



Designation: E308 – 22

Standard Practice for Computing the Colors of Objects by Using the CIE System¹

This standard is issued under the fixed designation E308; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the U.S. Department of Defense.

INTRODUCTION

Standard tables (Tables 1–4) of color matching functions and illuminant spectral power distributions have since 1931 been defined by the CIE, but the CIE has eschewed the role of preparing tables of tristimulus weighting factors for the convenient calculation of tristimulus values. There have subsequently appeared numerous compilations of tristimulus weighting factors in the literature with disparity of data resulting from, for example, different selections of wavelength intervals and methods of truncating abbreviated wavelength ranges. In 1970, Foster et al. (1)² proposed conventions to standardize these two features, and Stearns (2) published a more complete set of tables. Stearns' work and later publications such as the 1985 revision of E308 have greatly reduced the substantial variations in methods for tristimulus computation that existed several decades ago.

The disparities among earlier tables were largely caused by the introduction of computations based on 20-nm wavelength intervals. With the increasing precision of modern instruments, there is a likelihood of a need for tables for narrower wavelength intervals. Stearns' tables, based on a 10-nm interval, did not allow the derivation of consistent tables with wavelength intervals less than 10 nm. The 1-nm table must be designated the basic table if others with greater wavelength intervals are to have the same white point, and this was the reason for the 1985 revision of E308, resulting in tables that are included in the present revision as Tables 5.

1. Scope

1.1 This practice provides the values and practical computation procedures needed to obtain CIE tristimulus values from spectral reflectance, transmittance, or radiance data for object-color specimens.

1.2 Procedures and tables of standard values are given for computing from spectral measurements the CIE tristimulus values X , Y , Z , and chromaticity coordinates x , y for the CIE 1931 standard observer and X_{10° , Y_{10° , Z_{10° and x_{10° , y_{10° for the CIE 1964 supplementary standard observer.

1.3 Standard values are included for the spectral power of six CIE standard illuminants and three CIE recommended fluorescent illuminants. Weight sets are included for tristimulus integration of nine standard or recommended CIE LED illuminants combined with the two standard CIE observers.

1.4 Procedures are included for cases in which data are available only in more limited wavelength ranges than those recommended, or for a measurement interval wider than that recommended by the CIE. This practice is applicable to spectral data obtained in accordance with Practice E1164 with 1-, 5-, 10-, or 20-nm measurement interval.

1.5 This practice includes procedures for conversion of results to color spaces that are part of the CIE system, such as CIELAB and CIELUV (3). Equations for calculating color differences in these and other systems are given in Practice D2244.

1.6 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.7 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.8 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the*

¹ This practice is under the jurisdiction of ASTM Committee E12 on Color and Appearance and is the direct responsibility of Subcommittee E12.04 on Color and Appearance Analysis.

Current edition approved Aug. 1, 2022. Published August 2022. Originally approved in 1966. Last previous edition approved in 2018 as E308 – 18. DOI: 10.1520/E0308-22.

² The boldface numbers in parentheses refer to the list of references at the end of this practice.

Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.

2. Referenced Documents

2.1 ASTM Standards:³

D2244 Practice for Calculation of Color Tolerances and Color Differences from Instrumentally Measured Color Coordinates

E284 Terminology of Appearance

E313 Practice for Calculating Yellowness and Whiteness Indices from Instrumentally Measured Color Coordinates

E1164 Practice for Obtaining Spectrometric Data for Object-Color Evaluation

E2022 Practice for Calculation of Weighting Factors for Tristimulus Integration

E2729 Practice for Rectification of Spectrophotometric Bandpass Differences

2.2 ANSI Standard:⁴

PH2.23 Lighting Conditions for Viewing Photographic Color Prints and Transparencies

2.3 CIE/ISO Standards:

ISO Standard 11664-1:2007(E)/CIE S 014-1/E:2006 Standard Colorimetric Observers^{4,5}

ISO Standard 11664-2:2007(E)/CIE S 014-2/E:2006 Colorimetric Illuminants^{4,5}

CIE Standard D 001 Colorimetric Illuminants and Observers (Disk)⁵

2.4 ASTM Adjuncts:

Electronic file containing Tables 5⁶

3. Terminology

3.1 Definitions of terms in Terminology E284 are applicable to this practice (see also Ref (4)).

3.2 *Definitions*—Definitions are listed in dictionary alphabetical order which makes no distinction between capital and lower-case ordering of the letters of the alphabet, and disregards spaces between multiple-word definiens. Otherwise, order is determined by the UTF-8 value of the letter or symbol involved. Definitions that have the same meaning, but are not necessarily word-for-word identities as that contained in the committee terminology document, are notated with the designation of that document after the definition.

