More about lighting

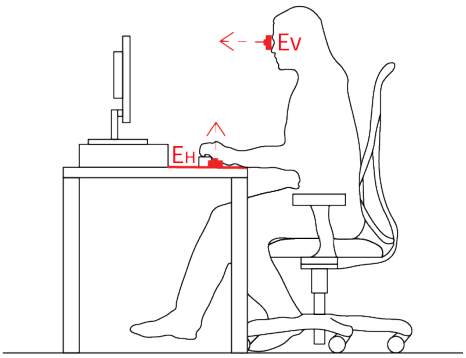
Measuring light

Illuminance (E) is the amount of luminous flux reaching a surface, and is measured in lumens per square meter (lux) or lumens per square foot (footcandle). One footcandle is equal to about ten lux. Lighting designs are concerned with two types of illuminance values: horizontal and vertical.

Horizontal illuminance (EH) is the light received on a surface, such as a table, desk, or counter. This is measured at work plane height, and the EH light levels are associated with the visual system, with concern about light falling on a work plane to see a task. To measure horizontal illuminance, hold an illuminance meter horizontal with the sensor facing upwards. This will measure how much light is falling on the surface.

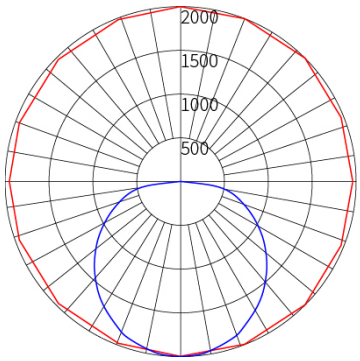
Vertical illuminance (EV) is light that is received at the eye. This is measurd at eye level height, and the EV light levels are associated with the circadian system. To measure vertical illuminance, hold the illuminance meter vertical with the sensor facing where the eye is looking. This direction can range depending on the occupant and the task. These values can be plugged into the CS calculator, along with the source SPD, to determine the CS value.

Direction of measuring horizontal illuminance (EH) (light received on a workplane)



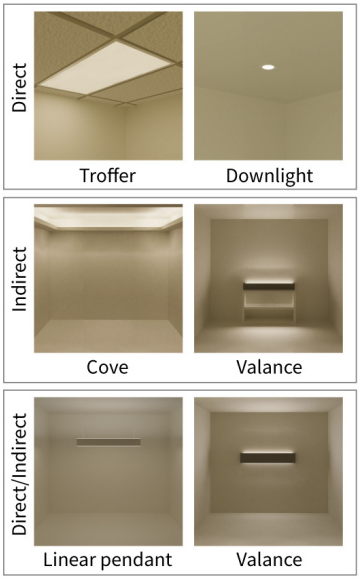
Direction of measuring vertical illuminance (EV) (light received at the eye)

Lumen output, beam distribution, and position of fixture



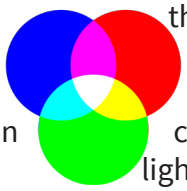
Intensity distribution example

When trying to achieve CS targets in a circadian design, being mindful of a few lighting characteristics can be beneficial to help meet the targets. First, the lumen output of a fixture will indicate the maximum amount of lumens a fixture will produce when it is turned fully on. The three-dimensional luminous field of how light leaves a fixture can be cut and shown in two dimensions in an **intensity distribution** plot. The blue curve of the intensity distribution indicates the plane of a source cut down the middle, while the red shows the plane of a source cut horiontally. The numbers indicate how many lumens reach each part of the cut. Distribution shapes vary depending on the source, and all have their benefits for different designs. Make sure your source has enough lumen output to get enough light to the eye. The position and location of fixtures can also change how much light gets to the eye. Typical orientations of fixtures includes direct, indirect, semi-direct, and direct/indirect. These terms were coined in reference of light that falls on the work plane, so 'direct' lighitng comes from fixtures in the ceiling, pointing down. Indirect fixtures, such as hanging pendants, direct light towards the ceiling to be reflected diffusely, which can give the space a more open feel. A pendant can also provide direct lighting on the other side, making it direct/indirect. When doing circadian designs, think about where you want light to be and what types of fixtures can achieve this. The LRC promotes using personal light devices that sit close and aim towards a user. This way, light will most effectively get to the eye, which is what circadian designs are concerned with.

