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TECHNICAL SPECIFICATION

colour inside

Photovoltaic modules – Extended-stress testing – Part 2: Polymeric component materials

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IEC Secretariat
3, rue de Varembé
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
info@iec.ch
www.iec.ch

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PHOTOVOLTAIC MODULES – EXTENDED-STRESS TESTING –

Part 2: Polymeric component materials

FOREWORD

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IEC TS 63209-2 been prepared by IEC technical committee 82: Solar photovoltaic energy systems. It is a Technical Specification.

The text of this Technical Specification: is based on the following documents:

Draft	Report on voting
82/2015/DTS	82/2058A/RVDTS

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this Technical Specification is English.

A list of all parts in the IEC 63209 series, published under the general title *Photovoltaic modules – Extended-stress testing*, can be found on the IEC website.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at http://www.iec.ch/standardsdev/publications.

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

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

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INTRODUCTION

This document is intended as a guide for component suppliers, module manufacturers and downstream durability assessments, and focuses on polymeric materials in crystalline silicon module laminates.

IEC TS 63209 series describes environmental stress tests which provide data for evaluation of the long-term reliability of PV modules, probing areas not addressed in the IEC 61215 and IEC 61730 series. IEC TS 63209-1 provides a menu of extended environmental stress tests for PV modules, and this document, IEC TS 63209-2, describes complementary component level testing which probes degradation modes which are not easily understood or addressed by module level testing. This document additionally describes an overlapping suite of component level tests useful for screening individual components and component combinations for a specific bill of materials (BOM).

The testing in this document is intended for reliability evaluation only, with no pass/fail requirements.

This document does not describe any new test or stress exposures, but takes the single component testing described in the IEC 62788 series as a base line for stress exposures which are then extended. As degradation of one component can be influenced by other components (e.g. some backsheets tested with one encapsulant may perform differently than with another, and vice versa), a slate of BOM-specific tests and related stress exposures are included which are described in IEC 62788 component standards, but are not typically part of component data sheets.

This document details component level stress sequences, sample construction and evaluation test methods which can assist in a durability analysis. A particular focus is given to UV stress alone and in combination with other stressors. UV exposures, in particular, are difficult to perform accurately at the module level due to time and space constraints. Polymeric components are known to have UV-induced degradation modes which progress relatively slowly. Testing at a component level allows for smaller sample sizes, longer stress exposures, and test coupons designed to target relevant properties after applied stress.

PHOTOVOLTAIC MODULES – EXTENDED-STRESS TESTING –

Part 2: Polymeric component materials

1 Scope

This part of IEC TS 63209 includes a menu of tests to use for evaluation of the long-term reliability of materials used as backsheets and encapsulants in PV modules. It is intended to provide information to supplement the baseline testing defined in IEC 61215 and IEC 61730, which are qualification tests with pass-fail criteria. It may be used by PV stakeholders in conjunction with IEC TS 63209-1, to provide more extended stress testing of the component materials than can practically be accomplished with PV modules. The data set resulting from testing is used for reliability analysis and is not intended to be used as a pass-fail test procedure. This document addresses polymeric materials in the crystalline silicon module laminates, specifically backsheets and encapsulants in Glass/Glass or Glass/Backsheet modules. Although not specifically addressed, it is expected to also have applicability to thin film technologies.

The included environmental stress tests are intended to cause degradation that is most relevant to field experience, but these may not capture all failure modes which may be observed in various locations.

The individual component standards provide a starting point for testing, and baseline data for reference in this document may be available from a characterization sheet developed in accordance with the Uniform Characterization Forms (UCF) of IEC TS 62788-2 and IEC 62788-1-1. Extended tests using the same methods allows for trend analysis.

Additional testing is included to address interactions with other polymeric packaging material, as individual components can perform differently depending on adjacent materials. These tests are designed with BOM-specific coupons and mini-modules, intended to complement the specific module bill of materials used in the IEC TS 63209-1 module tests.

As both test specimen form factor and I-V characteristics can play a role in degradation, some multicomponent tests are designed to use a polymeric stack, while others use mini-modules.

The included stress tests are not designed to test to failure, but to be representative of stress levels of the long-term application.

These tests are not intended to provide service life estimates, or to be indicative of fitness for use in specific climate/mounting configurations. For example, the same module deployed in two different locations or with different mounting methods may degrade in different ways, so a single test protocol cannot be expected to exactly match the performance in both environments; correlation to field will depend upon where and how the product is deployed.

