

# TECHNICAL SPECIFICATION



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

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INTERNATIONAL  
ELECTROTECHNICAL  
COMMISSION

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## CONTENTS

|   |    |
|---|----|
| FOREWORD.....   | 5  |
| 1 Scope.....  | 7  |
| 2 Normative references .....                                  | 8  |
| 3 Terms and definitions .....                                 | 10 |
| 4 Test procedures .....                                       | 13 |
| 4.1 General.....  | 13 |
| 4.1.1 Purpose.....  | 13 |
| 4.1.2 Sample pre-treatment .....                              | 14 |
| 4.1.3 Type of sample constructions .....                      | 15 |
| 4.2 Mechanical characteristics .....                          | 16 |
| 4.2.1 General .....   | 16 |
| 4.2.2 Thickness .....   | 16 |
| 4.2.3 Area weight .....                                       | 17 |
| 4.2.4 Tensile properties .....                                | 17 |
| 4.3 Adhesion testing .....                                    | 21 |
| 4.3.1 Purpose.....  | 21 |
| 4.3.2 General .....   | 21 |
| 4.3.3 Specific use cases.....                                 | 22 |
| 4.3.4 Methods .....   | 24 |
| 4.3.5 Reporting requirements .....                            | 29 |
| 4.4 Thermal characteristics .....                             | 30 |
| 4.4.1 Thermal endurance.....                                  | 30 |
| 4.4.2 Thermal failsafe test .....                             | 31 |
| 4.4.3 Dimensional stability.....                              | 32 |
| 4.4.4 Relative thermal expansion.....                         | 34 |
| 4.4.5 Thermal conductivity.....                               | 34 |
| 4.5 Electrical characteristics and insulation thickness ..... | 35 |
| 4.5.1 Breakdown voltage .....                                 | 35 |
| 4.5.2 Lamination protrusion test (aka DTI test) .....         | 40 |
| 4.5.3 Comparative tracking index (CTI) .....                  | 43 |
| 4.5.4 Volume resistivity .....                                | 44 |
| 4.6 Optical characteristics.....                              | 45 |
| 4.6.1 General .....   | 45 |
| 4.6.2 Specimen preparation.....                               | 46 |
| 4.6.3 Visual inspection .....                                 | 46 |
| 4.6.4 Optical transmittance.....                              | 47 |
| 4.6.5 Optical reflectance.....                                | 48 |
| 4.6.6 Yellowness index.....                                   | 48 |
| 4.6.7 Colour measurement .....                                | 49 |
| 4.6.8 Surface gloss.....                                      | 50 |
| 4.7 Diffusion characteristics .....                           | 51 |
| 4.7.1 Permeability of water vapour .....                      | 51 |
| 4.7.2 Permeability of oxygen .....                            | 52 |
| 4.8 Chemical characteristics .....                            | 52 |
| 4.8.1 Resistance to solvents.....                             | 52 |
| 4.9 Other characteristics.....                                | 54 |
| 4.9.1 Ignitability – Purpose .....                            | 54 |

|                       |   |    |
|-----------------------|---|----|
| 4.9.2                 | Flammability – Purpose .....                                  | 54 |
| 4.10                  | Accelerated ageing tests .....                                | 54 |
| 4.10.1                | Purpose .....   | 54 |
| 4.10.2                | Damp-heat ageing test .....                                   | 55 |
| 4.10.3                | UV weathering .....   | 56 |
| 4.10.4                | Abrasion test .....   | 61 |
| 4.11                  | Sequential UV/TC stress test ("solder bump test") .....       | 61 |
| 4.11.1                | Purpose .....   | 61 |
| 4.11.2                | Sample construction .....                                     | 62 |
| 5                     | Uniform characterization form .....                           | 68 |
| 5.1                   | General .....   | 68 |
| 5.2                   | Layer stack description .....                                 | 68 |
| 5.3                   | Material test results and reporting requirements .....        | 68 |
| 6                     | Data sheet .....  | 70 |
| 6.1                   | Purpose .....   | 70 |
| 6.2                   | Reporting requirements .....                                  | 70 |
| 7                     | Product identification sheet (label) .....                    | 70 |
| Annex A (normative)   | Sample preparation .....                                      | 71 |
| A.1                   | Purpose .....   | 71 |
| A.2                   | Sample constructions .....                                    | 71 |
| A.2.1                 | General considerations .....                                  | 71 |
| A.2.2                 | Materials and procedures .....                                | 71 |
| A.2.3                 | Overview of sample pre-treatments .....                       | 77 |
| Annex B (informative) | Overview of adhesion testing of front- and backsheets .....   | 79 |
| B.1                   | General .....   | 79 |
| B.2                   | Type of adhesion failure .....                                | 79 |
| B.3                   | Characteristics of peel tests .....                           | 80 |
| B.4                   | Characteristics of pluck and lap-shear tests .....            | 80 |
| B.5                   | Characteristics of cross-hatch tape test .....                | 81 |
| B.6                   | Characteristics of single cantilevered beam (SCB) test .....  | 81 |
| B.7                   | Other caveats .....   | 81 |
| Annex C (informative) | Abrasion testing .....  | 84 |
| C.1                   | Purpose .....   | 84 |
| C.2                   | Methods .....   | 84 |
| Annex D (informative) | Visual examination after sequential UV/TC stress test .....   | 85 |
| D.1                   | General .....   | 85 |
| D.2                   | Airside inspection of backsheet in reflection mode .....      | 85 |
| D.2.1                 | General .....   | 85 |
| D.2.2                 | Unexposed samples .....                                       | 85 |
| D.2.3                 | Airside: Rating of 1 .....                                    | 86 |
| D.2.4                 | Airside: Rating of 2 .....                                    | 87 |
| D.2.5                 | Airside: Rating of 3 .....                                    | 87 |
| D.2.6                 | Airside: Rating of 4 .....                                    | 88 |
| D.3                   | Glass side inspection of backsheet in transmission mode ..... | 89 |
| D.3.1                 | Unexposed samples .....                                       | 89 |
| D.3.2                 | Glass-side: Rating of A .....                                 | 89 |
| D.3.3                 | Glass-side: Rating of B .....                                 | 90 |
| D.3.4                 | Glass-side: Rating of C .....                                 | 91 |

