70.2 Other than as noted in 70.3, the potential for the production-line test shall be in accordance with Condition A or Condition B of Table 70.1 or Table 70.2 at a frequency within the range of 40 – 70 Hertz.

Table 70.1
Production-Line Test Conditions AC Rated Circuits

Circuit rating, Vac	Condition A		Condition B		Condition C		Condition D	
	Potential, volts ac	Time, seconds	Potential, volts ac	Time, seconds	Potential, volts dc	Time, seconds	Potential, volts dc	Time, seconds
250 or less	1000	60	1200	1	1400	60	1700	1
More than 250	1000+2 V[a]	60	1200+ 2.4 V[a]	1	1400+ 2.8 V[a]	60	1700+3.4 V[a]	1

[a] Maximum marked voltage.

Note: The multipliers in the table are chosen with the following background:

2.4 – A 20 % adder on the multiplier 2 to account for reduced test time.

2.8 – A √2, truncated after the first decimal (=1.4) multiplier on "2" from condition A to account for the peak value of an AC rms voltage to calculate the DC test potential of AC circuits.

3.4 – A combination of the two above: 2*1.2*1.4, rounded to the next decimal.

Table 70.2
Production-Line Test Conditions for DC Rated Circuits

Circuit rating, Vdc	Condition A		Condition B		Condition C		Condition D	
	Potential, volts ac	Time, seconds	Potential, volts ac	Time, seconds	Potential, volts dc	Time, seconds	Potential, volts dc	Time, seconds
250 or less	1000	60	1200	1	1400	60	1700	1
More than 250	1000+1.4 V[a]	60	1200+ 1.7 V[a]	1	1400+ 2 V[a]	60	1700+2.4 V[a]	1

[a] Maximum marked voltage.

70.3 A unit employing circuitry that is able to be damaged by an ac potential is able to be tested using a dc potential in accordance with Condition C or Condition D of Table 70.1 or Table 70.2.

70.4 Testing of a unit in a heated or unheated condition meets the intent of the requirement for manufacturing and production tests.

70.5 The test is to be performed on a complete, fully assembled unit. It is not intended that the unit be unwired, modified, or disassembled for the test.

Exception No. 1: A part, such as a snap cover or a friction-fit knob, that interferes with the performance of the test is to be removed.

Exception No. 2: The test is able to be performed on a partial or modified unit as long as it has been evaluated to be representative of a complete unit.

Exception No. 3: The grounding connection of a grounded input terminal is able to be disconnected.

70.6 A unit employing a solid-state component that is not relied upon to reduce a risk of electric shock and that is susceptible to damage by the dielectric potential, is able to be tested before the component is electrically connected or after the component is electrically disconnected. The circuitry is able to be rearranged for the purpose of the test to minimize the potential of solid-state-component damage while retaining representative dielectric stress of the circuit.

70.7 The test equipment for supplying an ac potential is to include a transformer having a sinusoidal output. The test equipment is to include a means of indicating the test potential, an audible or visual indicator of breakdown, and a manually reset device to restore the equipment after breakdown or a feature to automatically reject a noncomplying unit.

70.8 Where the output rating of the test equipment transformer is less than 500 VA, the equipment is to include a voltmeter in the output circuit to directly indicate the test potential.

70.9 Where the output rating of the test equipment transformer is 500 VA or more, the test potential is to be indicated:

a) By a voltmeter in the primary circuit or in a tertiary-winding circuit,

b) By a selector switch marked to indicate the test potential, or

c) In the case of equipment having a single test-potential output, by a marking in a readily visible location to indicate the test potential. When marking is used without an indicating voltmeter, the equipment shall include a positive means, such as an indicator lamp, to indicate that the manually reset switch has been reset following a dielectric breakdown.

70.10 Test equipment, other than that described in 70.7 – 70.9, is usable when found to accomplish the intended factory control.

70.11 During the test, the unit switches are to be in the on position, both sides of the input and output circuits of the unit are to be connected together and to one terminal of the test equipment, and the second test-equipment terminal is to be connected to the accessible dead metal.

Exception: A switch is not required to be in the on position when the testing means applies full test potential from the input and output wiring to dead metal parts with the switch not in the on position.

