

This is a preview - click here to buy the full publication



IEC 62688

Edition 1.0 2017-09

# INTERNATIONAL STANDARD



---

**Concentrator photovoltaic (CPV) modules and assemblies – Safety qualification**

INTERNATIONAL  
ELECTROTECHNICAL  
COMMISSION

---

ICS 27.160

ISBN 978-2-8322-4719-8

**Warning! Make sure that you obtained this publication from an authorized distributor.**

## CONTENTS

FOREWORD.....	8
1 Scope.....	10
2 Normative references .....	10
3 Terms and definitions .....	13
4 Sampling .....	15
5 Marking .....	20
5.1 Nameplate .....	20
5.2 Hazards .....	21
5.2.1 High intensity light .....	21
5.2.2 Field connections.....	21
5.2.3 Hot surfaces .....	22
6 Report .....	22
7 Requirements for construction – Module application classes .....	23
7.1 General.....	23
7.2 Class II – general access, hazardous voltage, current and power, double insulated/reinforced insulation.....	23
7.2.1 Electrical output.....	23
7.2.2 Protection .....	23
7.2.3 Application.....	24
7.3 Class 0 – Restricted access, hazardous voltage, current and power basic insulation only with no protection from faults .....	24
7.3.1 Electrical output.....	24
7.3.2 Protection .....	24
7.3.3 Application.....	24
7.4 Class 0-X – additional fire or concentrated light hazard.....	24
7.5 Class III – general access limited voltage, current and power .....	24
7.5.1 Electrical output.....	24
7.5.2 Protection .....	24
7.5.3 Application.....	24
7.6 Fire safety.....	25
8 Construction .....	25
9 Modifications .....	25
10 Requirements for supplied documents .....	25
10.1 General.....	25
10.2 Fire .....	25
10.3 Electrical.....	25
10.4 Mechanical .....	26
10.5 Temperature .....	26
10.6 Field assembly.....	26
10.7 Component ratings.....	26
11 Overcurrent protection .....	26
12 Metal parts .....	27
12.1 Combinations of metals.....	27
12.2 Corrosion protection .....	27
12.3 Edges .....	27
13 Polymeric materials .....	27

13.1	General.....	27
13.1.1	Overview .....	27
13.1.2	Solid insulation and cemented joints .....	27
13.1.3	Requirements for polymers .....	28
13.1.4	Operational categories for CPV modules and assemblies .....	29
13.2	Polymers serving as an enclosure for live parts (such as a junction box, connector, or plug).....	30
13.3	Polymers serving in direct support of live parts (such as integrated terminals and potting compounds).....	30
13.4	Polymers serving as an outer surface of a receiver (such as a front sheet or back sheet on a flat-plate profile receiver in a medium-X assembly).....	30
13.5	Polymers serving as an internal electrical barrier providing the sole insulation between live parts .....	31
13.6	Polymers serving as encapsulants .....	31
13.7	Polymers serving as adhesives for attachment (such as for a junction box).....	31
13.8	Polymers serving as moisture barriers (such as edge sealants) .....	31
13.9	Polymers serving as gaskets or seals (such as with front glass).....	31
13.10	Polymers serving as frames (such as with flat-plate profile medium-concentration receivers).....	32
13.11	Polymers serving as CPV optics .....	32
13.12	Polymers exposed to sunlight, serving as a mechanical support, not functioning in categories 13.2 to 13.11 .....	32
13.13	Polymers exposed to concentrated sunlight .....	32
14	Internal wiring and current-carrying parts.....	32
14.1	General.....	32
14.2	Internal wiring .....	32
14.3	Splices.....	32
14.4	Mechanical securement .....	33
15	Connections .....	33
15.1	Field connections – general requirements .....	33
15.2	Field wiring terminals .....	33
15.3	Connectors .....	34
15.4	Output lead or cables.....	34
16	Bonding and grounding.....	34
16.1	General.....	34
16.2	Lightning protection .....	35
17	Protection against electric shock and energy hazards.....	35
17.1	General.....	35
17.2	Fault conditions .....	35
17.3	Protection against electric shock.....	36
17.3.1	General .....	36
17.3.2	Module classification .....	36
17.3.3	Creepage and clearance distances .....	37
17.3.4	Degrees of pollution in the micro-environment .....	40
17.3.5	Cemented joints.....	40
18	Field wiring compartments with covers .....	42
18.1	General.....	42
18.2	Strain relief .....	42
18.3	Sharp edges .....	42
18.4	Conduit applications – Metallic.....	42

