PROCEDURES FOR SOLAR ELECTRIC (PHOTOVOLTAIC abbreviated as PV) SYSTEM DESIGN AND INSTALLATION

SECTION 4: SOLAR ELECTRIC (PV) SYSTEM INSTALLATION CHECKLIST

Following the completion of each item on the checklist below, check the box to the left of the item and insert the date and initials of the person completing the item. Stars (*) denote items that should be checked directly by the field superintendent with the installing contractor.

Before starting any PV system testing: (hard hat and eye protection required)

- ❑ 1._____________Check that non-current carrying metal parts are grounded properly (array frames, metal boxes, etc. are connected to the grounding system).
- ❑ 2._____________Ensure that all labels and safety signs specified in the plans are in place.
- ❑ 3. _____________Verify that all disconnect switches (from the main AC disconnect all the way through to the combiner fuse switches) are in the open position and tag each box with a warning sign to signify that work on the PV system is in progress.

PV ARRAY--General (hard hat, gloves, and eye protection required)

- ❑ 1. _____________Verify that all combiner fuses are removed and that no voltage is present at the output of the combiner box.
- ❑ *2. ____________Visually inspect any plug and receptacle connectors between the modules and panels to ensure they are fully engaged.
- ❑ *3. ____________Check that strain reliefs/cable clamps are properly installed on all cables and cords by pulling on cables to verify.
- ❑ *4. ____________Check to make sure all panels are attached properly to their mounting brackets and nothing catches the eye as being abnormal or misaligned.
- ❑ *5. ____________Visually inspect the array for cracked modules.
- ❑ *6. ____________Check to see that all wiring is neat and well supported.

PV ARRAY CIRCUIT WIRING (hard hat and eye protection required)

- ❑ 1._____________Check home run wires (from PV modules to combiner box) at DC string combiner box to ensure there is no voltage on them.

❑ 2. _____________Recheck that fuses are removed and all switches are open.

❑ 3. _____________Connect the home run wires to the DC string combiner box terminals in the proper order and make sure labeling is clearly visible.

REPETITIVE SOURCE CIRCUIT STRING WIRING (hard hat, gloves, and eye protection, required) (The following procedure must be followed for each source circuit string in a systematic approach—(i.e. east to west or north to south).) Ideal testing conditions are midday on cloudless days March through October.

❑ 4. _____________Check open-circuit voltage of each of the panels in the string being wired to verify that it provides the manufacturer's specified voltage in full sun. (Panels under the same sunlight conditions should have similar voltages--beware of a 20 Volt or more shift under the same sunlight conditions.)

❑ 5._____________Verify that the both the positive and negative string connectors are identified properly with permanent wire marking.

❑ 6._____________Repeat this sequence for all source circuit strings.

CONTINUATION OF PV ARRAY CIRCUIT WIRING (hard hat, gloves, and eye protection required)

❑ 7._____________Recheck that DC Disconnect switch is open and tag is still intact.

❑ 8._____________**VERIFY POLARITY** OF EACH SOURCE CIRCUIT STRING in the DC String Combiner Box (place common lead on the negative grounding block and the positive on each string connection--pay particular attention to make sure there is NEVER a negative measurement). Verify open-circuit voltage is within proper range according to manufacturers installation manual and number each string and note string position on as-built drawing. (voltages should match closely if sunlight is consistent)

NOTE: IF POLARITY OF ONE SOURCE CIRCUIT STRING IS REVERSED, THIS CAN START A FIRE IN THE FUSE BLOCK RESULTING IN THE DESTRUCTION OF THE COMBINER BOX AND POSSIBLY ADJACENT EQUIPMENT. REVERSE POLARITY ON AN INVERTER CAN ALSO CAUSE DAMAGE THAT IS NOT COVERED UNDER THE EQUIPMENT WARRANTY.

❑ 9._____________Retighten all terminals in the DC String Combiner Box.

WIRING TESTS--Remainder of System: (hard hat, gloves, and eye protection required)

❑ 10. ___________Verify that the only place where the AC neutral is grounded is at the main service panel.

☐ 11.____________Check the AC line voltage at main AC disconnect is within proper limits (115-125 Volts AC for 120 Volts and 230-250 for 240 Volts).

☐ 12.____________If installation contains additional AC disconnect switches, repeat the step 11 voltage check on each switch working from the main service entrance to the inverter AC disconnect switch, closing each switch after the test is made except for the final switch before the inverter (it is possible that the system only has a single AC switch).

