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TECHNICAL SPECIFICATION

colour inside

Measurement procedures for materials used in photovoltaic modules – Part 7-2: Environmental exposures – Accelerated weathering tests of polymeric materials

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Measurement procedures for materials used in photovoltaic modules – Part 7-2: Environmental exposures – Accelerated weathering tests of polymeric materials

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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MEASUREMENT PROCEDURES FOR MATERIALS USED IN PHOTOVOLTAIC MODULES –

Part 7-2: Environmental exposures – Accelerated weathering tests of polymeric materials

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- the subject is still under technical development or where, for any other reason, there is the future but no immediate possibility of an agreement on an International Standard.

Technical specifications are subject to review within three years of publication to decide whether they can be transformed into International Standards.

IEC TS 62788-7-2, which is a technical specification, has been prepared by IEC technical committee 82: Solar photovoltaic energy systems.

The text of this technical specification is based on the following documents:

Enquiry draft	Report on voting
82/1212/DTS	82/1262A/RVDTS

Full information on the voting for the approval of this technical specification can be found in the report on voting indicated in the above table.

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts in the IEC 62788 series, published under the general title *Measurement procedures for materials used in photovoltaic modules*, can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- transformed into an International standard,
- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

A bilingual version of this publication may be issued at a later date.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

MEASUREMENT PROCEDURES FOR MATERIALS USED IN PHOTOVOLTAIC MODULES –

Part 7-2: Environmental exposures – Accelerated weathering tests of polymeric materials

1 Scope

This part of IEC 62788 defines test procedures to characterize the weatherability of polymeric component materials used in photovoltaic (PV) modules or systems. The methods in this document have been focused on polymeric backsheets and encapsulants, but may be applied to other materials; however, these were not verified as part of the preparation.

This document includes a suite of artificial weathering exposures, consisting of a steady-state application of simulated solar irradiance, temperature, and humidity conditions maintained at stable levels through the weathering test. Cyclic stresses, including thermal and wet/dry cycles are left for future specifications.

Exposures in this document are intended for reference by other standards and as a tool to support research and product development for PV components and modules. Different exposures may be used to target specific climate/mounting configurations, with the specifics of how to apply the exposures left to those standards (e.g. component characterization standards, module qualification standards).

An informative annex including parametric descriptions of a range of climate/application configurations used in developing the exposure suites is provided as a reference.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60904-3, *Photovoltaic devices – Part 3: Measurement principles for terrestrial photovoltaic (PV) solar devices with reference spectral irradiance data*

IEC 61730-1, *Photovoltaic (PV) module safety qualification – Part 1: Requirements for construction*

IEC TS 61836, *Solar photovoltaic energy systems – Terms, definitions and symbols*

IEC 62788-1-4, *Measurement procedures for materials used in photovoltaic modules – Part 1-4: Encapsulants – Measurement of optical transmittance and calculation of the solar weighted photon transmittance, yellowness index and UV cut-off wavelength*

IEC TS 62788-2, *Measurement procedures for materials used in photovoltaic modules – Part 2: Polymeric materials – Frontsheets and backsheets*

ASTM G151, *Standard Practice for Exposing Nonmetallic Materials in Accelerated Test Devices that Use Laboratory Light Sources*

ASTM G154, *Standard Practice for Operating Fluorescent Ultraviolet (UV) Lamp Apparatus for Exposure of Nonmetallic Materials*

ASTM G155, *Standard Practice for Operating Xenon Arc Light Apparatus for Exposure of Non-Metallic Materials*

ASTM D7869, *Standard Practice for Xenon Arc Exposure Test with Enhanced Light and Water Exposure for Transportation Coatings*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC TS 61836, IEC 61730-1, as well as the following apply:

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1
natural weathering
degradation of materials in response to the naturally occurring climatic stresses at the site where PV modules are installed

3.2
artificial weathering
degradation of materials in response to controlled stresses applied using an artificial weathering chamber designed to simulate the effects of natural weathering

Note 1 to entry: Applied stresses, which should be automatically controlled, include simulated solar irradiance, temperature, and humidity.

3.3
specimen
material test coupon designed to comprise a part or component of a PV module, or a sample designed to replicate a part of a PV module

3.4
polymeric material
natural or synthetic materials that are primarily composed of chained molecules of monomers, that may also contain combinations of monomers, combined polymers, crosslinking agents, inorganic fillers, colorants, stabilizers, and other additive materials

3.5
laminate
product made by bonding together two or more layers of the same or different materials

3.6
ambient temperature
temperature of the air in degrees Celsius surrounding the modules or equipment at a PV installation location as measured and documented by meteorological services for that physical location

3.7
black panel thermometer
BPT
uninsulated black painted panel and attached temperature sensing element constructed according to ASTM G113 typically used to control the convective cooling or chamber air temperature in an artificial weathering chamber

