



Standard Tables for Reference Solar Spectral Irradiances: Direct Normal and Hemispherical on 37° Tilted Surface¹

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INTRODUCTION

A wide variety of solar spectral energy distributions occur in the natural environment and are simulated by artificial sources during product, material, or component testing. To compare the relative optical performance of spectrally sensitive products a reference standard solar spectral distribution is required. These tables replace ASTM standard G 159, which has been withdrawn. The solar spectral energy distribution presented in this standard are not intended as a benchmark for ultraviolet radiation in weathering exposure testing of materials. The spectra are based on version 2.9.2 of the Simple Model of the Atmospheric Radiative Transfer of Sunshine (SMARTS) atmospheric transmission code **(1,2)**.² SMARTS uses empirical parameterizations of version 4.0 of the Air Force Geophysical Laboratory (AFGL) Moderate Resolution Transmission model, MODTRAN **(3,4)** for some gaseous absorption processes, and recent spectroscopic data for others. An extraterrestrial spectrum differing only slightly from the extraterrestrial spectrum in ASTM E 490 is used to calculate the resultant spectra **(5)**. The hemispherical tilted spectrum is similar to the hemispherical spectrum in use since 1987, but differs from it because: (1) the wavelength range for the current spectrum has been extended deeper into the ultraviolet; (2) uniform wavelength intervals are now used; (3) more representative atmospheric conditions are represented; and (4) SMARTS Version 2.9.2 has been used as the generating model. For the same reasons, and particularly the adoption of a remarkably less turbid atmosphere than before, significant differences exist in the reference direct normal spectrum compared to previous versions of this standard. The input parameters used in conjunction with SMARTS for the selected atmospheric conditions are tabulated. The SMARTS model and documentation are available as an adjunct to this standard.

1. Scope

1.1 These tables contain terrestrial solar spectral irradiance distributions for use in terrestrial applications that require a standard reference spectral irradiance for hemispherical solar irradiance (consisting of both direct and diffuse components) incident on a sun-facing, 37° tilted surface or the direct normal spectral irradiance. The data contained in these tables reflect reference spectra with uniform wavelength interval (0.5 nanometer (nm) below 400 nm, 1 nm between 400 and 1700 nm, an intermediate wavelength at 1702 nm, and 5 nm intervals from 1705 to 4000 nm). The data tables represent reasonable cloudless atmospheric conditions favorable for photovoltaic (PV) energy production, as well as weathering and durability exposure applications.

1.2 The 37° slope of the sun-facing tilted surface was chosen to represent the average latitude of the 48 contiguous United States. A wide variety of orientations is possible for exposed surfaces. The availability of the SMARTS model (as an adjunct to this standard) used to generate the standard spectra allows users to evaluate differences relative to the surface specified here.

1.3 The air mass and atmospheric extinction parameters are chosen to provide (1) historical continuity with respect to previous standard spectra, (2) reasonable cloudless atmospheric conditions favorable for photovoltaic (PV) energy production or weathering and durability exposure, based upon modern broadband solar radiation data, atmospheric profiles, and improved knowledge of aerosol optical depth profiles. In nature, an extremely large range of atmospheric conditions can be encountered even under cloudless skies. Considerable departure from the reference spectra may be observed depending on time of day, geographical location, and changing atmospheric conditions. The availability of the SMARTS model (as an adjunct to this standard) used to generate the

¹ These tables are under the jurisdiction of ASTM Committee G03 on Weathering and Durability and is the direct responsibility of Subcommittee G03.09 on Radiometry.

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