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SUBJECT 8703

OUTLINE OF INVESTIGATION

FOR

CONCENTRATOR PHOTOVOLTAIC MODULES AND ASSEMBLIES

Issue Number: 3

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Summary of Topics

This is the third issue of the Outline of Investigation for Concentrator Photovoltaic Modules and Assemblies, which includes revisions to paragraphs 1.4 and 8.7. The revisions were issued to allow for a concentration ratio of up to 3 times for flat-plate versions of concentrators to be evaluated to UL 1703. This was the original intent for the outline and also reflects current practice.

The UL Foreword is no longer located within the UL Outline of Investigation. For information concerning the use and application of the requirements contained in this Outline of Investigation, the current version of the UL Foreword is located on ULStandardsInfoNet at: <http://ulstandardsinfo.net.ul.com/ulforeword.html>

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INTRODUCTION

1 Scope

1.1 These requirements cover concentrator photovoltaic (CPV) modules and assemblies that concentrate light on a target PV cell(s) for use in general and restricted areas in accordance with the unit's installation instructions. A CPV module is defined as any photovoltaic module which uses artificially elevated levels (i.e. concentrated) of solar irradiance to produce electrical energy.

1.2 These requirements address concentrator photovoltaic (CPV) modules and assemblies intended for installation in accordance with their installation instructions on or integral with buildings, or to be freestanding (i.e. ground mounted or otherwise not attached to buildings), in accordance with the National Electrical Code, NFPA 70, and model building codes.

1.3 The installation class for CPV modules and assemblies identifies the intended installation location as either general access areas designated "General," or restricted access areas designated "Restricted." General access units are able to be installed in open areas that may be contacted by the general public. Restricted access units are to be installed in areas that prevent general public access such as a locked and fenced in area.

1.4 These requirements cover CPV modules and assemblies intended for use in systems with a maximum system voltage of 1500 V.

Exception: CPV modules that are constructed in the flat plate module format as defined by the Standard for Flat-Plate Photovoltaic Modules and Panels, UL 1703, and with a concentration ratio of no more than 3 times shall be evaluated in accordance with all of the requirements in UL 1703.

2 Glossary

2.1 ARTIFICIALLY CONCENTRATED SOLAR IRRADIANCE (ACSI) – Any artificially (i.e. man made) elevated level of solar irradiance (examples: lenses, reflectors, etc.)

2.2 AIR MASS (AM) – A dimensionless quantity, the ratio of the actual path length of radiation through the atmosphere to the vertical path length of radiation through the atmosphere to sea level. At sea level, for all but very high zenith angles (q_z) (the angle subtended by the zenith and the line of sight to the sun).

2.3 BLOCKING DIODE – A diode used to block reverse current into a photovoltaic-source circuit.

2.4 BYPASS DIODE – A diode connected across one or more cells, modules, or assemblies in the forward current direction to allow current to bypass such cells, modules, or assemblies.

2.5 BARRIER – A part inside an enclosure that reduces access to a part that involves a risk of fire, electric shock, injury to persons, or electrical energy-high current levels.

2.6 CLASS 2 TRANSFORMER – A step-down transformer complying with the applicable requirements in the Standard for Class 2 and Class 3 Transformers, UL 1585.

2.7 CONCENTRATOR – The term associated with photovoltaic devices that use concentrated sunlight.

2.8 CONCENTRATOR ASSEMBLY – A group of receivers, optics, and other related components, such as interconnection and mounting, that accepts unconcentrated sunlight. All of these components would usually be shipped separately and need some field installation, and the focus point is field adjustable. An assembly could be made of several subassemblies. The subassembly is a physically stand-alone, smaller portion of the full-size assembly.

2.9 CONCENTRATOR CELL – A basic photovoltaic device that converts ACSI (Artificially Concentrated Solar Irradiance) to electrical energy.

2.10 CONCENTRATOR MODULE – A group of receivers, optics, and other related components, such as interconnection and mounting, that accepts unconcentrated sunlight. All of these components are usually prefabricated as one unit, and the focus point is not field adjustable. A module could be made of several sub-modules. The sub-module is a physically stand-alone, smaller portion of the full-size module.

