BS EN 61701:2012

BSI Standards Publication

Salt mist corrosion testing of photovoltaic (PV) modules

bsi.

...making excellence a habit.™

National foreword

This British Standard is the UK implementation of EN 61701:2012. It is identical to IEC 61701:2011. It supersedes BS EN 61701:2000 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee GEL/82, Photovoltaic Energy Systems.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Published by BSI Standards Limited 2012

ISBN 978 0 580 69180 5

ICS 27.160

Compliance with a British Standard cannot confer immunity from legal obligations.

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 30 April 2012.

Amendments issued since publication

Amd. No.	Date	Text affected

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 61701

March 2012

ICS 27.160

Supersedes EN 61701:1999

English version

Salt mist corrosion testing of photovoltaic (PV) modules
(IEC 61701:2011)

Essai de corrosion au brouillard salin des modules photovoltaïques (PV)
(CEI 61701:2011)

Salznebel-Korrosionsprüfung von photovoltaischen (PV-)Modulen
(IEC 61701:2011)

This European Standard was approved by CENELEC on 2012-01-19. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN-CENELEC Management Centre or to any CENELEC member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.

CENELEC members are the national electrotechnical committees of Austria, Belgium, Bulgaria, Croatia, Cyprus, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

CENELEC

European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

Management Centre: Avenue Marnix 17, B - 1000 Brussels

Ref. No. EN 61701:2012 E

Foreword

The text of document 82/668/FDIS, future edition 2 of IEC 61701, prepared by IEC TC 82, "Solar photovoltaic energy systems" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN 61701:2012.

The following dates are fixed:

• latest date by which the document has to be implemented at national level by publication of an identical national standard or by endorsement	(dop)	2012-10-19
• latest date by which the national standards conflicting with the document have to be withdrawn	(dow)	2015-01-19

This document supersedes EN 61701:1999.

EN 61701:2012 includes the following significant technical changes with respect to EN 61701:1999:

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

— Salt mist test is based on EN 60068-2-52 rather than EN 60068-2-11 as in EN 61701:1999 since the former standard is much more widely used in the electronic component field. According to this change EN 61701:2012 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 EN 61701:1999 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.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CENELEC [and/or CEN] shall not be held responsible for identifying any or all such patent rights.

Endorsement notice

The text of the International Standard IEC 61701:2011 was approved by CENELEC as a European Standard without any modification.

Annex ZA
(normative)

Normative references to international publications with their corresponding European publications

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.

NOTE When an international publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

Publication	Year	Title	EN/HD	Year
IEC 60068-2-52	-	Environmental testing - Part 2: Tests - Test Kb: Salt mist, cyclic (sodium chloride solution)	EN 60068-2-52	-
IEC 61215	2005	Crystalline silicon terrestrial photovoltaic (PV) modules - Design qualification and type approval	EN 61215	2005
IEC 61646	2008	Thin-film terrestrial photovoltaic (PV) modules - Design qualification and type approval	EN 61646	2008
IEC 61730-2 (mod)	2004	Photovoltaic (PV) module safety qualification - Part 2: Requirements for construction	EN 61730-2	2007
IEC 62108	2007	Concentrator Photovoltaic (CPV) modules and assemblies - Design qualification and type approval	EN 62108	2008
ISO/IEC 17025	-	General requirements for the competence of testing and calibration laboratories	EN ISO/IEC 17025	-

CONTENTS

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, $MgCl_2$, 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 l).

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 ± 0,5 % of reading.

c) Equipment for measuring test current at an accuracy of ± 0,5 % of reading.

4.2.3 Procedure

This procedure can be conducted in any ambient within 25 °C ± 10 °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.

