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Standard Terminology of Solar Energy Conversion¹

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1. Scope

1.1 This terminology pertains to the conversion of solar energy into other forms of energy by various means, including thermal absorption (i.e., solar thermal) and the photovoltaic effect (i.e., photovoltaics).

1.2 This terminology also pertains to instrumentation used to measure solar radiation.

1.3 This terminology also pertains to glass for solar energy applications.

1.4 Fundamental terms associated with electromagnetic radiation that are indicated as derived units in Standard **IEEE/ASTM SI 10** are not repeated in this terminology.

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

1.6 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the 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:²

- C162** Terminology of Glass and Glass Products
- C1048** Specification for Heat-Strengthened and Fully Tempered Flat Glass
- C1651** Test Method for Measurement of Roll Wave Optical Distortion in Heat-Treated Flat Glass
- D1003** Test Method for Haze and Luminous Transmittance of Transparent Plastics
- D1245** Practice for Examination of Water-Formed Deposits

¹ This terminology is under the jurisdiction of ASTM Committee E44 on Solar, Geothermal and Other Alternative Energy Sources and is the direct responsibility of Subcommittee E44.01 on Terminology and Editorial.

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² 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.

- by Chemical Microscopy
- D4865** Guide for Generation and Dissipation of Static Electricity in Petroleum Fuel Systems
- D5544** Test Method for On-Line Measurement of Residue After Evaporation of High-Purity Water
- D7236** Test Method for Flash Point by Small Scale Closed Cup Tester (Ramp Method)
- E349** Terminology Relating to Space Simulation
- E490** Standard Solar Constant and Zero Air Mass Solar Spectral Irradiance Tables
- E491** Practice for Solar Simulation for Thermal Balance Testing of Spacecraft
- E927** Classification for Solar Simulators for Electrical Performance Testing of Photovoltaic Devices
- E948** Test Method for Electrical Performance of Photovoltaic Cells Using Reference Cells Under Simulated Sunlight
- E816** Test Method for Calibration of Pyrheliometers by Comparison to Reference Pyrheliometers
- E1021** Test Method for Spectral Responsivity Measurements of Photovoltaic Devices
- E1036** Test Methods for Electrical Performance of Nonconcentrator Terrestrial Photovoltaic Modules and Arrays Using Reference Cells
- E1125** Test Method for Calibration of Primary Non-Concentrator Terrestrial Photovoltaic Reference Cells Using a Tabular Spectrum
- E1171** Test Methods for Photovoltaic Modules in Cyclic Temperature and Humidity Environments
- E1362** Test Methods for Calibration of Non-Concentrator Photovoltaic Non-Primary Reference Cells
- E1462** Test Methods for Insulation Integrity and Ground Path Continuity of Photovoltaic Modules
- E2236** Test Methods for Measurement of Electrical Performance and Spectral Response of Nonconcentrator Multi-junction Photovoltaic Cells and Modules
- E2527** Test Method for Electrical Performance of Concentrator Terrestrial Photovoltaic Modules and Systems Under Natural Sunlight
- F1863** Test Method for Measuring the Night Vision Goggle-Weighted Transmissivity of Transparent Parts
- G113** Terminology Relating to Natural and Artificial Weathering Tests of Nonmetallic Materials

G130 Test Method for Calibration of Narrow- and Broad-Band Ultraviolet Radiometers Using a Spectroradiometer
G138 Test Method for Calibration of a Spectroradiometer Using a Standard Source of Irradiance
G167 Test Method for Calibration of a Pyranometer Using a Pyrheliometer
G173 Tables for Reference Solar Spectral Irradiances: Direct Normal and Hemispherical on 37° Tilted Surface
G197 Table for Reference Solar Spectral Distributions: Direct and Diffuse on 20° Tilted and Vertical Surfaces
IEEE/ASTM SI 10 American National Standard for Metric Practice

2.2 *ISO Standard*.³

ISO 9060 Specification and Classification of Instruments for Measuring Hemispherical Solar and Direct Solar Radiation

2.3 *WMO Document*.⁴

WMO-No. 8 Guide to Meteorological Instruments and Methods of Observation, Seventh ed., 2008, World Meteorological Organization (WMO), Geneva

3. Adjectives for Electromagnetic Radiation

3.1 Properties and quantities associated with electromagnetic radiation vary with:

3.1.1 The direction and geometric extent (solid angle) over which the incident or exitant flux, or both, is evaluated, and

3.1.2 The relative spectral distribution of the incident flux and the spectral response of the detector for exitant flux.

