

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Salt mist corrosion testing of photovoltaic (PV) modules

Essai de corrosion au brouillard salin des modules photovoltaïques (PV)

IEC 61701:2011

<https://standards.iteh.ai/catalog/standards/sist/32d4e7c4-7076-4ab5-9368-e4e6fd2ac68/iec-61701-2011>



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IEC 61701

Edition 2.0 2011-12

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INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

COMMISSION
ELECTROTECHNIQUE
INTERNATIONALE

PRICE CODE
CODE PRIX

N

ICS 27.160

ISBN 978-2-88912-840-2

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

SALT MIST CORROSION TESTING OF PHOTOVOLTAIC (PV) MODULES

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International Standard IEC 61701 has been prepared by IEC technical committee 82: Solar photovoltaic energy systems.

This second edition cancels and replaces the first edition issued in 1995. This edition constitutes a technical revision.

The main technical changes with respect to the previous edition are as follows:

The scope has been updated to better reflect the applicability of the Standard.

Salt mist test is based on IEC 60068-2-52 rather than IEC 60068-2-11 as in edition 1 since the former Standard is much more widely used in the electronic component field. According to this change the new edition 2 includes a cycling testing sequence that combines in each cycle a salt fog exposure followed by humidity storage under controlled temperature and relative humidity conditions. This testing sequence is more suitable to reflect the corrosion processes that happen in PV modules subjected to permanent or temporary corrosive atmospheres (NaCl). In edition 1 only a salt fog exposure was considered.

Additional tests have also been included to verify the effect of the salt mist test not only in the PV module output but also in some of its components.

Different testing sequences are considered depending on the PV module technology involved: crystalline silicon, thin-film and concentrator photovoltaic (CPV) modules.

A test report clause has also been included.

The text of this standard is based on the following documents:

| FDIS | Report on voting |
|-------------|------------------|
| 82/667/FDIS | 82/681/RVD |

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication 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 web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

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SALT MIST CORROSION TESTING OF PHOTOVOLTAIC (PV) MODULES

1 Scope and object

Photovoltaic (PV) modules are electrical devices intended for continuous outdoor exposure during their lifetime. Highly corrosive wet atmospheres, such as marine environments, could eventually degrade some of the PV module components (corrosion of metallic parts, deterioration of the properties of some non-metallic materials - such as protective coatings and plastics - by assimilation of salts, etc.) causing permanent damages that could impair their functioning. Temporary corrosive atmospheres are also present in places where salt is used in winter periods to melt ice formations on streets and roads.

This Standard describes test sequences useful to determine the resistance of different PV modules to corrosion from salt mist containing Cl⁻ (NaCl, MgCl₂, etc.). All tests included in the sequences, except the bypass diode functionality test, are fully described in IEC 61215, IEC 61646, IEC 62108, IEC 61730-2 and IEC 60068-2-52. They are combined in this Standard to provide means to evaluate possible faults caused in PV modules when operating under wet atmospheres having high concentration of dissolved salt (NaCl). Depending on the specific nature of the surrounding atmosphere to which the module is exposed in real operation several testing severities can be applied, as defined in IEC 60068-2-52. For example severity (1) is intended to be used for PV modules used in a marine environment, or in close proximity to the sea. Severities (3) to (6) are intended for PV modules operating in locations where there could be a change between salt-laden and dry atmospheres, for examples in places where salt is used to melt ice formations. Severity (2) is not suitable for PV modules as testing conditions are too weak (this severity is originally intended for products exposed to corrosive environments from time to time that are normally protected by an enclosure) and should be avoided when applying this Standard.

