Ingress Protection Test Methods for PV Modules

Version 1.2
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Procedure Summary:

This procedure measures the potential for water and solid objects to enter and damage or degrade solar photovoltaic (PV) module junction boxes. This method is included in IEC TS 62257-9-5. This test is conducted with a sample size of n=1 for all test method types specified in IEC TS 62257-9-5 (ISM, QTM, MCM, and renewal testing). This policy is not applicable to integrated PV modules (PV modules that are built into the same unit as the battery and/or light), as they need not undergo these tests.

The result of the overall ingress protection (IP) test is a pass/fail assessment on the equivalent of IP3X and a modified IPX4.[1] IP3X is a physical ingress measure that protects against insect intrusion, while the modified IPX4 indicates protection from permanent outdoor exposure to water in the context of rooftop installation. PV modules in which the junction box is completely potted with silicone or similar sealant and modules without sensitive electronics are not required to undergo the modified IPX4 test for water ingress. PV modules must pass the IP3X test and either pass or be exempt from the modified IPX4 test to meet the applicable Quality Standards.[2]

There are three main steps:

1. Assess physical ingress protection class.*
2. Inspect the junction box for sensitive electronic components.
3. If sensitive components are present, assess water ingress protection class.*

*this step requires an unmodified PV module (i.e., the junction box has never been opened)

Note that if water ingress assessment is required, two unmodified PV modules are required – one for inspection and one for IP testing.

[1] The modified IPX4 assessment for water ingress protection follows the same procedure to test for IPX4 as described in IEC 60529 with the exception of the angle of spray. IEC 60529 requires that the device under test (DUT) be sprayed at angles ±180° from vertical, while the modified method described below requires that the DUT be sprayed at angles ±90° from vertical.

[2] VeraSol began referencing *IEC TS 62257-9-8: Integrated systems – Requirements for stand-alone renewable energy products with power ratings less than or equal to 350 W* in place of the Lighting Global Quality Standards in 2020. See https://verasol.org/updates/transition-to-iec-ts-62257-9-8 for detailed transition information. See the Change Log for Quality Standards for details on new requirements and the differences between the Standards.

IP Assessment for Solid Foreign Objects:

Note: This test can be destructive. Do not perform any additional tests on the sample's PV module after testing. The sample's PV module, including its enclosure and/or junction box, shall not have been altered in any way prior to testing; however, if the only alteration is that the PV module's connector (e.g. barrel plug) has been removed from the end of the PV cable, it may be used for IP assessment testing.

Assess the PV module for IP3X as described in Annex U of IEC TS 62257-9-5:

1. Before the measurement, be sure that the device under test (DUT) is properly functioning.

2. Explore the DUT's entire surface to test for penetration with a 2.5 mm probe.

3. If the probe can enter a part of the DUT's enclosure that contains electronic components, electrical connections or circuits, the DUT does not pass the IP assessment for ingress of solid foreign objects. If the probe can enter an external jack, this is not considered a failure, unless it can enter the DUT's enclosure through the external jack. Document any failures with photographs and text.

4. If the 2.5 mm probe cannot enter the DUT, the DUT meets the requirements for IP3X.

Note: Since the enclosure is not opened until the enclosure inspection procedure, below, it may not be possible to determine whether the DUT passes or fails this test until after the enclosure inspection procedure is performed.

Enclosure Inspection:

1. Open the junction box or PV enclosure to determine if a circuit board or other sensitive electronics are present. (This can be destructive.) If no circuit boards or sensitive electronics are present or if the junction box is completely potted with silicone or similar sealant, the product passes and the tester does not need to assess the DUT for water ingress.

If a circuit board or other sensitive electronic components are present within the junction box or PV enclosure, the water ingress test shall be conducted on a new sample.

Note: a single diode, not soldered to a circuit board, is not considered a "sensitive electronic component." Any printed circuit board is considered "sensitive." See Figures 1-2 for guidance.