71 Production Tests for Interactive Equipment

71.1 Products rated for compliance with IEEE 1547-2003 and IEEE 1547.1-2005 shall comply with the applicable requirements in IEEE 1547.1-2005, Section 6, Production tests.

CHARGE CONTROLLERS

INTRODUCTION

72 General

72.1 These requirements cover permanently connected charge controllers that are intended to be installed in photovoltaic panels, photovoltaic power distribution equipment, and control panels or systems.

72.2 The requirements in Sections 72 – 83 supplement and, in some cases, amend the requirements in Sections 6 – 70.

CONSTRUCTION

73 General

73.1 One of the internal current-carrying conductors (normally the negative), connecting the charge controller's input to output, shall be identified as the grounded conductor where the controller is used in

grounded circuits or systems. The grounded conductor shall not contain any components, such as relays, transistors or similar devices.

Exception: A shunt provided in the negative line is in compliance with the requirement.

73.2 When a shunt is provided in accordance with the Exception to 73.1, the point of connection to system ground shall be identified. The cross-sectional area of the shunt shall not be less than the minimum size conductor for the intended current and material type. See Table 21.2 for examples.

Exception: A smaller size shunt meets the intent of the requirement when:

a) The measured temperatures do not exceed the ratings of the support materials or surrounding components under normal operation, and

b) The shunt does not open as a result of the tests in Abnormal Tests, Section 50.

73.3 Controls for the adjustment of the state-of-charge of a battery shall be accessible for qualified service personnel only.

Exception: An on/off switch or disconnect device of a charge controller, power distribution panel, or inverter shall not be deemed a control for the state-of-charge of a battery.

73.4 When a charge controller employs temperature compensating monitoring, the monitoring means shall be remote from the charge controller, see 82.3 and 82.4.

Exception: The monitoring means is able to be internal to a unit when the unit is marked in accordance with 82.4 and, the unit is provided with instructions as described in 83.6.

73.5 The polymeric material in a charge controller that is intended to be installed internally to the wiring compartment of a photovoltaic module shall have a relative thermal index of 90 °C (194 °F) minimum.

PERFORMANCE

74 General

74.1 A charge controller shall be tested as described in 76.1 – 80.4.

74.2 A charge controller intended for use in a photovoltaic control panel is to be installed in the smallest specified size enclosure.

74.3 A charge controller intended for use in a photovoltaic module wiring compartment is to be installed in the smallest sized compartment in which the controller is able to be installed. Prior to testing, the charge controller is to be subjected to 20 cycles of the Temperature Cycle Test in accordance with the Standard for Flat-Plate Photovoltaic Modules and Panels, UL 1703. When performing the tests, the charge controller, without an electrical enclosure, is to be in an ambient of 60 °C (140 °F) minimum or as rated by the manufacturer.

75 Sources and Loads

75.1 When performing tests on a charge controller using a simulated source for the PV input, the test source is to be adjusted to the maximum rated input voltage, and the current source shall be capable of delivering the DUT's rated maximum input short-circuit current measured at the DUT terminals.

75.2 For the charge controller output, a battery or a simulated battery load is able to be used. A simulated battery load is to consist of one of the loads defined in Table 75.1 and illustrated in Figure 75.1. The capacitance is to be in parallel with a load resistor and a power supply adjusted to simulate the battery voltage and adjusted to draw a specified operational battery charge current as required by the charge controller design. A series resistance shall be added to the capacitor bank in order to achieve a time constant of not less than 3ms for battery ports with an I_{sc} max rating of 10kA or less, or 8ms if the rating exceeds 10kA. The source shall be capable of delivering the DUT's rated maximum battery short-circuit current measured at the DUT terminals.

