

# Module 3 Illumination Systems

# Lesson

# 14

# Color

## Instructional Objectives

1. What are Primary colors?
2. How is color specified?
3. What is CRI?

This lesson introduces concepts of color and how it is specified. Three basic elements in color perception are source of illumination, object illuminated and detector that recognizes color by the reflected light from the object. It is well known that human eye perceives between 400 to 700 nm as visible light. Radiation of a source is characterized by the Spectral Power Distribution (SPD) which affects the color of the illuminated object by way of shift in color under different types of Lamps.

Color implies different things under different contexts. Firstly at the Source color, characteristic by which an observer distinguishes patches of light of same shape and size. It connotes the Spectral Power Distribution. Perceived color, as perceived as object color. This is a result of object characteristics, viewing direction and adaptation of the observer. Lastly Object Color: Light reflected, transmitted or absorbed by a source when exposed to radiation from a Standard Light source. Normally selective absorption of incident light results in object color. However, color appearance depends on light reflected.

An important index to assess the color appearance due to a radiation from a source is Color Rendering Index (CRI). So, what is Color rendering? It is the property of making color appearance of objects under the source in question when compared to color under reference Light Conditions. This reference condition would no doubt be the conditions under natural day light conditions. From the point of view of color appearance lamps are broadly divided into three groups according to correlated color temperature. Table I lists a classification of correlated color temperature and color appearance.

**Table 1**

| <b>Correlated</b> | <b>Color</b>         |
|-------------------|----------------------|
| Color Temperature | Appearance           |
| >5300°K           | Cool (Bluish white)  |
| 3300 - 5300°K     | Intermediate (white) |
| > 3300°K          | Warm (Reddish white) |

A good quality Lighting calls for Good Illuminance level. As illuminance level increases color temperature also increases i.e. to say whiter should be the source.