3.2 Adjective modifiers can be used to indicate the geometric, spectral, and polarization conditions under which radiometric properties and quantities are evaluated. The adjectives defined in this Terminology are: **conical, diffuse, direct, directional, hemispherical, luminous, normal, and spectral**.

3.3 For reflectance and transmittance, the direction and geometric extent of both the incident beam and exitant beam must be specified.

3.4 For emittance, only the exitant beam need be specified, and for absorptance, only the incident beam need be specified.

3.5 Radiometric properties also vary with the polarization of the incident flux and the sensitivity to polarization of the collector-detector system for flux incident or exitant at angles greater than about 15° from normal.

3.6 An instrument used for solar energy measurements or a solar energy receiver will usually determine the directions and geometric extents, such as a pyranometer, a pyrheliometer, or a flat-plate solar thermal collector.

4. Terminology

ELECTROMAGNETIC RADIATION AND OPTICS

absorptance, n —ratio of the absorbed radiant or luminous flux to the incident flux. **E349**

absorption, n —transformation of radiant energy to a different form of energy by interaction with matter. **E349**

aerosol, n —any solid or liquid particles, with a nominal size range from 10 nm to 100 μm , suspended in a gas (usually air). **D5544**

aerosol optical depth, AOD, n —a measure of the extinction caused by aerosols in the atmosphere relative to the zenith and modeled with Ångström's turbidity formula.

DISCUSSION—Although it varies with wavelength, it is common to report aerosol optical depth at a single wavelength only, especially 0.5 μm .

air mass, AM, n —relative optical mass (see **optical mass, relative**) calculated using the density of air as a function of altitude.

$$AM \approx I_s/I_z = \sec\theta_z, \text{ for } \theta_z \leq 1 \text{ rad } (60^\circ) \quad (1)$$

DISCUSSION—Eq 1 is a simple approximation of the **optical mass, relative** (see Eq 5) that uses the ratio of the path length along the sun vector (I_s) to the path length along the zenith (I_z) (see **sun vector, zenith, and zenith angle, solar**). Other solutions are more complicated and take factors such as refraction and local air pressure into account.

DISCUSSION—The abbreviation **AM** is also commonly used to refer to a particular standard solar spectral irradiance, such as those in Standard E490, Tables G173, and Table G197. Thus, **AM0** can indicate the extraterrestrial spectral irradiance table in Standard E490, and **AM1.5** the hemispherical spectral irradiance table in Tables G173. Using AM1.5 in this way is discouraged because air mass is but one of many variables that modify solar spectral irradiance such as clouds, aerosol scattering, and water vapor absorption; note that both Tables G173 and Table G197 use an air mass value of 1.5, but differ greatly. The distinction between a spectral irradiance and a path length ratio should be made clear whenever these abbreviations are used.

air mass one, AM1, n —a relative optical mass (see **optical mass, relative**) that is equal to one. Because of the way in which relative optical mass is defined, AM1 always denotes a vertical path at sea level.

air mass, optical—see **optical mass, relative**.

air mass, pressure corrected, AM_p, n —an approximation of **air mass** for locations above sea level that uses the ratio of the local barometric pressure P , to the standard sea level atmospheric pressure $P_0 = 101.325 \text{ kPa}$ (see Eq 2).

$$AM_p \approx \frac{P}{P_0} AM \quad (2)$$

air mass ratio—see **optical mass, relative**.

air mass, relative optical—see **optical mass, relative**.

air mass zero, AM0, n —the absence of atmospheric attenuation of the solar irradiance at one astronomical unit from the sun. **E491**

albedo—discouraged in favor of the preferred term, **reflectance**.

angle of incidence, rad or °, n —the angle between a ray and the normal vector to the plane on which the ray is incident; especially the angle between the sun vector and the normal vector.

³ Available from International Organization for Standardization (ISO), 1, ch. de la Voie-Creuse, CP 56, CH-1211 Geneva 20, Switzerland, <http://www.iso.org>.

⁴ Available from World Meteorological Organization, <http://www.wmo.int>.