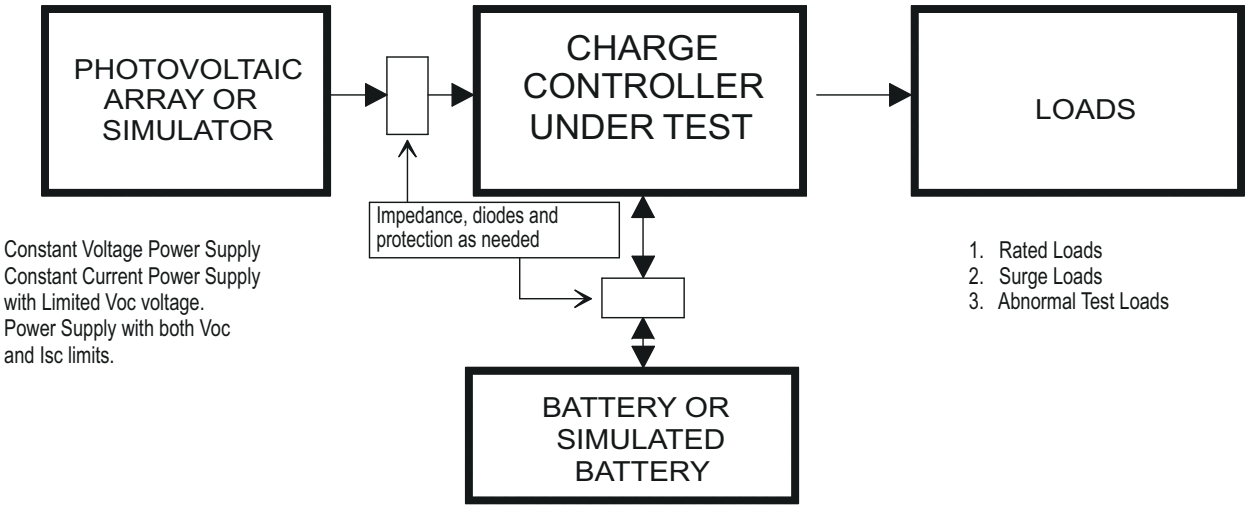
Note: These time constant specifications are aligned with the Standard for Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures, UL 489, for DC circuit breakers.

Table 75.1
Simulated Battery Loads

Battery current rating, amperes	Capacitance in microfarads
0 – 20	100,000
> 20 – 40	185,000
> 40	300,000

Figure 75.1

Charge Controller Test Configuration



* In accordance with 75.2.

76 Normal Operations

76.1 When tested as described in 76.3 – 76.5, a charge controller shall not exceed its rated input, output, or battery charge/discharge current by more than +10 percent.

76.2 When tested as described in 76.3 – 76.5, a charge controller shall not exceed its rated voltages. An on/off and constant voltage charge controller shall not have an output voltage at the battery terminals or at load terminals that exceeds its rated value by more than +10 percent after the first minute of operation.

76.3 The charge controller is to be connected to a photovoltaic array or simulated source adjusted as specified in Sources and Loads, Section 75. The battery interface terminals of the charge controller are to be open circuited. The output or load terminals of the charge controller are to be connected to a load. The load is to be adjusted to draw the maximum attainable output current from the charge controller and the voltage is to be measured at the load terminals and at the battery terminals. When the charge controller does not function with open-circuited battery terminals, the test method described in 76.5 is to be used.

76.4 Once operational, the load is then to be adjusted over a range of operation, excluding short-circuit, and the voltage is to be measured at the output (load) terminals and at the battery interface for each value of load.

76.5 For a charge controller that does not function with open-circuited battery terminals, the charge controller is to be connected to a photovoltaic source or simulated source capable of providing 125 percent of the rated current of the intended photovoltaic circuit. The output of the charge controller is to be connected to a load. The battery terminals are to be connected to a battery or battery simulator operating at the charge controller rated battery voltage. The load is to be adjusted to draw the maximum rated current of the charge controller. The test method specified in 76.4 is to be conducted while measuring output current.

77 Temperature

77.1 When tested as specified in Temperature, Section 46, the temperatures measured on polymeric materials in a charge controller intended to be installed in accordance with 73.5 shall not exceed the relative thermal index rating of the material determined in accordance with the Standard for Polymeric Materials – Long Term Property Evaluations, UL 746B.

78 Temperature Compensation

78.1 While the temperature sensor input is in a short- or open-circuit condition, a charge controller provided with integral temperature compensation shall shut down or limit the output charge to the load when tested as specified in 78.2.

