

# TECHNICAL SPECIFICATION



Measurement procedures for materials used in photovoltaic modules –  
Part 2: Polymeric materials – Frontsheets and backsheets  
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IEC TS 62788-2:2017

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## INTERNATIONAL ELECTROTECHNICAL COMMISSION

**MEASUREMENT PROCEDURES FOR MATERIALS USED  
IN PHOTOVOLTAIC MODULES –****Part 2: Polymeric materials – Frontsheets and backsheets**

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

IEC TS 62788-2, 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
82/1189/DTS	82/1243A/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.

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.

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

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## INTRODUCTION

Backsheets provide the electrical insulation at the backside of a PV module under the environmental stress factors and use conditions encountered during the intended lifetime of the module. Frontsheets have the same function at the front side of the module facing towards the sun. Both can be made from glass or polymeric material.

Polymeric backsheets and frontsheets are typically compositions of layered materials, such as films, adhesives or coatings, in which at least one material layer delivers the relied-upon insulation (RUI) for electrical safety. Other layers may provide extended protection of the RUI against the environmental factors or adhesive functionality. As an integral part of the PV module, backsheet and frontsheet shall provide their durable electrical insulating function in presence of the other components of the PV module, such as light-to-current conversion element (the “cell”), electrical circuits and connectors, frontsheet and encapsulant, sealing material, junction boxes, etc. These elements may introduce additional stresses on the backsheet or frontsheet (e.g. by chemical interactions or introducing thermal load or mechanical stress) or alter environmental stresses (e.g. filtering of UV radiation reaching the sun-facing side of the backsheet).

It is impractical to conduct all endurance tests for frontsheet or backsheet component on module level. Instead, testing is performed directly on these components for pre-qualification of the materials as such, as e.g. given by the thermal endurance test required for material intended for use as relied-upon-insulation, that is qualified by IEC 60216 (see IEC 61730-1:2016, 5.5.1.3.3) and results in RTE/RTI/TI ratings of  $\geq 90$  °C or maximum operating temperature (whichever is greater). In the case of thermal pre-qualification of backsheet and frontsheet only dielectric and mechanical material tests apply for RTE/RTI/TI assessment.

In analogy to RTE/RTI/TI, it is desirable to also obtain pre-qualification of backsheet and frontsheet films to provide durable electrical insulation after exposure to additional environmental factors, such as:

- a) Elevated moisture and temperature (damp heat), or
- b) UV-weathering in a manner representative of the field conditions. These tests can either be conducted direct on the backsheet or frontsheet films or on dedicated test coupons as engineering type specimens, which are prepared from the same materials and produced under comparable processing conditions (i.e. lamination) as the PV modules.
  - The portion of the backsheet that contributes to the relied upon insulation should be evaluated for d.c. voltage (V) breakdown strength according to IEC 60243-1 and IEC 60243-2, and meet the requirements as described in 5.6.4.3 of IEC 61730-1:2016. In this document a suitable choice of test parameters for the assessment of polymeric frontsheet and backsheet is defined.
  - The relied upon insulation material shall have a minimum thickness, also known as distance through insulation (dti) defined in the “thickness in thin layers” rows of Tables 3 and 4 in 5.6 of IEC 61730-1:2016.
  - Materials relied upon for insulation are further categorized into Materials Groups I, II, or III, according to CTI values describing potential tracking along interfaces that may get in contact with live parts.
  - Durable adhesion between components of the backsheet or frontsheet is needed to preserve the integrity of the sheet material in field conditions. Also, preservation of adhesion to other components of the module such as encapsulant and edge seal or adhesion to the junction box adhesive are important. Different test geometries may apply depending on the interface under test and construction of the sheet material.

Other characteristics of frontsheet or backsheet might be relevant for the electrical yield (e.g. optical transmittance or reflectance) or module producibility (e.g. lamination process).

This document defines test methods required for reporting of properties of polymeric frontsheet and backsheet in a datasheet. Those properties are related to safety and yield of the assembled PV module and may be applied to backsheet/frontsheet before and after specific ageing tests as mentioned before.

