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ANSI/IES LS-4-20

LIGHTING SCIENCE:
MEASUREMENT OF LIGHT – THE SCIENCE OF PHOTOMETRY

AN AMERICAN NATIONAL STANDARD

Approved American National Standard
ANSI

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When you can measure what you are speaking about, and express it in numbers, you know something about it.
– Lord Kelvin 1883, engineer and mathematical physicist

1.0 Introduction and Scope

1.1 Introduction

Lighting is anchored to meaningful visual phenomena by way of the definition of *light* it adopts: the joining of radiant power, a physical quantity, with visual response, a psychophysical quantity. The utility of the definition allows light to be measured and calculated; that is, light has the aspects of *quantity* that permit the engineering activities of measurement and prediction by calculation. This analytic aspect of light and lighting allows successful experience to be recorded and become quantity recommendations for other lighting projects, allows lighting equipment to be characterized in ways useful to designers, and allows predictions of likely outcomes of proposed lighting designs.

Optical radiation generally refers to all radiation that can be measured using certain techniques and equipment (mirrors, lenses, filters, diffraction gratings, prisms). Thus, visible, ultraviolet (UV), and infrared (IR) radiation are collectively considered as optical radiation.

The measurement of optical radiation, called *radiometry*, is the science of measuring radiant quantities and is part of the general science of measurement, metrology.

Photometry, a special branch of radiometry, is the measurement of radiation accounting for human visual response. The International Commission on Illumination (CIE) defines a "standard observer" in part by the photopic luminous efficiency function of wavelength, V(λ). The definition of this standard observer quantifies this visual response and defines the spectral response that photometric measurement equipment needs to exhibit.[1]

This standard observer response curve is used as a weighting function applied to the spectral power distribution (SPD) of the optical radiation being measured. The summation across all wavelengths of the weighted SPD defines luminous flux.[1] The weighting and summation are the very core of photometry. Though it is globally accepted and used, V(λ) is a compromise that always assumes the same predictable correlation of physical measurements with visual response. However, there are circumstances where photometric quantities are poor predictors of visual response. (Refer to ANSI/*IES LS-8-20, Lighting Science: Vision – Perceptions and Performance*.[2]) Thus, a basic understanding of photometry is essential to the balance that needs to be struck by a lighting designer between measurement on one hand and visual experience on the other.

Photometry and radiometry are used to determine properties of lighting equipment and materials, as well as aspects of the performance of lighting systems. Some of these measurements require photometric standards (for either sources or detectors) and are usually performed in a photometric laboratory; some are accomplished with equipment designed for field use. **Table 1-1** shows the most common types of photometric and radiometric measurement, along with the equipment and usual place of measurement.

1.2 Scope

This Lighting Science (LS) document describes the various types of photometry and photometric instrumentation, including laboratory and field equipment and measurement types, and instructions for some types of field measurements. However, it does not provide instructions or methodology for performing laboratory tests. For that kind of information, the reader is referred to the IES Lighting Measurement (LM) series of documents.

Sidebar: A Historical Note

Photometry is a word first used by Johann Heinrich Lambert as the title to his 1760 Latin treatise on the measurement of light. He coined it by combining the Greek words for *light* (*φωσ*) and *measure* (*μετον*). Lambert's word soon found its way into European languages.