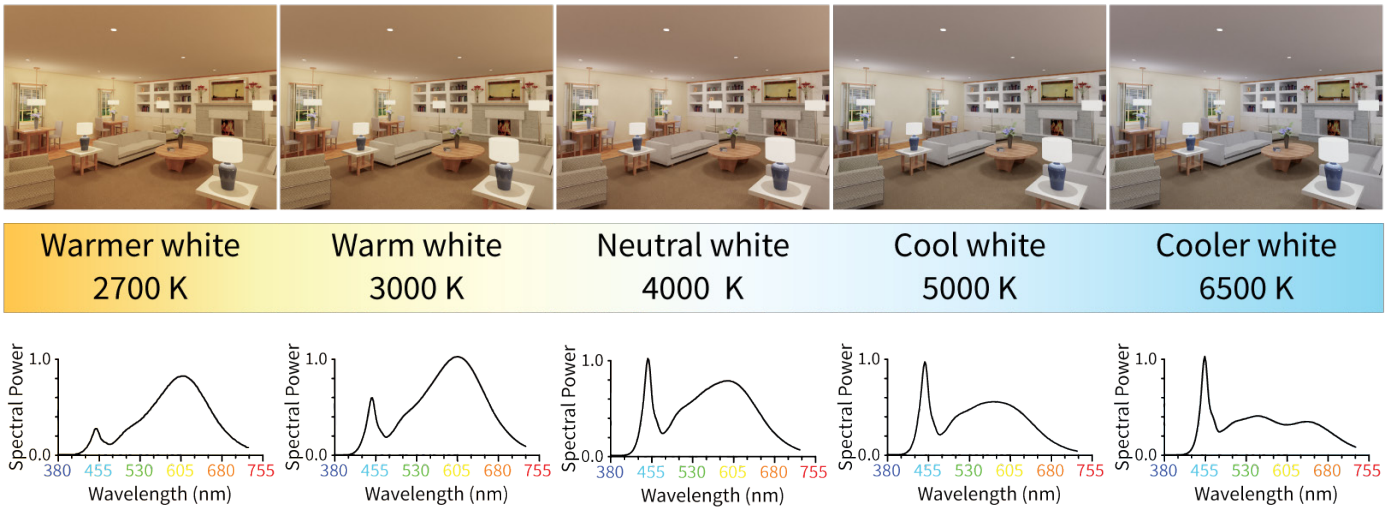


Correlated color temperature (CCT)- Ranges of white light

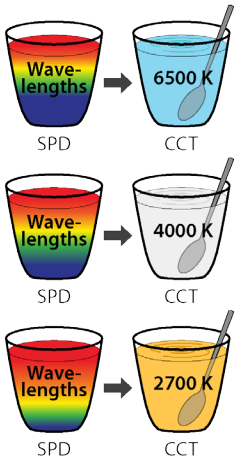
White light is made up of a combination of wavelengths in the visible spectrum, from about 380 nm - 780 nm. These wavelengths associate with colors that the eye perceives using the photoreceptors in the retina that have varying sensitivities to wavelengths. Essentially, the photoreceptors in the eye receive the energy from photons and with the response from all the photoreceptors, it will be perceived as a certain color by the brain. The color figure depicts the color creation when the primary colors of light (blue, green, and red) overlap. When similar amounts of blue, green, and red wavelengths are combined, white light is created.



A white light source can seem cooler (having a blue tint) or warmer (having a yellow tint), which is affiliated with its CCT (Correlated Color Temperature). CCT was derived from the color of light of a reference source when it is heated up to certain temperatures and is measured in degrees Kelvin (K). Typical CCT in designs can range from 2700 K (warmer white) to 6500 K (cooler white). The CCT along with brightness have an impact on CS as well as aestetics of how a space looks and feels.



SPD, or spectral power distribution graphs the amount of energy each wavelength has in a light source. Each light source is made up of a combination of wavelengths (x-axis), ranging in strength, which is indicated by relative spectral power (y-axis). With white light being a combination of the spectral power of the many wavelengths, it is possible to have different SPDs that the brain perceives to be the same color, or CCT. SPD curves with a similar trend that appear to be the same tint will can be classified under the same CCT, but can possess different qualities that can affect outcomes such as CS. With this being the case, it is important to use the correct SPD of sources used in a design to determine its CS contribution more accurately. The warm-white 2700 K shows a larger area of contribution from the longer wavelengths, and less contribution from the shorter wavelengths making it appear to have a yellower tint. Inversely, a cool-white 6500 K shows a greater peak in the shorter wavelengths, and a smaller area of long-wavelength contribution making it appear to have a bluer tint. In lighting designs, a static or tunable CCT approach can be used. A **static CCT system** in circadian design refers to single CCT that dims throughout the day to achieve vertical illuminance to reach CS targets. A **dynamic CCT system** refers to using multiple CCTs that can also dim. Cooler CCTs will generally reach a CS greater than 0.3 at lower light levels (compared to warm CCTs) which can be desired in some solutions that need lower horizontal light levels for visibility or energy savings. Creating a dynamic environment by changing the color temperature of the lighting in the space and/or dimming the light output throughout the day will provide a robust schedule that is beneficial for the circadian system to synchronize to the solar day.



An SPD with a higher concentration of shorter (blue) wavelengths mix to a cooler CCT white light, such as **6500 K**

An SPD with a similar amount of all visible wavelengths mix to a neutral CCT white light, such as **4000 K**

An SPD with a higher concentration of longer (red) wavelengths mix to a warmer CCT white light, such as **2700 K**