BRITISH STANDARD

BS EN
61730-2:2007

Photovoltaic (PV) module safety qualification —

Part 2: Requirements for testing

The European Standard EN 61730-2:2007 has the status of a British Standard

ICS 27.160

BSI
British Standards

National foreword

This British Standard is the UK implementation of EN 61730-2:2007. It is identical to IEC 61730-2:2007.

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

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

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Photovoltaic (PV) module safety qualification – Part 2: Requirements for testing

(IEC 61730-2:2004, modified)

Qualification pour la sûreté de fonctionnement des modules photovoltaïques (PV) – Partie 2: Exigences pour les essais (CEI 61730-2:2004, modifiée)

Photovoltaik (PV) -Module – Sicherheitsqualifikation – Teil 2: Anforderungen an die Prüfung (IEC 61730-2:2004, modifiziert)

CENELEC

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

Central Secretariat: rue de Stassart 35, B - 1050 Brussels

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Foreword

The text of the International Standard IEC 61730-2:2004, prepared by IEC TC 82, Solar photovoltaic energy systems, together with the common modifications prepared by the Technical Committee CENELEC TC 82, Solar photovoltaic energy systems, was submitted to the formal vote and was approved by CENELEC as EN 61730-2 on 2006-12-01.

The following dates were fixed:

– latest date by which the EN has to be implemented at national level by publication of an identical national standard or by endorsement	(dop)	2008-02-01
– latest date by which the national standards conflicting with the EN have to be withdrawn	(dow)	2010-02-01

Annex ZA has been added by CENELEC.

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Endorsement notice

The text of the International Standard IEC 61730-2:2004 was approved by CENELEC as a European Standard with agreed common modifications as given below.

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PHOTOVOLTAIC (PV) MODULE SAFETY QUALIFICATION –

Part 2: Requirements for testing

1 Scope and object

This part of EN 61730 describes the testing requirements for photovoltaic (PV) modules in order to provide safe electrical and mechanical operation during their expected lifetime. Specific topics are provided to assess the prevention of electrical shock, fire hazards, and personal injury due to mechanical and environmental stresses. EN 61730-1 pertains to the particular requirements of construction. This part of EN 61730 outlines the requirements of testing.

This standard attempts to define the basic requirements for various application classes of photovoltaic modules, but it cannot be considered to encompass all national or regional building codes. The specific requirements for marine and vehicle applications are not covered. This standard is not applicable to modules with integrated AC inverters (AC modules).

This standard is designed so that its test sequence can co-ordinate with those of IEC 61215 or IEC 61646, so that a single set of samples may be used to perform both the safety and performance evaluation of a photovoltaic module design.

The test-sequences of this standard are arranged in an optimal way so that tests of IEC 61215 or IEC 61646 can be used as basic preconditioning tests.

NOTE 1 The sequence of tests required in this standard may not test for all possible safety aspects associated with the use of PV modules in all possible applications. This standard utilizes the best sequence of tests available at the time of its writing. There are some issues, such as the potential danger of electric shock posed by a broken module in a high voltage system, that should be addressed by the systems design, location, restrictions on access and maintenance procedures.

The object of this document is to provide the testing sequence intended to verify the safety of PV modules whose construction has been assessed by EN 61730-1. The test sequence and pass criteria are designed to detect the potential breakdown of internal and external components of PV modules that would result in fire, electric shock and personal injury. The standard defines the basic safety test requirements and additional tests that are a function of the module end-use applications.

Test categories include general inspection, electrical shock hazard, fire hazard, mechanical stress, and environmental stress.

NOTE 2 The additional testing requirements outlined in relevant ISO standards, or the national or local codes which govern the installation and use of these modules in their intended locations, should be considered in addition to the requirements contained within this document.

2 Normative references

See Annex ZA.

3 Application classes

3.1 General

Photovoltaic modules may be installed in many different applications. Therefore, it is important to evaluate the potential hazards associated with those applications and to evaluate the construction of the module accordingly.

Relevant safety requirements and necessary tests shall be performed to verify the conformance to the requirements of that application class. This clause defines those application classes and construction qualities required for each class.

Application classes for PV-modules are defined as follows:

3.2 Class A: General access, hazardous voltage, hazardous power applications

Modules rated for use in this application class may be used in systems operating at greater than 120 V DC. Modules qualified for safety through EN 61730-1 and this part of EN 61730 within this application class are considered to meet the requirements for safety class II.

3.3 Class B: Restricted access, hazardous voltage, hazardous power applications

Modules rated for use in this application class are restricted to systems protected from public access by fences, location, etc. Modules evaluated within this application class provide protection by basic insulation, are considered to meet the requirements for safety class 0.

3.4 Class C: Limited voltage

Modules rated for use in this application class are restricted to systems operating at less than 120 V DC. Modules qualified for safety through EN 61730-1 and this part of EN 61730 within this application class are considered to meet the requirements for safety class III.

NOTE Safety classes are defined within EN 61140.

4 Test categories

4.1 General

The following hazards might influence the lifetime and the safety of PV modules. In accordance with these hazards, test procedures and criteria are described. The specific tests to which a module will be subjected will depend on the end use application for which the minimum tests are specified in Clause 5.

NOTE Module safety tests are labelled MST.

Tables 1 to 6 show the origin of the required tests. For some tests, the third column shows for information the origin of the tests, but the appropriate test requirements are given in Clauses 10 and 11. The rest of the tests are based on or identical to IEC 61215/IEC 61646, and references to the relevant Clauses are given in the last two columns. Some of the IEC 61215/IEC 61646-based tests were modified for EN 61730-2 and are included in Clauses 10 and 11.

4.2 Preconditioning tests

Table 1 – Preconditioning tests

Test	Title	References in Standards	According to	
			IEC 61215	IEC 61646
MST 51	Thermal cycling (TC50 or TC200)		10.11	10.11
MST 52	Humidity freeze (HF10)		10.12	10.12
MST 53	Damp heat (DH1000)		10.13	10.13
MST 54	UV preconditioning test		10.10	10.10

4.3 General inspection

Table 2 – General inspection test

Test	Title	References in Standards	According to	
			IEC 61215	IEC 61646
MST 01	Visual inspection		10.1	10.1

4.4 Electrical shock hazard tests

These tests are designed to assess the risk to personnel due to shock or injury because of contact with parts of a module that are electrically energised as a result of design, construction, or faults caused by environment or operation.

Table 3 – Electrical shock hazard tests

Test	Title	References in Standards	According to	
			IEC 61215	IEC 61646
MST 11	Accessibility test	ANSI/UL 1703		
MST 12	Cut susceptibility test (not required for glass surfaces)	ANSI/UL 1703		
MST 13	Ground continuity test (not required unless metal framed)	ANSI/UL 1703		
MST 14	Impulse voltage test	IEC 60664-1		
MST 16	Dielectric withstand test		10.3*	10.3*
MST 17	Wet leakage current test		10.15	10.20
MST 42	Robustness of terminations test		10.14	10.14
* The pass/fail criteria differ from those given in IEC 61215 and IEC 61646.				

4.5 Fire hazard tests

These tests assess the potential fire hazard due to the operation of a module or failure of its components.

Table 4 – Fire hazard tests

Test	Title	References in Standards	According to	
			IEC 61215	IEC 61646
MST 21	Temperature test	ANSI/UL 1703		
MST 22	Hot-spot test		10.9	10.9
MST 23	Fire test	ANSI/UL 790		
MST 25	Bypass diode thermal test		10.18	
MST 26	Reverse current overload test	ANSI/UL 1703		

4.6 Mechanical stress tests

These tests are to minimise potential injury due to mechanical failure.

