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BSI Standards Publication

Connectors for DC-application in photovoltaic systems — Safety requirements and tests

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National foreword

This British Standard is the UK implementation of EN 62852:2015. It is identical to IEC 62852:2014. It supersedes BS IEC 62852:2014, which is withdrawn.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.

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Foreword

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Endorsement notice

The text of the International Standard IEC 62852:2014 was approved by CENELEC as a European Standard without any modification.

In the official version, for Bibliography, the following notes have to be added for the standards indicated:

IEC 60068-2-70:1995	NOTE	Harmonized as EN 60068-2-70:1996 (not modified).
IEC 60112:2003	NOTE	Harmonized as EN 60112:2003 (not modified).
IEC 60364-4-41:2005	NOTE	Harmonized as HD 60364-4-41:2007 (modified).
IEC 60364-5-51:2005	NOTE	Harmonized as HD 60364-5-51:2009 (modified).
IEC 60364-5-54:2011	NOTE	Harmonized as HD 60364-5-54:2011 (not modified).
IEC 61730-1:2004	NOTE	Harmonized as EN 61730-1:2007 (modified).
IEC 61730-2	NOTE	Harmonized as EN 61730-2.

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CONNECTORS FOR DC-APPLICATION IN PHOTOVOLTAIC SYSTEMS – SAFETY REQUIREMENTS AND TESTS

1 Scope

This International Standard applies to connectors for use in the d.c. circuits of photovoltaic systems according to class II of IEC 61140:2001 with rated voltages up to 1 500 V d.c. and rated currents up to 125 A per contact.

This standard applies to connectors without breaking capacity but which might be engaged and disengaged under voltage.

This standard also applies to connectors which are intended to be built-in or integrated in enclosures of devices for photovoltaic systems. This standard may be used as a guide for connectors in photovoltaic systems of classes 0 and III according to IEC 61140:2001 as well as for protection for Class II equipment intended for use at less than 50 V d.c.

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 60050 (all parts): *International Electrotechnical Vocabulary* (available at http://www.electropedia.org)

IEC 60060-1:2010, *High-voltage test techniques – Part 1: General definitions and test requirements*

IEC 60068-1:2013, *Environmental testing – Part 1: General and guidance*

IEC 60068-2-14:2009, *Environmental testing – Part 2-14: Tests – Test N: Change of temperature*

IEC 60068-2-75:1997, *Environmental testing – Part 2-75: Tests – Test Eh: Hammer tests*

IEC 60068-2-78:2012, *Environmental testing – Part 2-78: Tests – Test Cab: Damp heat, steady state*

IEC 60228:2004, *Conductors of insulated cables*

IEC 60309-1:1999, *Plugs, socket-outlets and couplers for industrial purposes – Part 1: General requirements*

IEC 60352-2:2006, *Solderless connections – Part 2: Solderless crimped connections – General requirements, test methods and practical guidance*

IEC 60352-3:1993, *Solderless connections – Part 3: Solderless accessible insulation displacement connections – General requirements, test methods and practical guidance*

IEC 60352-4:1994, *Solderless connections – Part 4: Solderless non-accessible insulation displacement connections – General requirements, test methods and practical guidance*

IEC 60352-5:2012, *Solderless connections – Part 5: Press-in connections – General requirements, test methods and practical guidance*

IEC 60352-6:1997, *Solderless connections – Part 6: Insulation piercing connections – General requirements, test methods and practical guidance*

IEC 60352-7:2002, *Solderless connections – Part 7: Spring clamp connections – General requirements, test methods and practical guidance*

IEC 60364-7-712:2002, *Electrical installations of buildings – Part 7-712: Requirements for special installations or locations – Solar photovoltaic (PV) power supply systems*

IEC 60512 (all parts), *Connectors for electronic equipment – Tests and measurements*

IEC 60512-1:2001, *Connectors for electronic equipment – Tests and measurements – Part 1: General*

IEC 60512-11-7:2003, *Electromechanical components for electronic equipment – Basic testing procedures and measuring methods – Part 11-7: Climatic tests – Test 11g: Flowing mixed gas corrosion test*

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

IEC 60664-1:2007, *Insulation coordination for equipment within low voltage systems – Part 1: Principles, requirements and tests*

IEC 60695-2-11:2014, *Fire hazard testing – Part 2-11: Glowing/hot-wire based test methods - Glow-wire flammability test method for end-products (GWEPT)*

IEC 60695-11-10:2013, *Fire hazard testing – Part 11-10: Test flames – 50 W horizontal and vertical flame test methods*

IEC TR 60943:1998, *Guidance concerning the permissible temperature rise for parts of electrical equipment, in particular for terminals*

IEC 60998-2-3:2002, *Connecting devices for low-voltage circuits for household and similar purposes – Part 2-3: Particular requirements for connecting devices as separate entities with insulation-piercing clamping units*

IEC 60999-1:1999, *Connecting devices – Electrical copper conductors – Safety requirements for screw-type and screwless-type clamping units – Part 1: General requirements and particular requirements for clamping units for conductors from 0,2 mm^2 up to 35 mm^2 (included)*

IEC 60999-2:2003, *Connecting devices – Electrical copper conductors – Safety requirements for screw-type and screwless-type clamping units – Part 2: Particular requirements for clamping units for conductors above 35 mm^2 up to 300 mm^2 (included)*

IEC 61032:1997, *Protection of persons and equipment by enclosures – Probes for verification*

IEC 61140:2001, *Protection against electric shock – Common aspects for installation and equipment*

IEC 61210: 2010, *Connecting devices – Flat quick-connect terminations for electrical copper conductors –Safety requirements*

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

IEC 61984:2008, *Connectors – Safety requirements and tests*

IEC 62444:2010, *Cable glands for electrical installations*

IEC TS 62548, *Photovoltaic (PV) arrays – Design requirements*

ISO 4892-2, *Plastics – Methods of exposure to laboratory light sources – Part 2: Xenon-arc sources*

ISO 4892-3, *Plastics – Methods of exposure to laboratory light sources – Part 3: Fluorescent UV-lamps*

ISO 6988:1985, *Metallic and other non organic coatings – Sulfur dioxide test with general condensation of moisture*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60050-581, IEC 60050-826, IEC 60309-1, IEC 60664-1, IEC 60999-1 and IEC 61140, as well as the following apply.

3.1
connector
component which terminates conductors for the purpose of providing connection to and disconnection from a suitable mating component

[SOURCE: IEC 60050-581:2008, 581-06-01]

3.2
multi-way connector
connector with more than one contact

Note 1 to entry: Multiple single-way connectors used in a PV-junction box are not to be regarded as a multi-way connector according to this standard.

3.3
connector under voltage
CuV
connector specially designed to be engaged or disengaged in normal use when live but not under load

Note 1 to entry: In this standard, the term "live" is used if contacts are under an applied voltage, but not necessarily carrying current. The term "load" is used if a current is flowing through the contacts.

3.4
connector without breaking capacity
COC
connector which is not allowed to be engaged or disengaged in normal use when live or under load

[SOURCE: IEC 60050-581:2008, 581-27-73]

3.5
type of connector

3.5.1
free connector
connector for attachment to the free end of a wire or cable

[SOURCE: IEC 60050-581:2008, 581-06-12]

3.5.2
built-in connector
a pre-manufactured connector that is subsequently integrated into an enclosure

3.5.3
integrated connector
a connector assembly that is manufactured as an integral component during enclosure fabrication

3.6
non-rewirable connector
connector so constructed that the cable cannot be separated from the connector without making it permanently useless

[SOURCE: IEC 60309-1:1999, 2.5, modified]

3.7
connector for Class II equipment
connector in which the protection against indirect contact is realised by double or reinforced insulation

Note 1 to entry: Class II according to IEC 61140.

3.8
intended use
application conditions of connectors which are included within the permissible rated values and environmental conditions and characteristics assigned by the manufacturer

3.9
interlock
device, either electrical or mechanical, which prevents the contacts of a connector from becoming live before it is in proper engagement with its counterpart, and which either prevents the connector from being withdrawn while its contacts are live or makes the contacts dead before separation

[SOURCE: IEC 60309-1:1999, 2.9, modified]

3.10
cycle of mechanical operation
one insertion and one withdrawal of the connector with his counterpart

3.11
clamping unit
part(s) of the terminal necessary for the mechanical clamping and the electrical connection of the conductor(s), including the parts which are necessary to ensure the correct contact pressure

[SOURCE: IEC 60999-1:1999, 3.1]

3.12
upper limiting temperature
maximum temperature of a connector as defined by the manufacturer, in which the connector is intended to operate

Note 1 to entry: The abbreviation ULT is often used.

