

# INTERNATIONAL STANDARD

## NORME INTERNATIONALE

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

**Procédures de mesure des matériaux utilisés dans les modules  
photovoltaïques –  
Partie 1-7: Encapsulants – Procédure d'essai de la durabilité optique**



## THIS PUBLICATION IS COPYRIGHT PROTECTED

Copyright © 2020 IEC, Geneva, Switzerland

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from either IEC or IEC's member National Committee in the country of the requester. If you have any questions about IEC copyright or have an enquiry about obtaining additional rights to this publication, please contact the address below or your local IEC member National Committee for further information.

Droits de reproduction réservés. Sauf indication contraire, aucune partie de cette publication ne peut être reproduite ni utilisée sous quelque forme que ce soit et par aucun procédé, électronique ou mécanique, y compris la photocopie et les microfilms, sans l'accord écrit de l'IEC ou du Comité national de l'IEC du pays du demandeur. Si vous avez des questions sur le copyright de l'IEC ou si vous désirez obtenir des droits supplémentaires sur cette publication, utilisez les coordonnées ci-après ou contactez le Comité national de l'IEC de votre pays de résidence.

IEC Central Office  
3, rue de Varembe  
CH-1211 Geneva 20  
Switzerland

Tel.: +41 22 919 02 11  
[info@iec.ch](mailto:info@iec.ch)  
[www.iec.ch](http://www.iec.ch)

### About the IEC

The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

### About IEC publications

The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigendum or an amendment might have been published.

#### IEC publications search - [webstore.iec.ch/advsearchform](http://webstore.iec.ch/advsearchform)

The advanced search enables to find IEC publications by a variety of criteria (reference number, text, technical committee,...). It also gives information on projects, replaced and withdrawn publications.

#### IEC Just Published - [webstore.iec.ch/justpublished](http://webstore.iec.ch/justpublished)

Stay up to date on all new IEC publications. Just Published details all new publications released. Available online and once a month by email.

#### IEC Customer Service Centre - [webstore.iec.ch/csc](http://webstore.iec.ch/csc)

If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: [sales@iec.ch](mailto:sales@iec.ch).

#### Electropedia - [www.electropedia.org](http://www.electropedia.org)

The world's leading online dictionary on electrotechnology, containing more than 22 000 terminological entries in English and French, with equivalent terms in 16 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

#### IEC Glossary - [std.iec.ch/glossary](http://std.iec.ch/glossary)

67 000 electrotechnical terminology entries in English and French extracted from the Terms and Definitions clause of IEC publications issued since 2002. Some entries have been collected from earlier publications of IEC TC 37, 77, 86 and CISPR.

### A propos de l'IEC

La Commission Electrotechnique Internationale (IEC) est la première organisation mondiale qui élabore et publie des Normes internationales pour tout ce qui a trait à l'électricité, à l'électronique et aux technologies apparentées.

### A propos des publications IEC

Le contenu technique des publications IEC est constamment revu. Veuillez vous assurer que vous possédez l'édition la plus récente, un corrigendum ou amendement peut avoir été publié.

#### Recherche de publications IEC -

[webstore.iec.ch/advsearchform](http://webstore.iec.ch/advsearchform)

La recherche avancée permet de trouver des publications IEC en utilisant différents critères (numéro de référence, texte, comité d'études,...). Elle donne aussi des informations sur les projets et les publications remplacées ou retirées.

#### IEC Just Published - [webstore.iec.ch/justpublished](http://webstore.iec.ch/justpublished)

Restez informé sur les nouvelles publications IEC. Just Published détaille les nouvelles publications parues. Disponible en ligne et une fois par mois par email.

#### Service Clients - [webstore.iec.ch/csc](http://webstore.iec.ch/csc)

Si vous désirez nous donner des commentaires sur cette publication ou si vous avez des questions contactez-nous: [sales@iec.ch](mailto:sales@iec.ch).

#### Electropedia - [www.electropedia.org](http://www.electropedia.org)

Le premier dictionnaire d'électrotechnologie en ligne au monde, avec plus de 22 000 articles terminologiques en anglais et en français, ainsi que les termes équivalents dans 16 langues additionnelles. Egalement appelé Vocabulaire Electrotechnique International (IEV) en ligne.

