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colour inside

Photovoltaic (PV) modules – Qualifying guidelines for increased hail resistance

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PHOTOVOLTAIC (PV) MODULES – QUALIFYING GUIDELINES FOR INCREASED HAIL RESISTANCE

FOREWORD

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IEC TS 63397 has been prepared by IEC technical committee 82: Solar photovoltaic energy systems. It is a Technical Specification.

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

Draft	Report on voting
82/2062/DTS	82/2090/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.

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- withdrawn,
- replaced by a revised edition, or
- amended.

IMPORTANT – The "colour inside" logo on the cover page of this document 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 (2023-07) have been included in this copy.

INTRODUCTION

The hail test (MQT 17) of IEC 61215-2:2021, 4.17 examines PV modules for minimum hail resistance by using spherical ice balls of a minimum diameter of 25 mm, or optionally larger. The requirements after the test, as specified in IEC 61215-2, are:

a) no intermittent open-circuit fault detected during the test,

b) no evidence of major visual defects,

c) wet leakage current meeting the same requirements as for the initial measurements and the power loss requirement of (Gate No. 2) IEC 61215-1:2021, 7.2.3.

The hail test (MQT 17) may cause visible damage detectable by MQT 01 as well as invisible internal damage not detectable by MQT 01. Such invisible damage may also only be detected by Gate No. 2 (power loss measurement after stress tests) if the damage is relatively large.

The IEC 61215 series [1][1] lays down requirements for the design qualification and type approval of terrestrial photovoltaic modules suitable for long-term operation in open-air climates. It is however not written with the intent to detect medium to long term performance losses caused by hail to internal parts not visible to the naked eye. Such internal damages may be micro-cracks of cells which over time can be propagated by other mechanical and thermo-mechanical environmental stresses not addressed by the test flow of IEC 61215-1:2021, Figure 2.

The hail test (MQT 17) of IEC 61215-2:2021, 4.17 is sufficient for the generic design qualification and type approval for applications and environments where PV modules are unlikely to be exposed to severe hail exposure; however, a standardized test for applications and environments where PV modules are likely to be exposed to higher hail stress is considered useful.

IEC 61215-1:2021, Clause A.4 says: "Not all modules will experience extreme weather or mishandling. Qualification testing that tests for performance retention under these circumstances may lead to costly overdesign. … It is recommended to first develop and gain experience with a TS related to hail resistance, module handling, and related performance losses. Such a document should consider that thermal cycles might be more effective than DML."

The share of generated photovoltaic energy globally is ever rising and the reliability and more detailed prediction of generated power including energy loss is becoming more important for the industry, in particular to the finance and insurance section of the industry.

The tests given in this document can differentiate the hail resistance of PV modules by exposing samples to hail stress prior to the selected tests of IEC 61215-2:2021, Figure 2 and measure the additional power loss to reference modules going through the same tests without hail stress. The test sequence MQT 20 cyclic (dynamic) mechanical load test, MQT 11 thermal cycling test and MQT 12 humidity freeze test post-hail stress tests used in this document are identical to the test sequence 2 mechanical stress of IEC TS 63209-1:2021 [2]. The hail test HMQT 17 used in this document contains changes to IEC 61215-2:2021, MQT 17 to improve accuracy, comparability and repeatability of results. Additional information can be found in the Hail Register [3]. This document, IEC TS 63397, aims to support in the selection of modules for specific regions with higher risk to hail and the improvement of module design.

In addition to the power loss caused by the additional hail exposure the reporting section includes electroluminescence images. The changes in these images alone are not always indicative of power loss but may, together with the power measurement data, provide additional insight.

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[1] Numbers in square brackets refer to the Bibliography.

Recent trends towards larger cell and module sizes may add to the risk of power loss caused by hail. Recent, advanced cell interconnection technologies such as multi-wire technology aim to limit power and energy loss due to cell cracks. On the system site there are trackers to bring modules to their hail stow position to minimize impact.

Not all PV modules will be deployed to regions with increased risk of hail which is why it is not planned to add these requirements to the IEC 61215 series. Annex A gives an example of a global hail map with regions having a higher statistical average of hail exposure and hail ball size.

PHOTOVOLTAIC (PV) MODULES – QUALIFYING GUIDELINES FOR INCREASED HAIL RESISTANCE

1 Scope

This document defines additional testing requirements for modules deployed under applications or in environments where PV modules are likely to be exposed to the impact of hailstones leading to higher stress beyond the scope of the IEC 61215 series.

The current safety standards of the IEC 61730 series [4] and design qualification and type approval standards of the IEC 61215 series specify tests for the ability of PV modules to withstand a defined hail impact. The requirements therein are the minimum for market entrance and are not written to propagate potential cell damage caused by the hail impact by subsequent mechanical and thermo-mechanical tests simulating the environmental stress that modules will potentially be exposed to after hailstorms. In this document modules are initially exposed to 200 h of damp heat to account for some level of humidity and heat before the first hail exposure. After that they are exposed to hail stresses and then to the selected thermo-mechanical stress tests of sequence C of IEC 61215-1:2021, Figure 2. The power loss from these modules is then compared to reference modules that have been through the same stress tests except the hail stress.