3.13
ambient temperature
maximum temperature of the ambient assigned from the manufacturer, in which the connector is able to operate permanently without the upper limiting temperature being exceeded

3.14
lower limiting temperature
minimum temperature of a connector as defined by the manufacturer in which a connector is intended to operate

Note 1 to entry: The abbreviation LLT is often used.

3.15
clearance
the shortest distance in air between two conductive parts

[SOURCE: IEC 60664-1:2007, 1.3.2]

3.16
creepage distance
shortest distance along the surface of the insulating material between two conductive parts

[SOURCE: IEC 60664-1:2007, 1.3.3]

3.17
overvoltage category
numeral defining a transient overvoltage condition

[SOURCE: IEC 60664-1:2007, 1.3.10]

3.18
pollution
any addition of foreign matter, solid, liquid, or gaseous, that can result in a reduction of electric strength or surface resistivity of the insulation

[SOURCE: IEC 60664-1:2007, 1.3.11]

3.19
pollution degree
numeral characterising the expected pollution of the micro-environment

[SOURCE: IEC 60664-1:2007, 1.3.13]

3.20
rated voltage
value of voltage assigned by the manufacturer to the connector and to which operation and performance characteristics are referred

Note 1 to entry: Rated voltage is equivalent to the rated system voltage according to IEC 61730-1.

[SOURCE: IEC 60664-1:2007, 1.3.9, modified]

3.21
rated insulation voltage
r.m.s. withstand voltage value assigned by the manufacturer to the connector, characterising the specified (long term) withstand capability of its insulation

Note 1 to entry: The rated insulation voltage is not necessarily equal to the rated voltage, which is primarily related to functional performance.

[SOURCE: IEC 60664-1:2007, 1.3.9.1, modified]

3.22
rated impulse voltage
impulse withstand voltage value assigned by the manufacturer to the connector, characterising the specified withstand capability of its insulation against transient overvoltages

[SOURCE: IEC 60664-1:2007, 1.3.9.2, modified]

3.23
impulse withstand voltage
highest peak value of impulse voltage, of prescribed form and polarity which does not cause breakdown of the insulation under specified conditions

Note 1 to entry: The impulse withstand voltage is equal to or higher than the rated impulse voltage.

[SOURCE: IEC 60664-1:2007, 1.3.8.1]

3.24
r.m.s. withstand voltage
power-frequency withstand voltage
highest r.m.s. value of a voltage which does not cause breakdown of the insulation under specified conditions

[SOURCE: IEC 60664-1:2007, 1.3.8.2]

3.25
rated current
current value assigned by the manufacturer, which the connector can carry continuously (without interruption) and simultaneously through all its contacts wired with the largest specified conductor, preferably at an ambient temperature of 85 °C, without the upper limiting temperature being exceeded

Note 1 to entry:If other ambient temperature values are used for the definition of the rated current, the manufacturer should state in the technical documentation the ambient temperature on which the rating is based, with reference, if appropriate, to the derating curve defined in IEC 60512-5-2, test 5b.

3.26
functional insulation
insulation between conductive parts which is necessary only for the proper functioning of the equipment

[SOURCE: IEC 60664-1:2007, 1.3.17.1]

3.27
basic insulation
insulation applied to live parts to provide basic protection against electric shock

Note 1 to entry: Basic insulation does not necessarily include insulation used exclusively for functional purposes (see IEC 61140:2001, 3.10.1).

[SOURCE: IEC 60664-1:2007, 1.3.17.2]

3.28
supplementary insulation
independent insulation applied in addition to basic insulation, in order to provide protection against electric shock in the event of a failure of basic insulation (see IEC 61140:2001, 3.10.2)

[SOURCE: IEC 60664-1:2007, 1.3.17.3]

3.29
double insulation
insulation comprising both basic insulation and supplementary insulation (see IEC 61140:2001, 3.10.3)

[SOURCE: IEC 60664-1:2007, 1.3.17.4]

3.30
reinforced insulation
single insulation system applied to live parts, which provides a degree of protection against electric shock equivalent to double insulation under the conditions specified in the relevant IEC standard (see IEC 61140:2001, 3.10.4)

Note 1 to entry: A single insulation system does not imply that the insulation is a homogeneous piece. It may comprise several layers which cannot be tested separately as basic or supplementary insulation.

[SOURCE: IEC 60664-1:2007, 1.3.17.5]

3.31
internal insulation
part of basic insulation providing the required clearance and creepage distances inside a conductive housing or enclosure

4 Classification

4.1 General

In order to apply the relevant test requirements, connectors shall be classified by the manufacturer's specification, according to their intended use under consideration of class II, according to IEC 61140 and characteristics, as set out below.

4.2 Type of connector

a) Free connector.

b) Built-in connector.

c) Integrated connector.

4.3 Additional characteristics

a) Connector with cable anchorage.

b) IP-code of a connector according to IEC 60529.

c) Connector for Class II equipment.

d) Non-rewirable connector.

e) Rewirable connector.

f) Terminations and connection methods.

5 Constructional requirements and performance

5.1 General

This standard does not define electrical rating values for voltage and current. These values are assigned by the manufacturer.

Connectors shall be suitable for durable outdoor use in an ambient temperature area from –40 °C to +85 °C.

Multi-way connectors shall be designed so that these requirements for earth-faulted and short-circuit-proofed installation complies with IEC TS 62548 or IEC 60364-7-712.

Compliance with the requirements is verified by the specified tests of this standard.

5.2 Marking and identification

5.2.1 Identification

Connectors shall be identified and characterised by the following:

a) manufacturer’s name, trademark or mark of origin;

b) type reference (for example, the catalogue number);

c) rated current in amperes (A);

d) rated voltages or rated insulation voltages between line to earth and line to line in volts (V);

e) rated impulse voltage in kilovolts (kV), if specified;

f) pollution degree;

g) degree of protection by enclosure according to IEC 60529;

h) range of temperature (ULT and LLT, maximum ambient temperature);

i) type of terminals;

j) connectable conductors;

NOTE For current capacity of cables and wires, see IEC 60364-5-52.

k) reference to this standard or to the Detail Specification (DS), if applicable;

l) symbols „Do not disconnect under load“, as given in Annex A; alternatively an adequate warning notice can be found in particular national language;

m) polarity of connector, if applicable.

5.2.2 Marking

The marking shall be indelible and easily legible.

The minimum marking on the connector shall be that of item a), l) and m) in 5.2.1.

Symbol or warning notice listed in l) of 5.2.1 shall be imprinted or labelled close to connector. A notice to attach the label shall be given in technical documentation.

Markings a) and b) of 5.2.1 shall be applied on the smallest package unit.

5.2.3 Technical documentation

Identification items of 5.2.1 not marked on the connector according to 5.2.2 and the following information shall be given in the technical documentation of the manufacturer:

a) information regarding the type of cable suitable for termination, if applicable;

b) information regarding mounting, if applicable;

c) assembly information such as required tooling (part number) by manufacturer, if applicable.

5.3 Provision against incorrect mating (non-intermateable)

A multi-way connector shall be so designed that contact between live contacts of different polarity is not possible by engagement.

Compliance shall be tested by performing a polarisation test (see A3 of Table 6).

5.4 Protection against electric shock

5.4.1 A connector shall be so designed that, after mounting, its live parts are not accessible by the IEC test finger in accordance with IEC 60529.

5.4.2 Protection against electric shock shall be ensured also during insertion and withdrawal. Compliance shall be tested by the IEC test probe 11 in accordance with IEC 61032.

5.5 Terminations and connection methods

This standard applies to the following terminations and connection methods:

a) crimped connections	according to IEC 60352-2
b) insulation displacement connections	according to IEC 60352-3 (accessible IDC) or IEC 60998-2-3
c) insulation displacement connections	according to IEC 60352-4 (non-accessible IDC) or IEC 60998-2-3
d) press-in connections	according to IEC 60352-5
e) insulation piercing connections	according to IEC 60352-6 or IEC 60998-2-3
f) screwless-type clamping units	according to IEC 60999-1 or IEC 60999-2 or IEC 60352-7
g) screw-type clamping units	according to IEC 60999-1 or IEC 60999-2
h) flat, quick-connect terminations	according to IEC 61210

As a minimum the applicable tests according to 6.3.15 shall be performed for all terminations and connection methods intended to be used.