Table 5 – Mechanical stress tests

Test	Title	References in Standards	According to	
			IEC 61215	IEC 61646
MST 32	Module breakage test	ANSI Z97.1		
MST 34	Mechanical load test		10.16	10.16

4.7 Component tests

Table 6 – Component tests

Test	Title	References in Standards	According to	
			IEC 61215	IEC 61646
MST 15	Partial discharge test	IEC 60664-1		
MST 33	Conduit bending	ANSI/UL 514C		
MST 44	Terminal box knock out test	ANSI/UL 514C		

5 Application classes and their necessary test procedures

The specific tests to which a module will be subjected, depending on the application class defined in EN 61730-1, is described in Table 7. The order in which the tests are carried out shall be in accordance with Figure 1.

Some tests shall be carried out as preconditioning tests.

NOTE This test sequence has been designed so that EN 61730-2 can be performed in conjunction with IEC 61215 or IEC 61646. In this way, the environmental stress tests in IEC 61215 or IEC 61646 can serve as the preconditioning tests for EN 61730-2.

Table 7 – Required tests, depending on the application class

Application class			Tests
A	B	C	
			Preconditioning tests:
X	X	X	MST 51 Thermal cycling (T50 or T200)
X	X	X	MST 52 Humidity freeze (10HF)
X	X	X	MST 53 Damp heat (DH1000)
X	X	X	MST 54 UV resistance
			General inspection test:
X	X	X	MST 01 Visual inspection
			Electrical shock hazard tests:
X	X	-	MST 11 Accessibility test
X	X	-	MST 12 Cut susceptibility test
X	X	X	MST 13 Ground continuity test
X	X*	-	MST 14 Impulse voltage test
X	X*	-	MST 16 Dielectric withstand test
X	X	-	MST 17 Wet leakage current test
X	X	X	MST 42 Robustness of terminations test
			Fire hazard tests:
X	X	X	MST 21 Temperature test
X	X	X	MST 22 Hot spot test
X**	-	-	Fire test
X	X	-	MST 26 Reverse current overload test
			Mechanical stress tests:
X	-	X	MST 32 Module breakage test
X	X	X	MST 34 Mechanical load test
			Component tests:
X	-	-	MST 15 Partial discharge test
X	X	-	MST 33 Conduit bending
X	X	X	MST 44 Terminal box knockout test

X Test required.

- Test needs not be carried out.

* Different test levels for application classes A and B.

** A European fire test is under consideration.

6 Sampling

Six modules and a laminate[1] (a module without frame) for safety testing (plus spares as desired) and additional modules as required for the fire-test shall be taken at random from a production batch or batches, in accordance with the procedure given in IEC 60410. The modules shall have been manufactured from specified materials and components in accordance with the relevant drawings and process sheets and have been subjected to the manufacturer's normal inspection, quality control and production acceptance procedures. The modules shall be complete in every detail and shall be accompanied by the manufacturer's handling, mounting and connection instructions, including the maximum permissible system voltage.

When the modules to be tested are prototypes of a new design and not from production, this fact shall be noted in the test report (see Clause 7).

7 Test report

The results shall be laid down in a test report according to ISO/IEC 17025. The results shall be reported, normally in a test report and shall include all the information requested by the client and necessary to the interpretation of the test and all information required by the method used:

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;

d) name and address of client, where appropriate;

e) description and identification of the item tested;

f) characterization and condition of the test item;

g) date of receipt of test item and date(s) of test, where appropriate;

h) identification of test method used;

i) reference to sampling procedure, where relevant;

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

k) measurements, examinations and derived results supported by tables, graphs, sketches and photographs as appropriate including maximum systems voltage, safety class, mounting technique and any failures observed;

l) a statement indicating whether the impulse voltage test was performed on module or laminate;

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

n) 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;

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

p) a statement that the certificate or 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 manufacturer for reference purposes.

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[1] If the module is only used with frame and the frame is an essential part to fulfil the isolation requirement, the laminate can be replaced by a module.

8 Testing

The modules shall be divided into groups and subjected to the safety tests shown in Figure 1, carried out in the order specified. The modules shall be selected such that the preconditioning tests of 4.2 are met. Each box in Figure 1 refers to the corresponding subclause in this part of EN 61730.

NOTE Spare modules may be included in the safety test program provided that they have been appropriately environmentally tested to meet the necessary prerequisites.

Test procedures and criteria, including initial and final measurements where necessary, are detailed in Clauses 10 and 11. Some tests are identical to tests in IEC 61215/IEC 61646 and are detailed in Clause 4 instead. In carrying out these tests, the tester shall strictly observe the manufacturer's handling, mounting, and connection instructions.

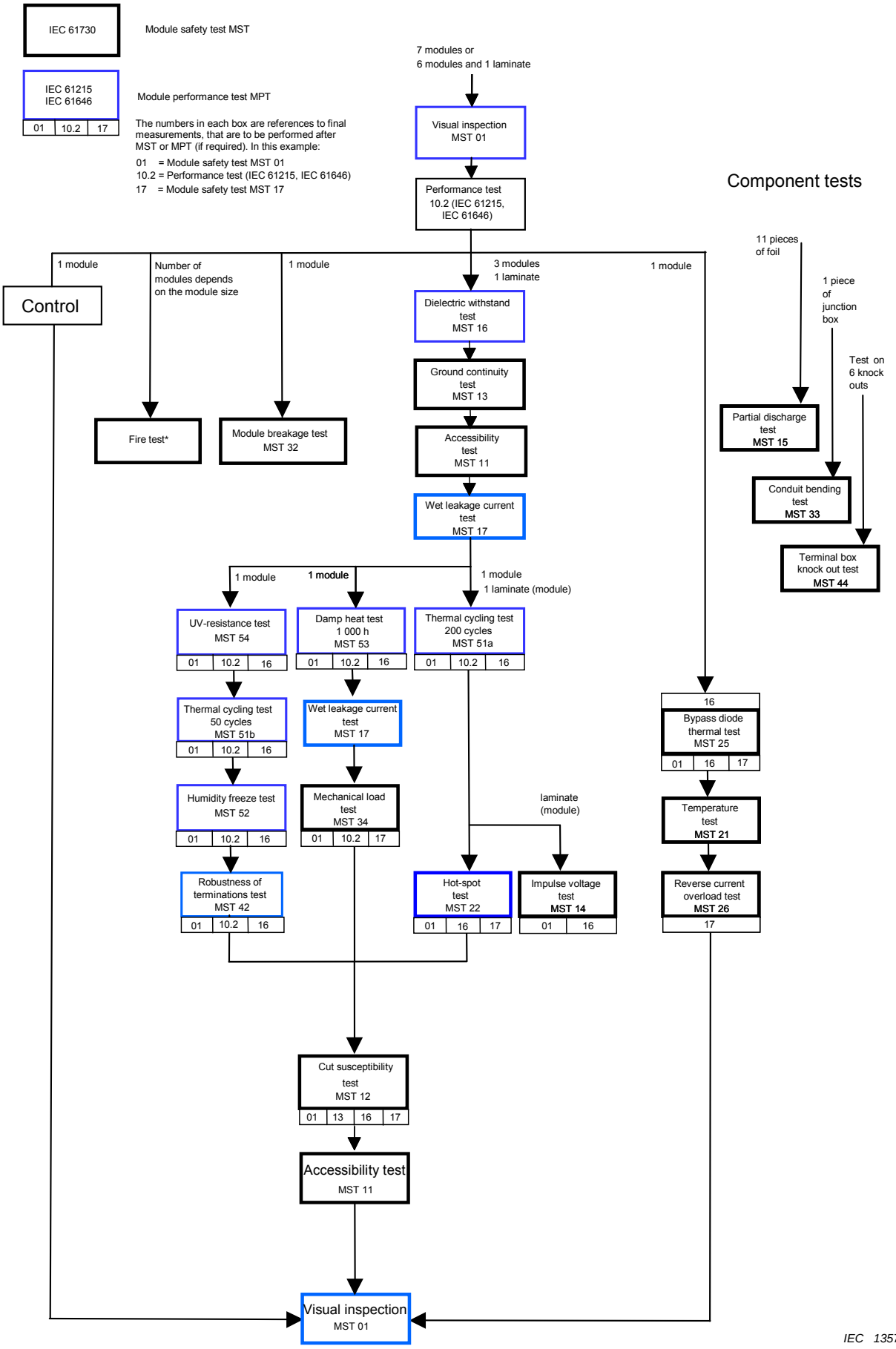


Figure 1 – Test sequences

* A European fire test is under consideration.