78.2 The charge controller is to be connected to its rated input supply and rated load. The temperature sensor input is to be open-circuited and then short-circuited, one at a time.

79 Connection Sequence

79.1 When tested as described in 79.2 – 79.4, the voltages and currents for a charge controller shall remain within their rated values.

79.2 A charge controller marked with a connection sequence is to be connected in the prescribed manner and then tested in accordance with Normal Operations, Section 76.

79.3 A charge controller not marked with a prescribed connection sequence is to be tested first, with the battery connected before the photovoltaic source, and then with the photovoltaic source connected and energized before the battery is connected. Output to the battery or load is to be measured in accordance with Normal Operations, Section 76.

79.4 For all charge controllers, the battery voltage is to be disconnected and reconnected during normal operation. The voltages and currents are to be measured at the photovoltaic input, load output, and battery terminals.

80 Abnormal Tests

80.1 General

80.1.1 When tested as described in 50.2 – 50.6 and 80.2 – 80.4, a charge controller shall comply with 50.1.1.

80.1.2 During any of the tests in 80.2 – 80.4, when shorting of the battery output terminals is required while under load, relaying shall be used to short the terminals of the unit under test while open-circuiting the battery.

80.2 Input and output faults

80.2.1 The photovoltaic array connections of a charge controller are to be connected to a dc simulator and the load (output) terminals are to be loaded to their rated load. While in a loaded state, the photovoltaic input to the charge controller is to be short-circuited.

80.2.2 The photovoltaic array connections of a charge controller are to be connected to a dc supply and the rated load (output). While in a loaded state, the output of the charge controller is to be short-circuited.

80.3 Charge controller miswiring

80.3.1 A charge controller is to be connected to its rated photovoltaic source or simulated photovoltaic source and battery as noted in Table 80.1. The connection order and polarity shall be as noted in the Table. When connecting the second supply source, battery or array, it is to be connected through a relaying device, such that the first source is already energized prior to the second source.

Exception: Those tests which limit the connection sequence do not apply to a charge controller which is marked in accordance with 81.1. For example, when a controller is marked in accordance with 81.1 indicating to connect array first, tests A, C, D, and E are not required to be performed.

Table 80.1
Connection Order and Polarity

Test condition	Supply to be connected first	Lead to be connected to positive terminal	Lead to be connected to negative terminal	Supply to be connected second[a] via relay	Lead to be connected to positive terminal	Lead to be connected to negative terminal
A	Battery	+	-	Array	+	-
B	Array	+	-	Battery	+	-
C	Battery	-	+	No connection		
D	Battery	-	+	Array	+	-
E	Battery	-	+	Array	-	+
F	Array	-	+	No connection		
G	Array	-	+	Battery	+	-
H	Array	–	+	Battery	–	+

[a] When connecting the second supply source, battery or array, it is to be connected through a relaying device, such that the first source is already energized prior to the second source.

80.3.2 When a simulated array source is used, a reverse-biased diode shall be placed across the supply to simulate the possible activation of an array bypass diode.

80.3.3 As a result of the test for charge controllers which have load control terminals, there shall not be reverse polarity voltage present on the terminals or current unless condition A of Table 80.1 occurs.

80.3.4 During the test, no additional external overcurrent protection is to be in the test circuit.

80.4 Low-voltage disconnect

80.4.1 When tested as described in 80.4.2, a charge controller shall operate in a stable, controlled manner over all ranges of charge and discharge of a battery load.

80.4.2 A charge controller with a low-voltage disconnect is to be connected to a source providing the charge controller's rated input, a battery or simulated battery load, and a rated load. The battery source is to be adjusted to 25 percent, 50 percent, 75 percent, and 100 percent of the rated battery voltage. The load is to be adjusted so that the charge controller cycles in accordance with the charge controller design from battery charge to battery discharge state. Adjustable charge set-points are to be set to their closest tolerance so that the charge controller cycles during the battery charge.

MARKING

81 Cautionary Markings

81.1 A charge controller which requires a specific connection method in accordance with 80.3.1 shall be marked "CAUTION: Risk of fire and shock, connect _____ terminals prior to the connection of _____ terminals" indicating the battery or array terminals as appropriate.

