ANSI/IES LS-5-21

Illuminating
ENGINEERING SOCIETY

LIGHTING SCIENCE:
COLOR

AN AMERICAN NATIONAL STANDARD

Approved American National Standard
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Prepared by
The IES Color Committee

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1.1 Introduction

The understanding of the color properties of light and their applications is finding an unprecedented relevance in the lighting industry. As a result, lighting professionals are faced with an increased need for accurate quantitative and qualitative descriptions of the color related performance of all light sources. Lighting professionals need an understanding of human vision and psychology to appreciate the ways that light and color will affect users. They also need a command of the vocabulary and methods used to describe and measure color. They should know the properties of available light source technologies. Finally, they are expected to have the artistic and technical ability to apply all of this information in the field in order to realize designs that meet the needs of the users, support the overall design and project goals, and use light appropriately and effectively.

1.2 Scope

This document covers the basics of color science, including color vision fundamentals and an overview of colorimetry. It also describes color terminology, color properties of light sources, and the use of color in applied lighting, which includes discussions of common color metrics. This document is not meant as a substitute for more comprehensive literature on this topic or for the standards that are referenced within; instead, it is meant to provide general knowledge to a lighting practitioner and direct readers to appropriate material. It focuses on practical use, rather than acting as a historical record.

2.0 Basic Concepts

2.1 Light

Light is radiant energy capable of exciting photosensitive cells in the retina and producing a visual sensation. The meaningful visible portion of the electromagnetic spectrum extends from about 380 to 780 nanometers (nm), as shown in **Figure 2-1**. Several different wavelength ranges are used when quantifying human visual response. The range of wavelengths that may induce a photoreceptor response does not have a sharp edge. The probability for inducing a response is reduced at the boundaries of the visible wavelength range (below 380 nm and above 780 nm). While laboratory studies show people can see intense light at wavelengths near the extreme edges of the visible range, human sensitivity is so low in those spectral regions that they generally have negligible practical impact. As an illustration of this, 99.94% of photopic response lies within the wavelength range 400 nm to 700 nm, making it sufficiently complete for almost all practical purposes. The range 380 nm to 780 nm is considered entirely adequate for all practical purposes. In addition, when there is scientific interest in tabulating all *detectable* visible response, then the range 360 nm to 830 nm is often used. Today, by far the most commonly used range for practical considerations of human visual response is 380 nm to 780 nm.

Light that has no perceptible color to a typical viewer is commonly described as “white light.” Most people are familiar with the idea of separating white light into its color components using a prism. These color components or, technically speaking, the radiant power at each wavelength, can vary greatly, but the overall effect from each source is an appearance of white light. When the radiant energy of a single wavelength is viewed, it appears to be of a single spectral color (see **Figure 2-1**).

> *One could ask: How many different colors can people see? Unfortunately, this simple question yields not just one answer but a whole series of them. If color samples are placed side by side, most people can distinguish more than a thousand different colors; however, if samples are presented one at a time, performance declines. In fact, when samples are seen one at a time, with several seconds elapsing between samples, most people can reliably recognize fewer than a dozen different colors.* – Halsey and Chapanis, 1951[1]