

# ARES Soiling Measurement System



## General Maintenance Guide

Revision C

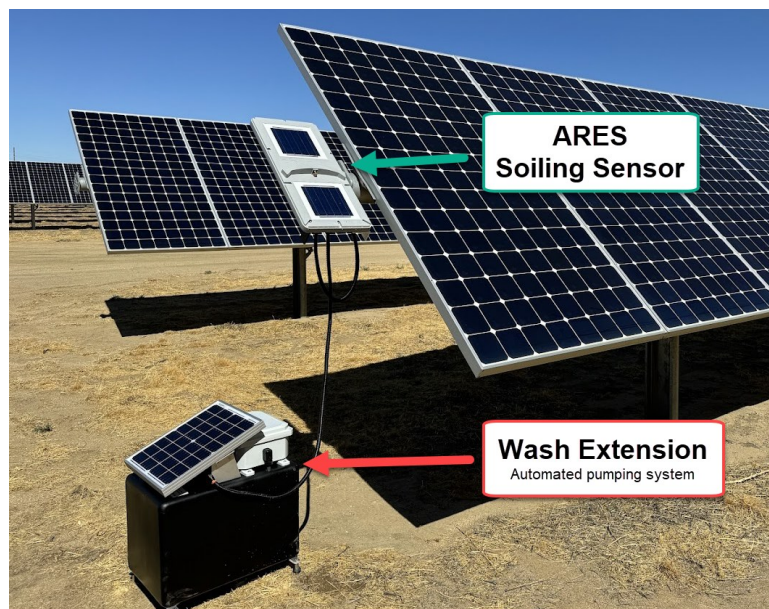
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This guide is intended for O&M teams to aid in the general on-going maintenance of the Fracsun ARES soiling measurement system. While the soiling stations are mostly autonomous (if the Wash Extension is installed), Fracsun recommends routine inspections to verify functionality of the station.

### O&M Maintenance Checklist

Use the checklist below in your O&M plan. The approximate time to perform these steps is *less than 5 minutes*. For additional information regarding the steps in this checklist, review the rest of this document.

- 1. Verify the *clean reference cell* is free of soiling debris.
- 2. Inspect all exterior connections between ARES and the Wash Extension.
- 3. Inspect the water level in the Wash Extension reservoir.
- 4. If the whole plant was recently cleaned, verify both reference cells were cleaned
- 5. Perform normalization as required



## Maintenance Details

### 1. Verify the clean reference cell is free of soiling debris

The ARES device should be inspected at least once every 4 weeks to verify that the clean reference cell is being successfully cleaned by the Wash Extension. The clean reference cell should be free of all soiling debris. If the reference cell does not appear to be clean, follow the manual cleaning instructions below.

#### Manually cleaning ARES

Use a clean damp microfiber towel to gently wipe away any soiling on the **clean reference cell only**. Do not forcefully scrub the glass, as this repeated practice will lead to scratches. When possible, dampen the microfiber towel with distilled or filtered water and dry with a second clean towel.

If a tougher cleaning agent is required, detergents intended for solar glass (plus filtered water) may be used to clean the cell.

Be careful when performing scheduled cleanings on tracking systems when the clean cell is above the soiled cell. Residual water can flow downward onto the soiled cell.



**Do not clean or touch the “soiled” reference cell at any time unless instructed to do so.**

#### Adding a routine cleaning schedule to your O&M plan

You should consider adding a routine cleaning schedule if:

- The Wash Extension is not functional, is waiting to be repaired, or has an empty reservoir
- The Wash Extension has been purged for winterization (see our Winterization Instructions)
- The spray nozzles on ARES are not cleaning sufficiently.

Manually cleaning ARES takes less than 1 minute to perform. When manually wiping down the “clean” reference cell, data granularity is determined by the frequency of cleanings.

- **Once per week** or **once every 2 weeks** is often an acceptable cleaning schedule for winterized
- **Once per day** in the morning (or evening) is the absolute best scenario, but is often impossible at unmanned plants.