|   |    |
|---|----|
| D.3.5 Glass-side: Rating of D.....  | 92 |
| Bibliography.....   | 93 |
| Figure 1 – Specimen dimensions and markings in tensile test (unstrained and strained).....  | 20 |
| Figure 2 – Fixation of the sample for 180° peel (for use with flexible/flexible samples).....   | 25 |
| Figure 3 – Single and multiple failure modes in a peel test.....  | 26 |
| Figure 4 – Sheet sandwich (top) for preparation of T-peel test specimens (bottom).....  | 27 |
| Figure 5 – Illustration of area removal by tape in cross-hatch test, with classification from 0 to 5 (from left to right) .....                                   | 28 |
| Figure 6 – Specimen before and after exposure .....   | 33 |
| Figure 7 – Equal electrodes for dielectric strength test.....   | 36 |
| Figure 8 – Schematics of test specimen for DTI test before and after lamination .....   | 41 |
| Figure 9 – Example of DTI cross-section of a backsheet.....   | 42 |
| Figure 10 – Schematic indicating need for CTI measurement of materials A and B to determine creepage distances .....  | 43 |
| Figure 11 – Side-view schematic of solder-bump coupon sample after lamination .....   | 62 |
| Figure 12 – Example of "solder-bump coupons" in a specimen holder.....  | 64 |
| Figure B.1 – Adhesive and cohesive failure type schematics for lap shear (top) and T-pluck (bottom).....  | 79 |
| Figure D.1 – Example of an open area with scratches.....  | 86 |
| Figure D.2 – Example of grey residue from the solder wire in the trench.....  | 86 |
| Figure D.3 – Example contamination (at different magnifications) .....  | 87 |
| Figure D.4 – Airside microscope image of ridge area with superficial "stretch marks".....   | 87 |
| Figure D.5 – Airside microscope images with cracks parallel to the ridge region .....   | 88 |
| Figure D.6 – Airside microscope images with cracks on the ridge and in the trench .....   | 88 |
| Figure D.7 – Airside image of a crack through all the RUI layers.....   | 89 |
| Figure D.8 – Observation of delamination artefact at the ends of the trench.....  | 89 |
| Figure D.9 – Backlit microscope image of a mark on the ridge of a transparent backsheet suspected to be a scratch as opposed to a degradation related crack ..... | 90 |
| Figure D.10 – Examples of cracks smaller than 2 mm at the perimeter .....   | 91 |
| Figure D.11 – Cracks greater than 2 mm at the perimeter and near ridge and trench .....   | 92 |
| Figure D.12 – Cracks across the open space .....  | 92 |
| Table 1 – Overview of typical front- and backsheet building blocks .....  | 15 |
| Table 2 – Overview of adhesion tests .....  | 22 |
| Table 3 – Overview of sample preparation for exposure of sun-facing (inner) side of backsheet depending on intended post evaluation (see Table A.1) .....         | 58 |
| Table 4 – UV exposure conditions.....   | 59 |
| Table 5 – Characterization categories.....  | 66 |
| Table 6 – Example table for recording inspection results after all intermediate UV and TC cycles with three test cycles of the sequential UV/TC stress test.....  | 67 |
| Table 7 – Uniform characterization form (UCF) for polymeric PV front- or backsheet. ....  | 69 |
| Table A.1 – Overview of sample preparation suitable for material tests.....   | 73 |
| Table A.2 – Sample pre-treatments.....  | 77 |
| Table B.1 – Overview of various adhesion tests and their general capability of testing polymeric front- and backsheet.....  | 82 |

