Imagery, if there were a Thermal and Non Thermal light source each of the same Color Temperature, a different filter would likely be required to use with each in order to make the appropriate color balance corrections to each to produce the same results.

Here is a chart showing some of the Color Temperatures of popular Light Sources:

Temperature	Source
1,700 K	Match Flame, LEDs
1,850 K	Candle Flame, The Horizon At Sunset and Sunrise, LEDs
2,700 K	Sodium Light Bulbs, Incandescent Light Bulbs, Warm White Linear & Compact Fluorescent Light Bulbs, LEDs
3,000 K	Halogen Light Bulbs & Soft White Linear & Compact Fluorescent Light Bulbs, LEDs
3,200 K	Halogen & Incandescent Studio Light Bulbs, Photofloods, LEDs
3,350 K	Incandescent & Halogen Studio Light Bulbs, Photofloods, LEDs
4,100–4,150 K	Natural Moonlight, Mercury Lamps, Linear & Compact Cool White Fluorescent Light Bulbs, LEDs
5,000 K	Natural Sunlight At Noon At The Horizon, Color Corrected Linear & Compact Fluorescent Light Bulbs, LEDs
5,500–6,000 K	Color Corrected, Full Spectrum, Linear & Compact Fluorescent Light Bulbs, Electronic Flash, LEDs
6,000 K	Xenon Light Sources, Metal Halide Light Sources, Linear & Compact Fluorescent Light Bulbs, LEDs
6,500 K	Metal Halide Light Sources, Daylight Linear & Compact Fluorescent Light Bulbs, LEDs
6,500–9,300 K	Metal Halide Light Sources, LCD and CRT Screen, LEDs
9,300-10,000+ K	Metal Halide Light Sources, LEDs
All Temperatures Are Approximate	

It should be noted that the Color Temperatures of Incandescent and Halogen light are generally within a relatively narrow and exclusive range because of their limited physical and electrical makeup. Linear and Compact Fluorescent and Metal Halide light sources can be made to perform over a wider range because they can be "doped" with additives to produce specific results and in multiple ranges of Color Temperatures. LEDs can be made to perform over an even broader range of Color Temperatures – theoretically at any Color Temperature. Changes to the Color Temperature of an LED is accomplished by modifications to its' power supply, resistors, heat synch material or other components.

References:

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