In analogy to RTE/RTI/TI testing, the test methods in this document are intended to be used in procedures for pre-qualification and/or quality assurance of frontsheet and backsheet components with respect to their endurance under damp-heat and UV weathering stresses – once these pre-qualification procedures are agreed on and implemented in alignment with the pertinent standards IEC 61730 and IEC 61215, in which the safety requirements on PV module level are defined.

NOTE At the time of writing this TS, an amendment project for IEC 61730-1 is in preparation, in which requirements for measurement of dti (distance through insulation) and resistance against weathering are planned based on methods defined in this document IEC TS 62788-2 as well as IEC TS 62788-7-2.

The test methods in these TS provide additional information on material properties and endurance of backsheet and frontsheet components that cannot be assessed in the tests on PV module alone.

Furthermore, optional characterization test methods are defined, addressing properties of backsheet and frontsheet that are of informative nature, e.g. in the context of PV module design, but which are not directly safety, yield or processing related.

Test methods for characterization of components of backsheet and frontsheet are described, which are useful in R&D context.

All of these test methods are set into perspective by indicating their use and limitations.

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# MEASUREMENT PROCEDURES FOR MATERIALS USED IN PHOTOVOLTAIC MODULES –

## Part 2: Polymeric materials – Frontsheets and backsheets

### 1 Scope

This part of IEC 62788 defines test methods and datasheet reporting requirements for safety and performance related properties (mechanical, electrical, thermal, optical and chemical) of non-rigid polymeric materials intended for use in terrestrial photovoltaic modules as polymeric frontsheets and backsheets.

The test methods in this document define how to characterize backsheet and frontsheet materials and their components in a manner representative of how they will be used in the module, which eventually includes combination with other matched components such as encapsulant or adhesives. The methods described in this document support the safety and performance related tests defined on PV module level as defined in the series IEC 61730 and IEC 61215.

This document also defines test methods for assessment of inherent material characteristics of polymeric backsheets and frontsheets or their components, which may be required in datasheet reporting or may be useful in the context of product development or design of PV modules.

Rigid polymeric sheet materials (also providing mechanical support) may require further consideration.

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IEC 60050-581, *International Electrotechnical Vocabulary – Part 581: Electromechanical components for electronic equipment*

IEC 60050-826, *International Electrotechnical Vocabulary – Part 826: Electrical installations*

IEC 60068-1, *Environmental testing – Part 1: General and guidance*

IEC 60112:2003, *Method for the determination of the proof and the comparative tracking indices of solid insulating materials*

IEC 60212, *Standard conditions for use prior to and during the testing of solid electrical insulating materials*

IEC 60216-1, *Electrical insulating materials – Properties of thermal endurance – Part 1: Ageing procedures and evaluation of test results*

IEC 60216-2:2005, *Electrical insulating materials – Thermal endurance properties – Part 2: Determination of thermal endurance properties of electrical insulating materials – Choice of test criteria*

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

IEC 60243-1:2013, *Electrical strength of insulating materials – Test methods – Part 1: Tests at power frequencies*

IEC 60243-2, *Electric strength of insulating materials – Test methods – Part 2: Additional requirements for tests using direct voltage*

IEC 60296, *Fluids for electrotechnical applications – Unused mineral insulating oils for transformers and switchgear*

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

IEC 60904-3:2016, *Photovoltaic devices – Part 3: Measurement principles for terrestrial photovoltaic (PV) solar devices with reference spectral irradiance data*

IEC 61140, *Protection against electric shock – Common aspects for installation and equipment*

IEC 61189-3, *Test methods for electrical materials, printed boards and other interconnection structures and assemblies – Part 3: Test methods for interconnection structures (printed boards)*

IEC 61215-1:2016, *Terrestrial photovoltaic (PV) modules – Design qualification and type approval – Part 1: Test requirements*

IEC 61215-2:2016, *Terrestrial photovoltaic (PV) modules – Design qualification and type approval – Part 2: Test procedures*

IEC 61730-1:2016, *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 62788-1-2, *Measurement procedures for materials used in photovoltaic modules – Part 1-2: Encapsulants – Measurement of volume resistivity of photovoltaic encapsulants and other polymeric materials*