Other terminations and connection methods shall be tested in accordance with the relevant standards.

Soldering and welding connections are also permitted.

Termination and connection methods shall provide sufficient means for retaining the conductor in position.

Electrical connections shall be so designed that the contact pressure is not transmitted through insulating material other than ceramic, pure mica or other material with characteristics not less suitable, unless there is sufficient resiliency in the metallic parts to compensate for any shrinkage or yielding of the insulating material (see IEC 60309-1:1999, 25.3 or IEC 60999-1:1999, Clause 7 or IEC 60999-2). Insulation piercing terminations and insulation displacement connections are excluded from this requirement because of the tests performed according to IEC 60352-6 or IEC 60998-2-3.

Precautions shall be taken to ensure that adequate contact pressure is maintained during connector lifetime.

To compensate for changes during use, (e.g. loosening at screw-type clamping units caused by thermal cycles) the use of a lock washer, spring washer or similar could be sufficient.

All terminations and connection methods shall be protected from mechanical and excessive thermal stress which could cause increased contact resistance.

5.6 Resistance to deterioration

If deterioration of specific parts might impair safety, the resistance of those parts to expected stresses shall be verified by the execution of the test program in Clause 6.

5.7 General design

5.7.1 Mechanisms which are used for mounting the connector and/or termination of conductors shall not be used to fix live parts in the connector housing, if it may impair the proper function of the mechanism or reduce the clearance and creepage distances below the requirements according to 5.18.

5.7.2 Connectors shall be so designed that connection of conductors of the type and cross-sectional areas as specified by the manufacturer is possible. Besides the termination of the conductor, care shall be taken that no damage of the insulation is possible, e.g. by avoiding sharp edges.

5.7.3 Cables connected to the connector shall be suitable for use in photovoltaic systems. The values of the rated current and the rated voltage shall have at least the rated values of the connector. Cables shall be flexible and the conductor shall be at least class 5 according to IEC 60228.

5.7.4 Non-rewirable connectors shall be so designed that:

– the flexible cable cannot be separated from the connector without making it permanently useless,
– the connector cannot be disassembled or parts of it cannot be removed by hand or by using a general purpose tool, for example a screwdriver, as intended,
– means are provided to prevent live parts, e.g. free strands of a conductor, from reducing the minimum insulation distance between such live parts and all accessible external surfaces of the connector, with the exception of the engagement face of the male connector,
– a connector becomes useless for further use when for the re-mounting, other parts than the original ones are necessary,
– connectors with non-rewirable terminations are also considered as rewirable, if they are reconstituted with original parts and with tools of the manufacturer, if applicable.

If this cannot be granted by the design or manufacturing process itself, the in-process test schedule according to 6.4 or another test of the same safety level shall be carried out.

5.8 Design of a free connector

In a free connector, the wires shall be protected against shear and tensile stress at the termination and be secured to prevent twisting.

This requirement does not apply to

a) free connectors for termination to cables in fixed mountings (plug connection in the sense of a detachable connection),

b) free connectors in which the termination is protected against pull and twisting mounting provisions in the end-use product.

5.9 Degree of protection (IP Code)

A connector shall have a degree of protection at least of IP55, according to IEC 60529.

Depending on the installation a higher degree of protection may be required.

5.10 Dielectric strength

A connector shall withstand the specified test voltage. Compliance is determined by the tests according to 6.3.8.

5.11 Mechanical and electrical durability

5.11.1 A connector shall meet the mechanical operations without load of 50 operating cycles.

5.11.2 A non-rewirable connector shall withstand number of bends as described in 6.3.6.

Compliance shall checked by the execution of tests in 6.3.5 and 6.3.6.

5.12 Range of ambient temperature

A connector shall withstand the upper and lower values of temperature range as given in 5.2.1 or as specified by the manufacturer, if lower than the minimum value or higher than the maximum value as defined in 5.2.1.

Compliance is determined by the tests according to test program in Clause 6.

5.13 Temperature rise

The sum of the ambient temperature and the temperature rise of a connector shall not exceed the upper limiting temperature.

Compliance shall be checked by the execution of test 6.3.4.

5.14 Cable anchorage

The cable anchorage shall be suitable for the cable to be connected. The range of acceptable cable diameters shall be specified in the manufacturer’s specification. Tensile and torsion requirements shall be as specified in Table 1.

Loose parts inserted to obtain clamping of the cable are permissible if they are fixed in the connector in the assembled state.

The cable anchorage can be made of insulating material or metal. If it consists of metal, it shall meet one of the following requirements:

a) be provided with a covering of insulating material to prevent any accessible metal part becoming live in case of a fault;

b) no contact shall be possible with the test finger according to IEC 60529.

Table 1 – Values for cable anchorage testing

Cable diameter mm	Tensile requirements		Torsion requirements	
	Tensile force N	Permissible displacement mm	Torque Nm	Permissible angle °
4 up to 9	80	3	0,10	±30
>9 up to 12	100		0,15	
>12 up to 20	120	5	0,6	±45
>20 up to 33	150		0,8	
>33 up to 42	200		0,9	
>42	250		1,2	

Compliance is checked by the execution of the test phase A6.1 and A6.2 of Table 6 with the values of Table 1.

For metric cable glands meeting the requirements of IEC 62444 the tests described in this subclause are not required.

5.15 Mechanical strength

5.15.1 A connector including its internal insulation shall show no damage likely to impair safety after exposure to mechanical stress according to Table 6.

5.15.2 In a connector assembled for final use, the contacts shall be securely retained in the contact insert.

5.16 Connector without locking device

Connectors without locking device or without snap-in device shall withstand a withdrawal force of at least 50 N.

Compliance shall be tested according to 6.3.13.

NOTE In some countries locking devices are required. Some countries also require locking devices which can be opened only by use of a tool.

5.17 Connector with locking device

Connectors with locking device or with snap-in device shall withstand a load of at least 80 N.

Compliance shall be tested according to 6.3.14.

5.18 Clearances and creepage distances

5.18.1 General

Clearances and creepage distances shall be dimensioned according to the following specifications.

For connectors the requirements for double insulation shall be met between energized and accessible parts in the engaged position.

For multi-way connectors the requirements for double or reinforced insulation shall be met between energized and accessible parts with different electrical potential in engaged and unengaged positions.

5.18.2 Clearances

Clearances through slots and openings in enclosures of insulating material shall be dimensioned according to Table 2.

Table 2 – Rated impulse voltages and minimum clearances

	Basic insulation		Reinforced insulation	
Rated DC voltage	**Rated impulse voltage**	**Clearance**	**Rated impulse voltage**	**Clearance**
V	kV (1,2/50 μs)	mm	kV (1,2/50 μs)	mm
100	1,5	0,5	2,5	1,5
150	2,5	1,5	4,0	3,0
300	4,0	3,0	6,0	5,5
600	6,0	5,5	8,0	8,0
1 000	8,0	8,0	12	14
1 500	10	11	16	19
Minimum values for pollution degree 2 is 0,2 mm and for pollution degree 3 is 0,8 mm.				
NOTE Values are derived from IEC 60664-1:2007 for overvoltage category III and IEC TR 60664-2-1.				

5.18.3 Creepage distances

5.18.3.1 General

Creepage distances between live parts and accessible surfaces shall be dimensioned for reinforced or double insulation according to Table 3 related to the rated voltage considering the pollution degree as specified in 5.18.3.2.

For relation between creepage distance and clearances see 5.2.2.6 of IEC 60664-1:2007.

Table 3 – Creepage distances for basic insulation

Voltage (DC) V	Pollution degree 1	Pollution degree 2			Pollution degree 3		
	All material groups	Material group I	Material group II	Material group III	Material group I	Material group II	Material group III
	mm	mm	mm	mm	mm	mm	mm
25	0,125	0,5	0,5	0,5	1,3	1,3	1,3
50	0,18	0,6	0,9	1,2	1,5	1,7	1,9
100	0,25	0,71	1,0	1,4	1,8	2,0	2,2
150	0,31	0,8	1,1	1,6	2,0	2,2	2,5
200	0,42	1,0	1,4	2,0	2,5	2,8	3,2
300	0,70	1,5	2,1	3,0	3,8	4,2	4,7
600	1,7	3,0	4,3	6,0	7,6	8,6	9,5
1 000	3,2	5,0	7,1	10,0	12,5	14,0	16,0
1 500	5,2	7,5	10,4	15	18,9	20,9	23,6

Linear interpolation is allowed.