Random cleanings not based on a schedule are not recommended but can be used to get a single datapoint.

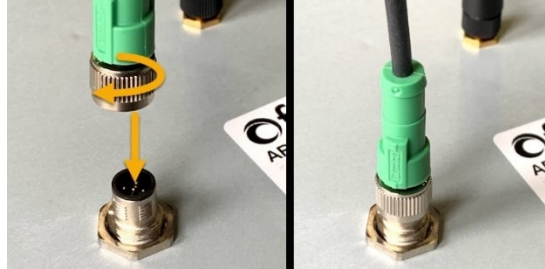
## 2. Inspect all exterior connections between ARES and the Wash Extension

### Tubing and cable connections

Verify that the antenna, tubing, and comm cable are connected between ARES and the Wash Extension. Cables should be twist-locked in place to their appropriate receptacles.



Bottom of ARES - antenna



Bottom of ARES – comm cable



Wash Extension - tubing

### Cuts and other damage

Inspect the corrugated sheathing for cuts or other damage. If the sheathing is damaged in any way, check the tubing and cable for additional damage as well.

Wild animals and frequent weed-abatement maintenance (sheep, weed-eaters, mowers) can damage the exterior connections.



## 3. Inspect the water level in the Wash Extension reservoir

Remove the cap from the reservoir to visually inspect the water level inside.

### Low tank alert

A liquid level sensor is installed inside the 16 gallon tank. When the sensor is triggered, a “low tank alert” is sent to the Fracsun cloud and you will receive an update via Email and the Web Portal. You will have approximately 60 days to refill the tank before it is completely dry. If rinsing does not occur, the soiling accuracy will be in jeopardy.

### Fluid type

The wash extension can hold up to **16 gallons** of rinsing fluid. The fluids list below are highly recommended for high soiling accuracy. Under no circumstances should tap water be used. Tap water contains minerals that will build up on the solar glass after each wash, affecting the irradiance measurement and soiling accuracy.

- Distilled water
- Filtered water (RO + DI preferred) with a TDS (total dissolved solids) value of less than 20 ppm



#### 4. If the whole plant was recently cleaned, verify both reference cells were cleaned

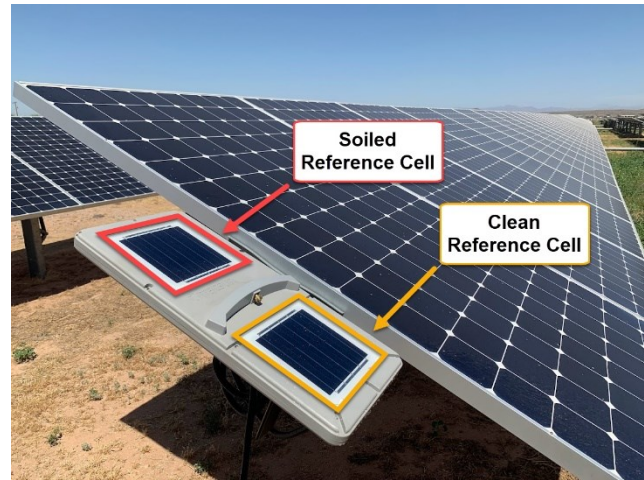
After the plant (or the section of the plant) is cleaned, the soiling sensor should be reset so that transmission loss ideally equals 0% (or soiling ratio equals 1).

##### Resetting the soiling measurement

To reset soiling, manually clean **both** the clean and soiled reference cells, as described in section 1, **Manually cleaning ARES.**

After both cells have been completely wiped down, verify that the irradiance is **greater than 500 W/m<sup>2</sup>** and approximately **-0.5% to 0.5% transmission loss** (soiling loss). If non-ideal GHI conditions are present on the cleaning day, verify the next day.

Irradiance values can be read in the Fracsun portal, or in the plant's DAS (data acquisition system) if using Modbus-only mode.



If transmission loss is outside the range of -0.5% to 0.5% with ideal GHI condition, normalization is recommended.