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 TS 60904-13:2018, *Photovoltaic devices – Part 13: Electroluminescence of photovoltaic modules*

IEC 61215-1-1:2021, *Terrestrial photovoltaic (PV) modules – Design qualification and type approval -Part 1-1: Special requirements for testing of crystalline silicon photovoltaic (PV) modules*

IEC 61215-2:2021, *Terrestrial photovoltaic (PV) modules – Design qualification and type approval – Part 2: Test procedures*

IEC 61730-2, *Photovoltaic (PV) module safety qualification – Part 2: Requirements for testing*

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

IEC 62788-1-1, *Measurement procedures for materials used in photovoltaic modules – Part 1-1: Encapsulants – Polymeric materials used for encapsulants*

IEC 62788-1-6, *Measurement procedures for materials used in photovoltaic modules – Part 1-6: Encapsulants – Test methods for determining the degree of cure in ethylene-vinyl acetate*

IEC 62788-1-7:2020, *Measurement procedures for materials used in photovoltaic modules – Part 1-7: Encapsulants – Test procedure of optical durability*

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

IEC TS 62788-6-3, *Measurement procedures for materials used in photovoltaic modules – Part 6-3: Adhesion testing of interfaces within PV modules*

IEC TS 62788-7-2:2017, *Measurement procedures for materials used in photovoltaic modules – Part 7-2: Environmental exposures – Accelerated weathering tests of polymeric materials*

IEC TS 62804-1, *Photovoltaic (PV) modules – Test methods for the detection of potential-induced degradation – Part 1: Crystalline silicon*

IEC TS 63209-1:2021, *Photovoltaic modules – Extended-stress testing – Part 1:* Modules

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC TS 62788-2, IEC 62788-1-1, IEC 62788-1-7, IEC TS 63209-1, IEC TS 61836 along with 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
Bill of Materials
BOM
list of the specific materials used to build a specific PV module, excluding equal alternates

3.2
Uniform Characterization Form
UCF
list of properties to be evaluated according to the tests in this document

3.3
Single Cantilever Beam
SCB
adhesion test using a single cantilever beam as described in IEC TS 62788-6-3

4 Failure modes and component interactions

Degradation of polymeric materials can occur both by chemical changes to a specific material, such as thermo-oxidative degradation, hydrolysis, photolysis, and by morphological changes, such as reordering of type or degree of crystallinity, which can significantly alter key properties. Subsequent mechanical, thermo-mechanical, or hydromechanical stresses such as obtained with thermal cycling, coefficient of thermal expansion (CTE) differentials, or from volume changes associated with moisture ingress/egress, can then induce physical degradation, such as delamination and cracking. Observed failure modes for backsheets and encapsulants are shown in Table 1.

Degradation of single components is evaluated by monitoring changes to key characteristics after single stresses (exposure to damp heat (DH), thermal, and ultraviolet (UV) as specified in the IEC 62788 series, using the Xe exposures defined in IEC TS 62788-7-2. In this document, the UV stress is extended and includes multiple data points to observe changes and allow for extrapolation to longer UV exposures. Specifics are detailed in the individual single component sections.

Observed failure modes of backsheets and encapsulants include: frontside (through glass) cracking, backside cracking, interlayer delamination, and discoloration as well as delamination and increased optical absorption of the encapsulant.

Failure modes can be influenced by other module components (see Bibliography for references providing pictures and more details). These interactions can result in both positive and negative effects as shown in Table 1. BOM specific testing is used to evaluate these effects, and adhesion.

Table 1 – Encapsulant and backsheet failure modes

Component	Degradation mode	Interactions with other components
Backsheet	cell side yellowing	**encapsulant** plus: UV filter minus: chemical interactions with base polymer, additives or impurities
	cell side cracking	
	backsheet / encapsulant delamination	
	loss of transmission (clear)	
	interlayer delamination	n/a
	air side yellowing	n/a
		encapsulant, connectors, cells • connectors provide localized stress points which can induce cracks • thickness and compliance of encapsulant can mitigate the stress from cell edges/connectors
	cell side and air side cracking	**encapsulant, connectors, cells** • connectors provide localized stress points • additive effects
Encapsulant	yellowing	**glass/backsheet** • oxygen transmission effects • additive effects
	transmission loss (non-yellowing)	**backsheet** • additive effects
	adhesion to glass	**glass** • glass treatment (adhesion promoter)
	adhesion to cell – front side	**cell**
	adhesion to cell – back side	**cell**
	adhesion to backsheet	**backsheet**

5 Selection of tests

This document contains a menu of tests, which are intended to supply information to supplement the reliability data obtained in IEC TS 63209-1. Users can select relevant tests from this list which are relevant to the targeted application. All test data is to be reported, with no pass/fail criterion applied.

6 Single component testing

6.1 Extended test procedures

This clause describes test for encapsulants and backsheets. Evaluation methods and stress exposure setpoints are the same as in the referenced IEC 62788 series specifications as shown in Table 2, with some stress durations extended from the referenced specifications.

Properties which are useful for evaluation of long-term durability of backsheets include both direct visual observations, e.g. of cracks or delamination, and secondary characteristics which inform as to the propensity to crack or delaminate. Quantitative property measurements are used to determine relative changes to project trends after stress exposures. Characterization methods for backsheets are provided in IEC TS 62788-2.

Optical transmission is the primary property for evaluating long term durability of encapsulants as a single component. This characterization method is provided in IEC 62788-1-7.