Designation: E1462 – 12

Standard Test Methods for Insulation Integrity and Ground Path Continuity of Photovoltaic Modules[1]

This standard is issued under the fixed designation E1462; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 These test methods cover procedures for (*1*) testing for current leakage between the electrical circuit of a photovoltaic module and its external components while a user-specified voltage is applied and (*2*) for testing for possible module insulation breakdown (dielectric voltage withstand test).

1.2 A procedure is described for measuring the insulation resistance between the electrical circuit of a photovoltaic module and its external components (insulation resistance test).

1.3 A procedure is provided for verifying that electrical continuity exists between the exposed external conductive surfaces of the module, such as the frame, structural members, or edge closures, and its grounding point (ground path continuity test).

1.4 This test method does not establish pass or fail levels. The determination of acceptable or unacceptable results is beyond the scope of this test method.

1.5 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.6 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

E772 Terminology of Solar Energy Conversion

2.2 *Underwriters Laboratories Standard:*[3]

ANSI/UL 1703 Standard for Safety for Flat-Plate Photovoltaic Modules and Panels

3. Terminology

3.1 *Definitions*—Definitions of terms used in this test method may be found in Terminologies E772.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *ground path continuity, n*—the electrical continuity between the external and conductive surfaces of a photovoltaic module and the intended grounding point of the module.

3.2.2 *insulation resistance, n*—the electrical resistance of a photovoltaic module insulation, measured at a specified applied voltage between the module internal circuitry and its grounding point or mounting structure.

4. Summary of Test Method

4.1 *Insulation Integrity*—Two procedures are provided for testing the isolation of the electrically active parts of the module from the accessible conductive parts and the exposed nonconductive surfaces. This isolation is necessary to provide for safe insulation, use, and service of a photovoltaic module or system.

4.1.1 *Dielectric Voltage Withstand Procedure*—A ramped voltage is applied between the photovoltaic circuit and the accessible parts and surfaces of the module outside of the photovoltaic circuit while monitoring the current, or by determining whether the leakage current exceeds a predetermined limit. The module is then inspected for evidence of possible arcing.

4.1.2 *Insulation Resistance Procedure*—The insulation resistance is measured between the photovoltaic circuit and the accessible parts and surfaces of the module outside of the photovoltaic circuit, using a high-impedance ohmmeter.

4.2 *Ground Path Continuity Procedure*—This procedure is intended for verification that electrical continuity exists between all of the external conductive components and the module grounding point specified by the manufacturer. This is accomplished by passing a current between the grounding

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Underwriters Laboratories Incorporated, Publication Stock, 333 Pfingsten Road, Northbrook, IL 60062.

terminal or lead and the conductive part in question and calculating the resistance between these two points.

5. Significance and Use

5.1 The design of a photovoltaic module or system intended to provide safe conversion of the sun's radiant energy into useful electricity must take into consideration the possibility of hazard should the user come into contact with the electrical potential of the module. These test methods describe procedures for verifying that the design and construction of the module or system are capable of providing protection from shock through normal installation and use. At no location on the module should this electrical potential be accessible, with the obvious exception of the intended output leads.

5.2 These test methods describe procedures for determining the ability of the module to provide protection from electrical hazards.

5.3 These procedures may be specified as part of a series of qualification tests involving environmental exposure, mechanical stress, electrical overload, or accelerated life testing.

5.4 These procedures are normally intended for use on dry modules; however, the test modules may be either wet or dry, as indicated by the appropriate protocol.

5.5 These procedures may be used to verify module assembly on a production line.

5.6 Insulation resistance and leakage current are strong functions of module dimensions, ambient relative humidity and absorbed water vapor, and the ground path continuity procedure is strongly affected by the location of contacts and test leads to the module frame and grounding points.

5.6.1 For these reasons, it is the responsibility of the user of these test methods to specify the maximum acceptable leakage current for the dielectric voltage withstand test, and the maximum acceptable resistance for the ground path continuity procedure.

5.6.2 Fifty μA has been commonly used as the maximum acceptable leakage current (see ANSI/UL 1703, Section 26.1), and 0.1 Ω has been commonly used as the maximum acceptable resistance.

5.7 Some module designs may not use any external metallic components and thus lack a ground point designated by the module manufacturer. In these cases, the ground path continuity test is not applicable.

6. Apparatus

6.1 *Variable d-c Voltage Power Supply*—For the dielectric voltage withstand test, a d-c voltage power supply capable of providing the specified test voltage (see 5.6) in a gradual and smooth manner is required. The application of voltage must not allow transients that may cause the instantaneous voltage to exceed the specified test voltage; nor may the flow of capacitive current, due to charging, cause the test to indicate an erroneous leakage current.

6.1.1 The power supply must include a means of indicating the test voltage that is applied to the module.

6.1.2 The output voltage of the power supply must be continuously adjustable and may have an automatically controlled ramp rate.

6.1.3 The power supply must be capable, as a minimum, of detecting a leakage current of 1 μA.

6.1.4 The power supply may, as an option, include a leakage current limit set-point that will shut down the power supply when the leakage current exceeds the set-point. Audible or visual alarms which indicate that the leakage current has exceeded the set-point are also acceptable.

6.2 *Ground Path Continuity Tester,* for measuring the resistance between any accessible conductive frame or support element and the module grounding point, with a minimum resolution of 0.01 Ω.

6.2.1 The tester must be capable of passing a current of twice the module short-circuit current through the module ground path being tested.

6.2.2 The tester must be able to limit the power applied to a module ground path to 500 W.

6.3 *Ohmmeter*—A high-impedance ohmmeter, or similar device, capable of measuring a minimum of 1000 MΩ, and can provide a voltage suitable for measuring high-resistances.

6.4 *Metallic Contact(s),* aluminum or other metallic foil, or a rigid metallic plate, placed on the surfaces of modules lacking a metallic frame. The metallic contact(s) function as a substitute for a metallic frame.

6.5 *Test Stand,* for holding modules during testing.

7. Procedures

7.1 *Procedure A—Insulation Integrity, Dielectric Voltage Withstand:*

7.1.1 Mount the module to be tested on the test stand and ensure that the module is not illuminated. This may be accomplished by placing it face down on the test stand or by shading the face of the module with an appropriately sized opaque material.

7.1.2 Short the output leads of the module together.

7.1.3 Ensure that the power supply is turned off before any electrical connections are made.

7.1.4 Connect the high potential output of the power supply to the module output leads.

7.1.5 Connect the grounded output of the power supply to the module grounding point or specific component being tested.

7.1.5.1 The module may contain separate and unconnected metallic components; if so, the procedure must be repeated for each metallic component. For example, a junction box not connected to the frame must be tested separately.

7.1.5.2 Any connections to metallic components must be made to uninsulated points for the procedure to be valid. For example, an anodized aluminum frame would not qualify unless the anodization was removed at the test point.

7.1.5.3 If the module lacks any exterior metallic components, the leakage current connection must be made to an insulating surface such as a nonmetallic module frame. A metallic contact (see 6.4) must be placed in contact with the surface, and connection is then made to the metallic contact.