Use of Standard Fluorescent UV Weathering Lamps to Perform UV Conditioning Tests Prescribed in IEC Qualification Standards

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Scope

IEC qualification tests require UV Conditioning exposures. Precisely how to meet these requirements has caused some confusion in the marketplace. Sources of confusion include:

- Different exposure requirements in each qualification standard
- Lack of readily available single light source to meet two of the standards
- Lack of specifics or references to other standards for guidance

ASTM Committee E44 intends to address these concerns by creating a standard on meeting the UV conditioning requirements of the IEC qualification standards.

WK38365: Standard Practice for Ultraviolet Conditioning of Photovoltaic Panels or Mini-Modules Using a Fluorescent Ultraviolet (UV) Lamp Apparatus

UV Conditioning Test Requirements

- IEC 61215 (Crystalline Si Modules Qualification)
  - 60°C module temperature
  - 15 kWh/m^2 280nm-385nm
  - 5 kWh/m^2 (minimum) 280nm-320nm
  - Consecutive exposures to UVA-340 and UVB-313 lamps
- IEC 61345 (UV Test of PV Modules)
  - 60°C module temperature
  - 15 kWh/m^2 320nm-400nm
  - 7.5 kWh/m^2 (minimum) 280nm-320nm
  - Consecutive exposures to UVA-340 and UVB-313 lamps
  - At end of initial exposure, expose back side of modules for an additional 10% of time
- IEC 61646 (Thin Film Modules Qualification)
  - 60°C module temperature
  - 15 kWh/m^2 280nm-400nm
  - .45-1.5 kWh/m^2 (minimum) 280nm-320nm
  - UVA-340 lamps only

Proposal: ASTM WK38365

- Perform UV conditioning tests according to method and apparatus described in ASTM G154-12: Standard Practice for Operating Fluorescent Ultraviolet (UV) Lamp Apparatus for Exposure of Nonmetallic Materials

Apparatus

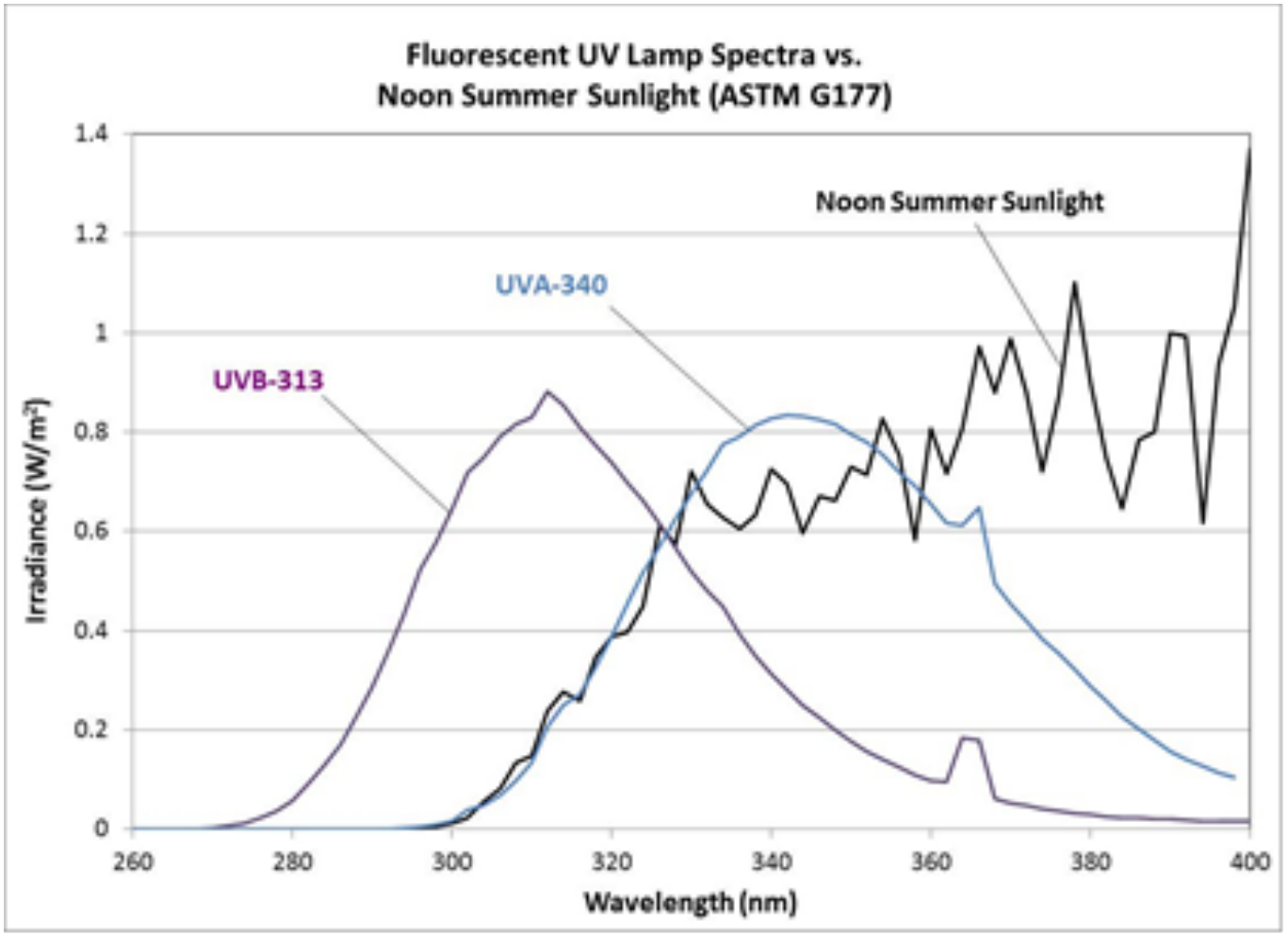
- Fluorescent Ultraviolet Lamp Apparatus (ASTM G154)

