JJF

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OF THE PEOPLE'S REPUBLIC OF CHINA

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Ultraviolet Radiometers

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Verification Regulation of Ultraviolet Radiometers

1 Scope

This Regulation applies to initial verification, subsequent verification and in-use inspection for standard-level, level-1 and level-2 ultraviolet radiometers that comply with the division of ultraviolet radiation UV-A, UV-B, UV-C, UV-A_1, UV-365, UV-310, UV-254 bands.

2 Overview

The International Commission on Illumination (CIE) divides ultraviolet radiation into three bands: UV-A (315nm~400nm), UV-B (280nm~315nm) and UV-C (100nm~280nm). Since ultraviolet radiation of 100nm~200nm is strongly absorbed in the air, for the UV-C band, this Regulation only considers the wavelength range of 200nm~280nm.

Ultraviolet radiometer that complies with the ultraviolet radiation UV-A, UV-B, UV-C, UV-A_1, UV-365, UV-310, and UV-254 band divisions is an instrument used to measure ultraviolet radiometer. It is widely used in fields such as medical treatment, epidemic prevention, optoelectronics, flaw detection, electric light sources, chemical industry, building materials, meteorology, material aging and aerospace. It mainly consists of detector, amplifier circuit and display instrument. The detector generally consists of a photodetector device, a filter (bandpass glass or interference filter) and a diffuser. Figure 1 is a schematic diagram of the general structure of an ultraviolet radiometer detector.

provisions of 3.1.

5 Measuring instrument control

Measuring instrument control includes initial verification, subsequent verification and in-use inspection.

5.1 Verification conditions

5.1.1 Equipment for verification

5.1.1.1 UV radiation illuminance standard device

There are three ultraviolet radiometer standard devices for each band.

The standard device for verifying the standard ultraviolet radiometer shall use the working reference ultraviolet radiometer. The standard device for verifying the level-1 ultraviolet radiometer shall use a standard-level ultraviolet radiometer (or a working reference ultraviolet radiometer). The standard device for verifying the level-2 ultraviolet radiometer shall use the level-1 ultraviolet radiometer (or standard-level ultraviolet radiometer, working reference ultraviolet radiometer). See 3.1~3.8 for the measurement performance requirements of standard-level and level-1 ultraviolet radiometers. For the measurement performance requirements of the working reference ultraviolet radiometer, see JJG 755.

5.1.1.2 UV radiation source

There is one ultraviolet radiation source for verification in different wavebands.

The ultraviolet radiation sources for verification of UV-A, UV-A_1 and UV-365 bands use black light high-pressure mercury lamps, high-pressure mercury lamps, UV-A fluorescent ultraviolet lamps, metal halide lamps, LED light sources (365nm), etc. UV-B and UV-310 bands use UV-B fluorescent UV lamps. The UV-C band uses low-pressure mercury lamps. In order to reduce the spectral mismatch error, the UV radiation source used for verification shall have the same spectral distribution as the UV radiation source used to calibrate the UV radiation illumination standard.

The UV radiation change rate of various UV radiation sources does not exceed ±1.0% within 15 min. The actual usable area of the UV radiation source shall be larger than the effective receiving area of the detector. Its unevenness does not exceed ±2.0%.

The UV radiation source is powered by a regulated power supply. Voltage instability does not exceed ±2.0%/h.

5.1.1.3 Measurement device for comparison of UV radiation illuminance

The long-wavelength response error of the ultraviolet radiometer shall comply with the provisions of 3.3.

5.3.3 Cosine characteristic (directional response) error

Install the detector of the ultraviolet radiometer on a rotating platform with a dial, so that the rotation axis of the platform passes through the center of the detector's receiving surface. Adjust the rotating platform so that the normal line passing through the center of the detection surface is consistent with the normal line of the ultraviolet radiation source.

Several apertures are placed between the UV radiation source and the detector. Adjust the position of each diaphragm so that it does not block the light radiation from the ultraviolet radiation source to the receiving surface. The distance between the UV radiation source and the detector is greater than 15 times the maximum linear dimension of the UV radiation source's luminous surface or the detector's receiving surface (for example: the maximum linear dimension of a circular luminous surface is the diameter of the circle, and the maximum linear dimension of a rectangular luminous surface are the diagonals of the rectangle).

