IEC TS 62804-1

Edition 2.0 2025-06

TECHNICAL SPECIFICATION

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

ICS 27.160

ISBN 978-2-8327-0455-4

IEC TS 62804-1:2025-06(en)

THIS PUBLICATION IS COPYRIGHT PROTECTED
Copyright © 2025 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.

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

Tel.: +41 22 919 02 11
info@iec.ch
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
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 It also gives information on projects, replaced and withdrawn publications.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
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
If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: sales@iec.ch.

IEC Products & Services Portal - products.iec.ch
Discover our powerful search engine and read freely all the publications previews, graphical symbols and the glossary. With a subscription you will always have access to up to date content tailored to your needs.

Electropedia - www.electropedia.org
The world's leading online dictionary on electrotechnology, containing more than 22 500 terminological entries in English and French, with equivalent terms in 25 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

Warning! Make sure that you obtained this publication from an authorized distributor.

CONTENTS

FOREWORD 3
INTRODUCTION 5
1 Scope 6
2 Normative references 6
3 Terms and definitions 7
4 Samples 7
5 Test procedures 9
5.1 General 9
5.2 Test for PID-shunting 9
5.2.1 General 9
5.2.2 Pre-stress tests 10
5.2.3 Voltage stress test procedures 11
5.2.4 Post-stress tests 15
5.3 Test for PID-polarization 16
5.3.1 General 16
5.3.2 Pre-stress tests 17
5.3.3 Voltage stress with irradiation test procedures 18
5.3.4 Post-stress tests 22
5.4 Test for PID-polarization recovery 23
5.4.1 General 23
5.4.2 Apparatus 23
5.4.3 Severities 23
5.4.4 Procedure 24
6 Test report 25
Annex A (informative) Benefit of electroluminescence imaging in PID testing 27
Bibliography 28

Figure 1 – PID test flow 10
Figure 2 – Example test time-temperature-humidity-voltage profile for application of stress in an environmental chamber 14
Figure 3 – Test time-temperature-voltage profile for stress method performed in 25 °C ambient 15
Figure 4 – Test flow for evaluation of PID-polarization of both faces of a PV module in both polarities 17
Figure 5 – Example of module preparation and connection scheme for PID-polarization testing on a framed module, illustrated here for testing on the module top face 21
Figure 6 – Test time-temperature-voltage-irradiance profile for application of stress for testing under irradiation 22
Figure 7 – PID recovery test flow 24
Figure 8 – Example test time-temperature-irradiance profile for recovery 25
Figure A.1 – Set of three electroluminescence images of a PV module showing the development of different contact scenarios with the glass during PID testing 27

INTERNATIONAL ELECTROTECHNICAL COMMISSION

_____

PHOTOVOLTAIC (PV) MODULES – TEST METHODS FOR THE DETECTION OF POTENTIAL-INDUCED DEGRADATION –

Part 1: Crystalline silicon

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) IEC draws attention to the possibility that the implementation of this document may involve the use of (a) patent(s). IEC takes no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, IEC had not received notice of (a) patent(s), which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at https://patents.iec.ch. IEC shall not be held responsible for identifying any or all such patent rights.

IEC TS 62804-1 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 2015. This edition constitutes a technical revision.

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

a) A procedure specifically for measuring PID-polarization was added.
b) A procedure specifically for measuring the extent of recovery of PID-polarization was added.

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

Draft	Report on voting
82/2366/DTS	82/2424/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. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

A list of all parts in the IEC 62804 series, published under the general title *Photovoltaic (PV) modules – Test methods for the detection of potential-induced degradation*, 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 webstore.iec.ch in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn, or
- revised.

INTRODUCTION

This part of IEC TS 62804 is for testing and measuring the resistance of crystalline silicon photovoltaic (PV) modules to stresses that cause potential-induced degradation (PID). The applied stresses, mainly system voltage, manifest in different degradation mechanisms depending on the module technology. A series of Technical Specifications is therefore developed to establish tests for measuring PID in different photovoltaic module technologies.

IEC TS 62804-1 defines test methods for measuring PID in crystalline silicon PV modules.