QUV Accelerated Weathering Tester from Q-Lab

UVTest Fluorescent/UV Instrument from Atlas

- UVA-340 lamps
- UVB-313 lamps
- Optional moisture (condensation, spray)

Common Fluorescent UV Lamps



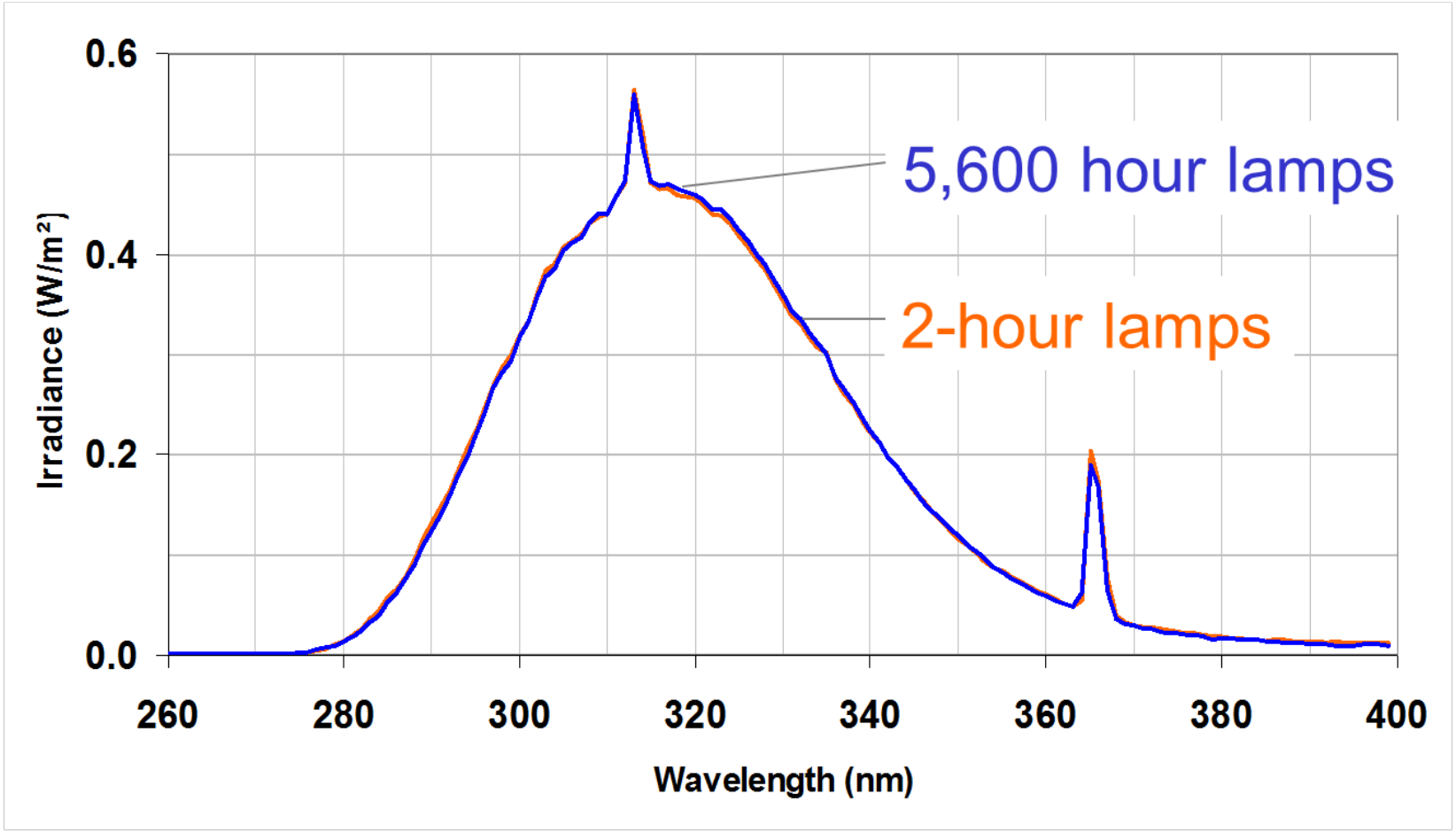
UVA-340 Lamps

Spectral Bandpass Wavelength λ in nm	Minimum Percent	Benchmark AM1.5 Solar Radiation Percent	Benchmark AM1 Solar Radiation Percent	Maximum Percent
λ <290				0.01
290 ≤ λ ≤ 320	5.9	3.5	5.8	9.3
320 < λ ≤ 360	60.9	38.0	40.0	65.5
360 < λ ≤ 400	26.5	58.5	54.2	32.8