11 Test report

A test report with measured performance characteristics and test results shall be prepared by the test agency in accordance with ISO/IEC 17025. The test report shall contain the following data:

a) a title;

b) name and address of the test laboratory and location where the tests were carried out;

c) unique identification of the certification or report and of each page, and a clear identification of the purpose of the test report;

d) name and address of client, where appropriate;

e) reference to sampling procedure, where relevant;

f) date of receipt of test items and date(s) of test, where appropriate;

g) description and identification of the items tested. If the test has been made on representative samples and not on the full-size samples this has to be clearly indicated;

h) characterization and condition of the test items;

i) identification of test method used;

j) characteristics of the salt solution used;

k) severity applied for the salt mist test according to IEC 60068-2-52;

l) any deviations from, additions to or exclusions from the test method, and any other information relevant to a specific test, such as environmental conditions;

m) measurements, examinations and derived results supported by tables, graphs, sketches and photographs as appropriate including any failures observed;

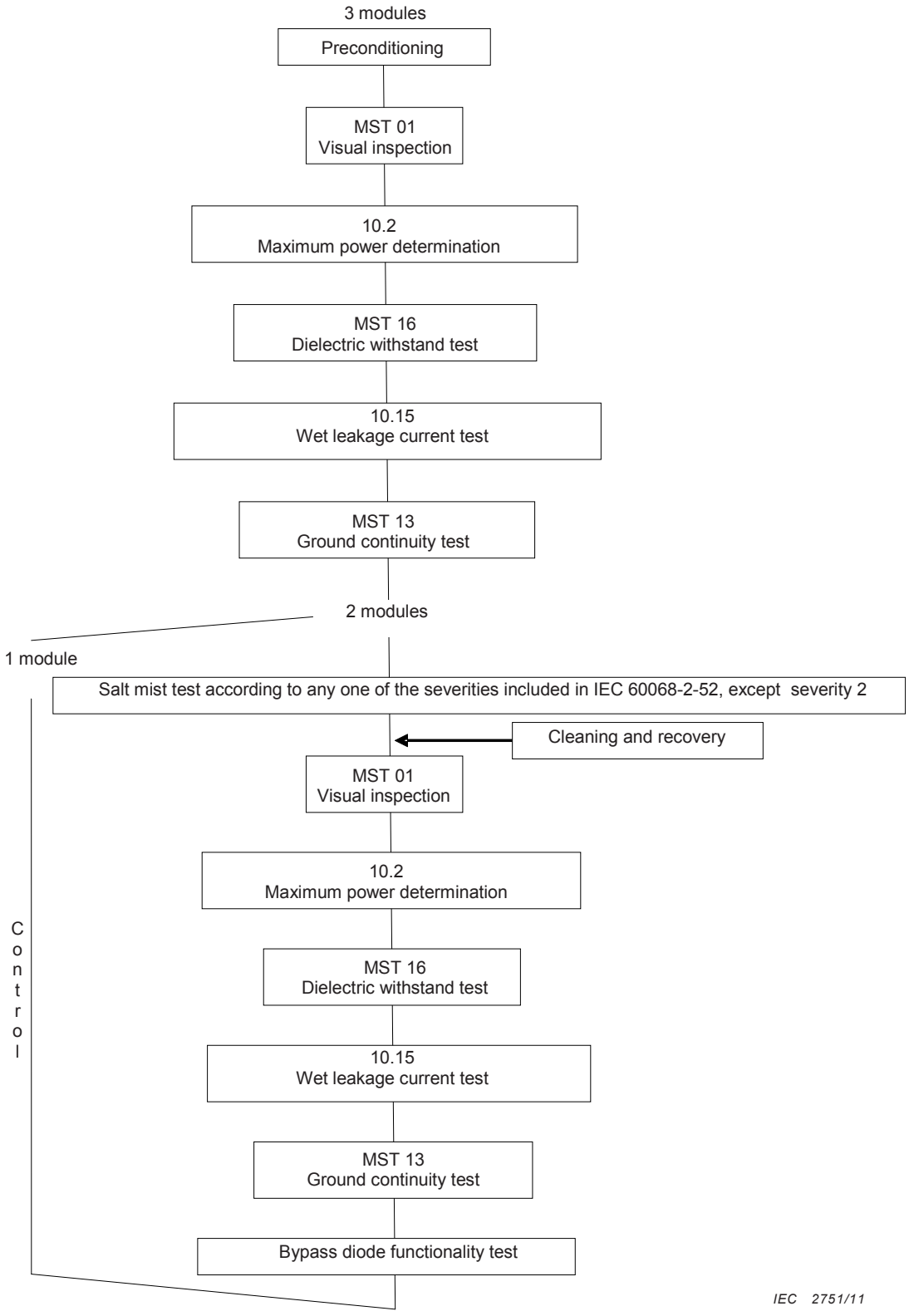
n) a statement of the estimated uncertainty of the test results (where relevant);

o) a signature and title, or equivalent identification of the person(s) accepting responsibility for the content of the certificate or report, and the date of issue;

p) where relevant, a statement to the effect that the results relate only to the items tested;

q) a statement that the report shall not be reproduced except in full, without the written approval of the laboratory.