9 Pass criteria

The module product under evaluation shall be judged to have passed the safety qualification test, if the test samples meet all of the criteria of each individual test.

If any module does not meet these test criteria, the module product under evaluation shall be deemed not to have met the safety test requirements.

NOTE The nature of the failure will determine the extent of re-testing requirements.

10 Test procedures

10.1 Visual inspection MST 01

10.1.1 Purpose

To detect any visual defects in the module.

10.1.2 Procedure

This test is identical with 10.1 from IEC 61215/IEC 61646 with the additional inspection criteria of

– any other conditions which may affect safety;
– markings not consistent with Clause 11 of EN 61730-1.

Make note of and/or photograph the nature and position of any cracks, bubbles or delaminations, etc. which may worsen and adversely affect the module safety in subsequent tests. Visual conditions other than the major defects listed below are acceptable for the purpose of safety test approval.

10.1.3 Pass criteria

For the purpose of the safety test approval, the following are considered to be major visual defects:

a) broken, cracked, or torn external surfaces;
b) bent or misaligned external surfaces, including superstrates, substrates, frames and junction boxes to the extent that the safety of the module would be impaired;
c) bubbles or delaminations forming a continuous path between any part of the electrical circuit and the edge of the module, or which exhibited significant growth during the testing and would, if testing were continued, reach such a condition;
d) evidence of any molten or burned encapsulant, back sheet, diode or active PV component;
e) loss of mechanical integrity to the extent that the safety of the installation and operation of the module would be impaired;
f) markings not complying with Clause 12 of EN 61730-1.

10.2 Accessibility test MST 11

10.2.1 Purpose

To determine if uninsulated electrical connections represent a shock hazard to personnel.

10.2.2 Apparatus

The apparatus is as follows:

a) A cylindrical test fixture Type 11 according to Figure 7 of IEC 61032.
b) An ohmmeter or continuity tester.

10.2.3 Procedure

The procedure is as follows:

a) Mount and wire the test module as recommended by the manufacturer.
b) Attach the ohmmeter or continuity tester to the module electric circuit and to the test fixture.
c) Remove all covers, plugs and connections from the module that can be removed without using a tool.
d) Probe with the test fixture in and around all electrical connectors, plugs, junction boxes and any other areas where the electrical circuit of the module may be accessible.
e) Monitor the ohmmeter or continuity tester during the probing to determine if the test fixture makes electrical contact to the module electric circuitry.

10.2.4 Final measurements

None.

10.2.5 Requirements

At no time during the test shall there be less than 1 MΩ resistance between the test fixture and the module electric circuit.

10.2.6 Pass criteria

At no time during the test shall the probe contact any live electrical part. This test is performed at the beginning and the end of the sequence according to Figure 1, but also can be used at any time during the test sequence if there is any reason to believe that active electric circuitry has been exposed by one of the other tests.

10.3 Cut susceptibility test MST 12

10.3.1 Purpose

To determine whether any front and rear surfaces of the module made of polymeric materials are capable of withstanding routine handling during installation and maintenance without exposing personnel to the danger of electric shock. This test is derived from ANSI/UL 1703.

10.3.2 Apparatus

A test fixture as shown in Figure 2, designed to draw a defined shaped object, a 0,64 mm ± 0,05 mm thick carbon steel blade (for example the back of a hacksaw blade) over the surface of the module with an applied force of 8,9 N ± 0,5 N.

10.3.3 Procedure

The procedure is as follows:

a) Position the module horizontally with the front surface facing upward.
b) The test fixture is to be placed on the surface for 1 min and then drawn across the surface of the module at a speed of (150 ± 30) mm/s.

Repeat the procedure five times in different directions.

c) Repeat a) and b) for the rear surface of the module.

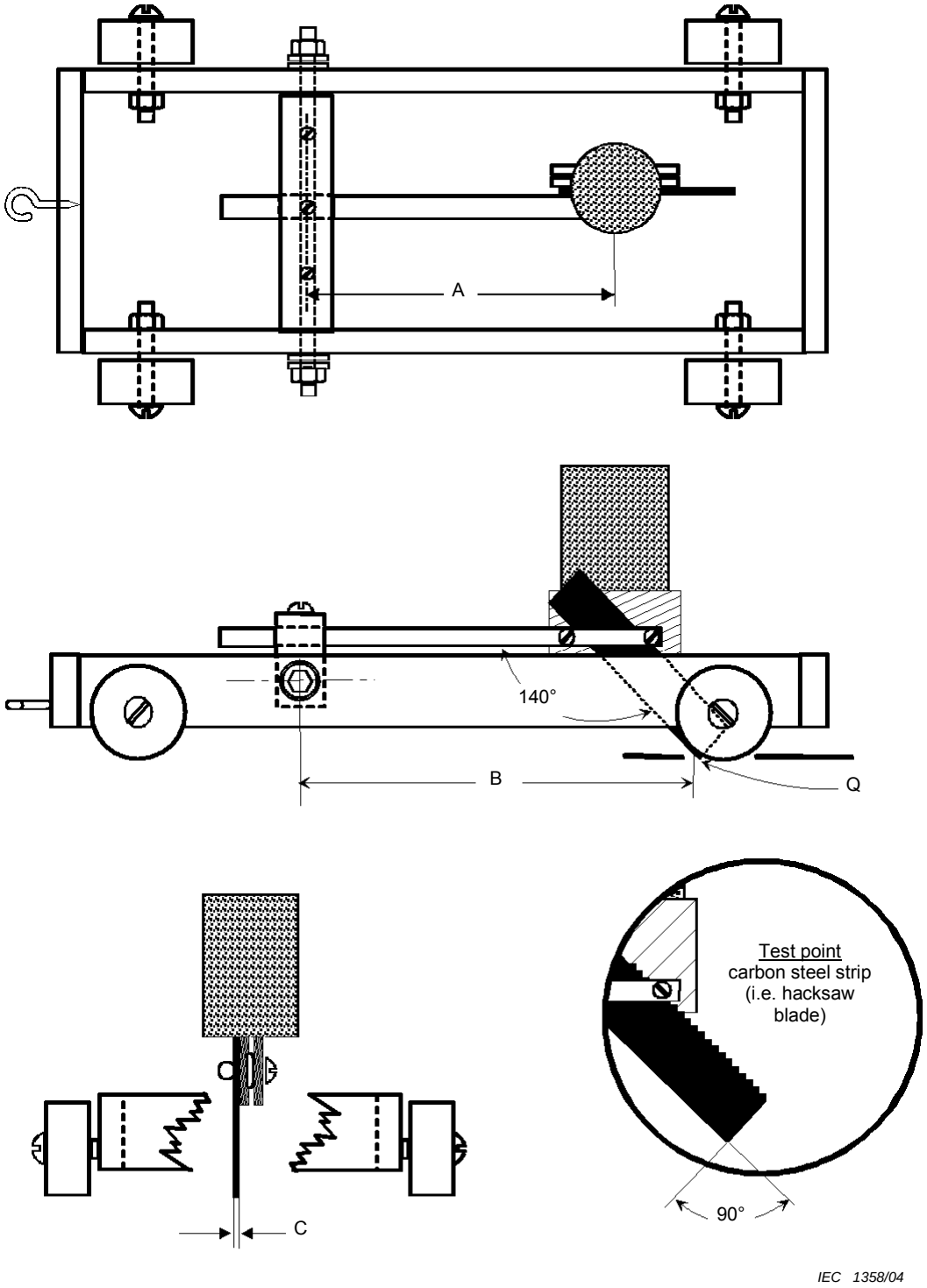
10.3.4 Final measurements

Repeat MST 01, MST 13, MST 16 and MST 17.