82 Details

82.1 A charge controller shall be marked in accordance with Details, Section 66, and Cautionary Markings, Section 67.

82.2 A charge controller intended to be installed in the wiring compartment of a photovoltaic module shall be marked to identify the manufacturer and model number of the photovoltaic module in which the controller is intended to be installed.

82.3 A charge controller with a temperature compensating set-point that is intended to be adjusted by service personnel shall be marked with set-point details.

82.4 A charge controller with an internal temperature compensating means shall be marked "CAUTION: Internal Temperature Compensation. RISK OF FIRE, USE WITHIN ____ m (ft) of BATTERIES" or "RISK OF FIRE, MOUNT IN CONTACT WITH BATTERIES."

82.5 A charge controller shall be marked with the minimum interrupting rating of the overcurrent protective device to be used for short-circuit protection. For example, "Minimum interrupting rating _____ A dc."

83 Important Safety Instructions

83.1 The installation instructions shall identify the conductor or the terminal described in 73.1 as the conductor or the terminal to be used as the grounded conductor in grounded circuits.

83.2 The installation instructions shall specify the type and chemical composition of the battery with which the charge controller is intended to be used [see 69.4(I)].

83.3 A charge controller intended for field installation shall be provided with a wiring diagram or installation instructions that specify the method of installation including the connection method and wire size range in accordance with Article 690 of the National Electrical Code, NFPA 70.

83.4 The installation instructions for a charge controller intended to be installed in the wiring compartment of a photovoltaic module shall specify the manufacturer and model of the photovoltaic module.

83.5 The installation instructions for a charge controller shall describe the maximum overcurrent protection to be provided in accordance with Article 690 of the National Electrical Code, NFPA 70.

83.6 The installation instructions for a charge controller with an internal temperature compensating means shall indicate where the controller is to be used with respect to the batteries (See 82.4) and the risks associated with the improper installation.

83.7 The installation instructions for a charge controller with service personnel adjustable temperature compensating set-points shall describe the battery chemistry and types for each set point. The instructions shall detail the risks associated with improper settings.

AC MODULES AND PV MODULES WITH INTEGRATED ELECTRONICS

INTRODUCTION

84 General

84.1 The requirements in Sections 85 – 91 supplement and, in some cases, amend the general requirements in Sections 6 – 71.

CONSTRUCTION

85 General

85.1 An AC module that is capable of utility interactive operation shall comply with the requirements for utility-interactive inverters in Sections 6 – 71.

85.2 The PV panel or module of an AC module or PVIE shall comply with the requirements in the Standard for Flat-Plate Photovoltaic Modules and Panels, UL 1703, or the Standard for Photovoltaic (PV) Module Safety Qualification – Part 1: Requirements For Construction, UL 61730-1 and the Standard for Photovoltaic (PV) Module Safety Qualification – Part 2: Requirements For Testing, UL 61730-2. Integrated electronics that provide a PV Module protective bypass diode functionality, shall comply with the construction requirements in 5.3.10 of UL 61730-1 as well as the referenced testing in UL 61730- The test shall provide power to the protection circuit as would be found in normal operation of the final assembly.

Note: UL 61730-1, Clause 5.3.10, requires that bypass diodes, and herein, integrated electronics exhibiting bypass diode protective functions, be rated to withstand the current and voltage for their intended use. Compliance is checked by bypass diode thermal test (MST 25), hot-spot endurance test (MST 22), bypass diode functionality test (MST 07) (following Sequences A-F sequential stress testing) and visual inspection (MST 01).

85.3 PV module junction boxes intended to be secured to the PV laminate shall comply with Standard for Photovoltaic Junction Boxes, UL 3730. Enclosures that are not a PV junction box shall be evaluated to the requirements in Sections 6 – 71.

85.4 All components across the dc input circuit of an AC module or module mounted electronics shall be rated for 125 percent of the PV module maximum open-circuit voltage or the voltage shall be derived from Sandia Report, SAND2004-3535 December 2004, under the conditions of -40 °C (-40 °F) ambient air temperature, 1000W/m^2 irradiance, AM1.5 Spectral content, and 1 m/s wind speed.