2.11 CONCENTRATOR OPTICS – An optical device that performs one or more of the following functions from its input to output: increasing the light intensity, filtering the spectrum, modifying light intensity distribution, or changing light direction. Primary optics receive unconcentrated sunlight directly from the sun. Secondary optics receive concentrated or modified sunlight from another optical device, such as primary optics or another secondary optics.

2.12 CONCENTRATOR RECEIVER – A group of one or more concentrator cells and secondary optics (if present) that accepts concentrated sunlight and incorporates the means for thermal and electric energy transfer. A receiver could be made of several sub-receivers. The sub-receiver is a physically standalone, smaller portion of the full-size receiver.

2.13 CONCENTRATOR REPORTING CONDITIONS (CRC) – The conditions of 900 W/m² DNI, AM 1.5, and 20°C ambient temperature.

2.14 CONTROL CIRCUIT – A circuit that carries electric signals and not main power, voltage or current.

2.15 CREEP – Creep, as function.

2.16 ENCLOSURE – A part of the product constructed to provide a degree of protection against:

- a) The accessibility of a part that potentially involves a risk of fire, electric shock or injury to persons, or
- b) The risk of propagation of flame, sparks, and molten metal initiated by an electrical disturbance occurring within.

2.17 FIELD-WIRING LEAD – A lead to which a supply, load, or other wire is intended to be connected by an installer.

2.18 FIELD-WIRING TERMINAL – A terminal to which a supply, load, or other wire is intended to be connected by an installer.

2.19 GROUNDED CONDUCTOR – A system or circuit conductor that is intentionally grounded.

2.20 HAZARDOUS VOLTAGE – Any voltage which poses a risk of electric shock.

2.21 HAZARDOUS ENERGY – Any energy above limited energy levels.

2.22 INTERCONNECT – A conductor within a unit that provides a mechanism for conducting electricity between cells.

2.23 KNOCKOUT – A portion of the wall of an enclosure so fashioned that it is capable of being readily removed by ordinary tools at the time of installation in order to provide an opening or hole for the attachment of an auxiliary device, raceway, cable, or fitting.

2.24 LOW-VOLTAGE, LIMITED-ENERGY (LVLE) CIRCUIT – A circuit involving a voltage of not more than those specified in Section 20, Electric Shock, and supplied by:

a) An inherently limited Class 2 transformer or a not inherently limited Class 2 transformer and an overcurrent protective device that is:

1) Not of the automatic reclosing type,

2) Trip-free from the reclosing mechanism, and

3) Not readily interchangeable with a device of a different rating or the device is marked in accordance with "WARNING – For Continued Protection Against Risk Of Fire, Replace Only With Same Type And Ratings Of Fuse." or the equivalent.

b) A combination of an isolated transformer secondary winding and one or more resistors or a regulating network complying with Section 29.11 of the Standard for Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources, UL 1741, that complies with all the performance requirements for an inherently limited Class 2 transformer or power source; or

c) A battery that is isolated from the primary circuit or a combination of a battery, including the battery charging circuit of a unit that is isolated from the primary circuit, and one or more resistors or a regulating network complying with Section 29.11 of UL 1741.

2.25 MAXIMUM SYSTEM VOLTAGE – The sum of the maximum open-circuit voltages of the maximum number of units to be connected in series in a system.

2.26 RISK OF FIRE – A risk of fire is considered to exist at any two points in a circuit where:

a) The open circuit voltage is more than 42.4 V peak and the energy available to the circuit under any condition of load including short circuit, results in a current of 8 A or more after 1 minute of operation, or

b) A power of more than 15 watts can be delivered into an external resistor connected between the two points.

2.27 REPRESENTATIVE TEST SAMPLES FOR CPV – In the case that a full-size module or assembly is too large and/or impractical to fit into available testing equipment, such as environmental chambers, a smaller representative sample may be used. Representative samples should include all components, except some repeated parts. If possible, the representative samples should use sub-receivers, sub-modules, or subassemblies. During the design and manufacturing of the representative samples, much attention should be paid to reach the maximum similarity to the full-size component in all electrical, mechanical, and thermal characteristics related to quality and reliability. Specifically, the cell string in representative samples should be long enough to include at least two bypass diodes, but in no case less than ten cells. The encapsulations, interconnects, terminations, and the clearance

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distances around all edges should be the same as on the actual full-size products. Other representative components, including lens/housing joints, receiver/housing joints, and end plate/lens should also be included and tested.