Values for reinforced or double insulation are twice the values for basic insulation.

NOTE Values are derived from IEC 60664 for overvoltage category III, some values are rounded.

5.18.3.2 Pollution degree

Creepage distances and clearances between hazardous live parts and accessible surfaces outside the enclosure shall be dimensioned according to pollution degree 3. Distances inside the enclosure shall be at least dimensioned for pollution degree 2.

5.18.3.3 Comparative tracking index (CTI)

Insulation materials are classified into four groups corresponding to their comparative tracking index (CTI), when tested in accordance with IEC 60112:

Material Group I CTI ≥600

Material Group II 400 ≤ CTI < 600

Material Group IIIa 175 ≤ CTI < 400

Material Group IIIb 100 ≤ CTI < 175

A material may be included in one of these four groups on the basis that the PTI, verified by the method of IEC 60112 using solution A, is not less than the lower value specified for the group.

The values specified for the groups are reference values and based on the test voltage of IEC 60112. The test voltage is not in relation to any voltage (system voltage, working voltage, etc.) of a PV module or system.

The test for comparative tracking index (CTI) in accordance with IEC 60112 is designed to compare the performance of various insulating materials under test conditions. It gives a qualitative comparison and in the case of insulating materials having a tendency to form tracks, it also gives a quantitative comparison.

5.19 Insulation parts

5.19.1 General

Insulating parts shall be so designed that they withstand the expected thermal requirements.

5.19.2 Outer accessible parts

Outer accessible parts consisting of isolating material whose deterioration could impair the safety of the connector shall meet following requirements:

a) Flammability Class minimum HB, or V-2 according to IEC 60695-11-10. This shall be proved by a data sheet of the material supplier or by a test of the end-product.

   Flammability V-1 or V-0 according to IEC 60695-11-10 are also acceptable.

b) Weather resistance according to ISO 4892-2, method A or ISO 4892-3 with a total duration of 500 h. Dielectric strength according to 6.3.8 b) shall be fulfilled after the test.

c) Glow wire test with 650 °C according to IEC 60695-2-11.

5.19.3 Inner parts

Inner parts consisting of isolating material retaining current carrying parts in position shall meet following requirements:

a) Flammability Class minimum HB, or V-2 according to IEC 60695-11-10. This shall be proved by a data sheet of the material supplier or a test of the end-product.

   Flammability V-1 or V-0 according to IEC 60695-11-10 are also acceptable.

b) Isolating material shall have a CTI-value complying with the rated values of this standard according to IEC 60664-1.

c) Glow wire test with 750 °C according to IEC 60695-2-11.

5.20 Current carrying parts and resistance against corrosion

5.20.1 Metal parts shall be so designed that corrosion shall not impair safety with regard to electrical and mechanical characteristics.

Compliance is checked by 6.3.9.

All current carrying parts shall consist of base metal and plating, such that under normal operation a sufficient mechanical strength, electrical conductivity and corrosion resistance as described in this standard are given.

5.20.2 Under wet ambient conditions all metal parts which have a difference of their electrochemical potentials more than 350 mV according to IEC/TR 60943 shall not be in contact with each other.

6 Tests

6.1 General

6.1.1 The tests shall be carried out in the sequence specified for each test group using the number of specimens as given in Table 4. For each test group a separate set of new specimens shall be used.

If designs of connectors require special tests or preparations which are not explicitly indicated in this standard they are chosen or carried out according to the manufacturers specification, e.g. mechanical locking during IP code testing.

Table 4 – Plan of specimens required for tests

Reference table	Test group	Number of specimens
6	Group A: mechanical	One per test
7	Group B: service life	3
8	Group C: service life	3
9	Group D: thermal	3
10	Group E: climatic	3
11	Group F: degree of protection	2
12	Group G: isolating material	3
NOTE For a connector family of the same design and comparable size, tests may be only for that member of a family which represents the worst case for that test.		

6.1.2 A pair of connectors (male and female) or free contacts are defined as a specimen. Unless otherwise specified in the test program the unmated pair of connectors shall be tested

6.1.3 The tests shall be made under the standard atmospheric conditions of IEC 60068-1, unless otherwise specified in the test schedule.

6.1.4 The specimen is deemed not to comply with this standard if the specimen fails in more than one of the tests of any test group. If the specimen fails in one of the tests, this test and the preceding tests which may have affected its results shall be repeated on a new set of specimen. This new specimen shall pass the repeated tests, otherwise the product is deemed not to comply.

6.1.5 All visual examination tests shall be performed with the naked eye, unless otherwise specified.

6.2 Preparation of specimens

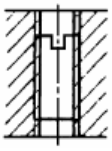
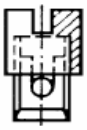
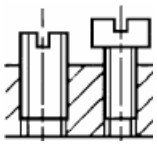
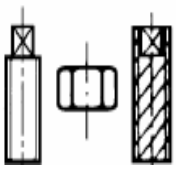
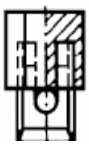
6.2.1 Specimens shall be pre-conditioned under standard conditions for testing, for a period of 24 h, in accordance with IEC 60512-1.

6.2.2 The tests shall be carried out with copper conductors unless otherwise specified by the manufacturer and with the type of conductor specified for the connector. If terminations are provided for all types of conductors, solid, stranded and flexible, the tests shall be carried out only with flexible conductors according to IEC 60228, Class 5.

6.2.3 Screw-type clamping units shall be tightened with the value of the torque stipulated in Table 5 according to IEC 60999-1 and IEC 60999-2 unless otherwise specified by the manufacturer.

6.2.4 Unless otherwise specified in the test schedule, all tests shall be made on the specimen completely assembled according to the manufacturer’s instructions.

Table 5 – Values of torque for screw-type clamping units

Nominal diameter of thread mm	 **I** Nm	 **II** Nm	 **III** Nm	 **IV** Nm	 **V** Nm
≤ 1,6			0,1	0,1	
> 1,6 up to 2,0			0,2	0,2	
> 2,0 up to 2,8	0,2		0,4	0,4	
> 2,8 up to 3,0	0,25		0,5	0,5	
> 3,0 up to 3,2	0,3		0,6	0,6	
> 3,2 up to 3,6	0,4		0,8	0,8	
> 3,6 up to 4,1	0,7	1,2	1,2	1,2	1,2
> 4,1 up to 4,7	0,8	1,2	1,8	1,8	1,8
> 4,7 up to 5,3	0,8	1,4	2,0	2,0	2,0
> 5,3 up to 6,0	1,2	1,8	2,5	3,0	3,0
> 6,0 up to 8,0	2,5	2,5	3,5	6,0	4,0
> 8,0 up to 10,0		3,5	4,0	10,0	6,0
> 10,0 up to 12,0		4,0		14,0	8,0
> 12,0 up to 15		5,0		19,0	10,0

Column I applies to screws without heads if the screw, when tightened, does not protrude from the screw hole and to other screws which cannot be tightened by means of a screwdriver with a blade wider than the diameter of the screw.

Column II applies to nuts of mantle clamping units which are tightened by means of a screwdriver.

Column III applies to other screws which are tightened by means of a screwdriver.

Column IV applies to screws and nuts, other than nuts of mantle clamping units, which are tightened by means other than a screwdriver.

Column V applies to nuts of mantle clamping units which can be tightened by means other than that of a screwdriver.

Where a screw has a hexagonal head with a slot and the values in columns III and IV are different, the test is made twice, first on a set of three specimens, applying to the hexagonal head the torque specified in column IV, and then to another set of three specimens, applying the torque specified in column III by means of a screwdriver. If the values in columns III and IV are the same, only the test with the screwdriver shall be made.

6.3 Performance of tests

6.3.1 General

In accordance with the test schedule given in 6.5, the general test methods specified in Tables 6 to 12, columns 3 and 7, shall be applied according to IEC 60512. Other tests are indicated in column 4.

6.3.2 Durability of marking

The test is made by rubbing the marking by hand for 15 s with a piece of cotton cloth soaked with water and again for 15 s with a piece of cotton cloth soaked in petroleum spirit.