85.5 For amorphous silicate or thin film PV modules, the components across the dc input circuit shall be rated for the PV module open-circuit voltage regardless of the temperature.

85.6 An ac or dc disconnection means shall be rated for disconnection of the electrical load under normal and foreseeable abnormal conditions for the electronics. A disconnect in the PV circuit shall be rated for 125 percent of the PV module maximum open-circuit voltage or the voltage shall be derived from Sandia Report, SAND2004-3535 December 2004, under the conditions of -40 °C (-40 °F) ambient air temperature, 1000W/m^2 irradiance, AM1.5 Spectral content, and 1 m/s wind speed. PV connectors are typically not rated for disconnection under load at rated voltage, they may be evaluated for disconnect functionality at the reduced voltage of a single PV module.

85.7 Polymeric materials excluding materials serving as a PV module encapsulant shall have a relative thermal index in accordance with the Standard for Polymeric Materials – Long Term Property Evaluations, UL 746B, not less than the temperature measured during the normal temperature test and not less than 90 °C (194 °F).

85.8 Connectors employed external to the module shall comply with the material and conditioning requirements in the Standard for Connectors for Use in Photovoltaic Systems, UL 6703, and connectors shall not be of a NEMA configuration used in other power systems. NEMA connectors configured specifically for use in PV or energy storage systems are permitted.

85.9 Wire harnesses shall comply with the Outline for Distributed Generation Wiring Harnesses, UL 9703.

85.10 Equipment grounding for a dc input circuit specified in 20.1.2 is not required for an AC module or PVIE.

85.11 Equipment bonding between the PV modules and electronics having accessible conductive surfaces shall comply with Section 88 and the Standard for Mounting Systems, Mounting Devices, Clamping/Retention Devices, and Ground Lugs for Use with Flat-Plate Photovoltaic Modules and Panels, UL 2703, Section 18, Humidity Test. This testing may be combined with the performance testing described in Section 87 when required.

85.12 A gasket provided as part of the protective housing used on an enclosure shall comply with the requirements in the Standard for Photovoltaic Junction Boxes, UL 3730.

85.13 If a control circuit is relied on to maintain downstream voltage or current within specified limits, and those limits determine the output ratings of the converter, the control(s) shall comply with the applicable requirements in Sections 43 and 48, and with the Standard for Tests for Safety-Related Controls Employing Solid-State Devices, UL 991, or with the Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1. If software is involved in the control, it shall comply with the Standard for Software in Programmable Components, UL 1998, or with UL 60730-1.

85.14 PVIE and AC modules with input current rating, output current rating or electronics backfeed current rating greater than the PV module fuse rating shall be tested in accordance with the Standard for Photovoltaic (PV) Module Safety Qualification – Part 2: Requirements For Testing, UL 61730-2, Continuity Test for Equipotential Bonding (MST13) and Reverse Current Overload (MST 26) at the higher current.

85.15 An AC module that consists of a separate microinverter connected to a PV module with conductors and connectors may be repairable in the field if that repair has been determined to be possible by the original manufacturer or the manufacturer of a suitable retrofit kit. An AC module that can be repaired in the field by replacing the microinverter or the PV module shall comply with the following:

a) Any mechanical device, threaded or unthreaded, that is used to electrically bond the microinverter to the PV module shall comply with the grounding impedance test of Section 51 after having been removed and reinstalled five (5) times. Bonding shall comply with the requirements in 85.11.

b) Any disconnected and exposed (to the environment) connectors attached to the PV module or the trunk cable or other ac output connector shall comply with 85.8 and be provided with protection from the deteriorating effects of the environment, when not connected.

c) Any and all input and output connections shall be accessible in the field and be capable of being disconnected using the proper tool without opening the microinverter enclosure or the PV module junction box. Any connectors used or reused shall be mated to connectors from the same manufacturer and series number (mate-ability shall be maintained). The requirements of 85.8 shall be met.

d) The manufacturer of the AC module or the manufacturer of the retrofit kit shall identify a suitable replacement microinverter or PV module and provide appropriate replacement instructions if the original equipment microinverter or PV module is no longer available. The retrofit kit shall include detailed instruction and procedures to perform the retrofit installation, including a list identifying all critical components.