Comparison of electroluminescence images and performance of both reference modules and modules exposed to hail stress provides additional insight regarding hail resistance and susceptibility.

This document aims to assist in the selection of modules for deployment in specific regions that have a higher risk of hail damage and to provide tools for improving module design.

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 TS 60904-13:2018, *Photovoltaic devices – Part 13: Electroluminescence of photovoltaic modules*

IEC 61215-1:2021, *Terrestrial photovoltaic (PV) modules – Design qualification and type approval – Part 1: Test requirements*

IEC 61215-1-1:2021, *Terrestrial photovoltaic (PV) modules – Design qualification and type approval – Part 1-1: Special requirements for testing of crystalline silicon photovoltaic (PV) modules*

IEC 61215-2:2021, *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*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 61215-1, IEC 61730-1, and IEC TS 61836 and the following apply:

ISO and IEC maintain terminology 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
MQT
module quality test
specific quality test carried out on a photovoltaic module in accordance with IEC 61215-1:2021

3.2
HMQT
hail module quality test
revised hail test MQT 17 of IEC 61215-2:2021 followed by mechanical and thermo-mechanical chamber stress tests

4 Number and selection of test samples

The sample selection, number of samples, and sample sets are left to the user based on the purpose of the data collection. For each ice-ball diameter to be tested, module type (individual bill of material (BOM), see also IEC TS 62915 [5]) and mounting configuration in this document, at least two samples shall be tested. Test results for modules made of different materials, modules with different designs and modules used in different mounting configurations are expected to be different. In addition, for each model tested, one reference sample not exposed to hail stress is required per ice-ball diameter to measure the power loss. To increase confidence in the test results a larger number of test samples, and inclusion of multiple samples is encouraged.

5 Test procedures

5.1 General

Subclauses 5.2 to 5.15 provide detailed instructions for performing each module quality test (MQT). A complete test flow can be found in Figure 3.

5.2 Visual inspection (MQT 01)

Observations are completed as defined in IEC 61215-2:2021, MQT 01. All observations shall be recorded and reported as part of the final report. Photographs shall be used to document any changes and included in the final report.

5.3 Initial stabilization (MQT 19.1)

Initial stabilization shall be completed as defined in IEC 61215-2:2021, MQT 19.1. All measurements (as defined in 5.4) shall be recorded after each stabilization step. These data shall be included in the final report.

5.4 Performance at STC (MQT 06.1)

The performance at standard test conditions (STC) shall be measured as defined in IEC 61215-2:2021, MQT 06.1. All measurements shall be included in the final report.

5.5 Performance at low irradiance (MQT 07)

The performance at low irradiance shall be measured as defined in IEC 61215-2:2021, MQT 07. All measurements shall be included in the final report.

5.6 Insulation test (MQT 03)

The insulation shall be tested as defined in IEC 61215-2:2021, MQT 03. The insulation resistance measurement shall be recorded and reported as part of the final report.

5.7 Wet leakage current test (MQT 15)

The wet leakage current shall be measured as defined in IEC 61215-2:2021, MQT 15. The measured leakage current shall be recorded and reported in the final report.

5.8 Electroluminescence imaging

Electroluminescent imaging for both the reference and HMQT sample shall be completed as defined in IEC TS 60904-13, using both low and high injection levels for the initial characterization. This test is for informative purposes only. No pass/fail criteria apply. For a schematic example see Table 3.

5.9 Damp heat test (MQT 13)

This test is equivalent to IEC 61215-2:2021, MQT 13, but for a duration of 200 h only. The measured leakage current shall be recorded and reported in the final report.

5.10 Hail test (HMQT 17)

5.10.1 General

This test is based on IEC 61215-2:2021, MQT 17 and the Hail Register. For the purposes of this document the ice-ball diameter shall be selected from Table 1.

Models may be tested for one or more ice-ball diameters. However, to evaluate ice-ball diameter specific changes in power loss and module damage it is encouraged to test for a number of different ice-ball diameters, starting with a small diameter.

Ice balls vary in mass within one ice-ball diameter. For comparability and repeatability of results it is important to stay within the kinetic energy range as described in Table 1. To account for the different masses of ice balls the velocity shall therefore be adjusted to stay within the kinetic energy range.

5.10.2 Purpose

To verify that the module is capable of withstanding the impact of hail.

5.10.3 Apparatus

a) Moulds of suitable material for casting spherical ice balls of the required diameter. For each ice-ball diameter to be tested, at least two modules shall be tested. The test report should indicate what ice-ball diameter, mass, test velocity and resulting kinetic energy were used for the hail test.

b) A storage freezer controlled at (−20 ± 3) °C.

c) A launcher capable of propelling an ice ball with adjustable velocity to reach the kinetic energy range, so as to hit the module within the specified impact location. The path of the ice ball from the launcher to the module may be horizontal, vertical or at any intermediate angle, so long as the test requirements are met.