Petroleum spirit is defined as the aliphatic solvent hexane with a content of aromatics of maximum 0,1 % volume, a kauri-butanol value of 29, initial boiling point of 65 °C, a dry point of 69 °C and a specific gravity of approximately 0,68 kg/l.

After this test, the marking shall be legible to normal or corrected vision without additional magnification.

This test shall be also carried out on an additional label with specified warning indication listed under l) from 5.2.1, if applicable.

Markings made by impression, moulding, pressing, or engraving or the like are not subjected to this test.

6.3.3 Protection against electric shock

6.3.3.1 Connectors shall be tested by the test probe 11 according to IEC 61032 using a test force of 10 N.

For the test all covers and housing parts which are detachable without a tool shall be removed.

6.3.3.2 The tests for the given IP code according to IEC 60529 shall be applied in the mated position.

Subsequently the dielectric strength test according to 6.3.8 shall be performed within 1 h of second IP numeral (water) test.

6.3.4 Temperature rise

The object of this test is to assess the ability of a connector to continuously carry the rated current without exceeding the upper limiting temperature.

The test shall be carried out according to test 5a of IEC 60512, under the following test conditions.

Test conditions:

– maximum permissible conductor cross-section according to manufacturer's specification. In case of a declared cross-section area with same rated current, the test will be applied to the most unfavourable cross-section;
– length of test cables = 500 mm ± 50 mm for cross-section ≤ 10 mm^2;
– length of test cables = 1 000 mm ± 100 mm for cross-section > 10 mm^2;
– the test shall be carried out with rated current as specified by the manufacturer at an ambient temperature of 85 °C or the maximum ambient temperature specified by manufacturer, if higher;
– the test shall be continued until a constant temperature is obtained.

6.3.5 Mechanical operation

The object of this test is to assess the mechanical operational endurance of a connector in the normal operational mode without electrical load. The test shall be carried out according to test 9a of IEC 60512, under the following conditions.

Test conditions:

– the specimens shall be engaged and disengaged by means of a device simulating normal operating conditions. The preparation and mounting of the specimen shall be as in normal use;
– the type and cross-section of the cable/wire bundle to be used shall be specified by the manufacturer;
– the speed of insertion and withdrawal shall be approximately 0,01 m/s with a rest in the unmated position of approximately 30 s.

6.3.6 Bending (flexing) test (see IEC 60309-1:1999, 24.4)

Non-rewirable connectors shall be subjected to a bending test in an apparatus similar to that shown in Figure 1.

The specimen is fixed to the oscillating member of the apparatus so that, when this is at the midpoint of its travel, the axis of the flexible cable, where it enters the specimen, is vertical and passes through the axis of oscillation.

The oscillating member is so positioned that the flexible cable makes a minimum lateral movement when the oscillating member of the test apparatus is moved over its full travel.

The cable is loaded with a weight such that the force applied is

- 20 N for non-rewirable connectors with a conductor cross-section $> 0{,}75\ mm^2$,
- 10 N for non-rewirable connectors with a conductor cross-section $\leq 0{,}75\ mm^2$.

A current equal to the rated current of the connector is passed through the conductors.

The oscillating member is moved backwards and forwards through an angle of 90° (45° on either side of the vertical). The rate of bends shall be 60 per minute. One bending is one movement, either backwards or forwards. The number of bends is 100.

Specimens with cables of circular cross-section shall be rotated approximately 90° around the vertical axis within the oscillating part after 50 % of flexings; specimens with flat flexible cables are only bent in a direction perpendicular to the plane containing the axis of the conductor.

During this test, there shall be no interruption of the test current.

After the test there shall be no damage; the cable support sleeve shall not be loosened from the body and the insulation shall show no signs of abrasion or of wear and tear. Broken strands shall not pierce the insulation, during the high voltage test according to 6.3.8.b) there shall be no breakdown of the test voltage.

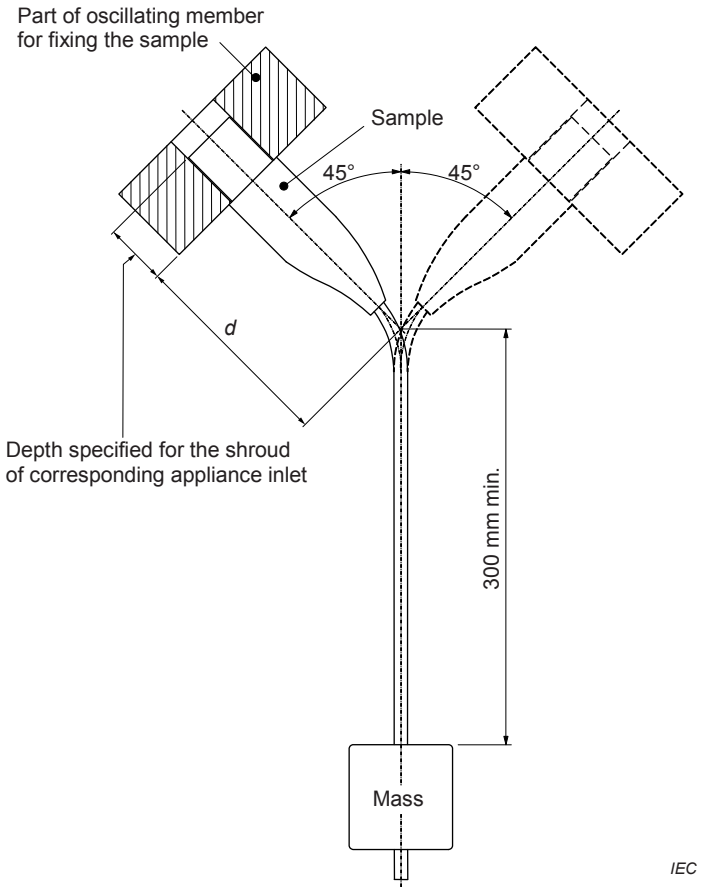


Figure 1 – Device for the bending test

6.3.7 Measurement of clearances and creepage distances

Clearances and creepage distances shall be measured according to Annex B with the following additional requirements.

For connectors without breaking capacity, clearances and creepage distances to the accessible surface shall be measured only in the mated position.

For multi-way connectors the requirements for double or reinforced isolation between active parts with different potential shall be determined in mated and unmated condition.

The surface of an unenclosed connector to be incorporated into an equipment or a device shall not be regarded as accessible, unless otherwise claimed by the manufacturer.

6.3.8 Dielectric strength

The test voltage has to be applied between the short circuited output terminals and a metal foil which is wrapped around the specimen after relevant conditioning. During dielectric strength test no breakdown of test voltage shall occur. The insulation shall be tested according to the following tests:

a) Impulse withstand test

The impulse withstand test shall be carried out with a voltage having a 1,2/50 μs waveform according to IEC 60060-1 with three impulses of each polarity and an interval of at least 1 s between impulses. The output impedance of the impulse generator should not be higher than 500 Ω. The test voltage shall comply with the rated impulse voltage according to table 2.

b) Voltage proof (IEC 60512-4-1, test 4a)

The voltage proof shall be performed by applying a r.m.s. withstand voltage (50 Hz/60 Hz) with a r.m.s. value of 2 000 V + 4 times rated voltage. The test duration shall be 1 min.

Voltage proof can also be performed with DC voltage. For this the value of test voltage shall be equal to the amplitude value of AC voltage.

6.3.9 Corrosion test

For testing the protection of contacts against the influence of a corrosive atmosphere, one of the two alternative tests shall be selected. In both cases, the specimens shall be mated.

Test 1: Flowing mixed gas corrosion according to test 11g of IEC 60512, with a choice of method 1 or method 4 (see IEC 60512-11-7:2003, Table 1)

The test duration shall be four days.

Test 2: Sulphur dioxide test with general condensation of moisture according to ISO 6988.

The test duration shall be 24 h (1 test cycle).

6.3.10 Mechanical strength at lower temperatures

The specimens and the test apparatus shall be stored for 5 h at a temperature of –40 °C or the minimum ambient temperature specified by the manufacturer, if lower, on a steel plate of 20 mm thickness. The test shall be carried out immediately after the storage duration in the cold chamber.

Test shall be carried according to the following procedure:

Four impacts on the specimen, an energy of 1 J with an appropriate impact test apparatus according to IEC 60068-2-75 shall be carried out at four uniformly distributed positions on the circumference.