## INTERNATIONAL ELECTROTECHNICAL COMMISSION

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

## FOREWORD

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IEC TS 62788-2 has been prepared by IEC Technical Committee 82: Solar photovoltaic energy systems. It is a Technical Specification.

This second edition cancels and replaces the first edition published in 2017. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

- a) With revision of IEC 61730-1 the requirements for the polymeric front- and backsheet have been moved from IEC 61730-1 into IEC 62788-2-1. This is reflected accordingly.
- b) The tensile testing method has been refined based on findings of round robin tests, including updated drawings.
- c) A thermal pre-exposure method has been introduced to be equivalent to the thermal effects of a "lamination" cycle. This pre-exposure defines the "fresh" state of the front- or backsheet in final application for evaluation of changes in ageing tests. For practical reasons, an oven exposure has been defined as an equivalent test.

- d) The multiple functions of the lamination protrusion test (previously DTI test) have been clarified, to identify and measure RUI layer thickness as well as to identify layers for which the comparative tracking index (CTI) needs to be determined. Also the content of IEC 62788-2-1 has been updated, by which the lamination protrusion test and MST 04 are additionally set in perspective to each other via engineering judgement.
- e) The DC breakdown voltage test method has been updated and the option to perform a withstand voltage test has been added (to reduce the required measurement voltage). The correction of DC breakdown voltage ( $V_{BD}$ ) measurements, needed in the presence of non-RUI layers and after the lamination protrusion test, has been defined more precisely.
- f) Details for thickness measurement have been added (engineered surface roughness due to embossing).
- g) The adhesion test methods have been reviewed and updated. The single cantilevered beam test has been added. Figures have been updated to align with IEC 62788-1-1.
- h) The thermal failsafe test has been added as a test method based on discussion in the parallel project for IEC 62788-2-1. The test method offers a single temperature-point evaluation to include elongation at break to the thermal endurance evaluation.
- i) A sequential UV/TC test ("solder bump test") has been added.

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

|             |                  |
|-------------|------------------|
| Draft       | Report on voting |
| 82/2109/DTS | 82/2169/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.

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](https://www.iec.ch/members_experts/refdocs). The main document types developed by IEC are described in greater detail at [www.iec.ch/publications](https://www.iec.ch/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.

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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, chemical) of non-rigid polymeric materials intended for use in terrestrial photovoltaic modules as polymeric front- and backsheets.

The test methods in this document define how to characterize front- and backsheet 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 encapsulants or adhesives. It is impractical to conduct all characterization and endurance tests for the front- or backsheet component on the module level. Instead, testing is performed directly on these components or on dedicated test coupons prepared under comparable processing conditions (i.e. lamination) as for PV modules.

Results of testing described in this document are called by IEC 62788-2-1 for safety qualification of polymeric front- and backsheets on component level and support the safety and performance-related tests defined on the PV module level as defined in the series IEC 61730 (for safety) and IEC 61215 (for performance). This document also defines test methods for assessing inherent material characteristics of polymeric front- and backsheets or their components, which can be required in datasheet reporting or can be useful in the context of product development or design of PV modules.

Backsheets provide the electrical insulation at the backside of a photovoltaic (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 sun-facing side of the module. Both can be made from glass or polymeric material.

Polymeric front- and backsheets 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 can provide extended protection of the RUI against the environmental factors or adhesive functionality. As an integral part of the PV module, the front- or backsheet provides their durable electrical insulating function in the presence of the other components of the PV module, such as solar cells, electrical circuits and connectors, encapsulant, sealing material, and junction boxes. These elements can introduce additional stresses on the front- or backsheet (e.g. by chemical interactions or introducing thermal load or mechanical stress) or alter environmental stresses (e.g. filtering of ultraviolet radiation reaching the sun-facing side of the backsheet).

Material characterization in this document is performed on unaged samples (after a thermal pre-exposure) or after accelerated ageing including thermo-oxidative ageing (thermal endurance and failsafe tests), hydrolytic ageing (damp heat), photolytic ageing (UV weathering), abrasion, and sequential UV ageing plus thermal cycling.

Rigid polymeric sheet materials (also providing mechanical support) can require further consideration, which is outside the scope of this document.