UVB-313 Lamps

Spectral Bandpass Wavelength λ in nm	Minimum Percent	Benchmark AM1.5 Solar Radiation Percent	Benchmark AM1 Solar Radiation Percent	Maximum Percent
λ <290	1.3			5.4
290 ≤ λ ≤ 320	47.8	3.5	5.8	65.9
320 < λ ≤ 360	26.9	38.0	40.0	43.9
360 < λ ≤ 400	1.7	58.5	54.2	7.2

Lamp Aging with Controlled Power Source



Test performed in a QUV with SOLAR EYE
Irradiance Control

Irradiance Measurement/Control

- G154 Instruments generally use narrow band irradiance measurement and control and irradiance is measured in Watts per square meter
  - 340 nm for UVA type lamps, 310 nm for UVB type lamps

    Example: 0.89 W/m^2 @ 340 nm
  - Necessary to convert to wide band values:

$$\int_{lower\ limit}^{upper\ limit} irradiance\ (W/m^2)$$

Where *lower limit* = 280 nm or 320 nm AND *upper limit* = 320 nm or 385 nm or 400 nm

Depending on the particular IEC method

IEC 61215

$$\int_{\lambda=280}^{385} \text{irradiance} \quad (W/m^2) \times \text{Time (hours)} = \textbf{15 kW•hr}$$

AND

$$\int_{\lambda=280}^{320} \text{irradiance} \quad (W/m^2) \times \text{Time (hours)} = \textbf{5 kW•hr}$$

IEC 61345

$$\int_{\lambda=280}^{320} \text{irradiance} \quad (W/m^2) \times \text{Time (hours)} = \textbf{7.5 kW•hr}$$

AND

$$\int_{\lambda=320}^{400} \text{irradiance} \quad (W/m^2) \times \text{Time (hours)} = \textbf{15 kW•hr}$$

IEC 61646

$$\int_{\lambda=280}^{400} \text{irradiance} \quad (W/m^2) \times \text{Time (hours)} = \textbf{15 kW•hr}$$

AND

$$\int_{\lambda=280}^{320} \text{irradiance} \quad (W/m^2) \times \text{Time (hours)} = \textbf{0.45-1.5 kW•hr}$$

Integration Factors to convert single wavelength irradiance measurements into wide band measurements

Wavelength Range	UVA-340 (340 nm)	UVB-313 (310 nm)
280-400 nm	54.5	46.3
280-320 nm	4.3	27.2
321-400 nm	50.2	19.2
280-385 nm	52.0	46.0

$Irradiance_{narrow\ band}$ (W/m^2) x Integration Factor x Time(hours) = Energy Dosage (Watt-hours

IEC 61215, C-Si UV Conditioning

[0.87 W/m^2 @ 340 nm] x 52.0 x 168 hours = 7.6 kW•hr (280-385 nm)
[0.87 W/m^2 @ 340 nm] x 4.3 x 168 hours = 0.6 kW•hr (280-320 nm)

[0.96 W/m^2 @ 310 nm] x 46.0 x 168 hours = 7.4 kW•hr (280-385 nm)
[0.96 W/m^2 @ 310 nm] x 27.2 x 168 hours = 4.4 kW•hr (280-320 nm)

Total: 15 kW•hr (280-385 nm) AND 5kW•hr (280-320 nm)

IEC 61646, Thin Film UV Conditioning

[1.15W/m^2 @ 340 nm] x 54.5 x 240 hours = 15.0 kW•hr (280-400 nm)
[1.15 W/m^2 @ 340 nm] x 4.3 x 240 hours = 1.2 kW•hr (280-320 nm)

IEC 61345, UV Test of PV Modules

[0.86 W/m^2 @ 340 nm] x 50.2 x 240 hours = 10.4 kW•hr (320-400 nm)
[0.86 W/m^2 @ 340 nm] x 4.3 x 240 hours = 0.9 kW•hr (280-320 nm)

[1.02 W/m^2 @ 310 nm] x 19.2 x 240 hours = 4.7 kW•hr (320-400 nm)
[1.02 W/m^2 @ 310 nm] x 27.2 x 240 hours = 6.6 kW•hr (280-320 nm)

Total: 15 kW•hr (320-400 nm) AND 7.5kW•hr (280-320 nm)