The test is passed successfully if no damage appeared which may impair the function of the connector and the dielectric strength test of 6.3.8 b) has been passed.

6.3.11 Change of temperature (IEC 60068-2-14 test Na)

The test shall be carried in climatic chamber without any pre-treatment of the specimens as follows:

– 30 min at upper specified ambient temperature, minimum +85 °C ± 2 °C;
– 30 min at lower specified ambient temperature, maximum –40 °C ± 2 °C;
– transfer duration t2 ≤ 3 min;
– number of test cycles: 200.

During thermal cycle test the rated current shall be applied such that it is conducted through the current-carrying contacts.

6.3.12 Damp heat test

The test shall be carried out according to IEC 60068-2-78 with the following test conditions:

Severity according to IEC 61215:2005, 10.13:

– test temperature: upper specified ambient temperature, minimum +85 °C ± 2 °C
– relative humidity: +85 % ± 5 %
– test duration: 1 000 h

6.3.13 Insertion and withdrawal force

The test shall be carried out with the relevant counterpart according to IEC 60512, test 13b.

The actuation speed shall be 50 mm/min.

The measured withdrawal force shall not be less than 50 N.

6.3.14 Effectiveness of connector coupling device

The test shall be carried out according to IEC 60512, test 15f.

The specified force of 80 N shall be applied in the direction of the separation of the mated pair with the rate of 10 N/s.

It shall not be possible to disengage the connector.

6.3.15 Terminations and connecting methods

The following applicable tests shall be conducted:

a) for crimped connections,

visual tests on the crimp barrel and tensile strength test of the crimp connection as specified in IEC 60352-2. If deviations to IEC 60352-2 exist, the tensile strength according to IEC 60352-2 and the dimensions according to the manufactures specifications are tested to fulfil IEC 61984;

b) and c) for insulation displacement connections,

visual examination is carried out on new parts for insulation displacement terminals according to IEC 60352-3:1993, 12.1 and for solderless non-accessible displacement terminals according to IEC 60352-4:1994, 12.2.4.

The electrical and thermal tests are carried out according to IEC 61984;

d) for press-in connections,

visual and dimensional tests on the press-in post and test of the push-out force as specified in IEC 60352-5;

e) insulation piercing connections according to IEC 60352-6 or IEC 60998-2-3;

f) for the screwless-type clamping unit,

mechanical tests on the conductor connection as specified in IEC 60999-1 or IEC 60999-2 or IEC 60352-7;

g) for the screw-type clamping unit,

mechanical tests on the conductor connection as specified in IEC 60999-1 or IEC 60999-2.

For prepared conductors the manufacturers instructions for the preparation applies;

h) for flat, quick-connect terminations,

dimensional tests and safety tests as specified in IEC 61210 as far as applicable.

The dimensional test is carried out according to IEC 61210. The compliance check of dimensions is the verification of the safety of the connection according to IEC 61984. If the dimensions do not comply with the specification the test requirements are not met.

Flat, quick-connect terminations, which are definitely not designed according to IEC 61210 can be used if the test program according to IEC 61984 is met.

Electrical and thermal tests on terminations shall be carried out in conjunction with the test on the connector.

6.4 Test schedule (routine test) for non-rewirable free connectors

For non-rewirable free connectors, it shall be ensured that live parts, e.g. loose strands, cannot become accessible. If this cannot be ensured by design or by the manufacturing process, each manufactured connector shall be subjected to the following test.

The accessible outer surface of the connector, with the exception of the engagement face of the male connector, shall be scanned by plane electrodes with a force of 20 N and each time the specified impulse withstand voltage of the connector shall be applied between all live parts and these electrodes according to 6.3.8.

Alternatively, the specified r.m.s. withstand voltage according to 6.3.8 shall be applied for a minimum of three full cycles (60 ms).

No breakdown or flashover shall occur.

6.5 Test schedule

Table 6 – Mechanical test group A (test group A are separate tests)

1	2	3	4	5	6	7	8
Test phase	**Designation**	**IEC 60512 test no.**	**Test according to**	**Severity or conditions**	**Measurements to beperformed**		**Requirements**
					Designation or title	**IEC 60512 test no.**	
A1.1				Any existing cover shall be removed, if required	Visual and dimensional examination	1a, 1b	5.2.3 Dimensions shall comply with the manufacturer's specification
A1.2	Clearances and creepage distances		6.3.7	Measuring of creepage distances and clearances according to annex B	Dimensional examinaton		5.18 Dimensions shall comply with 5.18
A2	Durability of marking		6.3.2	With the naked eye	Visual examination	1a	Markings according to 5.2
A3	Polarisation	13e		Test force: 20 N or 1,5 times the insertion force, whichever is higher, but not higher than 80 N			5.3
					Visual examination	1a	No damage likely to impair function
A4	Terminations		6.3.15	Verification by test report or minimum test			5.5
A5	Contact retention in insert	15a		Test load shall be three times the specified insertion force (mating) of one contact or the specified insertion force of one contact plus 50 N, whichever is less. The minimum test load shall not be less than 20 N.			5.15.2
					Visual examination	1a	No axial displacement likely to impair normal operation
A6.1	Cable clamp (pull)	17 c			Visual examination	1a	5.14, Table 1
A6.2	Cable clamp (torsion)	17 d			Visual examination	1a	5.14, Table 1
A7	Mechanical strength	7b		Only free connectors. Dropping height:			
					Visual	1a	Parts used for

1	2	3	4	5	6	7	8
Test phase	**Designation**	**IEC 60512 test no.**	**Test according to**	**Severity or conditions**	**Measurements to beperformed**		**Requirements**
					Designation or title	**IEC 60512 test no.**	
	impact			– 750 mm for specimens of mass ≤ 250 g, – 500 mm for specimens of mass > 250 g. Dropping cycles: 8 Positions in 45° steps, one cycle per position	examination		protection against electric shock shall not be damaged. A reduction of clearances and creepage distances is not allowed.
A8	Mechanical strength at lower temperature		6.3.10	Test temperature: lower limiting temperature specified for the specimen Test duration: 5 h			5.15
					Visual examination	1a	
					Dielectric strength		6.3.8 b)
A9	Insertion and withdrawal force	13 b	6.3.13	Only for connectors without coupling device or locking means			measured withdrawal force not less than 50 N
A10	Effectiveness of connector coupling device	15 f	6.3.14	Only for connectors with coupling device or locking means	Visual examination		5.17 No damage likely to impair function
NOTE Test group A consists of separate tests. There is no required test sequence.							

Table 7 – Service life test group B

1	2	3	4	5	6	7	8
Test phase	**Designation**	**IEC 60512 test no.**	**Test according to**	**Severity or conditions**	**Measurements to be performed**		**Requirements**
					Designation or title	**IEC 60512 test no.**	
B1	Initial measurement			Test current: 1 A Measuring points: At the end of the termination. Maximum three contacts per specimen	Contact resistance	2b	Reference value for subsequent measurement
B2	Mechanical operation	9a	6.3.5				5.11
					Visual examination	1a	No damage likely to impair function
B3	Final measurement			Same conditions as for test phase B1	Contact resistance	2b	Deviation of the contact resistance shall be no more than 50 % of the reference value or ≤ 5 mΩ. The higher value is permissible.

1	2	3	4	5	6	7	8
Test phase	**Designation**	**IEC 60512 test no.**	**Test according to**	**Severity or conditions**	**Measurements to be performed**		**Requirements**
					Designation or title	**IEC 60512 test no.**	
			6.3.8	Measuring points[b]: contact/contact contact/earth[a]	Voltage proof	4a	5.10 There shall be no breakdown or flashover

[a] Earth in the sense of non-live metal parts (e.g. fixing devices/housings/accessible surfaces).

[b] Measuring points: At the conductors as close as possible to the termination. If this is not possible, the conductor resistance shall be recalculated.