10.3.5 Pass criteria

The pass criteria are as follows:

a) No visual evidence that the superstrate or substrate surfaces have been cut, exposing the active circuitry of the module.
b) MST 13, MST 16, MST 17 shall meet the same requirements as for the initial measurements.



Key

A 150 mm from axis to center of weight.

B 170 mm from axis to test point.

C Test point – 0,64 mm thick steel strip.

Q Total force exerted at test point Q: 8,9 N

Figure 2 – Cut susceptibility test

10.4 Ground continuity test MST 13

10.4.1 Purpose

To demonstrate that there is a conductive path between all exposed conductive surfaces of the module, so that the exposed conductive surfaces can be adequately grounded in a PV system. This test is required only if the module has exposed conductive parts such as a metal frame or a metallic junction box.

10.4.2 Apparatus

The apparatus is as follows:

a) A constant current supply capable of producing a current that is 2,5 times the maximum over-current protection rating of the module under test. See MST 26.

b) A suitable voltmeter.

NOTE 1 According to EN 61730-1 the maximum over-current protection rating has to be provided by the manufacturer.

NOTE 2 The maximum over-current protection rating of a module can be interpreted as the module series fuse rating. A series fuse may be required in the installation of PV arrays. According to Subclause 12.2 of EN 61730-1 the maximum over-current protection rating has to be provided by the manufacturer.

NOTE 3 A procedure for determination of maximum reverse current is described in EN 50380.

10.4.3 Procedure

The procedure is as follows:

a) Select the manufacturer's designated grounding point and recommended grounding connection. Attach to one terminal of the constant current supply.

b) Select an adjacent (connected) exposed conductive component with the greatest physical displacement from the grounding point**,** and attach to the other terminal of the current supply.

c) Attach the voltmeter to the two conductive components attached to the current supply in proximity to the current leads.

d) Apply a current 2,5 times ± 10 % of the maximum over-current protection rating of the module for a minimum of 2 min.

e) Measure the applied current and the resultant voltage drop.

f) Reduce the current to zero.

g) Repeat the test on one additional frame component.

10.4.4 Final measurements

None.

10.4.5 Pass criteria

The resistance between the selected exposed conductive component and each other conductive component of the module shall be less than 0,1 Ω.

10.5 Impulse voltage test MST 14

10.5.1 Purpose

To verify the capability of the solid insulation of the module to withstand over-voltages of atmospheric origin. It also covers over-voltages due to switching of low-voltage equipment.

NOTE If the PV module is not going to be sold without frame, the impulse voltage test should be done with the module framed.

10.5.2 Apparatus

The apparatus is as follows:

a) Impulse voltage generator.
b) Oscilloscope.

10.5.3 Procedures

For the purposes of test reproducibility, this test is conducted under the conditions of room temperature and relative humidity of less than 75 %. The procedure is as follows:

a) Cover the whole module with a copper foil. Connect the foil to the negative terminal of the impulse voltage generator.
b) Connect the shorted output terminals of the module to the positive terminal of the impulse voltage generator.

   Specification of the foil:

   1) Thickness copper 0,03 mm to 0,05 mm.
   2) Conducting glue (conductivity <1 Ω, measuring area: 625 mm^2).
   3) Total thickness 0,05 mm to 0,07 mm.

c) With no illumination, apply the surge impulse voltage given in Table 8 with a waveform as shown in Figure 3 by the impulse voltage generator. The waveform of the pulse shall be observed by an oscilloscope and the rise time and the pulse duration shall be checked for each test.

   NOTE 1 According to 2.2.2.1.1 of IEC 60664-1, modules belong to the over-voltage category III. The test-level has been reduced by one step because systems are normally equipped with over-voltage protection devices. On the other hand, to verify reinforced insulation (as required for application class A and safety class II), the level for application class A has been increased by one step.

Table 8 – Impulse voltage versus maximum system voltage

Maximum system voltage V	Impulse voltage	
	Application class A V	Application class B V
100	1 500	800
150	2 500	1 500
300	4 000	2 500
600	6 000	4 000
1 000	8 000	6 000

NOTE 2 Linear interpolation is allowed for intermediate values of maximum system voltage.

d) Three successive pulses shall be applied.
e) Change the polarity of the terminals of the pulse generator and apply three successive pulses.

10.5.4 Final measurement

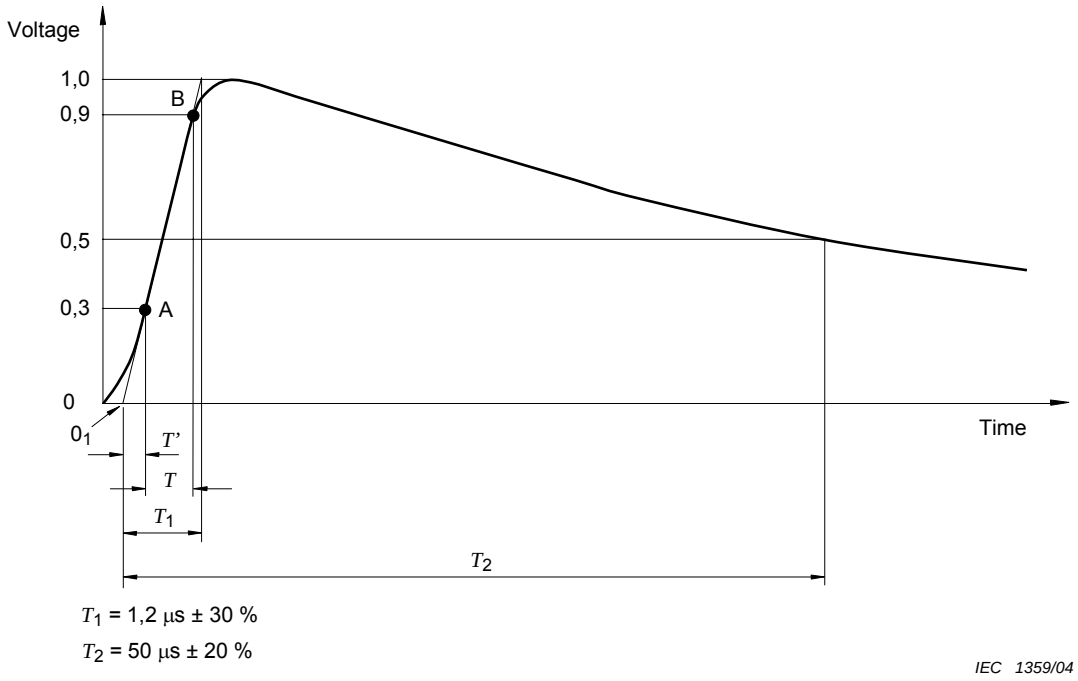
Repeat MST 01 visual inspection.

10.5.5 Pass criteria

The pass criteria are as follows:

a) No evidence of dielectric breakdown or surface tracking of the module is observed during the test.

b) No evidence of major visual defects as defined in 10.1.



NOTE The parameter 0_1 is the start point of the impulse voltage. In a diagram with linear time scale this is the intersection point of the time axis and the line defined by points A and B.

Figure 3 – Wave-form of the impulse voltage according to IEC 60060-1

10.6 Dielectric withstand test MST 16

10.6.1 Purpose

To determine whether or not the module is sufficiently well insulated between current carrying parts and the frame or the outside world.

