



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.



Cracked or broken modules represent a shock hazard due to leakage currents, and the risk of shock increases 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.

All Cleaning Techniques

- Clean modules only when in open circuit or when inverter is not operational. 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.

Cleaning Techniques for Uncoated Modules

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 $6.5 < \text{pH} < 8.5$ 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 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, and connectors). Do not brush or clean backside of module to avoid accidental stress to lead wires or junction box.

Dry or Brush Cleaning

- Please provide the specific brush material and data sheet for review
- 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

Cleaning Techniques for Anti-Reflective Coated (ARC) Modules

Wet Cleaning

- The wet spray cleaning techniques for uncoated modules above may be used for ARC modules.
- Wet contact cleaning (squeegees, sponges, cloths, etc.), which includes any simultaneous combination of water and scrubbing/wiping is prohibited for ARC modules.
- Excessively soiled spots on modules (i.e. bird droppings) may be spot-cleaned with soft cloth or mop and water if necessary for localized cleaning only.
- Use of hard water ($75 \text{ mg/L} < \text{total hardness} < 180 \text{ mg/L}$) is prohibited on ARC Modules.

Dry Cleaning

- Dry cleaning of ARC modules with soft cloths or mops is allowed up to six times annually. Examples of soft cloths or mops are shown in Figure 1 below.
- Dry cleaning with anything other than soft cloths or mops is prohibited (i.e. bristle brushes, sponges, or squeegees).



Module Load

Cleaning solutions vary in design and size that can affect the load dispersed onto the modules. Load specifications and data must be identified and submitted with the documentation for cleaning system approval.

- First Solar recommends no more than 90lbs per module that is evenly distributed while cleaning
 - Specific contact points (wheels or belts) can affect the load and pressure placed on the modules – review of this critical information is part of the approval process
 - Below are some examples of loads that shall not be exceeded:
 - 3 point loads (P1)
 - Max of 30lbs each in a row that are 16 inches apart

- Must be 5.25 inches or more from the long edge of the glass
- OR -
- Up to 1 lb./inch (P2) of contact length for a drive belt (max 47.62 inch length) anywhere on the module, except at the clips
- OR -
- Up to 1 lb./inch (P3) of contact length for brushes contacting the module (max 23.62 inch length) anywhere on the module
- OR -
- Some combination of the above load types so that $P1/30 + P2 + P3 \leq 1$
- Cleaning solutions must not affect or jeopardize any part of the mounting system
 - This includes all parts of the mounting system: clips, rails, and trackers
- Vibration from the cleaning solution shall not cause module breakage or any movement of the modules in their mounting hardware.

Module Shading

When module cell areas are shaded by cleaning devices of certain geometries, the module cells may experience damage driven by localized areas of reverse bias (negative voltage / positive current). High Risk (prohibited) shading detail can be found in the Module User Guide.

Important: Prohibited module shading may result in warranty coverage being voided. The customer, project owner, O&M provider, or entity responsible for the project site is responsible for seeking approval of any cleaning method to ensure it is suitable for use on modules and use in an outdoor environment

Snow Clearing

Varying snow conditions may be cleared from the modules when utilizing the All Cleaning Techniques protocol and aforementioned specific dry cleaning methods. Do not use prohibited tools or objects to remove snow as it may damage the modules. Other snow clearing methods, such as blowers, may be used depending on snow conditions and approval by First Solar. To prevent pile up and overload, periodically clearing snow from the bottom modules first in an array is a critical process.

Cleaning System Design Approval Process

Cleaning systems must complete the approval process outlined below for First Solar compliance and module warranty support. Required documentation is outlined below and should be submitted to the First Solar Technical Support team. Additional information may be requested upon review of the design.

Checklist

- MSDS & datasheets on the brush material
- Two samples of the brush material
- Water hardness, temperature and applied pressure
- MSDS & datasheets on the cleaning solution
- Conductivity of water solution
- Max point loads on module (including total system weight)
- Dimensions/drawings of cleaning system
- Photos/video of cleaning system
- Shading analysis
- Method of Procedure (MOP)

Samples may be required for further evaluation:

- The complete cleaning system
- If wet cleaning with detergents, samples of the solution and chemical composition

Upon receiving the above items, First Solar will review the proposed design and decide if the design is accepted or needs further review. If the review is successful, First Solar will provide a confirmation of compliance.

A copy of all submitted drawings will be retained by First Solar for historical record. First Solar may require a service fee to complete the process of a cleaning system approval. The invoicing information will be requested and required.

First Solar does not provide Warranty on modules that are deemed damaged by the cleaning methods used. Failure to comply with the Module Cleaning Guidelines may void warranty.

First Solar warrants its modules according to the First Solar Module Warranty Terms & Conditions provided the modules are installed, operated and serviced as described in the First Solar User Guide.

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