This Standard can be applied to both flat plate PV modules and concentrator PV modules and assemblies.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60068-2-52, *Environmental testing – Part 2-52: Tests – Test Kb: Salt mist, cyclic (sodium chloride solution)*

IEC 61215:2005, *Crystalline silicon terrestrial photovoltaic (PV) modules – Design qualification and type approval*

IEC 61646:2008, *Thin-film terrestrial photovoltaic (PV) modules – Design qualification and type approval*

IEC 61730-2:2004, *Photovoltaic (PV) module safety qualification – Part 2: Requirements for testing*

IEC 62108:2007, *Concentrator photovoltaic (CPV) modules and assemblies – Design qualification and type approval*

ISO/IEC 17025, *General requirements for the competence of testing and calibration laboratories*

3 Samples

Three identical samples of the model of PV module or assembly of interest shall be subjected to any of the testing sequences included in Figures 1, 2 or 3, depending on the PV technology considered, namely crystalline silicon, thin-film or concentrator photovoltaic (CPV) respectively. As the figures indicate one of these samples should be used as a control. The control sample should be used as a check every time the test samples are measured to evaluate the effect of the salt mist test.

In the case of CPV different situations for choosing the sample may occur. For non-field-adjustable focus-point CPV systems or modules, 3 modules are required to complete the testing sequence included in Figure 3. For field-adjustable focus-point CPV systems or assemblies, 3 receivers (including secondary optics sections, if applicable) and 3 primary optics sections are required to complete the testing sequence included in Figure 3. A complete description of the different types and components of CPV modules and assemblies can be found in IEC 62108.

If a full-size sample is too large to fit into the environmental chambers required for the salt mist test then a smaller representative sample may be specially designed and manufactured for this test. The representative sample should be carefully designed so that it can reveal similar failure mechanisms as the full-size one, and the fabrication process of the representative sample should be as identical as possible to the process of the full-size ones. The fact that the test has been made on representative samples and not on the full-size samples has to be indicated and reported in the test report under item g), see Clause 11.

If the PV module is provided with means for grounding then they constitute a part of the test sample.

4 Test procedures

4.1 General

All tests included in Figures 1, 2 or 3, except the bypass diode functionality test, are fully described (including purpose, apparatus, procedure and requirements) in the IEC Standards from where the specific tests are taken (see notes in the Figures). Tests included in Figures 1, 2 or 3 shall be performed in the specified order. In the case of CPV if some test procedures included in this Standard are not applicable to a specific design configuration, the manufacturer should discuss this with the testing agency to develop a comparable test program, based on the principles described in this Standard. Any changes and deviations shall be recorded and reported in detail, as required in Clause 11, item I).

4.2 Bypass diode functionality test

4.2.1 Purpose

To verify that the bypass diode(s) of the test samples remains functional following the salt fog exposure.

NOTE If in the test sample there are no bypass diodes or the bypass diodes do not have any metallic parts then this test is omitted.

4.2.2 Apparatus

- a) DC power source capable of applying a current up to 1,25 times the standard test conditions (STC) short-circuit current of the sample under test and means for monitoring the flow of current through the test sample during the test period.

- b) Equipment for measuring the voltage drop across the test sample at an accuracy of $\pm 0,5$ % of reading.
- c) Equipment for measuring test current at an accuracy of $\pm 0,5$ % of reading.

4.2.3 Procedure

This procedure can be conducted in any ambient within $25\text{ °C} \pm 10\text{ °C}$. During the test the sample shall not be subjected to illumination.

- a) Electrically short any blocking diodes incorporated to the test sample.
- b) Determine the rated STC short-circuit current of the test sample from its label or instruction sheet.
- c) Connect the DC power source's positive output to the test sample negative lead, and the DC power source's negative output to the test sample positive lead by using wires of the manufacturer's minimum recommended wire gauge. Follow the manufacturer's recommendations for wire entry into the wiring compartment. With this configuration the current shall pass through the cells in the reverse direction and through the diode(s) in the forward direction.

NOTE Some modules have overlapping bypass diode circuits. In this case it may be necessary to install a jumper cable to ensure that all of the current is flowing through one bypass diode.

- d) Apply a current equal to of 1,25 times (± 5 %) the STC short-circuit current of the test sample for a period of 1 h.