IEC TS 62804-1-1 defines test methods for measuring PID delamination in crystalline silicon PV modules.

IEC TS 62804-2 defines test methods for measuring PID in thin-film PV modules.

Additional Technical Specifications in the series may be introduced in the future for emerging module technologies or related degradation modes.

Voltage potential that exists between the active circuit and the grounded module surfaces can lead to module degradation by multiple mechanisms including ionic transport in the encapsulant, superstrate, or substrate, hot carriers in the cell, redistribution of charges that degrade the active layer of the cell or its surfaces, failure of adhesion at interfaces, and corrosion of module components. These degradation mechanisms in crystalline silicon photovoltaic modules caused by voltage stress and promoted by high temperature and humidity include potential-induced degradation, polarization, electrolytic corrosion, and electrochemical corrosion. They are most active in wet or damp environments, and in environments prone to soiling of modules with conductive, acidic, caustic, or ionic species that lead to increased conduction on the module surfaces. In the field, modules have been observed to degrade in positive as well as negative polarity strings depending on the cell construction, module materials, and design. The testing in this document therefore specifies the evaluation of the effects of voltage stress in the PV system mounting polarities permitted by the module manufacturer’s documented specifications. Some crystalline silicon module designs undergoing system voltage bias stress have shown degradation manifested by junction failure, leading to changes in the reverse-bias breakdown characteristics and a resulting degradation in safety because of the increased potential for development of hot spots in the module. This document defines methods to measure the ability of a module to withstand degradation from system voltage effects that manifest in the relatively short term, or what is categorized as an infant failure, based on inherent sensitives existing in a new module.

The stress-test levels in this document have not been related to those of the natural environment. Module types undergoing damp heat chamber testing with a 60 °C temperature and 85 % relative humidity stress level, with the temperature, humidity, and bias voltage ramped simultaneously at the start of a 96 h stress test without a PID recovery procedure, were found resistant to PID-shunting in outdoor tests in Florida, USA. However, to improve reproducibility, test details including environmental chamber temperature and humidity ramps and tolerances have been tightened, which very significantly reduces the total stress applied and invalidates the correspondences previously found. The relevance to real outdoor stress conditions of the test contained herein using foil as the ground conductor is also not proven. Alternative levels beyond the basic stress levels in this document are thus included.

It is known that variability in manufacturing processes can affect the susceptibility of modules to system voltage stress. Retesting of module samples by the test protocols contained herein, internal quality assurance programs, or external audits will aid in verifying not only the durability of the design of the module to system voltage stress, but also the effects of variability of the materials and manufacturing processes.

In this second edition, specific tests for PID-polarization and its recovery have been added. The factor of ultraviolet light has been included in the test to achieve a more representative test and therefore more meaningful results.

PHOTOVOLTAIC (PV) MODULES – TEST METHODS FOR THE DETECTION OF POTENTIAL-INDUCED DEGRADATION –

Part 1: Crystalline silicon

1 Scope

This part of IEC 62804 defines procedures to evaluate the durability of crystalline silicon photovoltaic (PV) modules to the effects of short-term high-voltage stress, primarily potential-induced degradation (PID). Three test methods are given. The first type, which has two variations, is conducted in the dark and is primarily designed for assessing PID-shunting. The second type, which also has two variations, incorporates the factor of ultraviolet light and is intended for assessing PID-polarization. A separate test for the recovery of PID polarization under ultraviolet light is also included.

The testing in this document is designed for crystalline silicon PV modules with silicon cells having passivating dielectric layers, for degradation mechanisms involving mobile ions influencing the electric field over the silicon semiconductor or electronically interacting with the silicon semiconductor. This document is not intended for evaluating modules with thin-film technologies, tandem, or heterojunction devices but can be used for guidance.

The actual durability of modules to system voltage stress depends on the environmental conditions under which they are operated and the voltage potential in the module relative to earth (ground). These tests are intended to assess PV module sensitivity to PID irrespective of actual stresses under operation in different climates and systems.

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 60068-2-78:2012, *Environmental testing – Part 2-78: Tests – Test Cab: Damp heat, steady state*

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

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

IEC 61724-1, *Photovoltaic system performance – Part 1: Monitoring*

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

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