18.5	Conduit applications – Non-metallic .....	42
19	Requirements for testing – Test categories .....	43
19.1	General.....	43
19.2	Preconditioning tests .....	43
19.3	General inspection .....	44
19.4	Electrical shock hazard .....	44
19.5	Fire hazard .....	44
19.6	Mechanical stress .....	45
20	Testing .....	45
20.1	General.....	45
20.2	Visual inspection.....	50
20.2.1	General .....	50
20.2.2	Requirements .....	50
20.3	Accessibility test.....	51
20.3.1	Purpose .....	51
20.3.2	Apparatus .....	51
20.3.3	Procedure.....	51
20.3.4	Requirements .....	51
20.4	Grounding/Bonding path continuity test.....	51
20.4.1	Purpose .....	51
20.4.2	Procedure.....	51
20.4.3	Requirements .....	51
20.5	Dielectric voltage withstand test.....	51
20.5.1	Purpose .....	51
20.5.2	Procedure.....	52
20.5.3	Requirements .....	52
20.6	Wet insulation test .....	52
20.6.1	Purpose .....	52
20.6.2	Procedure.....	52
20.6.3	Requirements .....	52
20.7	Reverse current overload.....	53
20.7.1	Purpose .....	53
20.7.2	Procedure.....	53
20.7.3	Requirements .....	53
20.8	Thermal cycling.....	53
20.8.1	General .....	53
20.8.2	Purpose .....	54
20.8.3	Procedure.....	54
20.8.4	Requirements .....	54
20.9	Humidity freeze.....	54
20.9.1	General .....	54
20.9.2	Purpose .....	54
20.9.3	Procedure.....	54
20.9.4	Requirements .....	54
20.10	Damp heat .....	54
20.10.1	General .....	54
20.10.2	Purpose .....	54
20.10.3	Procedure.....	55
20.10.4	Requirements .....	55

20.11	Bypass diode thermal.....	55
20.11.1	Purpose.....	55
20.11.2	Special test sample.....	55
20.11.3	Procedure.....	55
20.11.4	Requirements.....	55
20.12	Hot spot endurance.....	55
20.12.1	General.....	55
20.12.2	Procedure.....	56
20.12.3	Requirements.....	56
20.13	Off-axis beam damage.....	56
20.13.1	General.....	56
20.13.2	Purpose.....	56
20.13.3	Special case.....	56
20.13.4	Procedure.....	56
20.13.5	Requirements.....	56
20.14	Water spray.....	57
20.14.1	General.....	57
20.14.2	Purpose.....	57
20.14.3	Procedure.....	57
20.14.4	Requirements.....	57
20.15	Mechanical load.....	57
20.15.1	Purpose.....	57
20.15.2	Procedure.....	58
20.15.3	Requirements.....	58
20.16	Robustness of terminations.....	58
20.16.1	Purpose.....	58
20.16.2	Types of terminations.....	58
20.16.3	Procedure.....	58
20.16.4	Requirements.....	58
20.17	Impulse voltage.....	58
20.17.1	Purpose.....	58
20.17.2	Requirements.....	60
20.18	CPV temperature test.....	60
20.18.1	Purpose.....	60
20.18.2	Test apparatus.....	60
20.18.3	Procedure.....	60
20.18.4	Requirements.....	61
20.19	Fire test recommendation for CPV modules.....	62
20.19.1	General.....	62
20.19.2	Burning brand fire tests.....	62
20.20	CPV electrical parameters.....	64
20.20.1	General.....	64
20.20.2	Maximum open-circuit voltage.....	64
20.20.3	Maximum short-circuit current.....	64
20.20.4	The procedure for calculating maximum power (Max <i>P</i> ) is to be in accordance with the following:.....	65
20.21	Outdoor exposure.....	65
20.21.1	General.....	65
20.21.2	Purpose.....	65

20.21.3	Procedure.....	65
20.21.4	Requirements .....	65
20.22	Sharp edge test .....	66
20.22.1	General .....	66
20.22.2	Purpose.....	66
20.22.3	Procedure.....	66
20.22.4	Requirements .....	66
20.23	Blocked heat sink test.....	66
20.23.1	Purpose.....	66
20.23.2	Procedure.....	67
20.23.3	Requirements .....	67
20.24	Locked rotor test.....	67
20.24.1	Purpose.....	67
20.24.2	Procedure.....	67
20.24.3	Requirements .....	68
Annex A (informative)	Bimetallic junction .....	69
Annex B (normative)	Recommendations for testing of modules from production.....	70
B.1	General.....	70
B.2	Module output power.....	70
B.3	Insulation test .....	70
B.4	Wet insulation test .....	70
B.5	Visual inspection.....	71
B.6	Cable connections .....	71
B.7	Bypass diodes .....	71
B.8	Ground continuity.....	71
Annex C (normative)	Alternative test method to electricity safety of CPV receivers .....	72
C.1	General.....	72
C.2	Specifications for the proposed test method.....	72
C.3	Test method.....	73
C.3.1	Overview .....	73
C.3.2	Product identity .....	73
C.3.3	Manufacturer .....	73
C.3.4	System number.....	73
C.4	Test procedure.....	73
C.4.1	Physical background.....	73
C.4.2	Sampling .....	74
C.4.3	Marking .....	74
C.4.4	Test procedure .....	75
C.4.5	Pass criteria .....	76
Bibliography	.....	77
Figure 1	– Schematic of a point focus dish PV concentrator.....	17
Figure 2	– Schematic of a linear focus trough PV concentrator .....	18
Figure 3	– Schematic of a point focus Fresnel lens PV concentrator .....	19
Figure 4	– Schematic of a linear focus Fresnel lens PV concentrator .....	20
Figure 5	– Field connection warning label .....	21
Figure 6	– Symbol for hot surface can be used .....	22