Table 8 – Service life test group C

1	2	3	4	5	6	7	8
Test phase	**Designation**	**IEC 60512 test no.**	**Test according to**	**Severity or conditions**	**Measurements to be performed**		**Requirements**
					Designation or title	**IEC 60512 test no.**	
C1	Bending test		6.3.6	Only non-rewirable connectors			6.3.6
					Visual examination	1a	No damage likely to impair function
C2	Final measurement		6.3.8 b)	Measuring points: End of cable/metal foil	Voltage proof	4a	There shall be no breakdown or flashover
					Visual examination	1a	No loosening of the cable support sleeve from the body, no signs of abrasion or of wear and tear of insulation, broken strands shall not pierce the insulation

Table 9 – Thermal test group D (mated test specimen)

1	2	3	4	5	6	7	8
Test phase	**Designation**	**IEC 60512 test no.**	**Test according to**	**Severity or conditions**	**Measurements to be performed**		**Requirements**
					Designation or title	**IEC 60512 test no.**	
D1	Initial measurement			Test current: 1 A Measuring points: At the end of the termination. Maximum three contacts per specimen	Contact resistance	2b	Reference value for subsequent measurement
D2	Temperature rise test	5a	6.3.4				5.13 The upper specified temperature shall not be exceeded
D3	Dry heat	11i		Test temperature: Upper limiting temperature specified for the specimen Test duration: 1 000 h			
D4	Final measurement			Any existing cover shall be removed if required	Visual examination	1a	No damage likely to impair function
				Same conditions as in D1	Contact resistance	2 b	Deviation of the contact resistance shall be no more than 50 % of the reference value or $\leq 5\ m\Omega$. The higher value is permissible.

Table 10 – Climatic test group E (mated test specimen)

1	2	3	4	5	6	7	8
Test phase	**Designation**	**IEC 60512 test no.**	**Test according to**	**Severity or conditions**	**Measurements to be performed**		**Requirements**
					Designation or title	**IEC 60512 test no.**	
E1	Initial measurement			Test current: 1 A Measuring points[b]: At the end of the termination. Maximum three contacts per specimen	Contact resistance	2b	Reference value for subsequent measurement
E2	Change of temperature		6.3.11	Upper temperature: +85 °C Lower temperature: –40 °C Number of test cycles: 200	Visual examination	1a	No damage likely to impair function
E3	Damp heat		6.3.12	Test temperature: +85 °C Relative humidity: 85 % Test duration: 1 000 h	Visual examination	1a	No damage likely to impair function
E4	Dielectric strength		6.3.8 a) or b)	Measuring points[b]: contact/contact contact/earth[a] Test voltage (impulse withstand voltage) according to Table 2 for double or reinforced insulation shall be applied	a) Impulse withstand voltage		5.10 No breakdown or flashover
				Measuring points[b]: contact/contact contact/earth[a]	b) Voltage proof	4a	
E5	Corrosion test	11 g Alternative:	6.3.9	Test 1			5.20.1
		Corrosion test according to ISO 6988	6.3.9	Test 2	Visual examination	1a	No damage likely to impair function
E6	Final measurement			Same conditions as for test phase E1	Contact resistance	2b	Deviation of the contact resistance shall be no more than 50 % of the reference value or ≤ 5 mΩ. The higher value is permissible.

[a] Earth in the sense of non-live metal parts (e.g. fixing devices/housings/accessible surfaces).

[b] Measuring points: At the conductors as close as possible to the termination. If this is not possible, the conductor resistance shall be recalculated.

Table 11 – Degree of protection, test group F

1	2	3	4	5	6	7	8
Test phase	**Designation**	**IEC 60512 test no.**	**Test according to**	**Severity or conditions**	**Measurements to be performed**		**Requirements**
					Designation or title	**IEC 60512 test no.**	
F1	Degree of protection		6.3.3.1	Test probe 11 according to IEC61032 with test force of 10 N			No live part shall be accessible 5.4.2
F2	Degree of protection IP code		6.3.3.2	IP code as specified by the manufacturer			5.9 Mated connector
F3	Dielectric strength		6.3.8 b)	The test voltage shall be applied between all live parts and accessible surface.	Voltage proof	4a	5.10 No breakdown or flashover

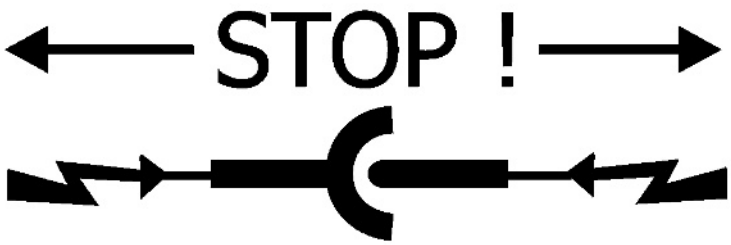
Table 12 – Insulation material, test group G

1	2	3	4	5	6	7	8
Test phase	**Designation**	**IEC 60512 test no.**	**Test according to**	**Severity or conditions**	**Measurements to be performed**		**Requirements**
					Designation or title	**IEC 60512 test no.**	
G1	Weather resistance			Test according to method ISO 4892-2 Irradiance: 60 W/m^2 Wave band: 300 nm – 400 nm Black standard temperature: 65 °C Relative humidity: 65 % Cycle: 18 min spraying, 102 min drying with Xenon-lamp Total duration: 500 h or Test according to ISO 4892-3	Visual examination		5.19.2 b) No cracks, Markings still legible
G2	Dielectric strength		6.3.8 b)	The test voltage shall be applied between all live parts and accessible surface.	Voltage proof	4a	5.10 No breakdown or flashover
G3	Flammability			Insulation material for outer housing material. Certificate of material supplier or test according to IEC 60695-11-10			5.19.2 a)
				Glow wire test according to IEC 60695-2-11 Test temperature: 650 °C			5.19.2 c) No inflame
G4	Flammability			Insulation material keeping active parts in position. Certificate of supplier or test according to IEC 60695-11-10			5.19.3 a)
				Glow wire test according to IEC 60695-2-11 Test temperature: 750 °C			5.19.3 c) No inflame

Annex A
(informative)

Warning symbols used on connectors

The following symbols (see Figures A.1 and A.2) may be used to show that a PV-connector according to this standard shall not be disconnected under load.



IEC

Figure A.1 – Symbol "DO NOT DISCONNECT UNDER LOAD"

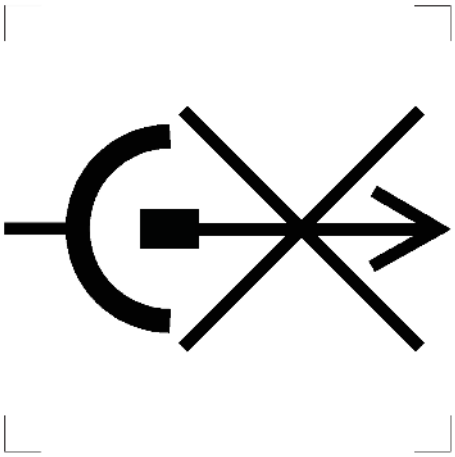


Figure A.2 – Symbol "DO NOT DISCONNECT UNDER LOAD" (IEC 60417-6070 (2014-06))

Annex B
(normative)

Measurement of clearances and creepage distances

The methods of measuring clearances and creepage distances are indicated in the following examples 1 to 11 (see Figure B.1). These cases do not differentiate between gaps and grooves or between types of insulation.

The following assumptions are made:

a) where the distance across a groove is equal to or larger than *X* (see Table B.1), the creepage distance is measured along the contours of the groove (see example 2);

b) any recess is assumed to be bridged with an insulating link having a length equal to *X* and being placed in the least favourable position (see example 3);

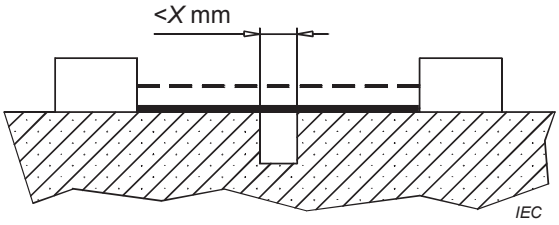
c) clearances and creepage distances measured between parts which can assume different positions in relation to each other are measured when these parts are in their least favourable position.

In the following examples dimension *X* has the value given in Table B.1 depending on the pollution degree.

Table B.1 – Dimensions of X

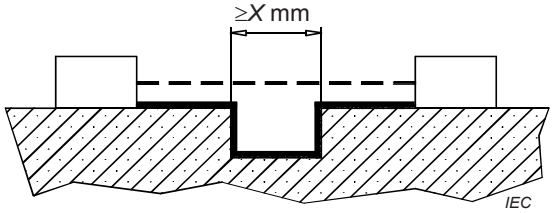
Pollution degree	Dimension *X* mm
1	0,25
2	1,0
3	1,5

If the associated clearance is less than 3 mm, the dimension *X* in Table B.1 may be reduced to one-third of this clearances.



