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Measurement procedures for materials used in photovoltaic modules -
Part 2-1: Polymeric materials - Frontsheet and backsheet - Safety requirements

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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Measurement procedures for materials used in photovoltaic modules - Part 2-1: Polymeric materials - Frontsheet and backsheet - Safety requirements

FOREWORD

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This consolidated version of the official IEC Standard and its amendment has been prepared for user convenience.

IEC 62788-2-1 edition 1.1 contains the first edition (2013-11) [documents 82/2123/FDIS and 82/2148/RVD] and its amendment 1 (2026-07) [documents 82/2625/FDIS and 82/2661/RVD].

In this Redline version, a vertical line in the margin shows where the technical content is modified by amendment 1. Additions are in green text, deletions are in strikethrough red text. A separate Final version with all changes accepted is available in this publication.

IEC 62788-2-1 has been prepared by IEC technical committee 82: Solar photovoltaic energy systems. It is an International Standard.

The text of this International Standard is based on the following documents:

Draft	Report on voting
82/2123/FDIS	82/2148/RVD

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 International Standard is English.

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 www.iec.ch/standardsdev/publications.

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 document and its amendment 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– withdrawn, or
– revised.

INTRODUCTION

This document provides test procedures and specifications for polymeric front- and backsheet constructions employed in a PV module for safety qualification on a component level. Test methods have been compiled to match the general requirements for polymeric materials used as relied-upon insulation defined in the IEC 61730 standard series in consideration of test methods in IEC TS 62788-2 (characterization of front- and backsheets), IEC TS 62788-7-2 [4][1](UV weathering test) and the retesting guidelines IEC TS 62915. This document provides clarifications on definitions of front- and backsheet construction types and related test requirements, and additional environmental stress testing, to which IEC 61730-1 refers. Separating out the component level testing into this document was considered to limit the complexity of the IEC 61730 standard series, also in view of the implementation of the test methods in the frame of IEC System of Conformity Assessment Schemes for Electrotechnical Equipment and Components (IECEE).

Test methods on a component level and PV module level are different for practical reasons. On a component level, the daylight filtered xenon test (IEC TS 62788-7-2) is applied for UV weathering, which is regarded as more representative to assess the durability of polymeric materials under outdoor weather conditions than the UVA test of IEC 61215-2. The latter has been developed in view of practicality of applying UV exposure to larger scale PV modules.

This document focusses on the safety relevant properties of front- and backsheets as required by IEC 61730.

The lamination protrusion test (aka DTI test) is required to measure the thickness of relied-upon insulation on the component level. The thickness of the RUI layer(s) is verified by MST 04 of IEC 61730-2 on PV module level. The test provides additional information needed for evaluation of the Comparative Tracking Index (CTI) and dielectric strength / breakdown voltage.

– The lamination protrusion test applies default lamination conditions, that are representative for a typical PV module manufacturing process. Using a 800 μm diameter solder wire that mimics severe solder peaks and/or slanted ribbons, the test serves as worst case scenario for measurement of potential displacement of material under lamination conditions. Even more harsh lamination process conditions can be selected as recommended by the manufacturer of the front- or backsheet.
– The lamination protrusion test is also used to identify additional inner layers of the front- or backsheet that potentially may be in contact with live parts and for which CTI shall be determined. Additional layers may require CTI depending on the construction of the PV module, e.g., due to specific sheet openings and through wiring for junction box connections with background provided in IEC 61730-1.
– The ratio of the measured distance through insulation (t_{DTI}) to the total thickness is used to calculate the effective dielectric strength or required withstand voltage when measured on final products that contain inner layers, which can be displaced under lamination conditions (see breakdown voltage test in 6.4).
– Because of the relationship with thermal endurance, t_{DTI} can be listed as a function of the module operating temperature rating.

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

This document specifies a suite of environmental stress tests to characterize the durability of the relied-upon insulation. In the evaluation of tensile testing a minimum elongation at break is considered in addition to retention of tensile strength, as this allows to differentiate known-bad and known-good materials. The thermal endurance performance, which is historically evaluated by tensile strength and dielectric strength in terms of TI or RTE (RTI), is therefore complemented by a thermal failsafe test to also evaluate elongation at break. The combination of these elements, tests covering thermal, damp heat and UV weathering stresses and evaluation of elongation at break, represents a step forward in safety testing of polymeric front- and backsheets that is still balanced in terms or practicality (duration) of testing.