2.28 REVERSE CURRENT – Current flowing in a reverse direction to the normal direction resulting from a normally illuminated PV module, resulting in a reversed polarity on the PV cell or device.

3 Units of Measurement

3.1 Values stated without parentheses are the requirement. Values in parentheses are explanatory or approximate information.

4 Undated References

4.1 Any undated reference to a code or standard appearing in the requirements of this Outline of Investigation shall be interpreted as referring to the latest edition of that code or standard.

5 Application Classes

5.1 Concentrator modules and assemblies 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 or assembly 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 concentrator modules are defined as follows:

- a) Class A: General access, hazardous voltage, hazardous energy applications - Modules rated for use in this application class may be used in systems operating at greater than 30 V DC.
- b) Class B: Restricted access, hazardous voltage, hazardous energy applications - Modules rated for use in this application class are restricted to systems protected from public access by fences, location, etc.
- c) Class X: Restricted access, hazardous voltage, hazardous energy applications with additional flame or concentrated light hazards - Modules rated for use in this application class are restricted to systems protected from public access by fences, location, etc. Additionally modules in this application class incorporate an unmitigated fire or concentrated light hazard and must be installed over a non combustible surface.
- d) Class C: Limited voltage - Modules rated for use in this application class are restricted to systems operating at less than 30 V DC.

6 Components

6.1 Except as indicated in 6.2, a component of a product covered by this outline shall comply with the requirements for that component. See Appendix A for a list of standards covering components generally used in the products covered by this outline.

6.2 A component need not comply with a specific requirement that:

- a) Involves a feature or characteristic not needed in the application of the component covered by this outline, or
- b) Is superseded by a requirement in this outline.

6.3 A component shall be used in accordance with its rating established for the intended conditions of use.

6.4 Specific components are incomplete in construction features or restricted in performance capabilities. Such components are intended for use only under limited conditions, such as certain temperatures not exceeding specified limits, and shall be used only under those specific conditions.

CONSTRUCTION

7 General

7.1 A concentrator module or assembly may be completely assembled when shipped from the factory, or may be provided in subassemblies, provided assembly of the system does not involve any action that is likely to affect compliance with the requirements of this outline.

Exception: An assembly part is not required to be affixed to the module at the factory.

7.2 A concentrator module or subassembly, assembly bolt, screw, or other part shall not be intended for securing the complete device to the supporting surface or frame.

7.3 Incorporation of a concentrator module or subassembly into the final assembly shall not require any alteration of the unit unless specific details describing necessary modification(s) for alternate installation(s) are provided in the installation instructions. If a module or subassembly must bear a definite relationship to another for the intended installation and operation of the array (for example, to allow connectors to mate), it shall be constructed to permit it to be incorporated into the array in the correct relationship without the need for alteration.

7.4 The construction of a product shall be such that during installation it will not be necessary to alter or remove any cover, baffle, insulation, or shield that is required to reduce the likelihood of:

- a) Excessive temperatures,
- b) Unintentional contact with a part that may involve a risk of electric shock, or mechanical injury, or
- c) Unintentional exposure to hazardous CSI.

Exception: A cover of a wiring compartment providing access to a connection means that may involve a risk of electric shock may be removable to allow for the making of electrical connections in the field.

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7.5 Parts shall be prevented from loosening or turning if such loosening or turning may result in a risk of fire, electric shock, or injury to persons. Friction between surfaces is not acceptable as the sole means to inhibit the turning or loosening of a part, but a properly applied lock washer is acceptable for this purpose.

7.6 An adjustable or movable structural part shall be provided with a locking device to reduce the likelihood of unintentional shifting, if any such shifting may result in a risk of fire, electric shock, or injury to persons.

7.7 Metals used in locations that may be wet or moist shall not be employed in combinations that could result in deterioration of either metal such that the product would not comply with the requirements in this outline.

7.8 The unit shall be designed so as to prevent the accumulation of debris in any area of the unit that may increase the risk of fire or electric shock.

7.9 Edges, projections, and corners of modules and assemblies shall be such as to reduce the risk of injury to persons.

7.10 Whenever a referee measurement is necessary to determine that a part as mentioned in 7.9 is not sufficiently sharp to constitute a risk of injury to persons, the method described in the Standard for Determination of Sharpness of Edges on Equipment, UL 1439, is to be employed.