The test shall be made on modules at ambient temperature of the surrounding atmosphere (see IEC 60068-1) and in a relative humidity not exceeding 75 %.

10.6.2 Procedure

This test is identical with test 10.3 from IEC 61215/IEC 61646 with test levels depending on the application class and the maximum system voltage.

The maximum test voltage shall be equal to 2 000 V plus four times the maximum system voltage for application-class A and equal to 1 000 V plus two times the maximum system voltage for application-class B.

10.6.3 Pass criteria

See IEC 61215/IEC 61646.

10.7 Temperature test MST 21

10.7.1 Purpose

This temperature test is designed to determine the maximum reference temperatures for various components and materials used to construct the module, in order to establish the suitability of their use.

10.7.2 Test conditions

The ambient temperature during the test may be in the range of 20 °C to 55 °C.

The irradiance during the test shall be no less than 700 W/m^2 measured coplanar with the module by a calibrated device with the accuracy to ±5 % in accordance with IEC 60904-2 and IEC 60904-6. All data shall be taken at wind-speeds of less than 1 m/s.

10.7.3 Procedure

The module under test shall be mounted on a platform constructed of wood, pressed wood, or plywood, approximately 19 mm thick. The platform is to be painted flat black on the side facing the test sample. The platform shall extend at least 60 cm beyond the module on all sides.

The module under test shall be mounted to the platform in accordance with the manufacturer's installation instructions. If the instructions offer more than one option, the option providing the worst-case shall be used. If no indications have been provided, the test module shall be mounted directly to the platform.

The module component temperatures shall be measured by a calibrated device or system, with an maximum uncertainty of ±2 °C.

The module is to be operated under both open- and short-circuit conditions, and stabilised temperature data for each test location shall be collected in each condition. Thermal stability has been attained when three successive readings, taken 5 min apart, indicate a change in temperature of less than ±1 °C.

The measured component temperatures (T_{obs}) shall be normalised by the addition of the difference between the 40 °C reference ambient and the measured ambient temperature (T_{amb}) according to the equation $T_{con} = T_{obs} + (40 - T_{amb}) \cdot T_{con}$ is the normalised temperature.

If an unacceptable performance is encountered during the temperature test and the performance is attributed to a test condition that although within the limits specified may be considered more severe than necessary; for example an ambient temperature near the limits allowed, the test may be conducted under conditions closer to the norm.

If the irradiance is other than 1 000 W/m^2, temperatures for more than two irradiance levels with at least 80 W/m^2 apart between the levels shall be determined, and a quadratic extrapolation conducted to determine the temperature under 1 000 W/m^2 irradiance.

Typical measurement points include:

- Module superstrate above the centre cell.
- Module substrate below the centre cell.
- Terminal enclosure interior surface.
- Terminal enclosure interior air space.
- Field wiring terminals.
- Insulation of the field wiring leads.
- External connector bodies (if so equipped).
- Diode bodies (if so equipped).

NOTE Due to the many possible variations in construction, more than one data gathering point for each cited location may be used, at the discretion of the test laboratory.

10.7.4 Requirements

The requirements are as follows:

a) No measured temperatures exceed any of the temperature limits of surfaces, materials, or components, as described in Table 9; or

b) No creeping, distortion, sagging, charring or similar damage to any part of the module, as indicated in 10.1.

Table 9 – Component temperature limits

Part, material or component	Temperature limits °C
Insulating materials: [c]	
Polymeric	[a]
Fiber	90
Laminated phenolic composition	125
Molded phenolic composition	150
Field wiring terminals, metal parts	30 above ambient
Field wiring compartments that wires may contact [d]	[a] or [d], whichever is greater, or [b]
Insulated conductors	[d]
Mounting surface (frame) and adjacent structural members	90

[a] The material's relative thermal index (RTI), less 20 °C.

[b] If a marking is provided to state the minimum temperature rating of the conductors to be used, the terminals at points within a wiring compartment may exceed the value specified but shall not attain a temperature higher than 90 °C.

[c] Higher temperatures than specified are acceptable if it can be determined that the higher temperatures will not cause a risk of fire or electric shock.

[d] Temperatures measured on insulated conductors shall not exceed the rated temperature of the conductor.

10.8 Fire test

Under consideration.

10.8.1 Approach

A PV module used in place of classified roofing material or mounted to or above an existing classified roofing material needs to comply with a single burning brand and spread of flame test, in accordance with the test outlined in Annex A, which are based on ANSI/UL 790. Sufficient samples shall be provided to create a single test assembly for a single spread of flame and a single burning brand test.

Products that comply with these tests are not readily flammable, afford a measurable degree of fire protection to the roof deck, do not slip from position, and are not expected to produce flying brands.

10.8.2 Pass criteria

The PV module system shall attain a fire resistance classification by compliance with the stated requirements of Annex A. Compliance with a single burning brand and spread of flame test is required for modules mounted over an existing roof covering. Additional sequential testing, such as that outlined in ANSI/UL 790, is required for modules acting as a roof covering material.

NOTE It is the intention of IEC Technical Committee 82 to use international standards, such as ISO 834, for fire resistance testing PV modules. Until this standard is available, the tests described here will be required as minimum safety qualification.

10.9 Reverse current overload Test MST 26

10.9.1 Purpose

Modules contain electrically conductive material, contained in an insulating system. Under reverse current fault conditions, the tabbing and cells of the module are forced to dissipate energy as heat, prior to circuit interruption by an over-current protector installed in the system. This test is intended to determine the acceptability of the risk of ignition or fire from this condition.

10.9.2 Procedure

The module under test is to be placed with its superstrate face down onto a 9 mm thick soft pine board, covered by a single layer of white tissue paper.

The back surface of the module shall be covered with a single layer of cheesecloth. The cheesecloth is to be untreated cotton cloth, running 26 m^2/kg to 28 m^2/kg and have a “thread count” of 32 by 28.

Any blocking diode provided shall be defeated (short-circuited).

The test shall be conducted in an area free of drafts.

The irradiance on the cell area of the module shall be less than 50 W/m^2.

A laboratory DC power supply shall be connected to the module with positive output connected to the positive terminal of the module. The reverse tests current (I_{test}) shall be equal to 135 % of the module’s overcurrent protection rating, as provided by the manufacturer. The test supply current should be limited to the value of I_{test}, and the test supply voltage shall be increased to cause the reverse current to flow through the module.

The test shall be continued for 2 h, or until ultimate results are known, whichever occurs first.

NOTE 1 Concerning the maximum overcurrent protection rating, see 12.2 of EN 61730-1.

NOTE 2 The maximum over-current protection rating of a module can be interpreted as the module series fuse rating. A series fuse may be required in the design of PV arrays. According to Subclause 12.2 of EN 61730-1 the maximum over-current protection rating has to be provided by the manufacturer.

10.9.3 Pass criteria

The pass criteria are as follows:

a) There shall not be flaming of the module, nor flaming or charring of the cheesecloth and tissue paper in contact with the module.

b) MST 17 shall meet the same requirements as for the initial measurements.

10.10 Module breakage test MST 32

10.10.1 Purpose

The purpose of this test is provide confidence that cutting or piercing injuries can be minimized if the module is broken.

NOTE If the glass is qualified in accordance with EN 12150-1 this test can be omitted.

10.10.2 Background

The test described herein is derived from ANSI Z97.1, Impact test.

