FS-Series PV Module Cleaning Guidelines

First Solar modules are frameless and do not require cleaning as installed. Installed modules may collect a light layer of dust and/or dirt over time. For many installations, rainfall should be sufficient to remove any lighter soiling. In locations with heavy soiling, properly timed module cleaning can improve energy yields.

Cleaning activities create risk of damage to the modules and array components, as well as the potential for electric shock.

Only properly trained personnel who understand the risks of applying water to electrical components should clean modules. Trained personnel shall wear appropriate electrically insulating Personal Protective Equipment (PPE) during cleaning, inspection operations, or when working near modules.

Professional cleaning services trained to work on live electrical systems are available for hire.

The module encapsulating material and glass provide protection from electrical shock hazard when intact. However, when cracked or chipped, the module's integrity is compromised (i.e., potential loss of electrical insulating properties,) thereby creating an electrical shock hazard.

Cracked or broken modules represent a shock hazard due to leakage currents, and the risk of shock is increased when modules are wet. Before cleaning, thoroughly inspect modules for cracks, damage, and loose connections.

The voltage and current present in an array during daylight hours are sufficient to cause a lethal electrical shock.

Acceptable module cleaning methods include spraying the modules with low-pressure water that is closely matched in temperature to the temperature of the module or to use a dry brushing technique. The following guidelines minimize impact to plant power generation, reduce safety hazards, and minimize risk of module damage.

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All Cleaning Techniques

- Clean modules only when in open circuit and when modules are locked out from the load. The recommended time to clean modules is from dusk to dawn when production is not affected and risk of electrical shock hazard is minimized
- To ensure warranty coverage, First Solar must review and approve:
  - Automated or motorized cleaning tools and methods
  - Cleaning fixtures or tools which are supported by or rest on modules
- The ideal time for cleaning modules is during low light conditions when production is lowest

Wet Cleaning

- Fresh water (TDS < 1500 mg/L) may be used to clean the modules. If needed, a mild, non-abrasive, non-caustic detergent with a final fresh water and detergent solution mix between 6.5 < pH < 8.5 at 25°C may be used.
- Water must be free of floating oil or other immiscible liquids, floating debris, excessive turbidity, and objectionable odors.
- When using water, RO water provides the best results. When RO water is not available, tap water with low mineral content (total hardness <75 mg/L) or deionized water may be used. Calcium should not exceed: 75 mg/ml.
- When using hard water (75 mg/L < total hardness < 180 mg/L), the water must be squeegeed off to prevent scale buildup.
- Chlorides should not exceed 250 mg/ml and water electrical conductivity should be < 250 mS/cm
- Do not use abrasive cleaners or de-greasers on the module. Do not use cleaning solutions containing hydrochloric acid, D-Limonene, ammonia, or sodium hydroxide
- Water pressure must not exceed 35 bar (500 psi) at the nozzle. Do not apply water that is more than 20°C warmer or colder than module surface temperature

- Do not spray pressurized water directly at sealed interfaces of module (junction box, edge seal, connectors). Do not brush or clean backside of module to avoid accidental stress to lead wires or junction box.

Dry or Brush Cleaning

- If excessive soiling is present, a non-conductive nylon or similar material brush, sponge, or other mild agitating method may be used with caution
- Ensure brushes or agitating tools are not abrasive to glass, EPDM, silicone, aluminum, or steel
- Ensure any brushes or agitating tools are constructed with non-conductive materials to minimize risk of electric shock

Module Shading

When module cell areas are shaded by cleaning devices of certain geometries, the modules cells may experience damages driven by localized areas or reverse bias (negative voltage / positive current). While there exist countless ways to shade a module, a few typical field scenarios that pertain to module cleaning can be divided into high, medium and no risk. To minimize the risk of module shading damage please follow the Module Shading Field Guide PD-5-366.

Module shading may result in warranty coverage being voided. The following types of High Risk Shading listed below are particularly problematic and related to module cleaning activities.

High Risk (Prohibited) Shading

1. Resting or adhering slender objects (tools, brooms, clothing, wires, tape) on sunny side of operating modules, or within inches above operating modules, especially when shadow oriented parallel to cells, can create high risk of undesirable shading. An example is shown in Figure 1
2. Fixed objects within ~5-7 feet above operating modules that cast a shadow over the long dimension of the cell should be avoided. Close objects like posts, ropes, signs, fences, or equipment can begin to increase risk of partial shading of full cells when nearer than ~5-7 feet from the sunny-side of operating module.
3. Working continuously with outstretched arms or tools over operating modules can create high risk of undesirable shading.

4. A support frame or mounting method on the short edge(s) of modules that fully shades the entire length of a cell (either partially or completely) can create a high risk of undesirable shading.

5. Cleaning apparatuses, including cleaning robots and other mechanisms that traverse the module repeatedly while the system is operating.

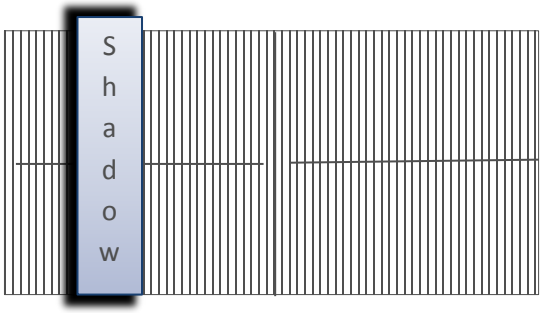

Figure 1. Example of "High Risk" shading

Important: The customer, project owner, O&M provider, or entity responsible for the project site is responsible for determining the extent to which any cleaning method is suitable for use on modules and use in an outdoor environment

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First Solar does not provide Warranty on modules that are deemed damaged by the cleaning methods used.

First Solar warrants its modules according to the First Solar Module Warranty Terms & Conditions (PD-5-102) provided the modules are installed, operated and serviced as described in the First Solar User Guide (PD-5-200, "*User Guide*") and in the System Design and Application document (PD-2-303, "*System Design and Application")*

For additional question regarding cleaning methods or approvals of mechanical cleaning methods, please contact the First Solar Technical Services team at technicalsupport@firstsolar.com.

