Designation: E 1802 – ~~96~~01

~~An American National Standard~~

Standard Test Methods for Wet Insulation Integrity Testing of Photovoltaic Modules[1]

This standard is issued under the fixed designation E 1802; 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~~ provide procedures ~~for verifying~~ to determine the ~~electrical~~ insulation ~~integrity~~ resistance of a photovoltaic (PV) module, i.e. the electrical resistance b~~y~~etween the module's internal electrical compong ~~i~~ents~~u~~ and its exposed, electrically conductive, non-current carrying parts and surf~~la~~wces.

1.2 The insulation integrity procedures are a combination of wet insulation resistance and wet ~~current leakage (high-potential)~~ dielectric voltage withstand test procedures.

1.3 These procedures are similar to and reference the insulation integrity test procedures described in Test Methods E 1462, with the difference being that the photovoltaic module under test is immersed in a wetting solution during the procedures.

1.4 These test methods do not establish pass or fail levels. The determination of acceptable or unacceptable results is beyond the scope of these test methods.

1.5 The values stated in SI units are to be regarded as the standard.

1.6 There is no similar or equivalent ISO standard.

1.67 *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.* For specific precautionary statements, see Section 6.

2. Referenced Documents

2.1 *ASTM Standards:*

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[1] These test methods are under the jurisdiction of ASTM Committee E~~-~~44 on Solar, Geothermal, and Other Alternative Energy Sources and are the direct responsibility of Subcommittee E44.09 on Photovoltaic Electric Power Conversion.

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E 772 Terminology Relating to Solar Energy Conversion[2]
E 1328 Terminology Relating to Photovoltaic Solar Energy Conversion[2]
E 1462 Test Methods for Insulation Integrity and Ground Path Continuity of Photovoltaic Modules[2]

3. Terminology

3.1 *Definitions*— Definitions of terms used in ~~these~~ this test method~~s~~ may be found in Terminology E 772 and Terminology E 1328.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *insulation resistance*—the electrical resistance of a photovoltaic module's insulation, measured between the photovoltaic circuit and exposed, electrically conductive non-current-carrying parts and surfaces of the module.

4. Significance and Use

~~4.1 Safe use~~

4.1 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 or system. In addition, the insulation system provides a barrier to electrochemical corrosion, and insulation flaws can result in increased corrosion and reliability problems. These test methods describe procedures for ~~power generation require~~ verifying that the design and construction of the module provides adequate electrical isolation ~~of~~ through normal installation and use. At no location on the ~~interior circuitry from~~ module should the ~~outside environment, especially when modules are wet. The purpose~~ PV generated electrical potential be accessible, with the obvious exception of ~~these procedures~~ the output leads. This isolation is necessary to provide for safe and reliable installation, use, and service of the photovoltaic system.

4.2 This test method describes a procedure for determining the ability of the module to provide protection from electrical hazards. Its primary use is to find insulation flaws that ~~may only~~ could be ~~evident~~ dangerous to persons who may come into contact with the module, especially when ~~a~~ module ~~is~~ are wet. For example, these flaws could be small holes in the encapsulation that allow hazardous voltages to be accessible on the outside surface of a module after a period of high humidity.

4.~~2~~3 Insulation flaws in a module may only become detectable after the module has been ~~immersed~~ wet for a certain period of time. For this reason, these procedures specify a minimum ~~amount of~~ time ~~that~~ a module must be immersed prior to the insulation integrity measurements.

4.~~3~~4 Electrical junction boxes attached to modules are often designed to allow liquid water, accumulated from condensed water vapor, to drain. Such drain paths are usually designed to permit water to exit, but not to allow impinging water from rain or water sprinklers to enter. It is important that all ~~unsubmerged~~ surfaces of junction boxes be thoroughly wetted by spraying during the tests to enable these protective drain features to be properly tested. Therefore, drain holes should not be plugged or otherwise protected.

4.5 These procedures may be specified as part of a series of qualification tests involving performance measurements and demonstration of functional requirements. Because insulation leakage resistance and insulation current leakage are strong functions of module dimensions, ambient relative humidity, absorbed water vapor and other factors, it is the responsibility of the user of these test methods to specify the minimum acceptable leakage resistance.

5. Apparatus

5.1 In addition to the apparatus required for the insulation integrity measurements of Test Methods E 1462, the following apparatus is required~~.~~:

5.1.1 *Wetting Solution*~~— A surfactant~~—A solution ~~with a maximum resistivity~~ of ~~35 Ωm~~ tap water and a ~~maximum~~ wetting agent[3], with a surface tension of 0.03 ~~Nm^{-1}. The temperature of the solution must be~~ N/m or less at 22 ± 3°C.

5.1.2 *Immersion Tray*— A tray containing the wetting solution (see 5.1.1) into which the test module is immersed during the integrity measurements. The tray must be deep enough to completely immerse the laminate portion of the module, and any mating connectors (if used) in the wetting solution.

NOTE 1—This requirement does not imply that any electrical junction boxes attached to the module must also be immersed.