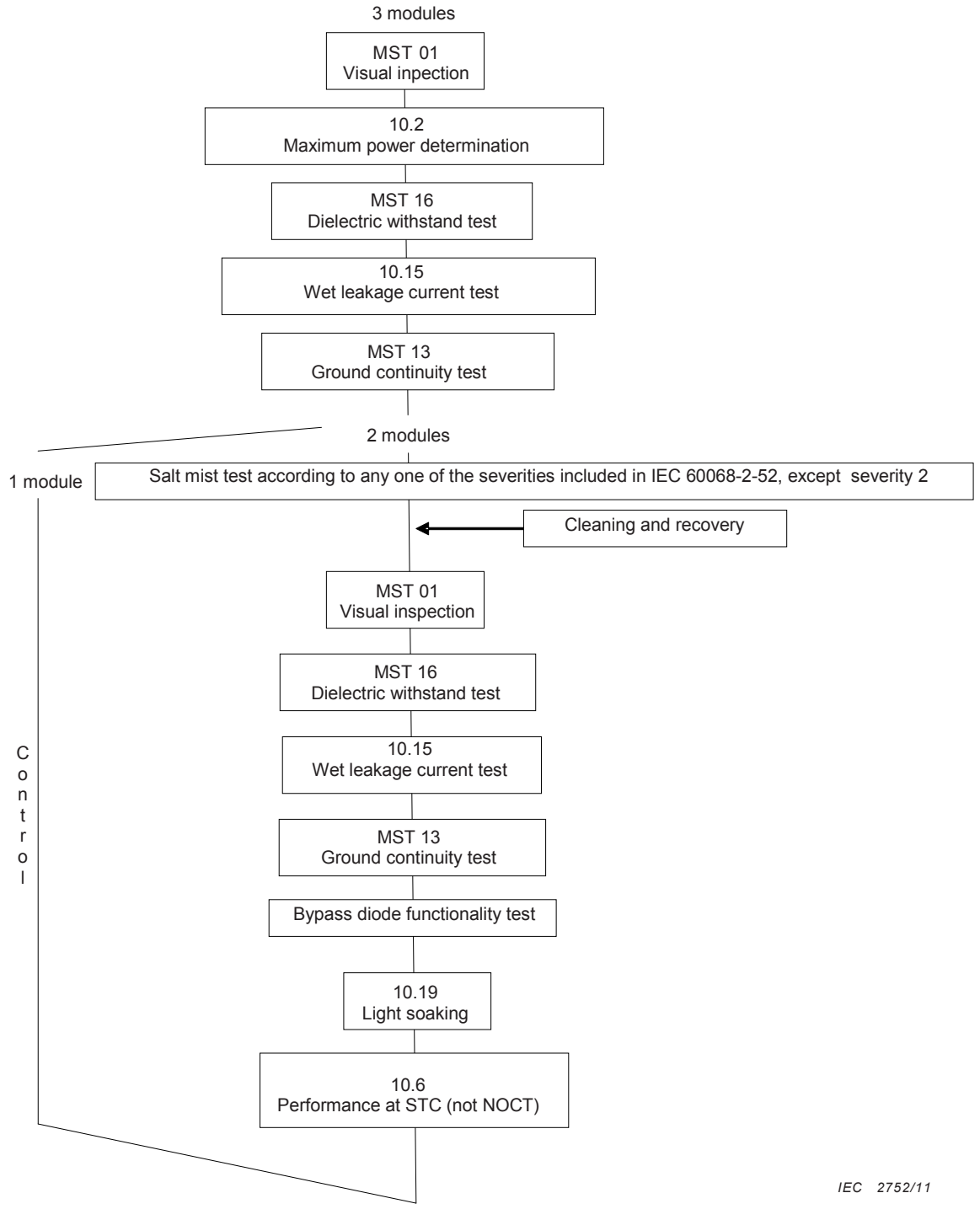
A copy of this report shall be kept by the laboratory and manufacturer for reference purposes.