INVERTER STARTUP TESTS (hard hat, gloves, and eye protection required)

☐ 1._____________Be sure that the inverter is off before proceeding with this section.

☐ 2._____________Test the continuity of all DC fuses to be installed in the DC string combiner box, install all string fuses, and close fuse switches in combiner box.

☐ 3._____________Check open circuit voltage at DC disconnect switch to ensure it is within proper limits according to the manufacturer's installation manual.

☐ 4._____________If installation contains additional DC disconnect switches, repeat the step 4 voltage check on each switch working from the PV array to the inverter DC disconnect switch, closing each switch after the test is made except for the final switch before the inverter (it is possible that the system only has a single DC switch).

☐ *5.____________At this point consult the inverter manual and follow proper startup procedure (all power to the inverter should be off at this time).

☐ *6.____________Confirm that the inverter is operating and record the DC operating voltage here: ________.

☐ *7.____________Confirm that the operating voltage is within proper limits according to the manufacturers installation manual.

☐ 8._____________After recording the operating voltage at the inverter, close any open boxes related to the inverter system.

☐ *9.____________Confirm that the inverter is producing the expected power output on the supplied meter.

☐ *10.___________Provide the homeowner with the initial startup test report.

***SYSTEM ACCEPTANCE TEST (hard hat and eye protection required)**

Ideal testing conditions are midday on cloudless days March through October. However, this test procedure accounts for less than ideal conditions and allows acceptance tests to be conducted on sunny winter days.

❑ *1.____________Check to make sure that the PV array is in full sun with no shading whatsoever. If it is impossible to find a time during the day when the whole array is in full sun, only that portion that is in full sun will be able to be accepted.

❑ *2.____________If the system is not operating, turn the system on and allow it to run for 15 minutes before taking any performance measurements.

❑ *3.____________Obtain solar irradiance measurement by one of two methods and record irradiance here: W/m^2. To obtain percentage of peak sun divide irradiance by 1000 W/m^2 and record the value here: . (example: 692 W/m^2 ÷ 1000 W/m^2 = 0.692 or 69.2%.)

Method 1: Take measurement from calibrated solar meter or pyranometer.

Method 2: Place a single, properly operating PV module, of the same model found in the array, in full sun in the exact same orientation as the array being tested. After 15 minutes of full exposure, test the short circuit current with a digital multimeter and place that reading here: _________Amps. Divide this number into the short circuit current (Isc) value printed on the back of the PV module and multiply this number by 1000 W/m^2 and record the value on the line above. (example: Isc-measured = 3.6 Amps; Isc-printed on module = 5.2 Amps; Irradiance = 3.6 Amps/5.2 Amps * 1000 W/m^2 = 692 W/m^2)

❑ *4.____________Sum the total of the module ratings and place that total here: _________$Watts_{STC}$. Multiply this number by 0.7 to obtain expected peak AC output and record here: _________$Watts_{AC\text{-}estimated}$.

❑ *5.____________Record AC Watt output from the inverter or system meter and record here: ____________$Watts_{AC\text{-}measured}$.

❑ *6.____________Divide $Watts_{AC\text{-}measured}$ by percent peak irradiance and record here: _________$Watts_{AC\text{-}corrected}$. This "AC-corrected" value is the rated output of PV system. This number must be within 90% or higher of $Watts_{AC\text{-}estimated}$ recorded in step 4. If it is less than 90%, the PV system is either shaded, dirty, miswired, fuses are blown, or the modules or inverter are not operating properly.

Example Test:

A PV system is made up of 20, 100 $Watt_{STC}$ PV modules operating at an estimated irradiance of 692 W/m^2 using method 2 shown above. The power output is measured to be 1000 $Watts_{AC\text{-}measured}$ at the time of the test. Is this system operating properly or not?

Example Solution:

Sum of module ratings = 100 $Watts_{STC}$ per module x 20 modules = 2,000 $Watts_{STC}$.

Estimated AC power output = 2,000 $Watts_{STC}$ x 0.7 = 1,400 $Watts_{AC\text{-}estimated}$.

Measured AC output = 1,000 $Watts_{AC\text{-}measured}$.

Corrected AC output = 1,020 $Watts_{AC\text{-}corrected}$ ÷ 0.692 = 1,474 $Watts_{AC\text{-}corrected}$.

Comparison of corrected and estimated outputs: 1,474 $Watts_{AC\text{-}corrected}$ ÷ 1,400 $Watts_{AC\text{-}estimated}$ = 1.05, which is ≥ 0.9, demonstrating acceptable performance