The requirements in this document for model or variant designations and (re)testing of similar materials have been aligned with developments for the IEC TS 62915 module retesting guidelines. The current requirements provide a first step towards more detailed requirements which may be developed in a future revision of this document or a dedicated component retesting standard.

A future revision of this document may consider sequential testing on engineering coupons with (solder wire) bumps to better mimic the combination of UV and cyclic stress fatigue, that is currently discussed as the next level in endurance testing of polymeric front- and backsheets in IEC TS 62788-2 and IEC TS 63209-2[6]. However, method consolidation requires more time than available for this project.

In view of requirements for material identification in the context of the retesting guidelines (IEC TS 62915), approaches for “finger-printing” are provided in Annex A.

The requirements in this document may be used in the context of Manufacturing Quality Assurance of polymeric front- and backsheets as explained in the guideline IEC 62941[5].

1 Scope

This document specifies the safety requirements for flexible polymeric front- and backsheet constructions, which are intended for use as relied-upon insulation in photovoltaic (PV) modules. The specifications in this document define the specific requirements of polymeric front- or backsheet constructions on the component level and cover mechanical, electrical, visual and thermal characterization in an unexposed state and/or after ageing.

This document covers class II and class 0 modules, as defined in IEC 61730-1. Class III modules are out of scope.

For qualification to IEC 61730-1 of a PV module using a polymeric front- or backsheet, the sheet must pass the requirements in this document for the specified module's safety class, rated system voltage, and module temperature rating.

Compliance with the safety requirements for a front- or backsheet on the component level does not replace the need for a safety qualification of the complete PV module, in which the front- or backsheet is integrated. The appropriate requirements for testing and qualification of PV modules, are defined in IEC 61730-1 and IEC 61215-1 (or IEC TS 62915 in case of retesting), with test methods provided by IEC 61730-2 and IEC 61215-2, respectively.

This document provides the requirements for qualification of front- and backsheets to be used in module safety qualification according to IEC 61730-1. Test method descriptions are provided in IEC TS 62788-2, along with additional characterization methods useful for performance or quality assurance.

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 60216-1**,** *Electrical insulating materials – Thermal endurance properties – Part 1: Ageing procedures and evaluation of test results*

IEC 60216-3**,** *Electrical insulating materials – Thermal endurance properties – Part 3: Instructions for calculating thermal endurance characteristics*

IEC 60216-5, *Electrical insulating materials – Thermal endurance properties – Part 5: Determination of relative temperature index (RTI) of an insulating material*

IEC 60664-1, *Insulation coordination for equipment within low-voltage supply systems – Part 1: Principles, requirements and tests*

IEC 61215-1, *Terrestrial photovoltaic (PV) modules – Design qualification and type approval – Part 1: Test requirements*

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

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

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

IEC TS 62915, *Photovoltaic (PV) modules – Type approval, design and safety qualification – Retesting*

IEC TS 63126:2020, *Guidelines for qualifying PV modules, components and materials for operation at high temperatures*

ISO 527-3, *Plastics – Determination of tensile properties – Part 3: Test conditions for films and sheets*

3 Terms, definitions and abbreviated terms

For the purposes of this document, the following terms and definitions apply, in addition to those in IEC TS 61836 and IEC TS 62788-2.

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 General terms and definitions

3.1.1
FBST
front- or backsheet safety test in accordance with IEC 62788-2-1

3.1.2
tolerance
permitted deviation between the declared value of a quantity and the measured value

[SOURCE: IEC 60050-411[2]:1996,411-36-19]

3.2 Sheet types and orientations

3.2.1
air-side
side of the front- or backsheet oriented towards the outside of the PV module, i.e., away from the cells

3.2.2
backsheet
(combination of) outer layer(s) of the PV module, located as substrate on the back of the PV module and providing protection of the inner components of the PV module from external stresses and weather elements, as well as providing electrical insulation

3.2.3
frontsheet
(combination of) outer layer(s) of the PV module designed for prolonged exposure to direct sunlight (> 300 W/m^2) and providing protection of the inner components of the PV module from external stresses and weather elements, as well as providing electrical insulation