#### 5. Perform normalization as needed

Normalization is a process where the two reference cell measurements are adjusted so that transmission loss between them equals 0% (or soiling ratio equals 1). Normalizing the ARES sensor is important during the following events:

- After installation / commissioning of the ARES sensor
- After the plant, or the section of the plant associated with ARES, is washed.
- Annually, whenever possible (typically after a heavy rain event)

After the auto-normalization process has completed, the normalization values will be set and saved in memory.

Specifically, these values are the irradiance adjustment required to match the clean and soiled ref cells @ 500 W/m<sup>2</sup>. For example, if the clean ref cell measured 495 W/m<sup>2</sup> and the dirty ref cell measured 505 W/m<sup>2</sup> during ~ 500 W/m<sup>2</sup> of irradiation, the normalization numbers would be set to 5 (clean) and -5 (dirty).

##### Normalization requirements

To prepare for normalization:

- Manually clean both the clean and soiled reference cells, as seen in Section 4.1 “Resetting the soiling measurement”.
- Verify that the irradiance is **greater than 500 W/m<sup>2</sup>**. If non-ideal GHI conditions are present on the cleaning day, try again the next day.
- Once all these conditions have been met, you may run the auto-normalization process.



**Warning:** Do not run auto-normalization if the above conditions are not met!

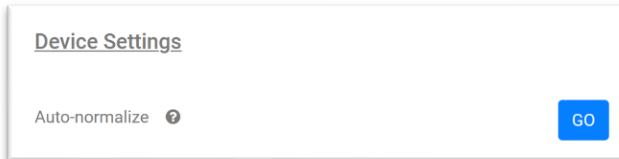
## Running auto-normalization in the Fracsun portal

If the ARES device is in Cellular-only mode, the best way to run auto-normalization is through the Device Configuration page in the Fracsun Web Portal.

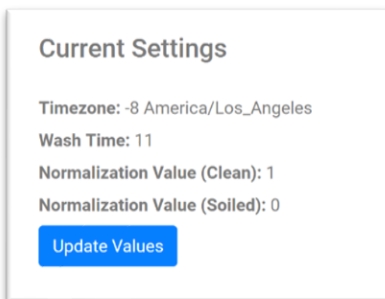
1. To initiate the auto-normalization process, login to the Fracsun Web Portal and go to the **Devices** page.
2. Locate the device in the list you would like to normalize and click the Config button.



3. Make note of the Clean and Soiled normalization values under *Current Settings*.
4. Under *Device Settings* section, click on the Go button next to **Auto-Normalize**.



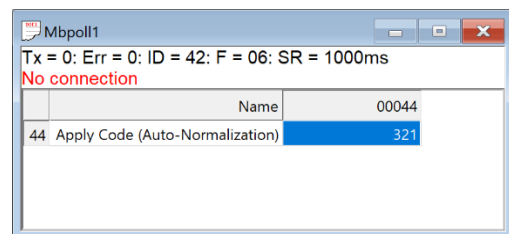
5. Wait approximately 90 seconds for the process to complete.
6. Under *Current Settings*, click on the Update Values button and wait 5 minutes for the values to be updated.
7. View the results of the auto-normalization process to verify it worked correctly.
  - a. The Clean and Soiled normalization values you made note of under the *Current Settings* section will be different than before normalization.



## Running auto-normalization via Modbus

If the ARES device is in Modbus-only mode, run the auto-normalization process through a Write Single Register command.

1. To initiate the auto-normalization process, perform a 0x06 (Write Single Register) operation to register 44 with value "321".
2. Wait approximately 90 seconds for the process to complete.
3. View the results of the auto-normalization process to verify it worked correctly.
  - a. Perform a 0x03 (Read Register) operation to register 46.
  - b. Register 46 will have the following values: 1 = Success, 2 = Failed during testing, 3 = Not enough sunlight to calibrate, 4 = No normalization reqd.
  - c. The new normalization values may be reviewed by reading registers 6 (clean) and 7 (soiled).





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