

SOLAR HOT WATER SYSTEM SPECIFICATIONS AND REQUIREMENTS

GENERAL

This specification addresses the installation of solar thermal hot water systems for use in domestic hot water heating or in swimming pool heating.

The Minimum Design Life for solar hot water systems is 20 years. The Minimum Design Life for solar swimming pool heaters is 12 years.

All documentation and components furnished by Design-Builder shall be developed, designed, and/or fabricated using high quality design, materials, and workmanship meeting the requirements of the Purchaser-Owner and all applicable industry codes and standards. Reference is made in these specifications to various standards under which the Work is to be performed or tested. The installations shall comply with at least, but not limited to, the latest approved versions of the International Building Code (IBC), National Electrical Code (NEC), and all other federal, state, and local jurisdictions having authority.

Design-Builder shall conform to all specification and guidelines from equipment manufacturers.

DESIGN STANDARDS

The design, products, and installation shall comply with at least, but not limited to, the following electrical industry standards, wherever applicable:

- Institute of Electrical and Electronics Engineers (IEEE) Standards
- National Electrical Manufacturers Association (NEMA)
- National Electric Code (NEC)
- Solar Rating and Certification Corporation (SRCC)
- Underwriters Laboratories, Inc. (UL)
- National Fire Protection Association (NFPA)
- Pacific Gas and Electric Utility Requirements
- American National Standards Institute (ANSI)
- Occupational Health and Safety Administration (OSHA)
- American Disabilities Act (ADA)
- American Society for Testing and Materials (ASTM)
- National Electrical Contractors Association (NECA)
- National Electrical Testing Association (NETA)
- International Building Code (IBC)
- International Code Council (ICC)
- International Association of Plumbing and Mechanical Officials (IAPMO)
- IAPMO Backflow Prevention Reference Manual Second Edition
- All other Authorities Having Jurisdiction

SOLAR COLLECTORS

In addition to the above, the solar collectors proposed by Design-Builder shall comply with at least, but not limited to, the following:

- Solar Rating & Certification Corporation Standard 100 Minimum Standards for Solar Thermal Collectors (SRCC OG-100)
- Solar Rating & Certification Corporation Standard 300 Minimum Standards for Solar Water Heating Systems (SRCC OG-300)
- All equipment shall be new, undamaged, fully warranted without defect.
- All equipment and installation shall qualify for available solar hot water incentives.
- Acceptable mounting methods for panels shall be provided by the manufacturer. Bolted and similar connections shall be non-corrosive and include locking devices designed to prevent twisting.
- If collectors using hazardous materials are to be provided, then the environmental impact of the hazardous material usage must be disclosed, including any special maintenance requirements and proper disposal/recycling of the collectors are the end of their useful life.
- Glazed Closed Loop Flat Plate Collector: Provide minimum 65% optical efficiency, rugged high quality construction using impact-resistant, anti-reflective solar glass, copper meander/serpentine absorber tube, selective-surface absorber plate, non-degrading thermal insulation and optional rapid connections kits to interconnect collectors, ports for collector temperature sensors, air vents and electronic differential controls.
- The collector shall have no less than 95% transmission, eta conversion factor of no less than 0.75 by gross area.