NOTE 1 Preconditioning and tests 10.2 and 10.15 are taken from IEC 61215. Tests MST 01, MST 13 and MST 16 are taken from IEC 61730-2.

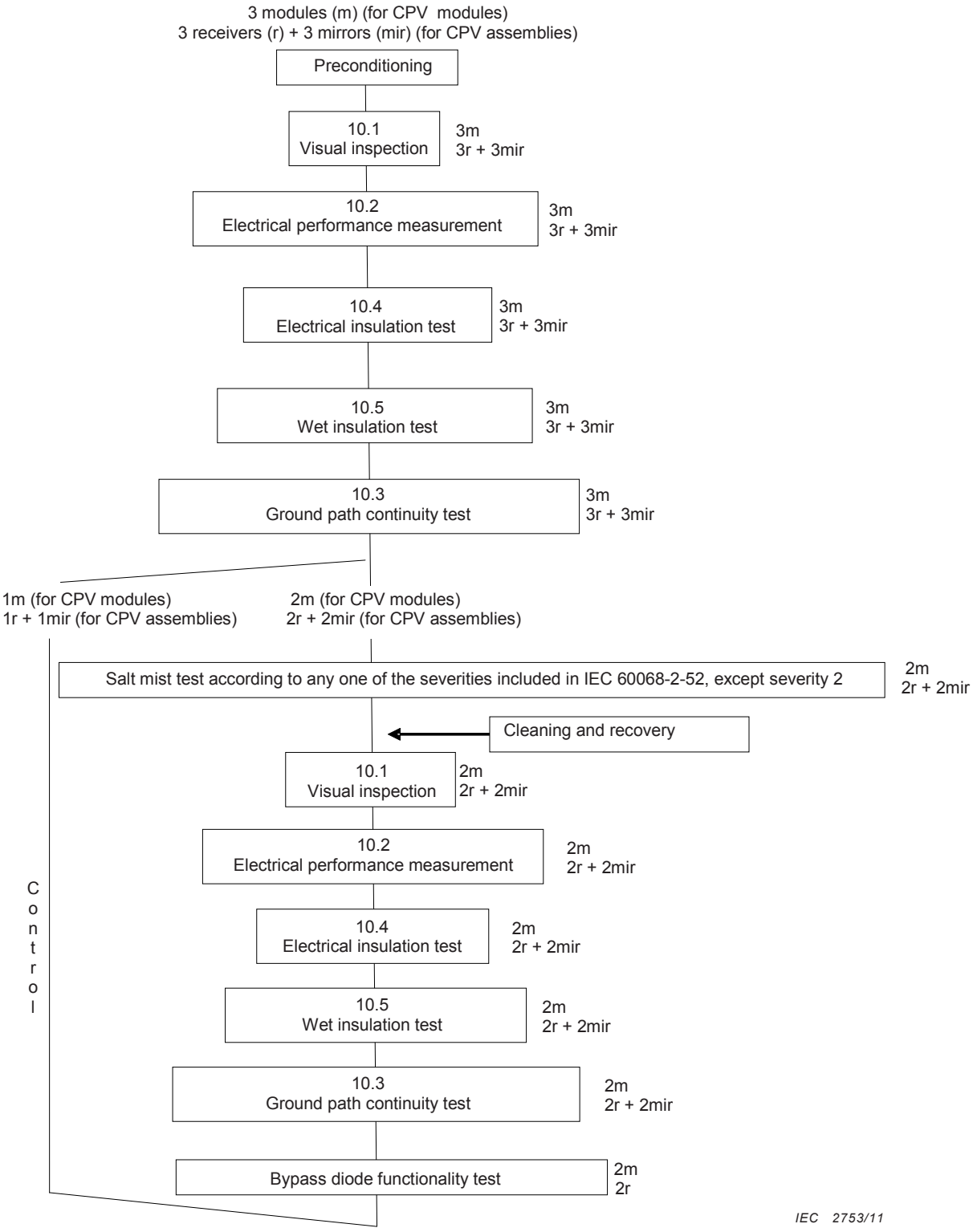
NOTE 2 The control module should be used as a check every time the test modules are measured to evaluate the effect of the salt mist test.

