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Guidelines for qualifying PV modules, components and materials for operation at high temperatures

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COMMISSION

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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GUIDELINES FOR QUALIFYING PV MODULES, COMPONENTS AND MATERIALS FOR OPERATION AT HIGH TEMPERATURES

FOREWORD

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The main task of IEC technical committees is to prepare International Standards. In exceptional circumstances, a technical committee may propose the publication of a Technical Specification when

- the required support cannot be obtained for the publication of an International Standard, despite repeated efforts, or
- the subject is still under technical development or where, for any other reason, there is the future but no immediate possibility of an agreement on an International Standard.

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

IEC TS 63126, 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:

Draft TS	Report on voting
82/1662/DTS	82/1706A/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.

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

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- transformed into an International standard,
- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

The contents of the corrigendum 1 (2022-09) have been included in this copy.

INTRODUCTION

The IEC 61215 series, IEC 61730 series, IEC 62790 and IEC 62852 are considered suitable for an environmental temperature range of at least -40 °C to + 40 °C and for modules operating in such conditions that a 98th percentile module operational temperature of 70 °C or less applies. This environmental temperature range encompasses many locations and installation styles in these locations. As an example, it has been determined that thermally unrestricted, or open-rack-style structures, in most cases do not result in 98th percentile module operational temperatures exceeding 70 °C and as such, the originating standards are suitable as written. Module operating temperatures exceeding 70 °C, on the other hand, at the 98th percentile typically will occur with roof-parallel or building-integrated roof top applications in climates with local environmental temperatures that exceed 40 °C.

This document is written for two purposes: to provide modified testing conditions for modules that will be deployed in climates that have a higher environmental air temperature than 40 °C and/or for module installation methods that restrict cooling, resulting in higher operational temperatures than anticipated in the originating standards. This work will also aid in providing an alternative definition of “rack mount” in the context of IEC 61215 series and IEC 61730 series. This term was initially used as a place holder to restrict the scope of PV module type testing for those installation styles that permit open and unrestricted cooling from all surfaces of a PV module. Now that the testing has matured there is a desire to refine definitions for the range of applicability of these standards.

This document is intended to be used as an intermediate step to define high temperature environment use requirements. These requirements are planned to be incorporated into standards in the future. It is not necessarily cost effective for module materials to comply with level 1 or level 2 requirements defined in this document, unless the module temperature is expected to exceed 70 °C at the 98th percentile. Module materials capable of temperature level 1 or temperature level 2 are expected to impose higher expectations of endurance and cost than normal modules.

Component standard IEC 62930 is considered to be adequate for modules operating at high temperatures without modification due to requiring cable to have a 120 °C or greater thermal endurance at a 20 000 h correlation lifetime. Similarly, IEC 62979 is considered adequate for bypass diode thermal runaway determination due to testing temperatures of 90 °C for roof-mounted modules and 75°C for “rack mounted” modules.

Similar to electric cables, IEC 61730-1 requires a RTI, TI, or RTE of 90 °C or larger. A module operating in an environment and installation style resulting in a 98th percentile temperature of 70 °C requires a RTI, TI, or RTE safety factor of +20 °C to establish a 25-year lifetime when the polymer has a minimum activation energy of 46 kJ/mol and the correlation lifetime is 20 000 h. This work applies that safety factor of +20 °C for polymer RTI, TI, or RTE when the 98th percentile operating temperature is above 70 °C.

Finally, data from PV modules in hot climates and modelling were used to understand operating temperatures and resulted in two categories of high temperature operation, temperature level 1 and temperature level 2. These categories are defined within this document and it is relevant to indicate that level 2 temperatures were not found in field data, but may result from insulated substrate modules on pitched roofs facing the sun when ambient air temperature exceeds 40 °C. This may be most consistent with building-integrated PV module roofs and to allow for this possibility, the temperature level 2 category remains in this document.

GUIDELINES FOR QUALIFYING PV MODULES, COMPONENTS AND MATERIALS FOR OPERATION AT HIGH TEMPERATURES

1 Scope

This document defines additional testing requirements for modules deployed under conditions leading to higher module temperature which are beyond the scope of IEC 61215-1 and IEC 61730-1 and the relevant component standards, IEC 62790 and IEC 62852. The testing conditions specified in IEC 61215-2 and IEC 61730-2 (and the relevant component standards IEC 62790 and IEC 62852) assumed that these standards are applicable for module deployment where the 98th percentile temperature (T_{98th}), that is the temperature that a module would be expected to equal or exceed for 175,2 h per year, is less than 70 °C.

NOTE 175,2 h represents 2 % of a total year as some thermal failure modes are a function of time at temperature and not sensitive to day-only or night-only exposure.

This document defines two temperature regimes, temperature level 1 and temperature level 2, which were designed considering deployment in environments with mounting configurations such that the T_{98th} is less than or equal to 80 °C for temperature level 1, and less than or equal to 90 °C for temperature level 2. This document provides recommended additional testing conditions within the IEC 61215 series, IEC 61730 series, IEC 62790 and IEC 62852 for module operation in temperature levels 1 and 2.

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 61215-2:2016, *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 62788-1-7, *Measurement procedures for materials used in photovoltaic modules – Part 1-7: Encapsulants – Test procedure of optical durability*

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

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 62852, *Connectors for DC-application in photovoltaic systems – Safety requirements and tests*

IEC 62930, *Electric cables for photovoltaic systems with a voltage rating of 1,5 kV DC*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC TS 61836 apply, as well as the following:

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
environmental temperature
air temperature defined in degrees Celsius for the geographic installation location as measured and documented by meteorological services for this geographic location

Note 1 to entry: The environmental temperature is typically measured 1 m above ground. PV modules deployed closer to the ground may experience higher ambient temperatures than this quoted environmental temperature.

3.2
ambient temperature
average temperature of air or another medium in the vicinity of the equipment

Note 1 to entry: During the measurement of the ambient temperature the measuring instrument/probe should be shielded from draughts and radiant heating.

Note 2 to entry: Ambient temperature is often called operating temperature or operational temperature.

3.3
module operational temperature
temperature representative of the PV module – usually of the junction of the solar cells within the module. This temperature may be measured by means of a temperature sensor or via the equivalent cell temperature technique according to IEC 60904-5

3.4
98th-percentile temperature
when temperature data from a varying temperature process are placed into rank order, the 98th-percentile temperature represents a temperature that is larger than 98 percent of remaining temperatures and is exactly met or exceeded only 2 % of the time

Note 1 to entry: The 98th-percentile temperature is to be determined from data taken at hourly, or more frequent, measurements. For a standard year, the 98th-percentile temperature would be met or exceeded for 175,2 h.

3.5
temperature level 1
is used to categorize test modifications and applies for PV modules whose 98th-percentile temperature falls into the range greater than 70 °C but less than or equal to 80 °C

3.6
temperature level 2
is used to categorize test modifications and applies for PV modules whose 98th-percentile temperature falls into the range greater than 80 °C but less than or equal to 90 °C