Designation: G 130 – 95

Standard Test Method for Calibration of Narrow- and Broad-Band Ultraviolet Radiometers Using a Spectroradiometer[1]

This standard is issued under the fixed designation G 130; 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 reappproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

INTRODUCTION

Accurate and precise measurements of ultraviolet irradiance are required in the determination of the radiant exposure of both total and selected narrow bands of ultraviolet radiation for the determination of exposure levels in (*1*) outdoor weathering of materials, (*2*) indoor accelerated exposure testing of materials using manufactured light sources, and (*3*) UV-A and UV-B ultraviolet radiation in terms both of the assessment of climatic parameters and the changes that may be taking place in the solar ultraviolet radiation reaching earth.

Although meteorological measurements usually require calibration of pyranometers and radiometers oriented with axis vertical, applications associated with materials testing require an assessment of the calibration accuracy at orientations with the axis horizontal (usually associated with testing in indoor exposure cabinets) or with the axis at angles typically up to 45° or greater from the horizontal (for outdoor exposure testing). These calibrations also require that deviations from the cosine law, tilt effects, and temperature sensitivity be either known and documented for the instrument model or determined on individual instruments.

This test method requires calibrations traceable to primary reference standards maintained by the National Institute of Standards and Technology (NIST).

1. Scope

1.1 This test method covers the calibration of ultraviolet light-measuring radiometers possessing either narrow- or broad-band spectral response distributions using either a scanning or a linear-diode-array spectroradiometer as the primary reference instrument. For transfer of calibration from radiometers calibrated by this test method to other instruments, Test Method E 824 should be used.

NOTE 1—Special precautions must be taken when a diode-array spectroradiometer is employed in the calibration of filter radiometers having spectral response distributions below 320-nm wavelength. Such precautions are described in detail in subsequent sections of this test method.

1.2 This test method is limited to calibrations of radiometers against light sources that the radiometers will be used to measure during field use.

NOTE 2—For example, an ultraviolet radiometer calibrated against natural sunlight cannot be employed to measure the total ultraviolet irradiance of a fluorescent ultraviolet lamp.

1.3 Calibrations performed using this test method may be against natural sunlight, Xenon-arc burners, metal halide burners, tungsten and tungsten-halogen lamps, fluorescent lamps, etc.

1.4 Radiometers that may be calibrated by this test method include narrow-, broad-, and wide-band ultraviolet radiometers, and narrow-, broad, and wide-band visible-region-only radiometers, or radiometers having wavelength response distributions that fall into both the ultraviolet and visible regions.

NOTE 3—For purposes of this test method, narrow-band radiometers are those with $\Delta\lambda \leq 20$ nm, broad-band radiometers are those with 20 nm $\leq \Delta\lambda \leq 70$ nm, and wide-band radiometers are those with $\Delta\lambda \geq 70$ nm.

NOTE 4—For purposes of this test method, the ultraviolet region is defined as the region from 285 to 400-nm wavelength, and the visible region is defined as the region from 400 to 750-nm wavelength. The ultraviolet region is further defined as being either UV-A with radiation of wavelengths from 315 to 400 nm, or UV-B with radiation from 285 to 315-nm wavelength.

1.5 *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 and health practices and determine the applicability of regulatory limitations prior to use.*

[1] This test method is under the jurisdiction of ASTM Committee G-3 on Durability of Nonmetallic Materialsand is the direct responsibility of Subcommittee G03.09 on Solar and Ultraviolet Radiation Measurement Standards.

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2. Referenced Documents

2.1 *ASTM Standards:*

E 772 Terminology Relating to Solar Energy Conversion[2]

E 824 Test Method for Transfer of Calibration from Reference to Field Pyranometers[2]

3. Terminology

3.1 *Definitions:*

3.1.1 *broad-band radiometer*—a relative term generally applied to radiometers with interference filters or cut-on/cut-off filter pairs having a FWHM between 20 and 70 nm and with tolerances in center (peak) wavelength and FWHM no greater than ±2 nm.

3.1.2 *diode array detector*—a detector with from 50 to 1000 silicon photodiodes affixed side-by-side in a linear array and mounted in the focal plane of the exit slit of a monochromator.

3.1.3 *full width at half maximum (FWHM)*—in a bandpass filter, FWHM is the interval between wavelengths at which transmittance is 50 % of the peak, frequently referred to as bandwidth.