Figure 1 – Salt mist corrosion testing sequence for crystalline silicon PV modules



NOTE 1 Tests 10.2, 10.6, 10.15 and 10.19 are taken from IEC 61646. Tests MST 01, MST 13 and MST 16 are taken from IEC 61730-2.
NOTE 2 The control module should be used as check every time the test modules are measured to evaluate the effect of the salt mist test.
NOTE 3 Maximum power determination after salt mist test according to test 10.2 of IEC 61646 could eventually be made for diagnostic purpose only.
NOTE 4 Test 10.6 is performed as a part of the requirements corresponding to test 10.19 a described in IEC 61646. For the remaining requirements use test MST 01 instead of 10.1 and MST 16 instead of 10.3.

Figure 2 – Salt mist corrosion testing sequence for thin-film PV modules



NOTE 1 Tests 10.1, 10.2, 10.3, 10.4 and 10.5 are taken from IEC 62108.

NOTE 2 The control sample should be used as a check every time the test sample are measured to evaluate the effect of the salt mist test.

Figure 3 – Salt mist corrosion testing sequence for concentrator photovoltaic (CPV) modules

This page deliberately left blank

British Standards Institution (BSI)

BSI is the national body responsible for preparing British Standards and other standards-related publications, information and services.

BSI is incorporated by Royal Charter. British Standards and other standardization products are published by BSI Standards Limited.

About us

We bring together business, industry, government, consumers, innovators and others to shape their combined experience and expertise into standards -based solutions.

The knowledge embodied in our standards has been carefully assembled in a dependable format and refined through our open consultation process. Organizations of all sizes and across all sectors choose standards to help them achieve their goals.

Information on standards

We can provide you with the knowledge that your organization needs to succeed. Find out more about British Standards by visiting our website at bsigroup.com/standards or contacting our Customer Services team or Knowledge Centre.

Buying standards

You can buy and download PDF versions of BSI publications, including British and adopted European and international standards, through our website at bsigroup.com/shop, where hard copies can also be purchased.

If you need international and foreign standards from other Standards Development Organizations, hard copies can be ordered from our Customer Services team.

Subscriptions

Our range of subscription services are designed to make using standards easier for you. For further information on our subscription products go to bsigroup.com/subscriptions.

With **British Standards Online (BSOL)** you'll have instant access to over 55,000 British and adopted European and international standards from your desktop. It's available 24/7 and is refreshed daily so you'll always be up to date.

You can keep in touch with standards developments and receive substantial discounts on the purchase price of standards, both in single copy and subscription format, by becoming a **BSI Subscribing Member**.

PLUS is an updating service exclusive to BSI Subscribing Members. You will automatically receive the latest hard copy of your standards when they're revised or replaced.

To find out more about becoming a BSI Subscribing Member and the benefits of membership, please visit bsigroup.com/shop.

With a **Multi-User Network Licence (MUNL)** you are able to host standards publications on your intranet. Licences can cover as few or as many users as you wish. With updates supplied as soon as they're available, you can be sure your documentation is current. For further information, email bsmusales@bsigroup.com.

BSI Group Headquarters

389 Chiswick High Road London W4 4AL UK

Revisions

Our British Standards and other publications are updated by amendment or revision.

We continually improve the quality of our products and services to benefit your business. If you find an inaccuracy or ambiguity within a British Standard or other BSI publication please inform the Knowledge Centre.

Copyright

Useful Contacts:

Customer Services
Tel: +44 845 086 9001
Email (orders): orders@bsigroup.com
Email (enquiries): cservices@bsigroup.com

Subscriptions
Tel: +44 845 086 9001
Email: subscriptions@bsigroup.com

Knowledge Centre
Tel: +44 20 8996 7004
Email: knowledgecentre@bsigroup.com

Copyright & Licensing
Tel: +44 20 8996 7070
Email: copyright@bsigroup.com

bsi.

...making excellence a habit.™