Figure 7 – IEC 62688 safety test plan for CPV modules (IEC 62108:2016).....	47
Figure 8 – Combined IEC 62108:2016 and IEC 62688 test plan for CPV modules .....	48
Figure 9 – IEC 62688 safety test plan for CPV assemblies (IEC 62108:2016) .....	49
Figure 10 – Combined IEC 62108:2016 and IEC 62688 test plan for CPV assemblies.....	50
Figure 11 – Waveform of the impulse voltage test.....	59
Figure C.1 – Decision chart of the alternative test.....	73
Figure C.2 – Formula (C.1) .....	73
Figure C.3 – Example of the acceleration of the breakdown voltage degradation by the voltage stress .....	74
Figure C.4 – Fitting to the power function in the double logarithmic chart.....	76
Table 1 – Touch temperature limits .....	22
Table 2 – Sizes of terminals for supply conductors.....	34
Table 3 – Minimum acceptable clearance distances.....	38
Table 4 – Multiplication factors for clearances of equipment rated for operation at altitudes up to 5 000 m .....	38
Table 5 – Minimum creepage distances for basic insulation .....	39
Table 6 – Minimum creepage distances for reinforced insulation.....	39
Table 7 – Rated impulse voltage .....	40
Table 8 – Wall thickness of polymeric boxes intended for conduit .....	43
Table 9 – Preconditioning tests.....	43
Table 10 – General inspection tests .....	44
Table 11 – Electrical shock hazard tests .....	44
Table 12 – Fire hazard tests .....	44
Table 13 – Fire hazard test applicability.....	45
Table 14 – Mechanical stress tests .....	45
Table 15 – Impulse voltage versus maximum system voltage.....	59
Table 16 – Brand size and its number .....	62
Table A.1 – Voltages developed on bimetallic junction (IEC 60943:1998, Table 3).....	69
Table C.1 – Maximum acceptable testing time .....	75

## INTERNATIONAL ELECTROTECHNICAL COMMISSION

# CONCENTRATOR PHOTOVOLTAIC (CPV) MODULES AND ASSEMBLIES – SAFETY QUALIFICATION

### FOREWORD

- 1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
- 2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
- 3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
- 4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
- 5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
- 6) All users should ensure that they have the latest edition of this publication.
- 7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
- 8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
- 9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

International Standard IEC 62688 has been prepared by IEC technical committee 82: Solar photovoltaic energy systems.

The text of this International Standard is based on the following documents:

FDIS	Report on voting
82/1299/FDIS	82/1323/RVD

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

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.



The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "<http://webstore.iec.ch>" in the data related to the specific document. At this date, the document will be

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

A bilingual version of this publication may be issued at a later date.

**IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.**

## CONCENTRATOR PHOTOVOLTAIC (CPV) MODULES AND ASSEMBLIES – SAFETY QUALIFICATION

### 1 Scope

This document describes the fundamental construction and testing requirements for Concentrator Photovoltaic (CPV) modules and assemblies 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.

This document attempts to define the basic requirements for various application classes of concentrator photovoltaic modules and assemblies, but it cannot be considered to encompass all national and regional codes.

This document is designed so that its test sequence can coordinate with those of IEC 62108, so that a single set of samples may be used to perform both the safety and performance evaluation of a CPV module and assembly.

CPV modules that are constructed in the flat plate module format and operate at 3X and less geometric concentration ratio are considered for evaluation to IEC 61730-1 and IEC 61730-2.