3.1.4 *narrow-band radiometer*—a relative term generally applied to radiometers with interference filters with FWHM ≤20 nm and with tolerances in center (peak) wavelength and FWHM no greater than± 2 nm.

3.1.5 *scanning monochromator*—a monochromator that uses either a single, or several interchangeable, detector(s) mounted at the exit slit, that is presented with dispersed light by sweeping the spectrum across the slit to illuminate the detector with a succession of different very narrow wavelength light distributions. The detector may be either a photomultiplier tube (PMT) or silicon photodiode (visible), or a PMT or an ultraviolet-enhanced silicon photodiode (ultraviolet and visible), or a lead sulfide cell or other solid state detector (near infrared), etc. The dispersed spectrum is swept across the monochromator's exit slit using a mechanical stage that rotates either a prism or a grating dispersive element, usually under the control of an external microprocessor or computer.

3.1.6 *spectroradiometer*—a radiometer consisting of a monochromator with special acceptance optics mounted to the entrance aperture and a detector mounted to the exit aperture, usually provided with electronic or computer encoding of wavelength and radiometric intensity. The monochromator of such instruments is either of the linear diode (often called *diode array*) or the scanning type.

3.1.7 *wide-band radiometer*—a relative term generally applied to radiometers with combinations of cut-off and cut-on filters with FWHM greater than 70 nm.

3.2 For other terms relating to this test method, see Terminology E 772.

4. Significance and Use

4.1 This test method represents the preferable means for calibrating both narrow-band and broad-band ultraviolet radiometers. Calibration of narrow- and broad-band ultraviolet radiometers involving direct comparison to a standard source of spectral irradiance is an alternative method for calibrating ultraviolet radiometers. An ASTM test method describing this procedure is under development by Subcommittee G03.09 on Radiometry.

4.2 The accuracy of this calibration technique is dependent on the condition of the light source (for example, cloudy skies, polluted skies, aged lamps, defective luminaires, etc.), and on source alignment, source to receptor distance, and source power regulation.

NOTE 5—It is conceivable that a radiometer might be calibrated against a light source that represents an arbitrarily chosen degree of aging for its class in order to present to both the test and reference radiometers a spectrum that is most typical for the type.

4.3 Spectroradiometric measurements performed using either an integrating sphere or a cosine receptor (such as a shaped TFE[3], or Al_2O_3 diffuser plate) provide a measurement of hemispherical spectral irradiance in the plane of the sphere's entrance port. As such, the aspect relative to the reference light source must be defined (azimuth and tilt from the horizontal for solar measurements, normal incidence with respect to the beam component of sunlight, or normal incidence and the geometrical aspect with respect to an artificial light source, or array). It is important that the geometrical aspect between the plane of the spectroradiometer's source optics and that of the radiometer being calibrated be as nearly identical as possible.

NOTE 6—When measuring the hemispherical spectral energy distribution of an array of light sources (for lamps), normal incidence is defined by the condition obtained when the plane of the sphere's aperture is parallel to the plane of the lamp, or burner, array.

4.4 Calibration measurements performed using a spectroradiometer equipped with a pyrheliometer-comparison tube (a sky-occluding tube), regardless of whether affixed directly to the monochromator's entrance slit, to the end of a fibre optic bundle, or to the aperture of an integrating sphere, shall not be performed unless the radiometer being calibrated is a true pyrheliometer (that is, unless it possesses a view-limiting device having the approximate optical constants of the spectroradiometer's pyrheliometer-comparison tube).

4.5 Spectroradiometric measurements performed using source optics other than the integrating sphere or the "standard" pyrheliometer comparison tube, shall be agreed upon in advance between all involved parties.

4.6 Calibration measurements that meet the requirements of this test method are traceable to the National Institute of Standards and Technology (NIST), largely through the traceability of the standard lamps and associated power supplies employed to calibrate the spectroradiometer.

4.7 The accuracy of calibration measurements performed employing a spectroradiometer is dependent on, among other requirements, the degree to which the temperature of the mechanical components of the monochromator are maintained during field measurements in relation to those that prevailed during calibration of the spectroradiometer.

NOTE 7—This requirement is covered in detail in an ASTM standard under development in Subcommittee G03.09 on Radiometry.

[2] *Annual Book of ASTM Standards*, Vol 12.02.

[3] Tetrafluoroethylene such as a special grade of Teflon® or an equivalent material, has been found suitable.