3.8
spectral power distribution
SPD
irradiance distribution in units of W/(m^2·nm) as a function of wavelength for an artificial light source used to simulate solar radiation

3.9
chamber temperature
ChT
air temperature maintained within the artificial weathering chamber representing the minimum temperature of specimens under exposure

3.10
action spectrum
susceptibility of a material to damage as a function of wavelength. Action spectrum can be unique to each characteristic examined, e.g., specimen transmittance or mechanical strength

3.11
filter
material which may consist of optical filter glass, or a representative stack of materials used in the module laminate (e.g. glass/encapsulant/encapsulant, as defined in IEC TS 62788-2)

3.12
transparent release material
TRM
UV stable film used within a laminated weathering coupon so as to allow for easy disassembly of the laminate after weathering for subsequent testing, with transmittance > 90 % over the range 280 nm to 450 nm as in IEC TS 62788-2

4 Artificial weathering exposures

4.1 General

A discussion and overview of general procedures for artificial weathering of non-metallic materials is provided in ASTM G151. The development of the practices included in this document are included in Annexes A and B.

The extent of weathering degradation in application, and in artificial weathering devices, can be sensitive to a number of factors, and the following are recommended as best practices:

- Follow manufacturers' recommendations for replacing the lamp and filters. Perform regular calibrations of irradiance, temperature and humidity according to manufacturer's recommendations. Replace reference black panel specimen according to manufacturer's recommendations.
- Exposure conditions within a device will vary with specimen placement; follow manufacturers' recommendations to move the specimens in a pattern designed to ensure consistent exposures between samples. For example, vary the top/middle/bottom position of samples in rotating devices, and shift sample locations within flatbed devices in a prescribed manner.
- Mount the samples in the chamber in a manner to achieve consistent airflow.

This document describes two artificial weathering methods for testing of PV component materials: xenon arc with daylight filters (Method A) and fluorescent ultraviolet devices with ASTM G154 compliant UVA-340 lamps (Method B). Both exposure methods have been shown to produce materials degradation similar to that observed from long term outdoor exposures. However, due to the combination of differences in the spectral power distribution (SPD) as shown in Figure 1, of the light sources and the differing spectral sensitivity of polymeric materials, degradation modes and rates can differ between the two methods and their equivalence shall not be assumed. Method A shall be the referee method in cases of dispute.

The use of light sources other than xenon arc or UVA-340 lamps for weathering exposures is not sufficiently standardized, and their use shall not be considered as equal alternates.