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 62788-1-5, *Measurement procedures for materials used in photovoltaic modules – Part 1-5: Encapsulants – Measurement of change in linear dimensions of sheet encapsulation material resulting from applied thermal conditions*

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

IEC 62790, *Junction boxes for photovoltaic modules – Safety requirements and tests*

IEC 62805-2, *Method for measuring photovoltaic (PV) glass – Part 2: Measurement of transmittance and reflectance*

ISO 291, *Plastics – Standard atmospheres for conditioning and testing*

ISO 527 (all parts): *Plastics*

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

ISO 536:2012, *Paper and board – Determination of grammage*

ISO 2409:2013, *Paints and varnishes – Cross-cut test*

ISO 2808, *Paints and varnishes determination of film thickness*

ISO 2813, *Paints and varnishes – Determination of gloss value at 20 degrees, 60 degrees and 85 degrees*

ISO 4587:2003, *Adhesives – Determination of tensile lap-shear strength of rigid-to-rigid bonded assemblies*

ISO 4593: *Plastics – Film and sheeting – Determination of thickness by mechanical scanning*

ISO 11359-1, *Plastics – Thermomechanical analysis (TMA) – Part 1: General principles*

ISO 11359-2: *Plastics – Thermomechanical analysis (TMA) – Part 2: Determination of coefficient of linear thermal expansion and glass transition temperature*

ISO 11664-1, *Colorimetry – Part 1: CIE standard colorimetric observers*

ISO 11664-2, *Colorimetry – Part 2: CIE standard illuminants*

ISO 11664-4, *Colorimetry – Part 4: CIE 1976 L\*a\*b\* Colour space*

ISO 15105-2, *Plastics – Film and sheeting – Determination of gas-transmission rate – Part 2: Equal-pressure method*

ISO 15106-1, *Plastics – Film and sheeting – Determination of water vapour transmission rate – Part 1: Humidity detection sensor method*

ISO 15106-2, *Plastics – Film and sheeting – Determination of water vapour transmission rate – Part 2: Infrared detection sensor method*

ISO 15106-3, *Plastics – Film and sheeting – Determination of water vapour transmission rate – Part 3: Electrolytic detection sensor method*

ISO 17223, *Plastics – Determination of yellowness index and change in yellowness index*

EN 821-2, *Advanced technical ceramics – Monolithic ceramics, thermo-physical properties – Part 2: Determination of thermal diffusivity by the laser flash (or heat pulse) method*

ASTM D374–16, *Standard Test Methods for Thickness of Solid Electrical Insulation*

ASTM D3487-16, *Standard Specification for Mineral Insulating Oil Used in Electrical Apparatus*

ASTM D 5402-06, *Standard Practice for Assessing the Solvent Resistance of Organic Coatings Using Solvent Rubs*

ASTM D7869-17, *Standard Practice for Xenon Arc Exposure Test with Enhanced Light and Water Exposure for Transportation Coatings*

ASTM E1461, *Standard Test Method for Thermal Diffusivity by the Flash Method*

UL 746B, *Standard for Polymeric Materials – Long Term Property Evaluations*

### 3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60050-581, IEC 60050-826, IEC 60664-1, IEC TS 61836, IEC 61730-1 and IEC 61140, together 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

##### **abrasion resistance**

ability of a material to withstand mechanical action such as rubbing, scraping, or erosion, that tends progressively to remove material from its surface

#### 3.2

##### **adhesive failure**

de-bonding occurring between the adhesive and the adherent, to be differentiated from cohesive failure within the adhesive material

Note 1 to entry: See also Clause A.1.

#### 3.3

##### **air-facing side**

side of the frontsheet or backsheet that is oriented towards the outside of the PV module, i.e. away from the cells

#### 3.4

##### **backsheet**

##### **BS**

outer layer of the PV module, located on the back of PV module and providing protection of the inner components of the module from external stresses and weather elements, as well as electrical insulation

#### 3.5

##### **bond strength**

force required to separate an adhesive from an adherent

#### 3.6

##### **breakdown voltage**

voltage at which electric breakdown occurs under prescribed test conditions, or in use