10.10.3 Apparatus

The apparatus is as follows:

a) Impactors shall be leather punching bags of similar shape and size. The bag shall be filled to the required weight using chilled lead shot or pellets (2,5 mm to 3,0 mm in diameter – No. 7½ shot). Figure 4 shows the designs for the impactor bag. The exterior of the bag shall be wrapped with tape as shown in the figures. During testing, the impactor shall be completely covered with a 1,3 cm wide glass filament reinforced pressure sensitive tape. (See Figure 4).

b) A test frame similar to that shown in Figures 5 and 6 shall be provided to minimize movement and deflection during testing. The structure framing and bracing shall be steel channel (approximately C100 mm × 200 mm) or larger and shall have a minimum moment of inertia of approximately 187 cm^4. The frame shall be welded or securely bolted at the corners to minimize twisting during impact. It shall also be bolted to the floor to prevent movement during impact testing.

c) When an impactor bag is filled with lead shot, it will weigh approximately 45,5 kg, and will be capable of delivering 542 J of kinetic energy when swung through a 1,2 m vertical drop.

10.10.4 Procedure

Mount the module sample so that it is centered and rigid on the test frame using the method described by the manufacturer. The procedure is as follows:

a) At rest, no more than 13 mm from the surface of the module sample and no more than 50 mm from the center of the module sample.

b) Lift the impactor to a drop height of 300 mm from the surface of the module sample, allow the impactor to stabilize, and then release it to strike the module sample.

c) If no breakage occurs, repeat the sequence of b) from a drop height of 450 mm. If still no breakage occurs, repeat from a distance of 1 220 mm.

10.10.5 Pass criteria

The module shall be judged to have successfully passed the module breakage test if it meets any one of the following criteria:

a) When breakage occurs, no shear or opening large enough for a 76 mm (3-inch) diameter sphere to pass freely shall develop.

b) When disintegration occurs, the ten largest crack-free particles selected 5 min subsequent to the test shall weigh no more in grams than 16 times the thickness of the sample in millimetres.

c) When breakage occurs, no particles larger than 6,5 cm^2 shall be ejected from the sample.

d) The sample does not break.