#### Glossaire IEC - [std.iec.ch/glossary](http://std.iec.ch/glossary)

67 000 entrées terminologiques électrotechniques, en anglais et en français, extraites des articles Termes et Définitions des publications IEC parues depuis 2002. Plus certaines entrées antérieures extraites des publications des CE 37, 77, 86 et CISPR de l'IEC.

# INTERNATIONAL STANDARD

## NORME INTERNATIONALE

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

**Procédures de mesure des matériaux utilisés dans les modules  
photovoltaïques –  
Partie 1-7: Encapsulants – Procédure d'essai de la durabilité optique**

INTERNATIONAL  
ELECTROTECHNICAL  
COMMISSION

COMMISSION  
ELECTROTECHNIQUE  
INTERNATIONALE

ICS 27.160

ISBN 978-2-8322-8035-5

**Warning! Make sure that you obtained this publication from an authorized distributor.  
Attention! Veuillez vous assurer que vous avez obtenu cette publication via un distributeur agréé.**

## CONTENTS

FOREWORD.....	3
INTRODUCTION.....	5
1 Scope.....	6
2 Normative references .....	6
3 Terms and definitions .....	7
4 Principle.....	7
5 Apparatus.....	7
5.1 Spectrophotometer for transmittance measurements.....	7
5.2 Environmental chamber for weathering .....	7
6 Test specimens .....	8
6.1 Specimen components and general considerations for all material types .....	8
6.2 Test specimens for datasheet reporting .....	8
6.3 Use of alternate superstrate and substrate materials .....	8
6.4 Witness specimens and experimental control.....	9
7 Measurement procedure.....	9
8 Artificial accelerated weathering.....	9
9 Calculation and expression of results .....	9
10 Test procedure .....	10
11 Pass/fail criteria.....	10
12 Test report.....	11
Bibliography.....	13

Technical Document is a preview generated by EVS

## INTERNATIONAL ELECTROTECHNICAL COMMISSION

---

**MEASUREMENT PROCEDURES FOR  
MATERIALS USED IN PHOTOVOLTAIC MODULES –**
**Part 1-7: Encapsulants –  
Test procedure of optical durability**
**FOREWORD**

- 1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
- 2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
- 3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
- 4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
- 5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
- 6) All users should ensure that they have the latest edition of this publication.
- 7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
- 8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
- 9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

International Standard IEC 62788-1-7 has been prepared by IEC technical committee 82: Solar photovoltaic energy systems.

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

FDIS	Report on voting
82/1669/FDIS	82/1704/RVD

Full information on the voting for the approval of this International Standard 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 document will remain unchanged until the stability date indicated on the IEC website under "<http://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.

This document is a preview generated by EVS

## INTRODUCTION

IEC 61215-2 (covering module design qualification and type approval) specifies a UV preconditioning of  $54 \text{ MJ}\cdot\text{m}^{-2}$  ( $15 \text{ kWh}\cdot\text{m}^{-2}$ ), which would be encountered after ~40 ideal sunny days of exposure to the AM1.5G UV spectrum in IEC 60904-3. IEC 61730-2 presently specifies 4x the same UV exposure, i.e., 5 months UV dose. The International PV Quality Assurance Task Force (PVQAT) leads global efforts to craft quality and reliability standards for solar energy technologies. These standards will allow stakeholders to quickly assess a solar photovoltaic (PV) module's performance and ability to withstand weather stresses, thereby reducing risk and adding confidence for those developing products, designing incentive programs, and determining private investments. As developed in conjunction with PVQAT, this part of IEC 62788-1 is intended to supplement module qualification, which typically covers reliability issues related to infant mortality, i.e., the first months of field use. This part of IEC 62788-1 may also facilitate the pre-qualification of encapsulation materials using coupon specimens, because long term weathering is not practical for larger module specimens. This part of IEC 62788-1 also importantly uses high fidelity UV irradiation (relative to the terrestrial solar spectrum), which is not practical to apply to module specimens (due to the lack of available commercial equipment and the anticipated cost of operation). This part of IEC 62788-1 is not presently specified for pre-qualification purposes in other standards, but may be used for that purpose by module manufacturers.