3.2.1 *bandpass, adj*—having to do with a passband. E284

3.2.2 *bandwidth, n*—the width of a passband at its half-peak transmittance. E284

3.2.3 *chromaticity, n*—the color quality of a color stimulus definable by its chromaticity coordinates. E284

3.2.4 *chromaticity coordinates, n*—the ratio of each of the tristimulus values of a psychophysical color to the sum of the tristimulus values. E284

3.2.4.1 *Discussion*—In the CIE 1931 standard colorimetric system, the chromaticity coordinates are: $x = X/(X + Y + Z)$, $y = Y/(X + Y + Z)$, $z = Z/(X + Y + Z)$; in the CIE 1964 colorimetric system, the same equations apply with all symbols having the subscript 10 (see 3.2.10).

3.2.5 *CIE, n*—the abbreviation for the French title of the International Commission on Illumination, Commission Internationale de l'Éclairage. E284

3.2.6 *CIE 1931 (x, y) chromaticity diagram, n*—chromaticity diagram for the CIE 1931 standard observer, in which the CIE 1931 chromaticity coordinates are plotted, with x as abscissa and y as ordinate. E284

3.2.7 *CIE 1931 standard colorimetric system, n*—a system for determining the tristimulus values of any spectral power distribution using the set of reference color stimuli, X, Y, Z and the three CIE color-matching functions $\bar{x}(\lambda)$, $\bar{y}(\lambda)$, $\bar{z}(\lambda)$ adopted by the CIE in 1931. E284

3.2.8 *CIE 1931 standard observer, n*—ideal colorimetric observer with color-matching functions $\bar{x}(\lambda)$, $\bar{y}(\lambda)$, $\bar{z}(\lambda)$ corresponding to a field of view subtending a 2° angle on the retina; commonly called the “2° standard observer.” E284

3.2.9 *CIE 1964 (x₁₀, y₁₀) chromaticity diagram, n*—chromaticity diagram for the CIE 1964 standard observer, in which the CIE 1964 chromaticity coordinates are plotted, with x_{10} as abscissa and y_{10} as ordinate. E284

3.2.9.1 *Discussion*—Fig. 1 shows the CIE 1931 and 1964 chromaticity diagrams, including the locations of the spectrum locus and the connecting purple boundary.

3.2.10 *CIE 1964 standard colorimetric system, n*—a system for determining the tristimulus values of any spectral power distribution using the set of reference color stimuli X_{10}, Y_{10}, Z_{10} and the three CIE color-matching functions $\bar{x}_{10}(\lambda)$, $\bar{y}_{10}(\lambda)$, $\bar{z}_{10}(\lambda)$ adopted by the CIE in 1964 (see Note 1). E284

NOTE 1—Users should be aware that the CIE 1964 (10°) system and standard observer assume no contribution or constant contribution of rods to vision. Under some circumstances, such as in viewing highly metameric pairs in very low light levels (where the rods are unsaturated), the amount of rod participation can vary between the members of the pair. This is not accounted for by any trichromatic system of colorimetry. The 10° system and observer should be used with caution in such circumstances.

3.2.11 *CIE 1964 standard observer, n*—ideal colorimetric observer with color-matching functions $\bar{x}_{10}(\lambda)$, $\bar{y}_{10}(\lambda)$, $\bar{z}_{10}(\lambda)$ corresponding to a field of view subtending a 10° angle on the retina; commonly called the “10° standard observer” (see Note 1). E284

3.2.12 *CIE 1976 (u', v') or (u'₁₀, v'₁₀) chromaticity diagram, n*—the uniform-chromaticity-scale diagram produced by plotting in rectangular coordinates v' against u' , quantities defined as follows:

$$u' = 4X/(X + 15Y + 3Z) = 4x/(-2x + 12y + 3) \quad (1)$$

³ For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

⁴ Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, <http://www.ansi.org>.

⁵ Available from CIE (International Commission on Illumination), <http://www.cie.co.at> or <http://www.techstreet.com>.

⁶ Electronically readable tables of tristimulus weight sets are available from ASTM Headquarters. Request Adjunct No. ADJE0308-EA. Originally approved in 2022.