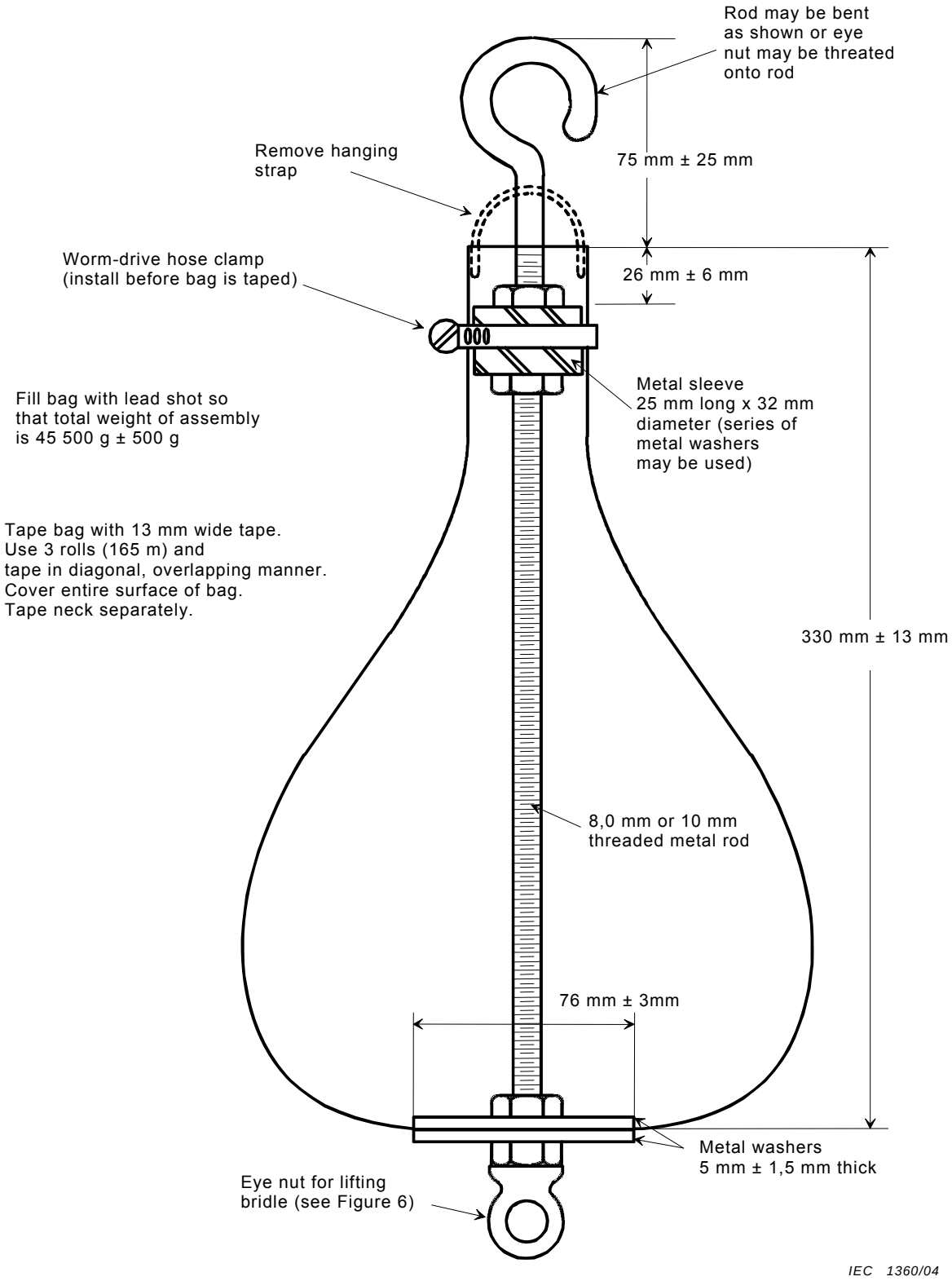


Figure 4 – Impactor

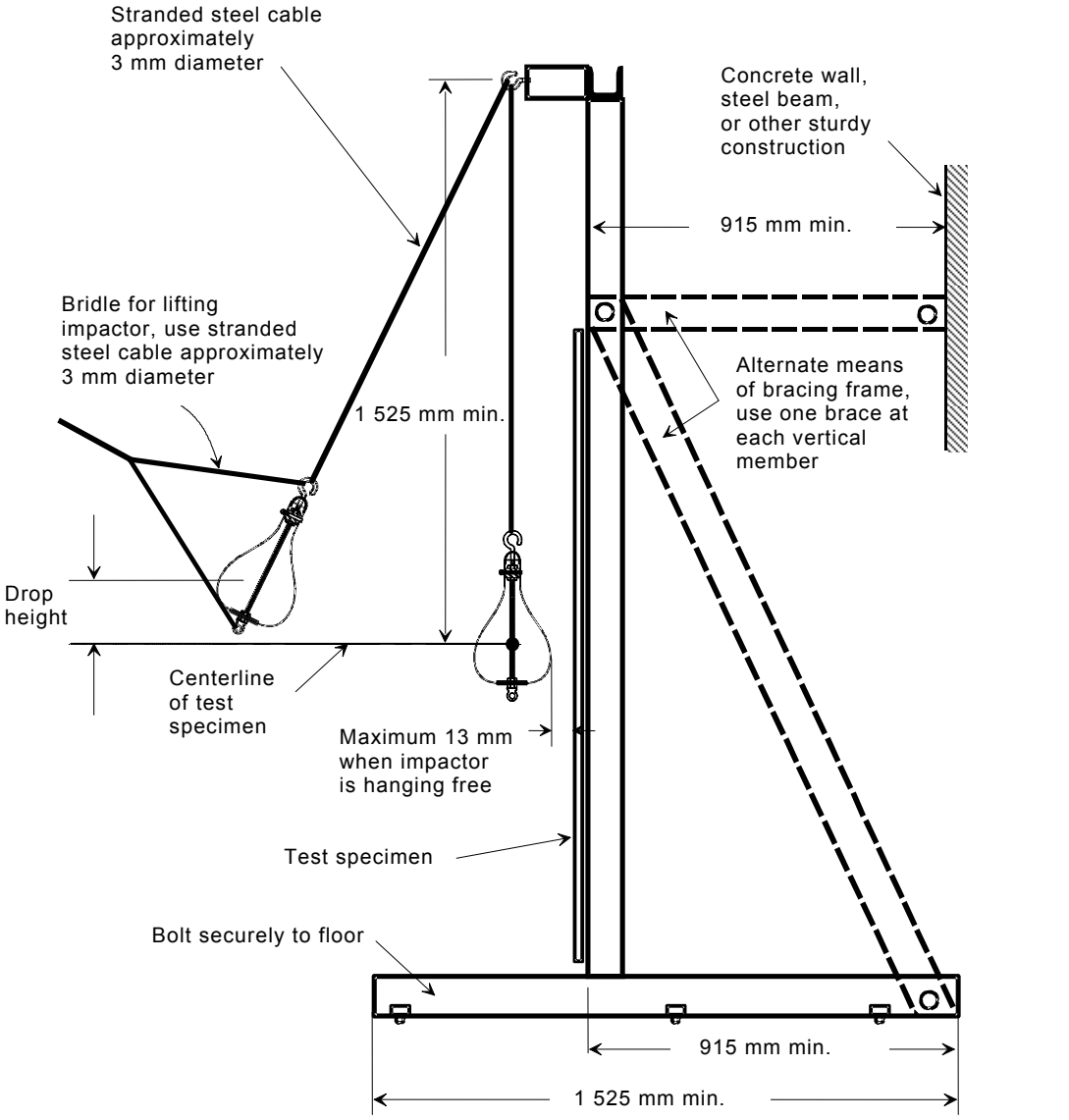
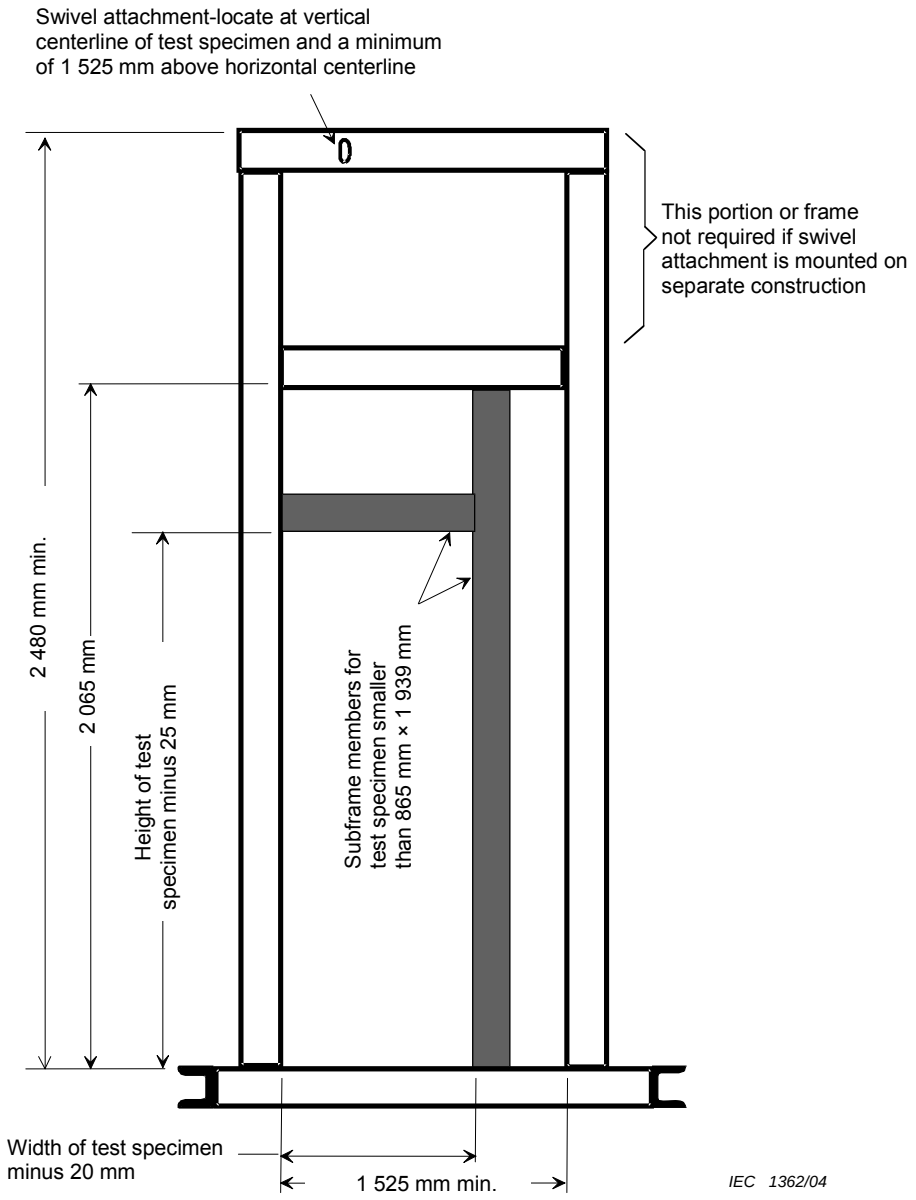


Figure 5 – Impact test frame 1



NOTE Clamping frame for holding test specimen not shown.

Figure 6 – Impact test frame 2

11 Component tests

11.1 Partial discharge-test MST 15

The test refers to 4.1.2.4 of IEC 60664-1.

11.1.1 Purpose

Polymeric materials intend for use as a superstrate or substrate, without appropriate IEC insulation pre-qualification must comply with the partial discharge test. This test should applied to any polymeric material serving as a superstrate or substrate (see also EN 61730-1).

11.1.2 Preconditioning

It is advisable to perform the partial discharge-test before using the back sheet foil in the PV module construction.

NOTE In order to achieve a certain statistical relevance 10 pieces should undergo the test. The size of the specimen depends on requirement originating from the test apparatus.

11.1.3 Apparatus

Calibrated charge measuring device or radio interference meter according to IEC 60664-1. The geometry of the electrodes shall be in conformance with EN 60243-1.

11.1.4 Procedure

The procedure is as follows:

a) According to C.2.1 and Clause D.1 of IEC 60664-1, starting from a value below the maximum system voltage, up to the point at which partial discharge takes place (inception voltage), the test voltage shall be further increased by 10 %.

NOTE 1 Any voltage below maximum systems voltage can be used but the test should start at zero voltage because it may happen that maximum systems voltage is not stated or unknown.

NOTE 2 When increasing the test voltage partial discharges may appear periodically. In that case, the inception voltage is the test voltage at which permanent discharges occur for a duration of at least 60 s.

b) The voltage shall then be lowered to the point at which the partial discharge extinction voltage is reached.

NOTE 3 Because partial discharges can disappear periodically, partial discharges at extinction voltage should stay below 1 pC for a minimum of 60 s.

c) The extinction voltage shall be considered to be reached once the charge intensity has dropped to a value of 1 pC. This voltage shall be measured with an accuracy better than 5 %.

d) The partial discharge extinction voltage may be influenced by environmental conditions. These influences are taken into account by a basic safety factor F_1 of 1,2.

e) The hysteresis factor according to 4.1.2.4 of IEC 60664-1 is reduced to 1. The additional safety factor for reinforced insulation F_3 = 1,25 is required for safety class A. The initial value of the test voltage is therefore 1,5 V_{OC} (system voltage given by the module manufacturer).

f) Repeat the measurement with 10 test samples.

11.1.5 Pass criteria

The solid insulation has passed the test if the mean value minus the standard deviation of the partial discharge extinction voltage is greater than 1,5 times the given maximum system voltage.