PERFORMANCE

86 General

86.1 Where electronics are mounted to the PV module with adhesive, the securement to the module shall be in accordance with PV Module Mounted Equipment Securement Test, Section 87.

86.2 The Temperature Test, Section 46, is to be conducted as defined in either 86.3 or 86.4 based on the manufacturer's specified environmental temperature rating. The environmental temperature rating used shall be marked on the product and included in the installation instructions.

86.3 The temperature test shall be performed in a controlled thermal chamber operating in a temperature range between 35 °C (95 °F) and the manufacturer's specified environmental ambient temperature rating of the AC module or PVIE + 5 °C (9 °F) with an irradiation of at least 1000w/m^2 from a class CCC (or better) continuous solar simulator in accordance with the Standard for Photovoltaic devices – Part 9: Solar simulator performance requirements, IEC 60904-9. The wind speed shall be 1 m/sec or less and the PV module shall be mounted according to the manufacturers installation instructions in the manner which will cause the highest heat build-up on the PVIE. The electronics are to be electrically loaded to maximum input and output current or other conditions that result in maximum heating of the assembly.

86.4 If a controlled thermal chamber with a solar simulator is not available for use, the following procedure may be used:

a) The baseline temperature profile of the module with the power converter or control device connected is to be determined using the UL 1703, Section 19, Temperature test at open circuit voltage or UL 61730-2, MST 21, maximum electrical load conditions. In addition to the thermocouple locations identified in Section 46, the following additional thermocouple locations shall be monitored:

1) The electronics' localized air ambient below the module, which is likely to be different than the ambient air temperature above the module.

2) The integrated electronics' surface in contact with or closest to the module, T_{close}.

3) The remaining integrated electronics' surfaces, T_a (average of remaining surfaces).

b) Using the data collected from (a), the module is to be operated in a controlled thermal chamber at T_a. The PV module is to be heated to T_{close} using either:

1) A power supply in the forward bias condition (+ to + and – to –) with current adjusted to reach the target T_{close} temperature, or

2) Via the application of an external heating source such as an electrically heated plate or pad applied adjacent to the electronics. The heating pad shall cover at least four times the area as the electronics enclosure and be centered over the installed electronics.

c) The module mounted electronics is to be energized to worst case operating conditions for the circuit design using an externally controlled power supply to cause the highest heating of the critical electronic circuit components. This is normally a maximum output current. Some electronic circuits may require two separate tests to attain the worst case normal conditions because as some circuits and components will be subjected to higher temperatures under a low voltage condition while other circuit components will be subjected to higher temperatures under a high voltage conditions.

86.5 For units that are not rated for installation in the test ambient, the temperature test data shall be corrected for the rated installation ambient rating of the unit in accordance with Table 46.3. The measured temperature is to be corrected by addition (when the test ambient temperature is lower than the rated ambient temperature) or by subtraction (when the test ambient temperature is higher than the rated ambient temperature) of the difference between the rated ambient temperature and the test ambient temperature.

86.6 Electronics for field installation on a module or mounting system with an enclosure rating shall be evaluated and found compliant with the requirements and testing for that enclosure rating.

87 PV Module Mounted Equipment Securement Test

87.1 Equipment secured to a PV module with adhesive shall comply with Sequence C in Figure 1 of the Standard for Photovoltaic (PV) Module Safety Qualification – Part 2: Requirements For Testing, UL 61730-2. During the MST 16 testing of Sequence C, the electronics may alternatively be tested with the Dielectric Voltage-Withstand Test, Section 47, in place of the Sequence C Insulation Test.

Exception No. 1: Connection means that do not include polymeric materials need not be subjected to the UV Test (MST 54) if in the intended installation configuration, the adhesive will not be exposed to sunlight.

Exception No. 2: The applied force shall be the greater of 156 N (35 lbf) or 4 times the weight of the complete module mounted electronics assembly.

87.2 In addition to the compliance criteria defined in the referenced tests for 87.1, the test shall not result in:

a) Exposure of live parts,

b) Separation of the enclosure from the substrate or superstrate, or

c) Fracturing of the enclosure, substrate, or superstrate.