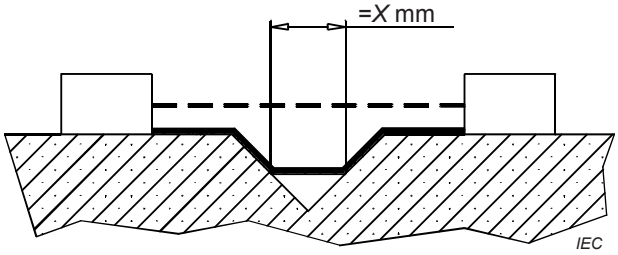
EXAMPLE 1 The path includes a parallel- or converging-sided groove of any depth with a width less than *X*.

The clearance and the creepage distance are measured directly across the groove as shown.



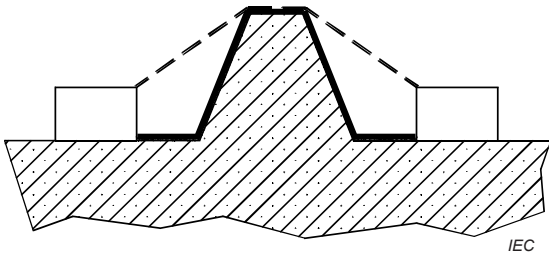
EXAMPLE 2 The path includes a parallel-sided groove of any depth and equal to or more than *X*.

The clearance is the “line-of-sight” distance. The creepage distance follows the contour of the groove.



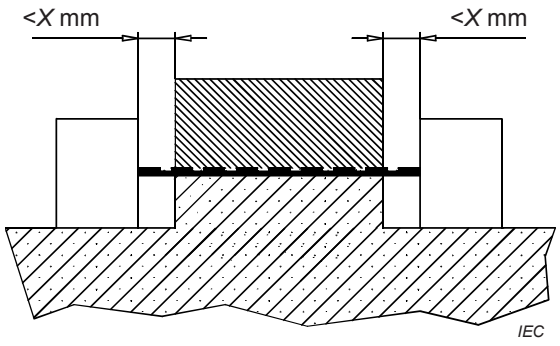
EXAMPLE 3 The path includes a V-shaped groove with a width greater than *X*.

The clearance is the “line-of-sight” distance. The creepage distance follows the contour of the groove but “short-circuits” the bottom of the groove by *X* link.



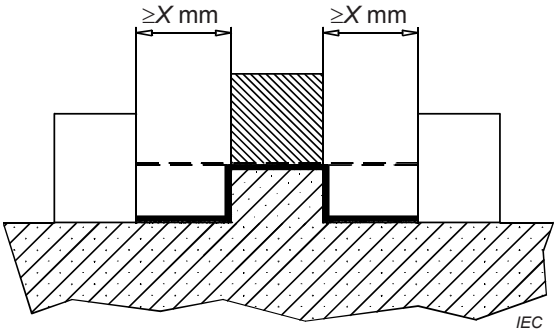
EXAMPLE 4 The path includes a rib.

The clearance is the shortest direct air path over the top of the rib. The creepage distance follows the contour of the rib.



EXAMPLE 5 The path includes an uncemented joint with grooves less than *X* wide on each side.

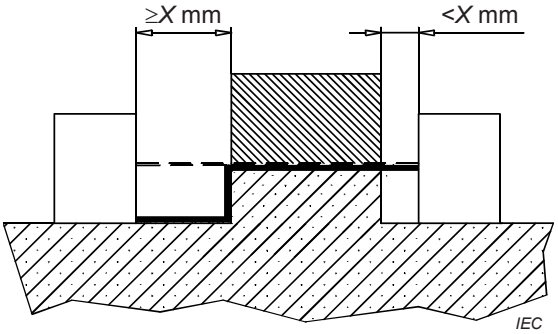
The clearance and the creepage distance path is the “line-of-sight” distance shown.



EXAMPLE 6 The path includes an uncemented joint with grooves equal to, or more than, *X*.

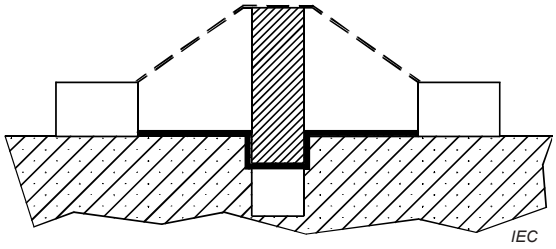
The clearance is the “line-of-sight” distance.

The creepage distance follows the contour of the grooves.



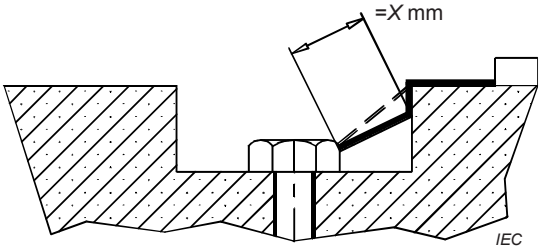
EXAMPLE 7 The path includes an uncemented joint with a groove on one side less than *X* wide and the groove on the other side equal to, or more than, *X* wide.

The clearance and the creepage distance are as shown.

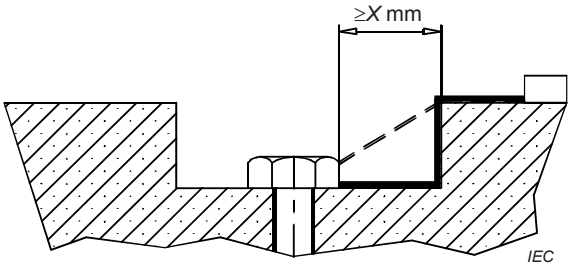


EXAMPLE 8 The creepage distance through the uncemented joint is less than the creepage distance over the barrier.

The clearance is the shortest direct air path over the top of the barrier.

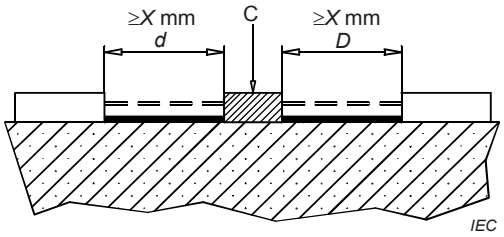


EXAMPLE 9 The gap between the head of the screw and the wall of the recess is too narrow to be taken into account.



EXAMPLE 10 The gap between the head of the screw and the wall of the recess is wide enough to be taken into account.

Measurement of the creepage distance is from screw to wall when the distance is equal to *X*.



EXAMPLE 11 C = floating part

The clearance is the distance $d + D$. The creepage distance is also $d + D$.

Creepage distance

Clearance

Figure B.1– Examples of methods of measuring clearances and creepage distances

Bibliography

IEC 60068-2-70:1995, *Environmental testing – Part 2: Tests – Test Xb: Abrasion of marking and letterings caused by rubbing of fingers and hands*

NOTE Harmonized as EN 60068-2-70:1996 (not modified).

IEC 60112:2003, *Method for the determination of the proof and the comparative tracking indices of solid insulating materials*

NOTE Harmonized as EN 60112:2003 (not modified).

IEC 60364-4-41:2005, *Low-voltage electrical installations – Part 4-41: Protection for safety – Protection against electric shock*

NOTE Harmonized as HD 60364-4-41:2007 (modified).

IEC 60364-5-51:2005, *Electrical installations of buildings – Part 5-51: Selection and erection of electrical equipment – Common rules*

NOTE Harmonized as HD 60364-5-51:2009 (modified).

IEC 60364-5-54:2011, *Low-voltage electrical installations – Part 5-54: Selection and erection of electrical equipment – Earthing arrangements and protective conductors*

NOTE Harmonized as HD 60364-5-54:2011 (not modified).

IEC 60417, Graphical symbols for use on equipment. Available from: http://www.graphical-symbols.info/equipment

IEC TR 60664-2-1, *Insulation coordination for equipment within low-voltage systems – Part 2-1: Application guide – Explanation of the application of the IEC 60664 series, dimensioning examples and dielectric testing*

IEC 60884-1:2002, *Plugs and socket-outlets for household and similar purposes – Part 1: General requirements*

IEC 61730-1:2004, *Photovoltaic (PV) module safety qualification – Part 1: Requirements for construction*

NOTE Harmonized as EN 61730-1:2007 (modified).

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

NOTE Harmonized as EN 61730-2.

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