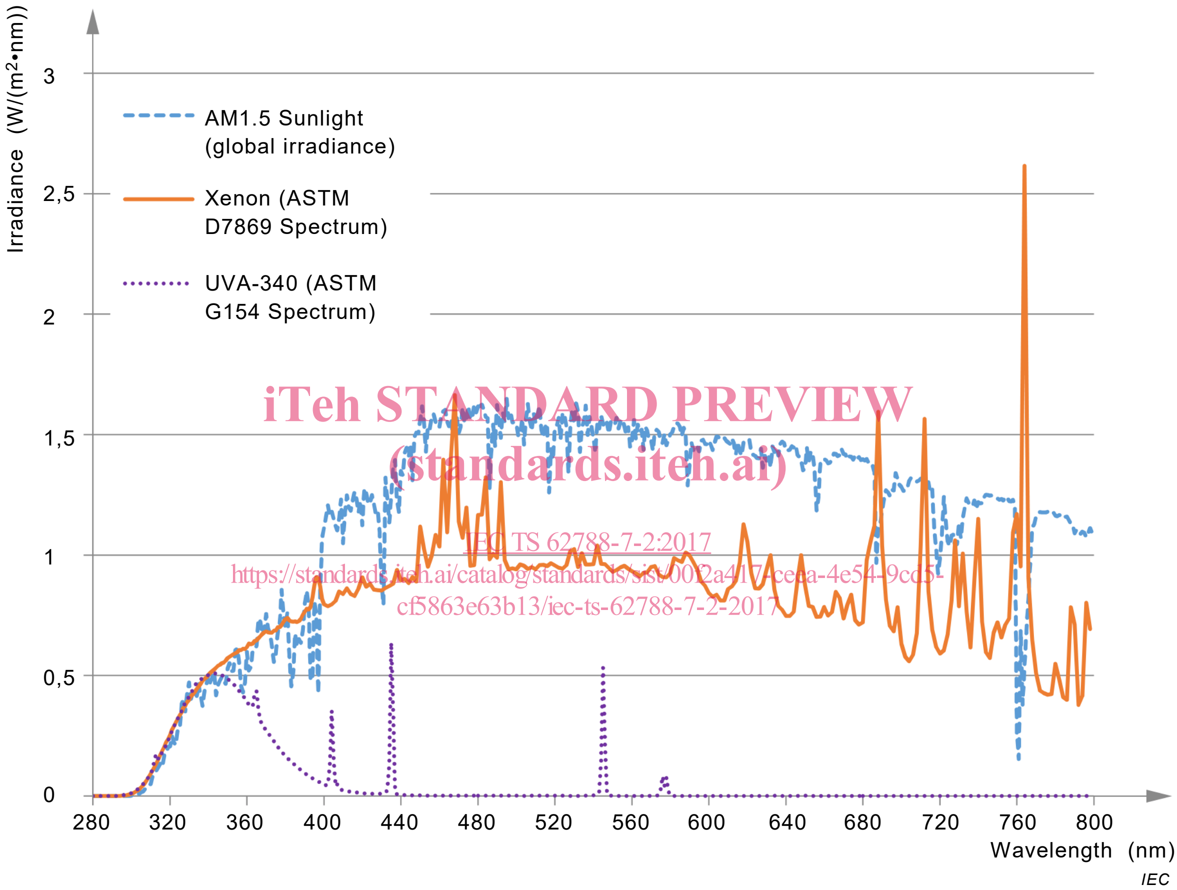

Figure 1 – Spectral irradiance power distributions: solar, xenon arc, fluorescent UV

NOTE The reference terrestrial solar spectrum is shown as in IEC 60904-3. Xenon arc and fluorescent UVA-340 spectra are scaled to match the solar spectrum at 340 nm, whereas the exposures specified in this document are elevated to 0,8 W/(m^2·nm) at 340 nm.

4.2 Method A: filtered xenon arc with daylight filters

4.2.1 General

Xenon arc lamps in combination with the appropriate optical filters produce an irradiance spectrum that is a good simulation of terrestrial sunlight. Compared to other light sources, this light source will produce the most representative response over a wide variety of materials, and is recommended here for qualification of a material and comparisons between different materials.

Operating parameters for xenon arc artificial weathering chambers are specified in ASTM G155.

Exposure set point conditions for Method A are summarized in Table 1.

Table 1 – Method A exposure conditions

Condition #	Chamber air temperature °C	Black panel temperature °C	Irradiance W/(m²·nm) at 340 nm	Relative humidity %
A1	45	70	0,8	20
A2	55	80	0,8	20
A3	65	90	0,8	20
A4	75	100	0,8	20
A5	85	110	0,8	20 (nominal)

NOTE Table 1 provides operational set-point conditions for the xenon arc artificial weathering chambers. Water spray is not used in this document. Laboratory measurements have shown that these conditions will for example produce a nominal specimen temperature for white backsheet film specimens of 75 °C for A3.

4.2.2 Light source, irradiance levels

This practice uses a xenon arc light source with optical filters conforming to Annex A.1 of ASTM D7869. The irradiance set-point shall be 0,80 W/(m^2·nm) at 340 nm. In chambers equipped to control the irradiance from 300 nm to 400 nm, the set point shall be 81 W/m^2. A representative xenon arc spectrum is compared to the terrestrial solar spectrum in Figure 1.

Higher irradiance intensity levels do provide a higher dose in a shorter time, but the same results should not be expected for a material exposed to the same dosage at two different irradiance set points, e.g. 0,8 W/(m^2·nm) for 4 000 h, and 1,6 W/(m^2·nm) for 2 000 h. Both false positive and false negative results have been observed at highly accelerated exposure levels. A common observation is for the rate of UV degradation to be significantly sub-linear, e.g. in the example above, the specimen exposed at the greater irradiance would exhibit less degradation (false positive). Conversely, another common result of artificial weathering is for materials exposed at high relative irradiance levels to show a type of degradation that does not occur in service (false negative)[9][1], [10], [11]. The elevated irradiance level selected for this specification is intended to provide a degree of acceleration compared to the application environment, and in general, maintain a similar mode of degradation as in application.

4.2.3 Temperature

Annex A provides a treatment of the range of module temperatures occurring during peak UV stress in field applications. In a weathering chamber, the actual specimen temperature during exposure will vary depending upon the absorptance of the specimen (radiant heating), the Chamber Temperature (ChT) and the heat transfer within the chamber (convective cooling). The ChT and Black Panel Thermometer (BPT) control the lower bound and upper bound of the specimen temperature, respectively. Specimen temperatures for white or clear materials (typical frontsheets, backsheets, and encapsulants) will be closer to the ChT than to the BPT in a xenon arc device. Conversely, a black specimen will be close to the BPT. BPTs in this practice were set at a level that may be obtained by contemporary equipment. For a better understanding of the specimen response to the conditions of Table 1, the temperature may be measured for a specimen under test.

NOTE When used in a PV module a black backsheet will see a temperature rise similar to that of a white backsheet because the majority of the energy absorption occurs in the cells, not the backsheet. Outdoors, a module with a black backsheet would be expected to see a temperature as much as 2 °C or 3 °C hotter than a white backsheet, but in a weathering instrument a 20 °C or greater temperature difference can exist between white and black specimens facing a xenon arc lamp.

———————————

[1] Numbers in square brackets refer to the Bibliography.