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

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

IEC 60112, *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 – Thermal endurance properties – Part 1: Ageing procedures and evaluation of test results*

IEC 60216-2, *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, *Electrical strength of insulating materials – Test methods – Part 1: Tests at power frequencies*

<https://www.ies.org/standards/62788-2-2024> 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, *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 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 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 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 62788-2-1, *Measurement procedures for materials used in photovoltaic modules – Part 2-1 Polymeric materials – frontsheet and backsheet – Safety requirements*

IEC 62788-6-2, *Measurement procedures for materials used in photovoltaic modules – Part 6-2: General tests – Moisture permeation testing of polymeric materials*

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, *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 527-1, *Plastics – Determination of tensile properties – Part 1: General principles*

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

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

ISO 1519, *Paints and varnishes – Bend test (cylindrical mandrel)*

ISO 1520, *Paints and varnishes – Cupping test*

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

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

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*

ISO 22007-4, *Plastics – Determination of thermal conductivity and thermal diffusivity – Part 4: Laser flash method*

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

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

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 61140, IEC 61730-1, and IEC TS 61836, 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/>
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#### 3.1

##### **abrasion resistance**

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

Note 1 to entry: See IEC 62788-7-3 for abrasion testing methods.

#### 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 Annex B.

#### 3.3

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

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

### **3.4 backsheet**

BS  
(combination of) outer layer(s) of the PV module, located as substrate on the back of the PV module (designed for prolonged use only with indirect or limited direct sunlight < 300 W/m<sup>2</sup>) and providing protection of the inner components of the PV module from external stresses and weather elements, as well as providing electrical insulation

### **3.5 breakdown voltage**

$V_{BD}$

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

Note 1 to entry: Breakdown voltage testing in the context of PV modules and component materials applies direct current (DC).

[SOURCE: IEC 60050-212:2010, 212-11-34, modified – added symbol, added "DC" in the definition, and added Note 1 to entry.]

### **3.6 cohesive failure**

crack propagating within the adhesive during adhesion test, e.g., peel test

### **3.7 comparative tracking index**

CTI

numerical index value related to the maximum voltage that a material can withstand without formation of a permanent and electrically conductive carbon (tracking) path and without a persistent flame occurring, when evaluated under specified test conditions defined in IEC 60112

Note 1 to entry: The mentioned maximum test voltage is not in conjunction with any system or operational voltage, but it is used for evaluation of material groups.

[SOURCE: IEC 60050-212:2010, 212-11-59, modified – The definition has been rephrased by also clarifying that CTI is an index value to evaluate material groups according to IEC 60112. Note 1 to entry has also been added.]

### **3.8 directions of films, specimens and cracks**

#### **3.8.1 machine direction**

MD

direction along which the material layer was extruded or produced, extending out of a die or other manufacturing equipment in a production line

#### **3.8.2 transverse direction**

TD

direction perpendicular to which the material layer was extruded or produced

### **3.9 distance through insulation**

$t_{DTI}$

thickness of relied-upon insulation (RUI) after the lamination protrusion test, with the minimum allowable value defined by the maximum working voltage

**3.10  
elongation at break** $\epsilon_B$ 

strain at which the specimen under test breaks

**3.11  
frontsheet**

FS

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

**3.12  
inner side**

side of the front- or backsheet that is oriented to the solar cells, typically laminated to the encapsulant

**3.13  
material group**

category of insulation materials according to IEC 60664-1 as defined by the results of the CTI test

**3.14  
polymeric material**

materials that are either natural or synthetic and are primarily composed of chained molecules of monomers, combinations of monomers, and combined polymers and may contain cross-linking agents, fillers, colorants, and other materials

**3.15  
release material**

rm

film material that is inserted in a layer stack before lamination to render inactive the adhesion between interfaces

Note 1 to entry: Examples of suitable release materials are fluoropolymer sheets (e.g. PTFE, FEP, ETFE) as well as silicon treated sheets.

**3.16  
relied-upon insulation**

RUI

solid insulation system providing protection against electric shock in the final application, with the material's requirements for thermal endurance and resistance against environmental stress factors

Note 1 to entry: Thin-films used as polymeric front- or backsheet can consist of RUI plus additional layers that have other functions, e.g., they protect the polymeric materials from UV radiation.

**3.17  
relative thermal endurance index**

RTE

numerical value of the Celsius temperature expressed in degrees Celsius at which the estimated time to endpoint of an insulating material is the same as the estimated time to endpoint of a control material at a temperature equal to its assessed thermal endurance

[SOURCE: IEC 60050-212:2010, 212-12-14, modified – Abbreviated term added and notes to entry omitted.]