



Designation: E 1524 – 98

Standard Test Method for Saltwater Immersion and Corrosion Testing of Photovoltaic Modules for Marine Environments¹

This standard is issued under the fixed designation E 1524; 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 This test method provides a procedure for determining the ability of photovoltaic modules to withstand immersion or splash exposure by fresh or seawater as might be encountered when installed in a marine environment. This is one of several tests, including environmental cycling exposure and exposure to a corrosive environment, that are intended to provide an accelerated basis for evaluating the aging effects of a marine environment on module materials and construction specific to marine applications.

1.2 This test method defines photovoltaic module test specimens and requirements for positioning modules for test, references suitable methods for determining changes in electrical performance and characteristics, and specifies parameters which must be recorded and reported.

1.3 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.

1.4 *Units*—The values stated in SI units are to be regarded as the standard. No other units of measurement are included in this standard.

1.5 *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:

D 1141 Specification for Substitute Ocean Water²

E 772 Terminology Relating to Solar Energy Conversion³

E 1036 Test Methods for Electrical Performance of Non-concentrator Terrestrial Photovoltaic Modules and Arrays Using Reference Cells³

E 1171 Test Method for Photovoltaic Modules in Cyclic Temperature and Humidity Environments³

¹ This test method is under the jurisdiction of ASTM Committee E-44 on Solar, Geothermal, and Other Alternative Energy Sources and is the direct responsibility of Subcommittee E44.09 on Photovoltaic Electric Power Systems.

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² *Annual Book of ASTM Standards*, Vol 11.02.

³ *Annual Book of ASTM Standards*, Vol 12.02.

E 1328 Terminology Relating to Photovoltaic Solar Energy Conversion³

E 1462 Test Methods for Insulation Integrity and Ground Path Continuity of Photovoltaic Modules³

3. Terminology

3.1 *Definitions*—For definitions of terms used in this test method, see Terminologies E 772 and E 1328.

4. Significance and Use

4.1 The useful life of photovoltaic modules deployed in marine applications may depend on the ability to withstand repeated exposure to salt atmosphere, immersion in seawater, and the temperature changes associated with seawater splashing on modules at operating temperatures. The effects of these exposures may be physical or electrical changes in the module, or both.

4.2 This test method describes a procedure for positioning the test specimen for saltwater immersion and corrosion tests. It also references methods for conducting a temperature-humidity cycling test and reporting the results.

4.3 The test specimen is positioned horizontally in the test chamber with its optical surface facing up to represent the most likely orientation of the module as deployed. Data generated by this test method may be used to evaluate and compare the effects of a simulated marine environment on test specimens. This test method requires recording of visible effects as well as electrical performance.

4.3.1 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.

5. Apparatus

5.1 In addition to the apparatus required for Methods E 1036 and and Test Methods E 1462, the following apparatus is required.

5.2 *Environmental Chamber*—A thermally insulated test chamber with a main chamber of sufficient volume to contain the test modules during salt spray test. Temperatures throughout the working volume shall be within $\pm 2^{\circ}\text{C}$ of the specified

temperature. Relative humidity shall be controlled with $\pm 5\%$ of that specified for all temperatures above 25°C during salt spray test. All equipment shall be of corrosion resistant materials.

5.3 Immersion Tank—A corrosion-resistant tank of sufficient volume to hold the module(s) under test. Depth of tank shall be sufficient to permit the modules being tested to be covered with solution as specified in 6.5.2.

6. Procedure

6.1 Select a minimum of five modules considered to be representative of the type to be tested. Reserve one of the five modules as a control sample. Follow the test sequence as outlined in the flow chart shown in Fig. 1.

NOTE 1—No disassembly, alteration of, or modification to the samples or any part thereof shall be permitted during the test sequence.

6.2 Electrical Tests:

6.2.1 Electrical Performance—Measure each module in accordance with Test Methods E 1036, to establish a baseline electrical performance.

6.2.2 Ground Path Continuity Test—Test any module with a grounding terminal to determine the maximum resistance

between the grounding terminal or lead and any accessible conductive part using 7.3 of Test Methods E 1462.

6.2.3 Insulation Integrity Test—Subject each module to a test of the electrical isolation capability according to 7.1 and 7.2 of Test Methods E 1462.

6.2.3.1 The test voltage shall be equivalent to twice the specified maximum system voltage (open-circuit voltage at 0°C cell temperature plus 1000 Vdc). If the maximum system voltage is less than 30 Vdc, employ a test voltage of 500 Vdc.

