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An American National Standard

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

This standard is issued under the fixed designation E1802; 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 provide procedures to determine the insulation resistance of a photovoltaic (PV) module, i.e. the electrical resistance between the module's internal electrical components and its exposed, electrically conductive, non-current carrying parts and surfaces.

1.2 The insulation integrity procedures are a combination of wet insulation resistance and wet dielectric voltage withstand test procedures.

1.3 These procedures are similar to and reference the insulation integrity test procedures described in Test Methods E1462, 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 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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.* For specific precautionary statements, see Section 6.

1.7 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

E772 Terminology of Solar Energy Conversion

E1462 Test Methods for Insulation Integrity and Ground Path Continuity of Photovoltaic Modules

3. Terminology

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

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 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 verifying that the design and construction of the module provides adequate electrical isolation through normal installation and use. At no location on the module should the PV-generated electrical potential be accessible, with the obvious exception of 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 could be dangerous to persons who may come into contact with the

[1] These test methods are under the jurisdiction of ASTM Committee E44 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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[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.

module, especially when modules 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.

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

4.4 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 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 E1462, the following apparatus is required:

5.1.1 *Wetting Solution*—A solution of tap water and a wetting agent,[3] with a surface tension of 0.03 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.

[3] An acceptable wetting solution is 1 part Liqui-nox detergent in 500 parts water by volume.

The sole source of supply of Liqui-Nox known to the committee at this time is Alconox, Inc., 9T East 40th St., New York, NY, 10016, as part number C6308-2. If you are aware of alternative suppliers, please provide this information to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee,[1] which you may attend.

7. Procedure

7.1 Assemble the required equipment and prepare the wetting solution.

7.1.1 If both the dielectric voltage withstand and insulation 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 *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 4.4). 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.

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 ungrounded output of the power supply to the module output leads.

7.2.8 Place the grounded output of the power supply 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 2 min and a maximum of 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 E1462.

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 dielectric voltage withstand test (see 7.1), prepare the module for the insulation resistance test using 7.2.1 – 7.2.9 of the dielectric voltage withstand procedure.

7.3.2 Measure and record the minimum insulation resistance according to 7.2 of Test Methods E1462, using a voltage of 500 V 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.