SOLAR COLLECTOR ARRAY

- Array Layout: Collector array shall be oriented so that all collectors face the same direction. Space collectors arranged in multiple rows so that no shading from other collectors is evident between 1000 hours and 1500 hours solar time on December 21. Indicate minimum spacing between rows. Collector array must have a minimum surface orientation factor (SOF) of 0.75.
- Piping: Connect interconnecting array piping between solar collectors, in a reverse-return configuration with approximately equal pipe length for any possible flow path. Indicate flow rate through the collector array. Provide each collector bank isolated by valves, with a pressure relief valve and with the capability of being drained. Locate manually operated air vents at system high points, and pitch array piping a minimum of 0.25 inch per foot so that piping can be drained by gravity. Supply calibrated balancing valves at the outlet of each collector bank as indicated.
- Supports for Solar Collector Array: Utilize the existing support structure and recertify that it will be covered under the Design-Builders warranty of 10 years with an optional 20 warranty. If a new support is proposed, the Design-Builder must provide a support structure for the collector array of aluminum, stainless steel, or other corrosion-resistant approved material. Furnish a support structure which secures the collector array at the proper tilt angle with respect to horizontal and orientation with respect to true south. Provide a support structure that will withstand the static weight of filled collectors and piping, wind, seismic, and other anticipated loads without damage. Provide a support structure which allows access to all equipment for maintenance, repair, and replacement. Neoprene or EPDM washers shall separate all dissimilar metals. Depending on system type, supports for solar array could terminate in ballast blocks to avoid roof penetrations.

TRANSPORT SUBSYSTEM

- Heat Exchanger (if required by system design): For system designs requiring a heat exchanger, provide a minimum design pressure rating of 150 psi. Construct heat exchanger of 316 stainless steel, titanium, copper-nickel, or brass. Furnish heat exchanger with a capability of withstanding temperatures of at least 240 °F. Tube-in-tube copper side-arm heat exchangers are acceptable for appropriate system types.

- Pumps (for active systems): For active solar system designs requiring a pump, provide electrically-driven, single-stage, centrifugal type circulating pumps. Support pumps on a concrete foundation or mounting intended for the purpose, or by the piping on which installed if appropriate to the size. Construct the pump shaft of corrosion resistant alloy steel with a mechanical seal. Provide stainless steel impellers and casings of bronze. Pump motor start stop shall be controlled by the solar thermal temperature control system that is compatible with open communication protocol and meets CSI thermal incentive program requirements complete with manual override (Hand-Off-Automatic). Pumps shall be installed with isolation valves so the pump can be serviced without draining the system.
- Heat Transfer Fluid Heat transfer fluid shall be compatible with all materials in the system. The nature and amount of heat transfer fluid will depend on the type of system proposed and the freeze conditions encountered at the site. Any anti-freeze, conditioners or corrosion inhibitors added to the heat transfer fluid must be non-toxic and intended for use in potable water systems when used with single wall heat exchangers.

PIPING SYSTEM

Provide a piping system complete with pipe, pipe fittings, valves, strainers, expansion loops, pipe hangers, inserts, supports, anchors, guides, sleeves, and accessories with this specification and the drawings. Pipe shall be designed to observe limits on flow velocity, pressure drop and gauge pressure associated with the pipe type and characteristics.

Provide piping flow rates below 5 feet per second. Piping shall be Type L or Type M copper tubing, ASTM B-88, with 95-5 tin-antimony soldered joints. If cold water piping supplying the SWH system is of another type, such as PVC, it shall be replaced within 10 feet of the SWH system with copper to avoid bulging and rupture due to proximity to the higher temperatures of the solar system.

All work performed as described herein including but not limited to piping, fixtures, fitting, solder, flux and panels shall meet California Code requirements for Lead Free products and the installation of these products as set forth in California Health and Safety Code, Sections 116875-116880.