6.3 Visual Inspection:

6.3.1 Visually inspect each module to determine the presence or absence of defects or anomalies.

6.3.2 Defects are considered to be any obvious deviations from acceptable appearance. Such defects may include delaminations or voids, discolorations, corrosion, rust, or cracks in any part of the assembly.

6.3.3 Record the results of the visual examination using photographs or a diagram of the specimen, or both, showing the location and type of defect.

6.4 Instrumentation—Attach one or more temperature sensors to the exterior of the module to monitor the temperature of that portion of the module likely to exhibit the longest thermal time constant.

6.5 Immersion Tests:

6.5.1 Simulated Seawater Preparation—Prepare a sufficient quantity of simulated seawater solution to fill the testing tanks required for each test series. An acceptable solution consists of a mixture of 3.63 kg of dry sea salt for every 94.6 L of tap water, in accordance with Specifications D 1141. Adjust and maintain the specific gravity of the solution to $1.025 \pm .005$ at 15°C during the test. Maintain the temperature at $15 \pm 3^{\circ}\text{C}$ during the immersion tests.

6.5.2 Salt Water Immersion—Prepare a solution of simulated seawater according to 6.5.1, and place it in an open tank of dimensions sufficient to contain the modules being tested, with a water depth sufficient to cover the uppermost module with at least 75 mm of the solution.

6.5.3 Test Sample Installation in Immersion Tank—Seal any open junction box fittings or feedthroughs with suitable caulking. If equipped with output leads, the ends of the leads must be held above the solution during the immersion. Immerse the module in the seawater solution for a minimum period of 48 h. The module shall be positioned horizontally, with the optical surface facing up to simulate the normal mounting position for a typical marine application.

6.5.4 Upon removal of the modules from the tank, rinse with fresh tap water to remove any encrusted salt. Only towel or free air drying of the samples shall be permitted. Compressed air, heated air, or other methods of drying the modules will not be permitted.

6.5.5 Repeat electrical tests as outlined in 6.2

NOTE 2—After removal from the tank, sample modules are permitted to sit for no more than 1 h before the ground path continuity and insulation integrity tests.

6.5.6 Perform visual inspection and record all apparent effects of the immersion in accordance with 6.3.

6.6 Corrosion Tests:

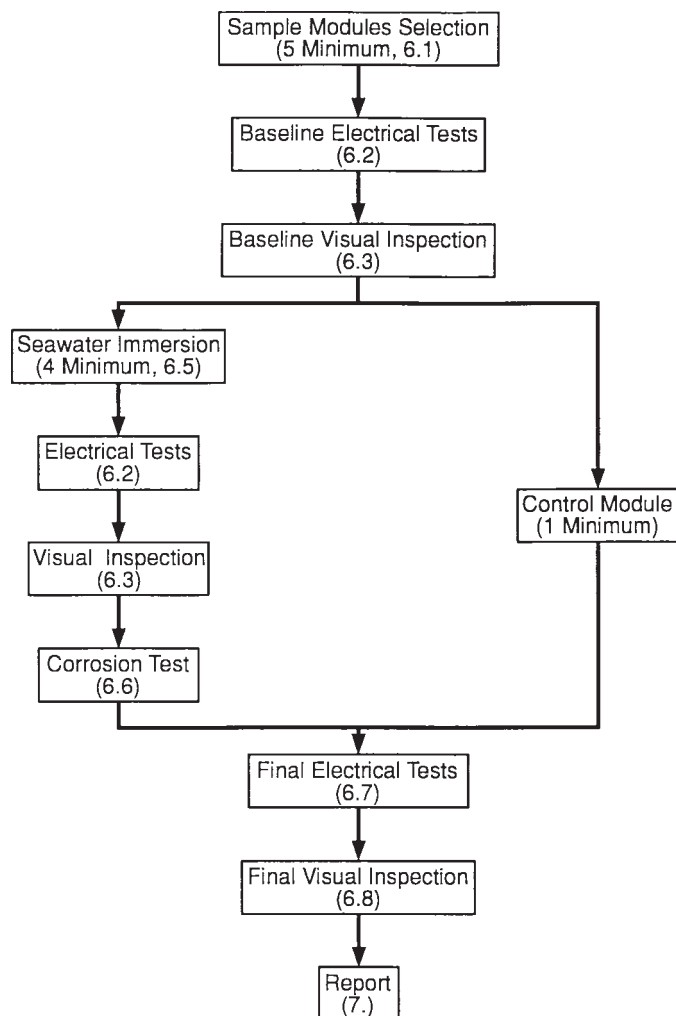


FIG. 1 Test Sequence