7.11 Electronic controls and electrical power circuits shall comply with the Standard for Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources, UL 1741.

7.12 Motorized actuators and trackers that can pose a safety hazard shall be evaluated for such hazards.

7.13 Software or firmware providing a safety function to prevent a risk of electric shock, fire, CSI and mechanical hazards, shall be evaluated for reliability in accordance with the Standard for Software in Programmable Components, UL 1998.

Exception: A UL 1998 evaluation of any specific software is not required where the reliability of the software can be evaluated as a part of end product testing.

7.14 Solar thermal collectors shall comply with the applicable sections of the Outline of Investigation for Solar Collectors, Subject 1279.

7.15 Liquid cooling systems shall comply with the applicable section of the Standard for Power Conversion Equipment, UL 508C.

8 Polymeric Materials

8.1 The following properties shall be considered for all polymeric materials as applicable:

- a) Dielectric Strength,
- b) Volume Resistivity,
- c) Flammability,
- d) Permanence,
- e) Distortion Under Load,
- f) Dimensional Change Due to External Stresses (Creep),
- g) HAI,
- h) HWI,
- i) Tensile or Flexural Strength; Tensile, Izod, or Charpy Impact,
- j) Maximum Use Temperature,
- k) CTI, PTI or Inclined Plane Tracking,
- l) UV Resistance,
- m) Outdoor Exposure,
- n) Compression,
- o) Elongation, and
- p) Adhesion.

8.2 A polymeric material on which an uninsulated live parts is mounted shall be rated V-0, V-1, V-2 or HB in accordance with the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94.

Exception: This requirement does not apply to a material supporting live parts only connected in low-voltage, limited-energy (LVLE) circuits where deterioration of the material does not involve a risk of fire or electric shock.

8.3 Vulcanized fiber shall not be used as the sole support of an uninsulated live part where shrinkage, current leakage, or warpage introduces a risk of fire or electric shock. Electrical grade vulcanized fiber may be used for an insulating bushing, a washer, a separator, or a barrier.

8.4 A polymeric material used to support an uninsulated live part or parts; or a polymeric material serving as the enclosure of a part involving a risk of fire or electric shock shall comply with the applicable requirements as determined in accordance with the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

Exception: A polymeric material serving as the enclosure of a part involving a risk of fire or electric shock may have a flame rating of V-0, V-1, V-2 or HB if containment of any fire within the enclosure can be shown through end product burning brand and spread of flame tests, Section 41, and the system is used under application class B or X.

8.5 Any polymeric material exposed to direct un-concentrated sunlight shall comply with the UV Resistance test from the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

8.6 Any polymeric material exposed to liquid water as a part of its normal operation shall comply with the Water exposure test from the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

8.7 Any polymeric material exposed to concentrated sunlight above 3 times concentration shall be evaluated for the degrading effects of concentrated sunlight, and shall show that such degradation would not increase the risk of fire or electric shock.

8.8 All polymeric materials shall have applicable thermal indices 20°C above the measured operating temperature. The measured operating temperature is the temperature measured during the open-circuit mode for Temperature Test, Section 31, or the temperature during the short-circuit mode, whichever is greater.

8.9 A polymeric material that serves as the outer enclosure for a concentrator module or assembly that is intended to be installed in a multi-module system or assembly; or has an exposed surface area greater than 10 ft² (0.93 m²) or a single dimension larger than 6 ft (1.83 m):

- a) Shall have a flame spread index of 100 or less as determined in accordance with the Standard Method of Test for Surface Flammability of Materials Using a Radiant Heat Energy Source, ASTM E162-2001; or
- b) The complete module or assembly shall comply with the requirements of the spread of flame and burning brand tests, Section 41; or
- c) The markings and installation manual shall specify that the module or assembly is only for use in application class X for use when installed in a restricted access location and over a non-combustible surface.

Exception: A material that serves as the outer enclosure for a small cover or box used for electrical connections is not required to have an index of 100 or less.

8.10 Materials used for gaskets, seals, and the like (other than cork, fibrous material, and similar products) shall comply with the Accelerated-Aging Test, Section 43.