The optical performance (transmittance) of polymeric frontsheets and backsheets is not covered in this part of IEC 62788-1. These components are addressed in the IEC TS 62788-2.

# MEASUREMENT PROCEDURES FOR MATERIALS USED IN PHOTOVOLTAIC MODULES –

## Part 1-7: Encapsulants – Test procedure of optical durability

### 1 Scope

IEC 61215-2 provides a set of qualification tests that indicate that a PV module design is likely to be free of flaws that will result in early failure. However, IEC 61215-2 does not address the long term wear-out of PV modules. This part of IEC 62788-1 is designed as a more rigorous qualification test, using accelerated UV exposure at elevated temperature to determine whether polymeric encapsulants can suffer loss of optical transmittance. IEC 61215-2 already includes a UV preconditioning test (MQT 10), however, the parameters for that test only represent a limited level of exposure (~weeks of UV dose). This test procedure is intended for representative coupon specimens, applying stress at a greater intensity (designed relative to Phoenix, AZ), using a radiation spectrum that is more similar to the terrestrial solar spectrum, and using a duration of exposure that is more relevant to the PV application (i.e., equivalent to several years of outdoor exposure). This test quantifies the degradation rate of encapsulants so that the risk of the materials losing optical transmittance during operation in the terrestrial environments can be managed. The quantitative correlation between climate (or location of use), a specific application (utility-installation, residential-installation, roof-mount, rack-mount, use of a tracker, the system electrical configuration and its operation), and the test can be established for each specific encapsulant material, but is beyond the scope of this document.

The method herein is intended to qualify encapsulants for use in a PV module. This document is intended to apply to encapsulants used in PV modules deployed under temperature conditions of normal use, as defined in IEC TS 63126. The use of this method for encapsulants in modules deployed under conditions of higher temperature is specified elsewhere, for example IEC TS 63126. The method here is intended to be used to examine a particular encapsulant and does not cover incompatibilities between the encapsulant and other packaging materials. This document covers PV technology constructed using a transparent incident surface/encapsulant/photovoltaic device construction, the relevance to other geometries where the encapsulant layer is located behind the photovoltaic device layer, is outside the scope of this document. In the case of bifacial cell technology, the module can accept light from its front and back surfaces – the transmittance of a frontsheet (if used), encapsulant, and transparent backsheet (if used) is relevant for both active surfaces. The optical durability of frontsheets and backsheets, however, is addressed separately in the IEC TS 62788-2. Thin coatings that might be added for antireflection or anti-soiling purposes are outside the scope of this document. The method in this document can be used for other purposes (e.g., research and development); many details of alternate uses of the method (e.g., alternate test durations or measurement increments) are not described here.

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

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

IEC TS 63126<sup>1</sup>, *Guidelines for qualifying PV modules, components, and materials for operation at high temperatures*

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

ASTM G7, *Standard practice for atmospheric environmental exposure testing of nonmetallic materials*

### 3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC TS 61836 and IEC 61730-1 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>

### 4 Principle

The total spectral transmittance shall be quantified using a spectrophotometer equipped with an integrating sphere (IEC 62788-1-4). Artificial weathering shall be performed at stable specified irradiance, temperature, and relative humidity conditions using an environmental chamber (IEC TS 62788-7-2). The changes in transmittance resulting from weathering shall be quantified using subsequent spectrophotometer measurement(s). The results of this artificial weathering test may be benchmarked against natural weathering, for example ASTM G7.

### 5 Apparatus

#### 5.1 Spectrophotometer for transmittance measurements

A double beam or single beam spectrophotometer equipped with an integrating sphere and conforming to the requirements of IEC 62788-1-4 shall be used.

#### 5.2 Environmental chamber for weathering

An artificial weathering apparatus shall be used, as specified in IEC TS 62788-7-2. The weathering apparatus shall meet the requirements of the artificial accelerated weathering method specified, for example IEC TS 62788-7-2, method A3.

---

<sup>1</sup> Under preparation. Stage at the time of publication: IEC/DTS 63126:2019.