Designation: E1171 – 15 (Reapproved 2019)

An American National Standard

# Standard Test Methods for Photovoltaic Modules in Cyclic Temperature and Humidity Environments[1]

This standard is issued under the fixed designation E1171; 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 for stressing photovoltaic modules in simulated temperature and humidity environments. Environmental testing is used to simulate aging of module materials on an accelerated basis.

1.2 Three individual environmental test procedures are defined by these test methods: a thermal cycling procedure, a humidity-freeze cycling procedure, and an extended duration damp heat procedure. Electrical biasing is utilized during the thermal cycling procedure to simulate stresses that are known to occur in field-deployed modules.

1.3 These test methods define mounting methods for modules undergoing environmental testing, and specify parameters that must be recorded and reported.

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 Any of the individual environmental tests may be performed singly, or may be combined into a test sequence with other environmental or non-environmental tests, or both. Certain pre-conditioning tests such as annealing or light soaking may also be necessary or desirable as part of such a sequence. The determination of any such sequencing and pre-conditioning is beyond the scope of this test method.

1.6 These test procedures are limited in duration and therefore the results of these tests cannot be used to determine photovoltaic module lifetimes.

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

1.8 *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.*

1.9 *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

E1036 Test Methods for Electrical Performance of Nonconcentrator Terrestrial Photovoltaic Modules and Arrays Using Reference Cells

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

E1799 Practice for Visual Inspections of Photovoltaic Modules

2.2 *IEC Standards:*[3]

IEC 61215 Crystalline Silicon Terrestrial Photovoltaic (PV) Modules — Design Qualification and Type Approval

IEC 61646 Thin-Film Terrestrial Photovoltaic (PV) Modules — Design Qualification and Type Approval

## 3. Terminology

3.1 *Definitions*—Definitions of terms used in this standard may be found in Terminology E7721.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *module ground point, n*—the terminal or lead identified by the manufacturer as the grounding point of the module.

## 4. Significance and Use

4.1 The useful life of photovoltaic modules may depend on their ability to withstand repeated temperature cycling with

[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.

Current edition approved April 1, 2019. Published April 2019. Originally approved in 1996. Last previous edition approved in 2015 as E1171 – 15. DOI: 10.1520/E1171-15R19.

[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] Available from International Electrotechnical Commission (IEC), 3 rue de Varembé, Case postale 131, CH-1211, Geneva 20, Switzerland, http://www.iec.ch.

varying amounts of moisture in the air. These test methods provide procedures for simulating the effects of cyclic temperature and humidity environments. An extended duration damp heat procedure is provided to simulate the effects of long term exposure to high humidity.

4.2 The durations of the individual environmental tests are specified by use of this test method; however, commonly used durations are 50 and 200 thermal cycles, 10 humidity-freeze cycles, and 1000 h of damp heat exposure, as specified by module qualification standards such as IEC 61215 and IEC 61646. Longer durations can also be specified for extended duration module stress testing.

4.3 *Mounting*—Test modules are mounted so that they are electrically isolated from each other, and in such a manner to allow free air circulation around the front and back surfaces of the modules.

4.4 *Current Biasing:*

4.4.1 During the thermal cycling procedure, test modules are operated without illumination and with a forward-bias current equal to the maximum power point current at standard reporting conditions (SRC, see Test Methods E1036) flowing through the module circuitry.

4.4.2 The current biasing is intended to stress the module interconnections and solder bonds in ways similar to those that are believed to be responsible for fill-factor degradation in field-deployed modules.

4.5 *Effects of Test Procedures*—Data generated using these test methods may be used to evaluate and compare the effects of simulated environment on test specimens. These test methods require determination of both visible effects and electrical performance effects.

4.5.1 Effects on modules may vary from none to significant changes. Some physical changes in the module may be visible when there are no apparent electrical changes in the module. Similarly, electrical changes may occur with no visible changes in the module.

4.5.2 All conditions of measurement, effects of cycling, and any deviations from this test method must be described in the report so that an assessment of their significance can be made.

4.6 *Sequencing*—If these test methods are performed as part of a combined sequence with other environmental or non-environmental tests, the results of the final electrical tests (6.2) and visual inspection (6.3) determined at the end of one test may be used as the initial electrical tests and visual inspection for the next test; duplication of these tests is not necessary unless so specified.

## 5. Apparatus

5.1 In addition to the apparatus required for Test Methods E1036 and E1462 the following apparatus is required.

5.2 *Environmental Chamber(s)*—A chamber or chambers in which modules are mounted during the environmental tests.

5.2.1 Air temperature throughout the working volume shall be within ±2 °C of that specified.

5.2.2 Relative humidity shall be controlled within ±5 % of that specified. For temperatures below 80 °C, relative humidity control is not required.

5.2.3 Provisions for monitoring and recording the chamber temperature and relative humidity throughout the environmental testing shall be provided.

5.3 *Temperature Measurement Equipment*—An instrument or instruments used to measure module temperature during the environmental testing with a resolution of at least 0.1 °C, and a total error of less than ±2 °C of reading.

5.3.1 Temperature sensors suitable for the test temperature range, such as thermocouples or thermistors, shall be attached to the portions of the modules likely to exhibit the longest thermal time constant. For flat-plate modules, attach the sensors near the middle of the front or back surfaces of the modules.

5.3.2 If more than one module of identical design and construction is tested simultaneously, it is not necessary to monitor the temperature of all identical modules.

5.4 *Test Frame*—A frame inside the environmental chamber which supports the test modules during the test procedures.

5.4.1 It is not required to mount the test modules at an angle such as when modules are installed as part of an array; they may be mounted vertically to facilitate testing multiple modules inside the environmental chamber.

5.4.2 The test modules shall be mounted in a manner that allows free air circulation around the modules.

5.4.3 The test frame should be constructed such that corrosion of the test frame during the environmental testing does not adversely affect the test modules.

5.5 *Current-Biasing Power Supply*—A dc power supply capable of operating a test module at a point on the dark forward current-voltage curve equal to the maximum power current at SRC during the thermal cycling procedure.

5.5.1 Provisions must be made for removing the current bias when the module temperature is less than 20 °C.

5.5.2 The current biasing power supply should be capable of setting a voltage compliance limit equal to 1.25 times the open-circuit voltage at SRC to prevent over-voltage operation of the test modules at high temperatures.

## 6. Procedure

6.1 *Sample Selection and Test Sequence*—Although the temperature cycling, humidity-freeze cycling, and damp heat procedures may be performed individually, the requirements of any test sequence (see 1.5 and 4.6) may determine the order in which the environmental tests are performed, and also may impose restrictions on which test modules are to be subjected to individual procedures. The sequencing may also specify when modules undergo electrical testing (see 6.2) and visual inspections (see 6.3).

6.1.1 A typical combined thermal and humidity-freeze cycling sequence is illustrated in Fig. 1.

6.2 *Electrical Tests*—Perform the following electrical tests before and after each of the test procedures.

6.2.1 *Electrical Performance*—Measure and record the electrical performance of each module. A suitable method for nonconcentrator modules is Test Methods E1036.

6.2.2 *Ground Path Continuity*—Test any module with a grounding terminal identified by the module manufacturer to