9 Current Carrying Parts and Internal Wiring

9.1 Current carrying parts and internal wiring of the CPV module shall comply with Section 8 of the Standard for Flat-Plate Photovoltaic Modules and Panels, UL 1703, or Section 21 of the Standard for Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources, UL 1741, depending on the specific construction of the CPV module.

10 Wireways

10.1 Wireways of the CPV module shall comply with Section 9 of the Standard for Flat-Plate Photovoltaic Modules and Panels, UL 1703, depending on the specific construction of the CPV module.

11 Connection Means

11.1 Connection means shall comply with Section 10 of the Standard for Flat-Plate Photovoltaic Modules and Panels, UL 1703, and/or Sections 16 and 17 of the Standard for Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources, UL 1741, depending on the specific construction of the CPV module.

12 Bonding and Grounding

12.1 Bonding and grounding of the CPV module shall comply with Section 11 of the Standard for Flat-Plate Photovoltaic Modules and Panels, UL 1703, and/or Sections 18 and 20 of the Standard for Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources, UL 1741, depending on the specific construction of the CPV module.

13 Spacings

13.1 Spacings for the CPV module shall comply with Sections 24 and 25 of the Standard for Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources, UL 1741.

14 Wiring Compartments and Supply Connections

14.1 Wiring compartments and supply connections shall comply with Section 13 of the Standard for Flat-Plate Photovoltaic Modules and Panels, UL 1703, and/or Sections 16 and 17 of the Standard for Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources, UL 1741, depending on the specific construction of the CPV module.

15 Corrosion Resistance

15.1 Corrosion resistance shall comply with Section 14 of the Standard for Flat-Plate Photovoltaic Modules and Panels, UL 1703, and/or Section 6 of the Standard for Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources, UL 1741, depending on the specific construction of the CPV module.

16 Accessibility of Uninsulated Live Parts

16.1 Accessibility of uninsulated live parts of the CPV module shall comply with Section 15 of the Standard for Flat-Plate Photovoltaic Modules and Panels, UL 1703.

17 Fire Resistance

17.1 Fire resistance of the CPV module shall comply with Section 16 of the Standard for Flat-Plate Photovoltaic Modules and Panels, UL 1703.

18 Frame and Enclosure

18.1 The frame and enclosure of the CPV module shall comply with Section 5 of the Standard for Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources, UL 1741, as applicable, depending on the specific construction of the CPV module.

Exception: For polymeric enclosure requirements, see Polymeric Materials, Section 8.

19 Protection of Service Personnel

19.1 Protection of service personnel shall comply with Section 10 of the Standard for Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources, UL 1741, as applicable, depending on the specific construction of the CPV module.

20 Electric Shock

20.1 Electric shock shall comply with Section 11 of the Standard for Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources, UL 1741, as applicable, depending on the specific construction of the CPV module.

21 Switches and Controls

21.1 Switches and controls of the CPV module shall comply with Section 12 of the Standard for Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources, UL 1741, as applicable, depending on the specific construction of the CPV module.

22 Disconnect Devices

22.1 Disconnect devices of the CPV module shall comply with Section 13 of the Standard for Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources, UL 1741, as applicable, depending on the specific construction of the CPV module.

23 Separation of Circuits

23.1 Separation of circuits shall comply with Section 23 of the Standard for Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources, UL 1741, as applicable, depending on the specific construction of the CPV module.

24 Isolated Accessible Signal Circuits

24.1 Isolated accessible signal circuits of the CPV module shall comply with Section 28 of the Standard for Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources, UL 1741, as applicable, depending on the specific construction of the CPV module.

25 Control Circuits

25.1 Control circuits of the CPV module shall comply with Section 29 of the Standard for Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources, UL 1741, as applicable, depending on the specific construction of the CPV module.

26 Over Current Protection

26.1 Over current protection for the CPV module shall comply with Section 30 of the Standard for Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources, UL 1741, as applicable, depending on the specific construction of the CPV module.

27 Printed-Wiring Boards

27.1 Printed-wiring boards for the CPV module shall comply with Section 32 of the Standard for Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources, UL 1741, as applicable, depending on the specific construction of the CPV module.