4.2.4 Requirements

After the 1 h of current flow check that the bypass diode(s) remains operational. A possible method is to again pass a forward current through the diode(s) by passing a reverse current through the cells and then monitor the temperature of the diode(s) with the aid of a thermal IR camera. Diode(s) shall reach thermal equilibrium with the environment after step d) above before applying this procedure. Another option is to shade a solar cell protected by each diode (one per string, step by step) in the PV module and verify the characteristics of the resulting I-V curve (under illumination close to STC) to check if the bypass diode(s) is(are) working.

5 Preconditioning

All test samples shall be preconditioned with either global or direct normal sunlight (natural or simulated) according to the specifications given in the applicable design qualification and type approval IEC Standard applicable to the PV module technology considered, i.e., IEC 61215 for crystalline silicon, IEC 61646 for thin-film materials and IEC 62108 for concentrator photovoltaic (CPV). At the time of writing this Standard no preconditioning is specified for thin-film technologies in IEC 61646.

6 Initial measurements

6.1 The following initial measurements shall be performed on the selected samples depending on the PV module technology being evaluated.

6.2 Crystalline silicon. The test order is included in Figure 1.

- Tests according to IEC 61215:
 - a) 10.2: Maximum power determination
 - b) 10.15: Wet leakage current test
- Tests according to IEC 61730-2
 - c) MST 01: Visual inspection

- d) MST 13: Ground continuity test
- e) MST 16: Dielectric withstand test

NOTE The reference before each test corresponds to its identification in the relevant IEC Standard.

6.3 Thin-film technologies. The test order is included in Figure 2.

- Tests according to IEC 61646:
 - a) 10.2: Maximum power determination.

NOTE 1 The only purpose of this test is to verify that the PV module is operational before being subjected to the subsequent tests of the sequence.

- b) 10.15: Wet leakage current test
- Tests according to IEC 61730-2
 - c) MST 01: Visual inspection
 - d) MST 13: Ground continuity test
 - e) MST 16: Dielectric withstand test

NOTE 2 The reference before each test corresponds to its identification in the relevant IEC Standard.

6.4 Concentrator photovoltaic (CPV) modules. The test order is included in Figure 3.

- Tests according to IEC 62108:
 - a) 10.1: Visual inspection
 - b) 10.2: Electrical performance measurement
 - c) 10.3: Ground path continuity test
 - d) 10.4: Electrical insulation test
 - e) 10.5: Wet insulation test

NOTE The reference before each test correspond to its identification in IEC 62108.

7 Salt mist test procedure

Apply to the test samples under study the salt mist test as described in IEC 60068-2-52 following the general conditions, apparatus, characteristics of the salt solution, severities and other specifications included. The severity of the salt mist test shall be chosen according to the atmospheric conditions prevailing in the place where the installation of the PV modules is intended. Severity (2) is not suitable for PV modules as testing conditions are too weak (it is intended for products exposed to corrosive environments from time to time that are normally protected by an enclosure) and should be avoided when applying this Standard. During testing the face of the PV module normally exposed to solar irradiance shall be inclined 15° to 30° from vertical inside the salt fog chamber. The module can be placed vertically in the humidity chamber used for the humidity storage portion of the test.

8 Cleaning and recovery

After the salt mist test all samples shall be washed to remove the adherent salt using running tap water (not artificially pressurised) for a maximum time of 5 min per square metre of area of the sample. Once the washing is finished distilled or demineralized water shall be used to rinse the samples, followed by complete drying at room temperature. To accelerate drying it is allowed to shake the test sample by hand or to use air blasts with the aid of a fan. The temperature of the water used for washing shall not exceed 35 °C. During cleaning or drying the use of cloths, gauzes or any other woven material shall be avoided and no scraping is allowed. After drying, the recovery time shall be minimised and the applicable testing sequence shall be continued as soon as possible to avoid further damage produced by salt depositions.

9 Final measurements

9.1 After the salt mist test the test samples shall be subjected to the following tests depending on the PV module technology.