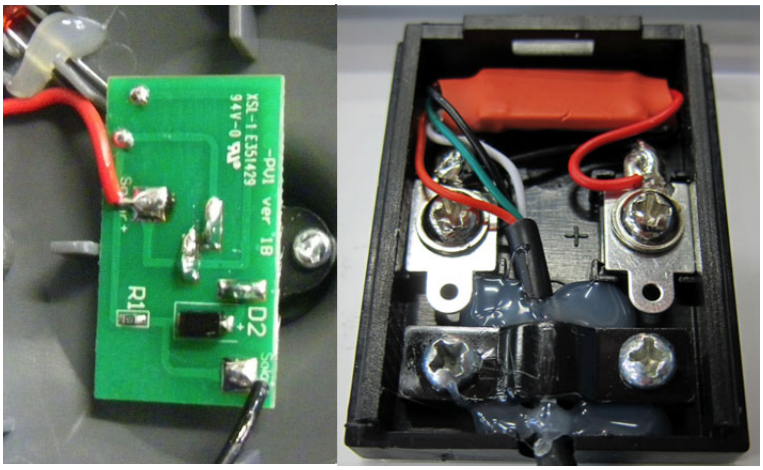

Figure 1. Examples of DUTs containing "a circuit board or other sensitive electronics" and requiring water ingress testing.

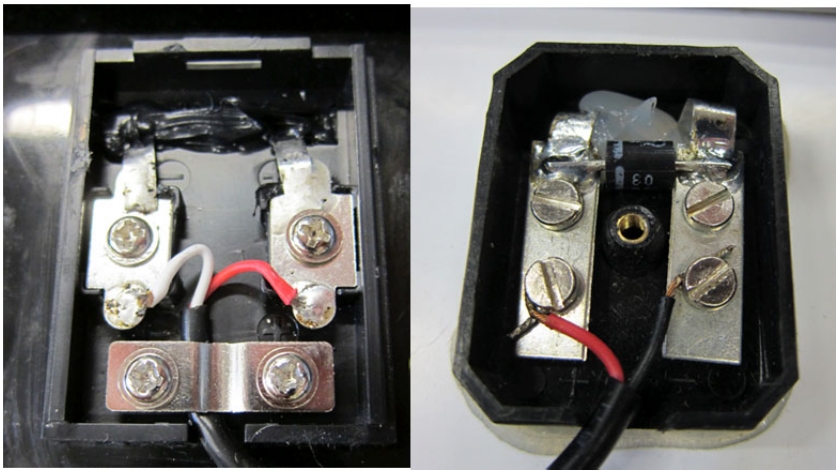

Figure 2. Examples of DUTs *not* containing "a circuit board or other sensitive electronics" and *not* requiring water ingress testing. (The picture on the right is an example of a junction box that contains a diode, but would not be considered to contain "sensitive electronics".)

IP Assessment for Water:

Note: This test can be destructive. Do not perform any additional tests on the sample after testing. The sample's PV module, including its enclosure and/or junction box shall not have been altered in any way prior to testing; however, if the only alteration is that the PV module's connector (e.g. barrel plug) has been removed from the end of the PV cable, it may be used for IP assessment testing.

1. Place the DUT with the active PV area facing up on a smooth, solid, flat surface that is tilted at a 10° angle from the horizontal (Figure 3). The DUT shall be placed in the least favorable orientation on the surface. The placement is intended to resemble common rooftop installations and allow for the possibility that water would run behind the module. This will

typically be accomplished by allowing the PV cord to rest under the frame as could occur when installed.[3]

Note: The least favorable orientation is typically the one in which the cable exits the junction box on the upslope side.

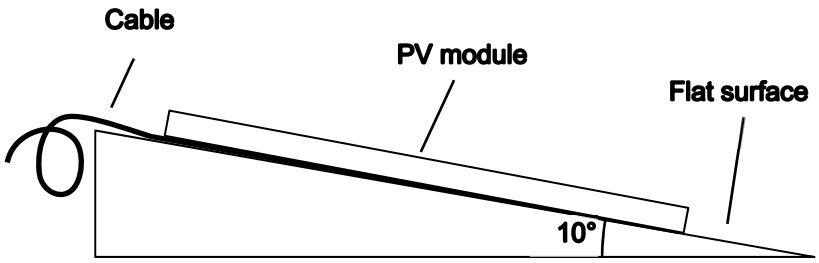

Figure 3. Side view of module prepared for testing.