PERFORMANCE

28 General

28.1 The reference standards below, related to the determination of performance conditions, shall be used in the Temperature Test, Section 31, CPV Electrical Parameters, Section 30, Hot-Spot Endurance Test, Section 49, Outdoor Exposure Test, Section 55, Ultraviolet Conditioning Test, Section 54, and Off-Axis Beam Damage Test, Section 53. The procedures described in the following standards shall be used where applicable:

- a) Standard Tables for Reference Solar Spectral Irradiances: Direct Normal and Hemispherical on 37° Tilted Surface, ASTM G173;
- b) Standard Specifications for Solar Simulation for Terrestrial Photovoltaic Testing, ASTM E927;
- c) Standard Test Method for Rating Electrical Performance of Concentrator Terrestrial Photovoltaic Modules and Systems Under Natural Sunlight, ASTM E2527;
- d) Procedures for Temperature Irradiance Corrections to Measured I-V Characteristics of Crystalline Silicon Photovoltaic Devices, IEC 60891;
- e) Photovoltaic Devices, Part 1: Measurement of Photovoltaic Current-Voltage Characteristics, IEC 60904-1; and
- f) Photovoltaic Devices, Part 3: Measurement Principles for Terrestrial Photovoltaic (PV) Solar Devices With Reference Spectral Irradiance Data, IEC 60904-3.

28.2 With reference to the tests mentioned in this Section, parameters may be measured under conditions other than specified irradiance, air mass, or temperature, and the values at the required reporting conditions calculated using correction coefficients described in the referenced standards.

28.3 Samples of the unit, or partial or representative samples, shall be subjected to the tests indicated in Table 28.1, and Figures 28.1 and 28.2. The order of the tests in Table 28.1 is for convenience only. It is not intended to imply that any one sample be subjected to the complete sequence or a partial sequence of tests unless specifically stated in the sequence flow charts of Figures 28.1 and 28.2. Unless one sample is to be subjected to a specific sequence of tests, separate samples are able to be used for each test.

Table 28.1
Module test list

Section	Test Description
29	Visual Inspection (as-received)
37	Bonding Path Resistance Test (as-received)
32	Electrical Insulation Test (as-received)
33	Wet Insulation-Resistance Test (as-received)
44	Thermal Cycling (TC) Test - Sequence A
32	Electrical Insulation Test (Post TC)
33	Wet Insulation-Resistance Test (Post TC)
37	Bonding Path Resistance Test (Post TC)
29	Visual Inspection (Post TC)
46	Humidity Freeze (HF) Cycling Test - Sequence B
32	Electrical Insulation Test (Post HF)
33	Wet Insulation-Resistance Test (Post HF)
37	Bonding Path Resistance Test (Post HF)
29	Visual Inspection (Post HF)
45	Damp Heat (DH) Test – Sequence C
32	Electrical Insulation Test (Post DH)
33	Wet Insulation-Resistance Test (Post DH)
37	Bonding Path Resistance Test (Post DH)
29	Visual Inspection (Post DH)
50	Mechanical Load Test – Sequence D ^a
IEC ONLY	Robustness of Terminations Test ^a
34	Strain Relief Test ^a
54	Ultraviolet Conditioning Test – Sequence E
55	Outdoor Exposure Test
30	Electrical Parameters
32	Electrical Insulation Test (Post Sequence E)
33	Wet Insulation-Resistance Test (Post Sequence E)
37	Bonding Path Resistance Test (Post Sequence E)
29	Visual Inspection (Post Sequence E)
53	Off-Axis Beam Damage Test (as needed) ^a
32	Electrical Insulation Test (Post OA) ^a
29	Visual Inspection (Post OA) ^a
42	Water Spray (WS) Test ^a
32	Electrical Insulation Test (Post WS) ^a
29	Visual Inspection (Post WS) ^a
35	Push Test (PT) ^a
32	Electrical Insulation Test (Post PT) ^a
29	Visual Inspection (Post PT) ^a
	Electrical Parameter Stabilization

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Table 28.1 Continued

Section	Test Description
31	Temperature Test
29	Visual Inspection (Post Temp.)
38	Reverse Current Overload Test ^a
39	Terminal Torque Test (as needed) ^a
43	Accelerated Aging Test (as needed) ^a
52	Bypass/Blocking Diode Thermal Test ^a
36	Cut Test (as needed) ^a
40	Impact Test ^a
41	Fire Tests (Spread of flame and Burning Brand as needed) ^a

^a These tests may be run separately from the sequences shown in Figures 28.1 and 28.2.