### 2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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

IEC 60065, *Audio, video and similar electronic apparatus – Safety requirements*

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

IEC 60216-5, *Electrical insulating materials – Thermal endurance properties – Part 5: Determination of relative thermal endurance index (RTE) of an insulating material*

IEC 60243-2, *Electric strength of insulating materials – Test methods – Part 2: Additional requirements for tests using direct voltage*

IEC 60417, *Graphical symbols for use on equipment – 12-month subscription to regularly updated online database comprising all graphical symbols published in IEC 60417*

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

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

IEC TR 60664-2-1:2011, *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 60664-3:2016, *Insulation coordination for equipment within low-voltage systems – Part 3: Use of coating, potting or moulding for protection against pollution*

IEC 60695-1-10, *Fire hazard testing – Part 1-10: Guidance for assessing the fire hazard of electrotechnical products – General guidelines*

IEC 60695-1-11, *Fire hazard testing – Part 1-11: Guidance for assessing the fire hazard of electrotechnical products – Fire hazard assessment*

IEC 60695-2-10, *Fire hazard testing – Part 2-10: Glowing/hot-wire based test methods – Glow-wire apparatus and common test procedure*

IEC 60695-11-20, *Fire hazard testing – Part 11-20: Test flames – 500 W flame test method*

IEC 60904-3, *Photovoltaic devices – Part 3: Measurement principles for terrestrial photovoltaic (PV) solar devices with reference spectral irradiance data*

IEC 60947-1, *Low-voltage switchgear and control gear – Part 1: General rules*

IEC 60950-1:2005, *Information technology equipment – Safety – Part 1: General requirements*

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

IEC 61140:2016, *Protection against electric shock – Common aspects for installation and equipment*

IEC 61215-2, *Terrestrial photovoltaic (PV) modules – Design qualification and type approval – Part 2: Test procedures*

IEC 61508 (all parts), *Functional safety of electrical/electronic/programmable electronic safety-related systems*

IEC 61730-1:2016, *Photovoltaic (PV) module safety qualification – Part 1: Requirements for construction*

IEC 61730-2:2016, *Photovoltaic (PV) module safety qualification – Part 2: Requirements for testing*

IEC TS 61836, *Solar photovoltaic energy systems – Terms, definitions and symbols*

IEC 62108:2016, *Concentrator photovoltaic (CPV) modules and assemblies – Design qualification and type approval*

IEC 62305-2, *Protection against lightning – Part 2: Risk management*

IEC 62305-3, *Protection against lightning – Part 3: Physical damage to structures and life hazard*

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

IEC 62670-1, *Concentrator photovoltaic (CPV) performance testing – Part 1: Standard conditions*

IEC 62790, *Junction boxes for photovoltaic modules – Safety requirements and tests*

IEC 62852:2014, *Connectors for DC-application in photovoltaic systems – Safety requirements and tests*

ISO 179-1, *Plastics – Determination of Charpy impact properties – Part 1: Non-instrumented impact test*

ISO 261, *ISO general-purpose metric screw threads – General plan*

ISO 262, *ISO general-purpose metric screw threads – Selected sizes for screws, bolts and nuts. Media and price*

ISO 527 (all parts), *Plastics – Determination of tensile properties*

ISO 834-1, *Fire-resistance tests – Elements of building construction – Part 1: General Requirements*

ISO TR 834-3, *Fire-resistance tests – Elements of building construction – Part 3: Commentary on test method and test data application* guide to the application of the outputs from the fire-resistance test

ISO 1456, *Metallic and other inorganic coatings – Electrodeposited coatings of nickel, nickel plus chromium, copper plus nickel and of copper plus nickel plus chromium*

ISO 1461, *Hot dip galvanized coatings on fabricated iron and steel articles – Specifications and test methods*

ISO 2081, *Metallic coatings – Electroplated coatings of zinc with supplementary treatments on iron or steel*

ISO 2093, *Electroplated coatings of tin – Specification and test methods*

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

ISO 5657, *Reaction to fire tests – Ignitability of building products using a radiant heat source*

ISO 8124-1, *Safety of toys – Part 1: Safety aspects related to mechanical and physical properties*

ENV 1187-1 to -4, *Test methods for roof coverings under the influence of a thermal attack of burning brands and radiant heat*

ANSI/UL 790 (April 2004), *Standard Test Methods for Fire Tests of Roof Coverings*

ANSI/UL 746B, *Standard for Polymeric Materials – Long Term Property Evaluations*

UL 746C, *Standard for Polymeric Materials – Use in Electrical Equipment Evaluations*

UL 1703, *Standard for Flat-Plate Photovoltaic Modules and Panels*

ASTM E162-13, *Standard Test Method for Surface Flammability of Materials Using a Radiant Heat Energy Source*

ASTM D3755-14, *Standard Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials Under Direct-Voltage Stress*

ASTM D257-14, *Standard Test Methods for DC Resistance or Conductance of Insulating Materials*

ASTM D1002-10, *Standard Test Method for Apparent Shear Strength of Single-Lap-Joint Adhesively Bonded Metal Specimens by Tension Loading (Metal-to-Metal)*

EN 13501-1:2007 + A1, *Fire classification of construction products and building elements – Part 1: Classification using data from reaction to fire tests*