2. Conduct the modified IPX4 equivalent test as follows:

    a. Spray water from the controlled water source over the DUT in all practical directions (at angles +/- 90° from vertical). The water flow rate shall be close to 10 l/min. Spray the water over the DUT for 1 min per square meter of enclosure surface area for a minimum of 5 minutes. The distance between the water source and the DUT should be between 0.3 m and 0.5 m.
    b. After spraying water over the DUT, dry the DUT's exterior on all sides with a towel without tilting the DUT.
    c. Open the junction box or enclosures protecting electronic components. (This can be destructive.) To the degree practical, avoid tilting the DUT while opening the junction box.
    d. If the module does not have a typical junction box, but rather its connections are within an enclosure around the PV module itself (for example, see Figure 4), open the enclosure with the proper screwdriver(s) or other devices. (This can be destructive.)

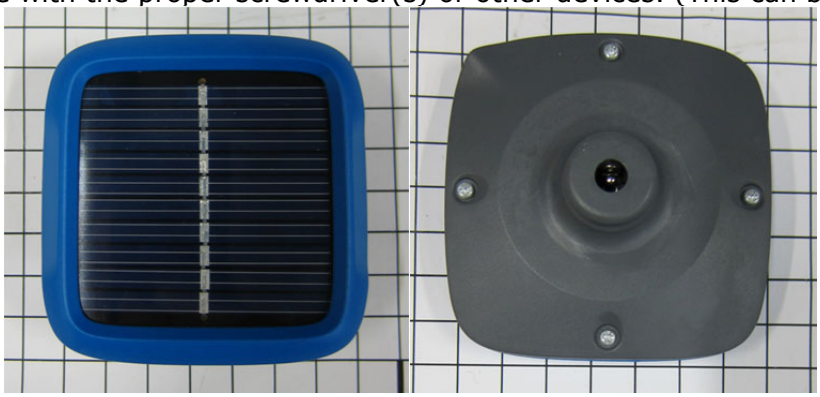

Figure 4. Example of a module without a "typical junction box."

3. After opening the junction box and enclosures, note if there are any unsealed penetrations through which water could reach the active material of the PV module.

[3] See the full test procedure in IEC TS 62257-9-5 for guidance on testing "rooflights" in which the PV module is designed to be permanently installed on the roof with the lighting unit attached inside the structure, but connected directly to the PV module through the roof without the use of wires or cables.

4. If no water is found inside the junction box, enclosures or any unsealed penetrations, the product passes.
5. If any water is found inside the junction box, enclosures or any unsealed penetrations where it could reach sensitive electronics or active material, the module fails the modified IPX4 test. Document with photographs and text.

   Note: If a product fails the modified IPX4 test, it could still meet the requirements of the Quality Standards if the electronic components and active material of the PV module have adequate "technical protection" as outlined in Annex V of IEC TS 62257-9-5. Adequate protection is evaluated by an organization with expertise in product design, failure analysis, energy systems, and general engineering practices. The water ingress protection requirement cannot be met through labeling or consumer-facing documentation.

About VeraSol

An evolution of Lighting Global Quality Assurance, the VeraSol program supports high-performing, durable off-grid products that expand access to modern energy services. VeraSol builds upon the strong foundation for quality assurance laid by the World Bank Group and expands its services to encompass off-grid appliances, productive use equipment, and component-based solar home systems. Like Lighting Global Quality Assurance, the VeraSol program is managed by CLASP in collaboration with the Schatz Energy Research Center at Humboldt State University. Foundational support is provided by the World Bank Group's Lighting Global program, UKaid, IKEA Foundation, Good Energies Foundation, and others.

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