11.2 Conduit bending test MST 33

11.2.1 Purpose

Modules provided with junction boxes intended for attachment of a permanent wiring system using conduit must provide assurance of the ability of the box construction to withstand load forces which may be applied to the conduit during and after installation.

11.2.2 Procedure

Two 460-mm lengths of proper trade size conduit with appropriate fitting for the box shall be assembled and installed onto the box on opposing surfaces. For boxes intended for use with non-metallic conduit, the conduit test lengths are to be to welded to the fittings and allowed to dry no less than 24 h prior to assembly.

The test assembly, with the box at the centre, is to be placed on supports as illustrated in Figure 7. The supports are to be separated by a distance of 760 mm plus the distance between the ends of the conduit in the box, to give the required bending moment on the sample under test.

The load specified in Table 10 for the size of conduit used, is to be suspended from the centre of the box for 60 s. During this time, the box and the lengths of conduit shall be rotated through one complete revolution about the major axis of the assembly.

11.2.3 Pass criteria

The attachment walls of the module junction box shall not rupture or separate from the conduit.

NOTE If breakage of the conduit occurs prior to damage to the box or separation of the joint, performance of the box is considered acceptable.

Table 10 – Bending loads

Trade size of conduit mm	**Force load** N
13 to 25	220
26 to 50	330
51 to 100	490

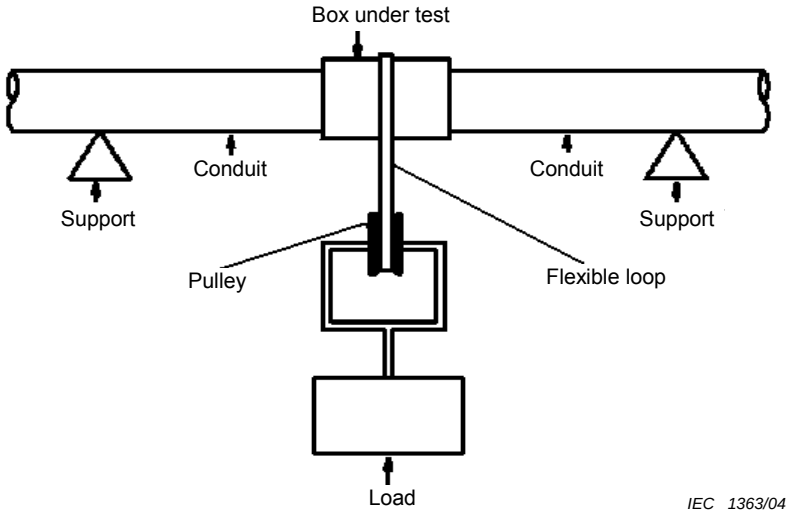


Figure 7 – Test fixture assembly

11.3 Terminal box knockout tests MST 44

11.3.1 Purpose

Removable hole covers in the walls of module terminal enclosures (knockouts) shall remain in place under nominal force application and also be easily removed for the field application of permanent wiring system components.

11.3.2 Condition

A sample of the polymeric terminal box with knockouts will be tested in an “as-received“ condition at a 25 °C ambient temperature.

Another sample of the polymeric box is to be conditioned for 5 h in air maintained at –20 °C ±1 °C. The test shall be repeated on the box immediately following this conditioning.

11.3.3 Procedure

The knockout shall be easily removed without leaving any sharp edges or causing any damage to the box. The procedure is as follows:

Step 1 – A force of 44,5 N shall be applied to a knockout for 1 min by means of a mandrel, minimum 38 mm long by 6,4 mm diameter, with a flat end. The force is to be applied in a direction perpendicular to the plane of the knockout and at the point most likely to cause movement. Wait 1 h and measure the displacement between the knockouts and the box.

Step 2 – The knockout shall then be removed by means of a screwdriver, used as a chisel. The edge of a screwdriver blade may be run along the inside edge of the resulting opening once only, to remove any fragile tabs remaining along the edge.

Step 3 – Repeat steps 1 and 2 on two additional knockouts.

For a box employing multi-stage knockouts, there shall be no displacement of a larger stage when a smaller stage is removed.

11.3.4 Pass criteria

The knockout shall remain in place after the application of the steady force and the clearance between the knockout and the opening shall not be more than 0,75 mm when measured.

The knockout shall be easily removed without leaving any sharp edges or causing any damage to the box.

Bibliography

IEC 60068-2-21:1999, *Environmental testing – Part 2-21: Tests – Test U: Robustness of terminations and integral mounting devices*

NOTE Harmonized as EN 60068-2-21:1999 (not modified).

IEC 60364-1:2001, *Electrical installations of buildings – Part 1: Fundamental principles, assessment of general characteristics, definitions*

NOTE Superseded by IEC 60364-1:2005, which is at draft stage for harmonization as HD 60364-1 (modified).

IEC 60529:1989, *Degrees of protection provided by enclosures (IP Code)*

NOTE Harmonized as EN 60529:1991 (not modified).

IEC 61345:1998, *UV test for photovoltaic (PV) modules*

NOTE Harmonized as EN 61345:1998 (not modified).

IEC 61721:1995, *Susceptibility of a photovoltaic (PV) module to accidental impact damage (resistance to impact test)*

Annex ZA
(normative)

Normative references to international publications with their corresponding European publications

The following referenced documents are indispensable for the application 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.

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
–	–	Glass in building - Thermally toughened soda lime silicate safety glass – Part 1: Definition and description	EN 12150-1	–[1)]
–	–	Datasheet and nameplate information for photovoltaic modules	EN 50380	2003
IEC 60060-1	–[1)]	High-voltage test techniques – Part 1: General definitions and test requirements	HD 588.1 S1	1999[2)]
IEC 60068-1	–[1)]	Environmental testing – Part 1: General and guidance	EN 60068-1	1994[2)]
IEC 60243-1	1998	Electrical strength of insulating materials - Test methods – Part 1: Tests at power frequencies	EN 60243-1	1998
IEC 60410	–[1)]	Sampling plans and procedures for inspection by attributes	–	–
IEC 60664-1 + A1 + A2	1992 2000 2002	Insulation coordination for equipment within low-voltage systems – Part 1: Principles, requirements and tests	EN 60664-1	2003
IEC 60904-2	–[1)]	Photovoltaic devices – Part 2: Requirements for reference solar devices	EN 60904-2	2007
IEC 61032	1997	Protection of persons and equipment by enclosures - Probes for verification	EN 61032	1998
IEC 61140	–[1)]	Protection against electric shock - Common aspects for installation and equipment	EN 61140	2002[2)]
IEC 61215	2005	Crystalline silicon terrestrial photovoltaic (PV) modules - Design qualification and type approval	EN 61215	2005
IEC 61646	1996	Thin-film terrestrial photovoltaic (PV) modules - Design qualification and type approval	EN 61646	1997
IEC 61730-1 (mod)	2004	Photovoltaic (PV) module safety qualification– Part 1: Requirements for construction	EN 61730-1	2007
ISO/IEC 17025	–[1)]	General requirements for the competence of testing and calibration laboratories	EN ISO/IEC 17025	2005[2)]
ANSI/UL 514C	–[1)]	Non-metallic outlet boxes, flush device boxes and covers	–	–
ANSI/UL 790	–[1)]	Tests for Fire Resistance of Roof Covering Materials	–	–
ANSI/UL 1703	–[1)]	Flat – Plate Photovoltaic Modules and Panels	–	–

[1)] Undated reference.
[2)] Valid edition at date of issue.

Publication	Year	Title	EN/HD	Year
ANSI Z97.1	–[1)]	American National Standard for Safety Glazing Materials Used in Buildings - Safety Performance Specifications and Methods of Test	–	–

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