## Color Specification Systems

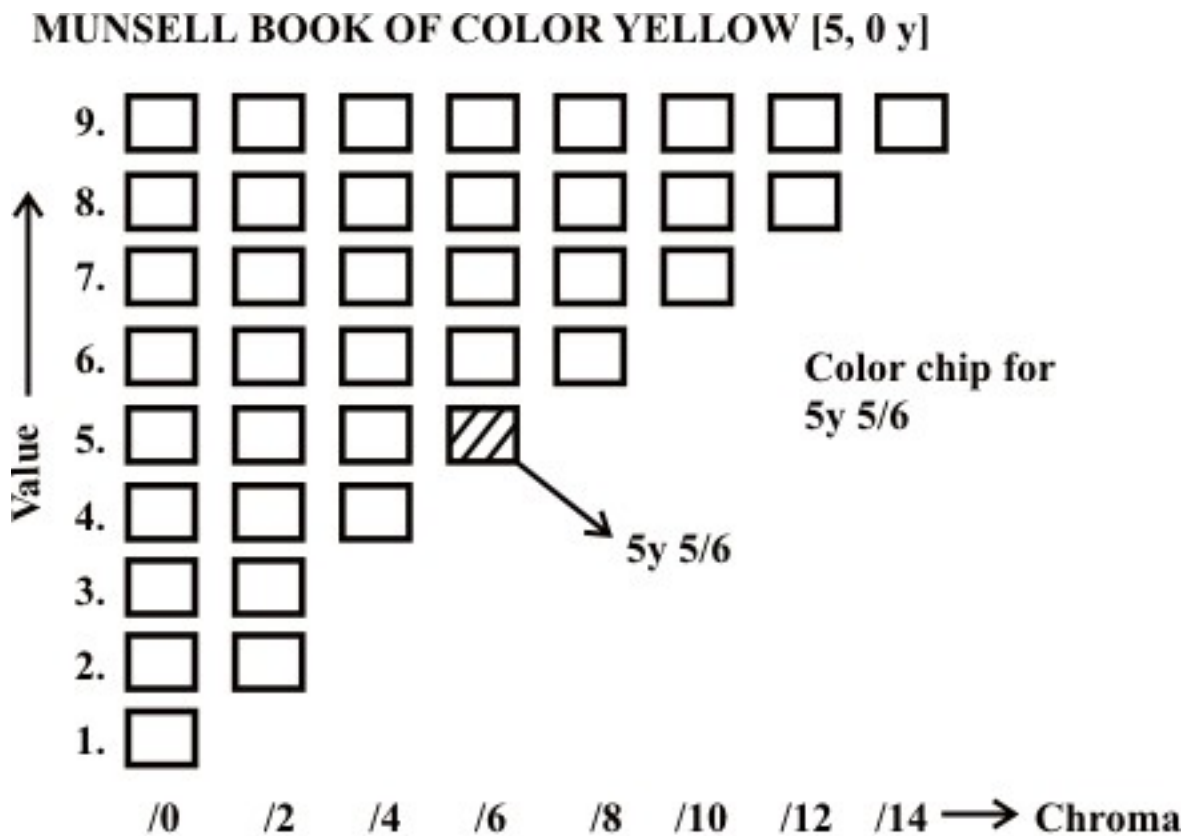
### Munsell system

Surface colors in day light conditions are best specified according to Munsell system. According to this system color has three dimensions i.e. hue, value and chroma. Each of these dimensions

are given a scale of values. Scales themselves being made of collection of color chips forming books of color charts. Each chart has one of the three kept constant.

Hue contains five Principal Hues namely, Red (R), Yellow (Y), Green (G), Blue (B) and Purple (P). Five intermediate Hues are also used they are, YR, GY, BG, PB and RP.

Value indicates lightness or brightness of the hue on a Grey Scale from (0) corresponding to black, (10) corresponding to white. Chroma is index of saturation – given in 14 steps indicates freedom from dilution with white. In munsell system, 5y 5/6, indicates yellow with half way up the Grey scale and six steps away from neutral in chroma. Sequence in specifying is Hue, value/chroma. Fig 1 shows a typical Munsell color chart for 5y5/6.



**Fig 1. Typical Munsell Color Chart**

## CIE System

Around 1931 – mathematically exact specification of the color based on color triangle also termed chromaticity diagram was introduced. This relies on two chromaticity coordinates x and y obtained from spectral distribution of Lamp and standard colorimetric observer to three Primary colors Red, Green and Blue. Saturated Light colors are at the edge of the triangle diluting to white towards the centre.

## L \*a \* b Colors Space

It is the prevalent CIE system of color specification. Both Munsell and CIE are subjective and rely on visual comparison of colors differences. Standard colors observer of CIE requires objective measurements. According to L\*a\*b system space is defined by two mutually perpendicular axes (a & b) in a horizontal plane and a vertical axis 'L'. Here Positive 'a' indicates Red content, Negative 'a' indicates Green content, Positive 'b' indicates Yellow content, and Negative 'b' indicates Blue content. While values along 'L' (in Munsell system) the value or lightness from 0 (Black) to 100 (white), a and b effect hue and saturation respectively.

## Color Rendering: Index Ra

Index that compares color appearance of various light sources. It is based on appearance of number of test colors under different illuminants. The average shift of chromaticity when test colors illuminated by test lamp and reference source of same color temperature give a measure of color rendering. For sources having color temperature  $\leq 5000^\circ\text{K}$  full radiator of nearest color temperature is taken as reference. For sources having color temperature  $> 5000^\circ\text{K}$  – simulated daylight of appropriate color temperature is used. Earlier 8 Munsell test colors of medium saturation were used for measurement. Now fourteen test colors are employed. In these system general color rendering index Ra can have a maximum of 100 when spectral distributions are identical for both test and reference source. Some discharge lamps have spectral energy distribution is close to that of the reference source. Thus they have high color rendering, even though efficacy may be low.

This lesson covered essentials of Color. Three prevalent color specification schemes are studied. Color rendering Index for is a way to assess color rendering property of any radiation.

## Tutorial Questions

- What are primary Colors?

Primary Colors are Red, Green and Blue

- What are the various Color Specification schemes?

Color specification schemes in vogue are Munsell system, CIE system and L\*a\*b Color space.

- What are basic elements in Color Specification?

Basic elements in Color Specification are hue, value and chroma

- What is Perceived Color?

Color that is perceived as object color. This is a result of object characteristics, depending on the viewing direction and adaptation of the observer

- What is CRI?

It is the property of making color appearance of objects under the source in question, when compared to color under reference Light Conditions.