Ignite the UV radiation source. Preheat for 30 min. Then turn the platform to the left so that the ultraviolet radiometer displays a certain value (50%~80% of the maximum value). Note the turntable angle at this time. Then turn the platform to the right to make the display value of the ultraviolet radiometer reach the above display value. Note the angle of the turntable at this time. The average of these two angles is the normal irradiance incidence angle (i.e., 0°). Record the display value of the ultraviolet radiometer at this angle. Then turn the platform. Record the display values of the ultraviolet radiometer when the angles are ±5°, ±10°, ±15°, ±20°… ±85°.

The detector of the ultraviolet radiometer shall produce a response to incident radiation that conforms to the cosine law. Calculate the error f_2 (ε, ϕ) caused by the direction of incident radiation according to formula (4) (Figure 3):

$$f_2(\varepsilon, \phi) = \left[\frac{Y(\varepsilon, \phi)}{Y(0, \phi) \cdot \cos\varepsilon} - 1\right] \times 100\% \tag{4}$$

Where,

ε - the incident angle between the incident radiation and the normal line of the detector receiving surface, (°);

ϕ - the azimuth angle of the receiving surface’s rotation along the optical axis, (°);

Y (ε, ϕ) - when the incident angle of radiation is ε and the azimuth angle is ϕ, the display value of the radiation meter, μW/cm^2 (or mW/cm^2, etc.);

is X. Then move the radiation source so that the display value of the ultraviolet radiometer reaches Y_{max} (near full scale). The corresponding standard irradiance value is X_{max}.

Calculate the nonlinear error f_3 of the Ultraviolet radiometer according to formula (6).

$$f_3 = \left(\frac{Y}{Y_{max}} \times \frac{X_{max}}{X} - 1 \right) \times 100\% \qquad (6)$$

Where,

f_3 - the nonlinear error, %;

X - the standard irradiance value, μW/cm2 (or mW/cm2, etc.);

Y - the display value of Ultraviolet radiometer when the standard irradiance value X during irradiation, μW/cm^2 (or mW/cm^2, etc.);

X_{max} - the standard irradiance value corresponding to the maximum display value Y_{max}, μW/cm^2 (or mW/cm^2, etc.);

Y_{max} - the maximum display value of UV radiation illuminance meter, μW/cm^2 (or mW/cm^2, etc.).

The nonlinear error f_3 of the ultraviolet radiometer shall comply with the provisions of 3.5.

5.3.5 Shifting error

The test is performed between two different ranges of the Ultraviolet radiometer. Ultraviolet radiometers with a single range do not perform this test.

The measuring device is shown in Figure 2. Adjust the positions of the luminous surface of the radiation source and the receiving surface of the detector so that they are perpendicular to the optical axis and centered on the measurement optical axis. Adjust the position of each aperture between the radiation source and the detector so that it does not block the radiation from the radiation source to the receiving surface of the detector. Ignite the UV radiation source. Preheat for 30 min.

In the low range A, adjust the distance between the detector receiving surface and the radiation source so that the display value Y(A) of the ultraviolet radiometer is greater than 90% of the full scale. The corresponding standard irradiance value at this time is X (A). Adjust the distance between the receiver and the radiation source so that the standard irradiance value X (B) is k times X (A). Record the Ultraviolet radiometer display value Y (B). Calculate the shift error caused by range change according to formula (7).

$$f_4=\left(\frac{Y(\mathrm{B})}{kY(\mathrm{A})}-1\right)\times 100\% \tag{7}$$

Where,

f_4 - the shifting error, %;

Y(A) - the display value of the ultraviolet radiometer in the low range A, corresponding to the standard radiation illuminance value X (A), μW/cm^2 (or mW/cm^2, etc.);

Y(B) - the display value of the ultraviolet radiometer in the high range B, corresponding to the standard radiation illuminance value X (B), μW/cm^2 (or mW/cm^2, etc.);

k - the shifting coefficient, which is the ratio of the full-scale reading of range B to the full-scale reading of range A.

The shifting error of the ultraviolet radiometer shall comply with the provisions of 3.6.

5.3.6 Fatigue error

Install the detector and UV radiation source of the Ultraviolet radiometer on the measuring device (Figure 2). Adjust the light path according to the requirements for calibrating the Ultraviolet radiometer. Then cover the detector so that it is not exposed for 24 h.