9.2 Crystalline silicon. The test order is included in Figure 1.

- Tests according to IEC 61215:
 - a) 10.2: Maximum power determination
 - b) 10.15: Wet leakage current test
- Tests according to IEC 61730-2:
 - c) MST 01: Visual inspection
 - d) MST 13: Ground continuity test
 - e) MST 16: Dielectric withstand test

NOTE The reference before each test corresponds to its identification in the relevant IEC Standard.

- Test according to this Standard:
 - f) Bypass diode functionality test

9.3 Thin-film technologies. The test order is included in Figure 2.

- Tests according to IEC 61646:
 - a) 10.6: Performance at STC (not NOCT)
 - b) 10.15: Wet leakage current test
 - c) 10.19: Light soaking
- Tests according to IEC 61730-2:
 - d) MST 01: Visual inspection
 - e) MST 13: Ground continuity test
 - f) MST 16: Dielectric withstand test

NOTE The reference before each test corresponds to its identification in the relevant IEC Standard.

- Test according to this Standard:
 - g) Bypass diode functionality test

9.4 Concentrator photovoltaic (CPV) module. The test order is included in Figure 3.

- Tests according to IEC 62108:
 - a) 10.1: Visual inspection
 - b) 10.2: Electrical performance measurement
 - c) 10.3: Ground path continuity test
 - d) 10.4: Electrical insulation test
 - e) 10.5: Wet insulation test

NOTE The reference before each test corresponds to its identification in IEC 62108.

- Test according to this Standard:
 - f) Bypass diode functionality test

10 Requirements

10.1 General

The following requirements shall be fulfilled by the two PV samples that undergo the testing sequences included in Figures 1, 2 or 3:

10.2 Crystalline silicon

- After the salt mist test there shall be no evidence of major visual defects as described in IEC 61730-2 including also no mechanical deterioration or corrosion of module components which would significantly impair their function during their intended life.
- After the salt mist test the maximum power shall not decrease by more than 5 % of the initial value.

NOTE The pass/fail criteria should consider the laboratory uncertainty of measurement.

- All pass fail criteria corresponding to tests 10.15, MST 13 and MST 16 shall be fulfilled according to what is specified in IEC 61215 and IEC 61730-2 for these specific tests.
- The requirement for the bypass diode functionality test shall be also fulfilled.

10.3 Thin-film technologies

- After the salt mist test there shall be no evidence of major visual defects as described in IEC 61730-2 including also no mechanical deterioration or corrosion of module components which would significantly impair their function during their intended life.
- After the light soaking the maximum power at Standard Test Conditions (STC) shall not be less than 90 % of the minimum value specified by the manufacturer in the marking of the PV module.

NOTE 1 The pass/fail criteria should consider the laboratory uncertainty of measurement.

- All pass fail criteria corresponding to tests 10.15, 10.19, MST 13 and MST 16 shall be fulfilled according to what is specified in IEC 61646 and IEC 61730-2 for these specific tests.

NOTE 2 In the case of the requirements corresponding to test 10.19 (light soaking) MST 01 of IEC 61730-2 should be applied instead of test 10.1 of IEC 61646 and MST 16 of IEC 61730-2 should be applied instead of test 10.3 of IEC 61646.

- The requirement for the bypass diode functionality test shall be also fulfilled.

10.4 Concentrator photovoltaic (CPV) modules

- After the salt mist test there shall be no evidence of major visual defects as described in IEC 62108 including also no mechanical deterioration or corrosion of test sample components which would significantly impair their function during their intended life. No significant amount of water should remain inside the test sample after the salt mist test (the depth of the remaining water should not reach any electrically active parts in any possible position).
- After the salt mist test the relative power degradation shall not exceed 7 % if the I-V measurement is under outdoor natural sunlight, or 5 % if the I-V measurement is under solar simulator.

NOTE The pass/fail criteria should consider the laboratory uncertainty of measurement.

- All pass fail criteria corresponding to tests 10.3, 10.4 and 10.5 shall be fulfilled according to what is specified in IEC 62108 for these specific tests.
- The requirement for the bypass diode functionality test shall be also fulfilled.