6. Hazards

6.1 The electrical measurements used to determine the insulation integrity require applying a high voltage between a test module and a wetting solution (see 5.1.1). Therefore, in addition to the high voltage hazard, additional hazards may exist due to unforeseen conductive paths between the high-voltage source and operators of the test through any spilled wetting ~~solution. It is recommended that testing personnel be isolated from the testing area while the high voltage is activated. Use of an interlocked cage to isolate the testing area is recommended.~~ solution.

[2] *Annual Book of ASTM Standards*, Vol 12.02.

[3] An acceptable wetting solution is 1 part Liqui-nox detergent in 500 parts water by volume. Liqui-Nox is available from Alconox, Inc., 9T East 40th St., New York, NY, 10016; as part number C6308-2.

7. Procedure

7.1 Assemble the required equipment and prepare the wetting solution.

7.1.1 If both the ~~wet current leakage~~ dielectric voltage withstand and insulation ~~current leakage~~ resistance procedures are to be performed, the tests may be performed sequentially during a single immersion if the minimum and maximum soak time requirement of 7.2.9 is met.

7.2 ~~*Current Leakage*~~*Dielectric Voltage Withstand Procedure*:

7.2.1 Unless already provided, connect output leads to the module in accordance with the wiring method specified by the module manufacturer. If more than one method is specified, use the method least likely to restrict water entrance. Seal any threaded openings intended to terminate electrical conduit, unless the threaded openings are selected as the most likely to allow entrance of water.

7.2.2 Short the output leads of the test module.

7.2.3 Place the test module face down in the immersion tray, with the output leads held out of the immersion tray.

7.2.4 Add the wetting solution to the immersion tray such that the front and back surfaces of the module are completely submerged. For framed modules, it may be necessary to pour wetting solution directly onto the back surface. The interface between the back surface and any leads or junction boxes must be completely submerged, but maintain the wetting solution level below any junction box covers and vents in the junction boxes (see 4.3~~4~~). If mating connectors are part of the module design, the connectors must be immersed.

7.2.5 Wet any unsubmerged surfaces of the module by spraying with the wetting solution. Do not wet the shorted output leads of the test module, except where the leads exit the module or junction boxes.

7.2.6 Ensure that the variable d-c voltage power supply is turned off before any electrical connections are made.

7.2.7 Connect the ~~high potential~~ ungrounded output of the power supply to the module output leads.

~~7.2.8 Connect~~

7.2.8 Place the grounded output of the power supply ~~using one of the following methods as appropriate:~~

~~7.2.8.1 If the module has a grounding point designated by the manufacturer, connect the grounded output to this point.~~

~~7.2.8.2 If the module does not have a grounding point designated by the manufacturer, and the immersion tray is metallic, connect the grounded output to the immersion tray.~~

~~7.2.8.3 If the module does not have a grounding point designated by the manufacturer, and the immersion tray is nonmetallic, place the grounded output~~ in the wetting solution.

7.2.9 Maintain the wetted condition of the module (see 7.2.4 and 7.2.5) for a minimum of ~~5~~ 2 min and a maximum of ~~6~~ 10 min.

7.2.10 Test the module for current leakage using the procedure in 7.1.6 through 7.1.9 of Test Methods E 1462.

7.2.11 Turn off the power supply.

7.2.12 Disconnect the test module.

7.2.13 Remove the module from the immersion tray.

7.3 *Insulation Resistance Procedure*:

7.3.1 If the insulation resistance test is not performed sequentially with the ~~current leakage~~ dielectric voltage withstand test (see 7.1), prepare the module for the insulation resistance test using 7.2.1-7.2.9 of the ~~current leakage~~ dielectric voltage withstand procedure.

7.3.2 Measure and record the minimum insulation resistance ~~in accordance with~~ according to 7.2 of Test Methods E 1462, using a voltage of 500 V ~~potential~~ or the rated system voltage, whichever is greater, between the shorted module leads and the wetting solution.

7.3.3 Turn off the power supply.

7.3.4 Disconnect the test module.

7.3.5 Remove the module from the immersion tray.

8. Report

8.1 The report shall include the following items as a minimum:

8.1.1 Module manufacturer and complete test specimen identification~~;~~.

8.1.2 Description of module construction~~;~~.

8.1.3 Description of electrical measurement equipment, and measurement conditions or parameters, including total immersion time in the wetting solution~~;~~.

8.1.4 Results of the ~~current leakage~~ dielectric voltage withstand test as required by 8.1.5 of Test Methods E 1462~~;~~.

8.1.5 Results of the insulation resistance test as required by 8.1.7 of Test Methods E 1462.

8.1.6 A description of any apparent changes as a result of the testing.

8.1.7 Observations or indications of any shorting, arcing, or other failures.

8.1.8 Identification of areas of the module where problems were found.

8.1.~~6~~9 Any deviations from the standard test procedures.

9. Precision and Bias

9.1 Because this test method uses the insulation integrity procedures of Test Methods E 1462, the determination of precision

and bias is not practicable, for the ~~numeric results will be identical to those of~~ same reasons stated in Test Methods E 1462.

10. Keywords

10.1 dielectrica voltage wi~~n~~thsulatioand; electrical ~~resistance;~~ testing; energy; insulation integrity; insulation resistance; modules; photovoltaics; solar