Ignite the UV radiation source. Preheat for 30 min. Adjust the distance between the receiving surface of the detector and the radiation source so that the display value of UV-A, UV-A_1 and UV-365 ultraviolet radiometers ≥1mW/cm^2; the display value of UV-B and UV-310 ultraviolet radiometers ≥500 μW/cm^2; the display value of UV-C and UV- 254 ultraviolet radiometers ≥250 μW/cm^2. Record the display values Y (10s) and Y (30min) of the detector after irradiation for 10s and 30min respectively. In order to eliminate the radiation drift of the ultraviolet radiation source itself over time, a stable monitoring ultraviolet radiometer is used for control measurement, and the displayed values Y_s (10s) and Y_s (30min) at 10s and 30min. Calculate the fatigue error f_5 of the ultraviolet radiometer according to formula (8).

$$f_5=\left(\frac{Y(30\ \mathrm{min})/Y_s(30\ \mathrm{min})}{Y(10\ \mathrm{s})/Y_s(10\ \mathrm{s})}-1\right)\times 100\% \tag{8}$$

Where,

f_5 - the fatigue error, %;

Y(30min) - the display value of UV radiation illuminance meter after 30min exposure, μW/cm^2 (or mW/cm^2, etc.);

Y_s(30min) - the display value monitoring ultraviolet radiometer after exposure for 30 min, μW/cm^2 (or mW/cm^2, etc.);

Y(10s) - the display value of UV radiation illuminance meter for 10 s, μW/cm^2 (or mW/cm^2, etc.);

Y_s(10s) - the display value monitoring ultraviolet radiometer after exposure for 10 s, μW/cm^2 (or mW/cm^2, etc.).

The fatigue error of the ultraviolet radiometer shall comply with the provisions of 3.7.

5.3.7 Relative indication error

The measuring device is shown in Figure 2. Different ultraviolet radiation sources shall be used to calibrate ultraviolet radiometers in different bands. See 5.1.1.2 for the selection method. Since most ultraviolet radiometers have spectral selectivity, it is recommended that the spectral distribution of the ultraviolet radiation source used for verification and the ultraviolet radiation source used in the ultraviolet radiometer standard certificate and the ultraviolet radiation source to be measured (the test object of the ultraviolet radiometer to be tested) shall be the same or close to reduce the test error, so as to reduce test errors.

Adjust the luminous surface of the UV radiation source and the receiving surface of the detector so that they are perpendicular to the optical axis and the center is located on the measurement optical axis. Adjust the position of each aperture between the radiation source and the detector so that it does not block the radiation from the radiation source to the receiving surface of the detector. Varying the distance between the radiation source and detector produces different irradiance values.

Ignite the UV radiation source. Preheat for 30 min. Install the detectors of the three ultraviolet radiation illumination standard devices on the fixture in sequence. Record the irradiance value at this distance respectively. Take the average value of the three instruments as the standard irradiance value. Install the detector of the Ultraviolet radiometer under inspection on the fixture so that its receiving surface is in the same position as the receiving surface of the standard detector. During verification, record the displayed value after irradiating the detector for 1 min. Each tested Ultraviolet radiometer shall be tested three times. Take the average. During the verification process, a stable Ultraviolet radiometer is used to monitor the radiation source. If changes are found, the standard value shall be corrected in time. Calculate the relative indication error of the tested Ultraviolet radiometer according to formula (9).

$$\Delta E = \left(\frac{E_m - E_s}{E_s}\right) \times 100\% \tag{9}$$

Where,

Annex C

Examples of measurement uncertainty evaluation for standard UV radiation illuminance meter (UV-A band)

This appendix evaluates the measurement uncertainty of standard-level UV radiation illuminance meters. The standard instrument used is a working reference ultraviolet radiometer.

C.1 Overview of verification methods

The relative indication error of the tested standard UV radiation illuminance meter is obtained by using the substitution method of comparison with the working reference UV radiation illuminance meter. First, adjust the entire optical path system. Ignite the UV radiation source. Warm up. Install three working reference Ultraviolet radiometers on the fixture in sequence. Take the average measurement value of the three instruments as the standard UV radiation illuminance value at this distance. Install the tested standard Ultraviolet radiometer under the same geometric conditions. Take value. Calculate the correction factor or relative indication error of the tested standard Ultraviolet radiometer.

C.2 Measurement model for uncertainty assessment

The measurement model of the correction factor of the inspected standard Ultraviolet radiometer is:

$$K = \frac{E_s}{E_m} \tag{C. 1}$$

Where,

K - Correction factor;

E_s - the average measurement value of the working reference Ultraviolet radiometer group, μW/cm^2 (or mW/cm^2, etc.);

E_m - the measured value of the tested standard Ultraviolet radiometer, μW/cm^2 (or mW/cm^2, etc.).

The measurement model of the relative indication error of the tested standard Ultraviolet radiometer is:

------ The End ------