- Provide outside array piping insulation with a capability of withstanding 250 °F, except that piping insulation within 1.5 feet of collector connections shall be capable of withstanding 400°F. Protect outside piping insulation from water damage and ultraviolet degradation with a suitable outer coating manufactured for this purpose (aluminum, sunlight resistant PVC or approved equal).
- If systems are proposed with multiple collector banks, provide calibrated balancing valves suitable for 125 psig and 250 °F service. Furnish calibrated balancing valves with bronze body/brass ball construction with seat rings compatible with system fluid and differential readout ports across valve seat area. Provide readout ports fitted with internal insert of compatible material and check valve. Provide calibrated balancing valves with a memory stop feature to allow valve to be closed for service and reopened to set point without disturbing balance position, and with a calibrated nameplate to assure specific valve settings. Provide calibrated balancing valves and ball valves at the outlet of each collector bank. The balancing valves are specified to allow the array to be flow balanced. The ball valves are required to enable the array to be disconnected for maintenance or repair.
- Provide pressure gauges with throttling type needle valve or a pulsation dampener and shutoff valve. Furnish a 3-1/2 inch minimum dial size.
- Supply thermometers with wells and separable bronze sockets.
- Support and hang piping so that the weight of the piping is not supported by drywall, siding, or other building members not designed to bear load. Support piping so that thermal expansion and contraction of pipe lengths is accommodated. Supports shall be replaced to ensure piping does not sag.
- Provide valves compatible with the piping. Ball valves shall be used for shutoff, with full port, bronze body, bronze ball and Teflon seat. Bronze hose-end gate valves shall be used for draining low points of piping.

- All exposed and accessible hot water piping must be insulated with material which has a minimum of R2.6 value.

ELECTRICAL COMPONENTS

Provide electrical equipment and wiring in accordance with NFPA 70, the NEC, and UL. Furnish motor starters complete with thermal overload protection and other appurtenances necessary for the motor control specified. Provide each motor of sufficient size to drive the equipment at the specified capacity without exceeding the nameplate rating of the motor. Motors shall be high efficiency motors.

MOUNTING SYSTEM

The mounting systems shall be designed and installed such that the panels may be fixed with reliable components proven in similar projects, and shall be designed to resist dead load, live load, corrosion, UV degradation, wind loads, and seismic loads appropriate to the geographic area over the expected 25-year lifetime. The Design-Builder's design shall sufficiently respond to the design requirements imposed by Federal, State, and local jurisdictions in effect at the time of Agreement execution and any pending code decisions affecting the design shall be identified during Schematic Design. Design-Builder shall conduct an analysis, and submit evidence thereof, including calculations, of each structure affected by the performance of the scope described herein, and all attachments and amendments. The analysis shall demonstrate that existing structures are not compromised or adversely impacted by the installation of panels, equipment, or other activity related to this scope. Mounting systems must also meet the following requirements at a minimum:

- All structural components, including array structures, shall be designed in a manner commensurate with attaining a minimum 25-year design life. Particular attention shall be given to the prevention of corrosion at the connections between dissimilar metals.
- Thermal loads caused by fluctuations of component and ambient temperatures shall be accounted for in the design and selection of mounting systems such that neither the mounting system nor the surface on which it is mounted shall degrade or be damaged over time.
- Each collector mounting system must be certified by the collector manufacturer as (1) an acceptable mounting system that shall not void the module warranty, and (2) that it conforms to the module manufacturer's mounting parameters.
- Final coating and paint colors shall be reviewed and approved by the Purchaser-Owner during Design Review.
- Painting or other coatings must not interfere with the grounding and bonding of the array.

CORROSION CONTROL

In addition to the above, Corrosion Control proposed by Design-Builder must comply with at least, but not limited to the following requirements:

- Fasteners and hardware throughout system shall be stainless steel or material of equivalent corrosion resistance
- Racking components shall be anodized aluminum, hot-dipped galvanized steel, or material of equivalent corrosion resistance
- Unprotected steel not to be used in any components
- Each system and associated components must be designed and selected to withstand the environmental conditions of the site (e.g., temperatures, winds, rain, flooding, etc.) to which they will be exposed.

ROOFING REQUIREMENTS

The installation of collectors and other equipment shall provide adequate room for access and maintenance of existing equipment on the building roofs. A minimum of three feet of clearance will be provided between equipment and existing mechanical equipment and other equipment mounted on the roof. A minimum of four feet of clearance shall be provided between equipment and the edge of the roof. Clearance guidelines of the local fire marshal shall be followed. The equipment shall not be installed in a way that obstructs air flow into or out of building systems or equipment.

Proposed roof top mounted systems may be ballasted, standing seam attachment, or penetrating systems and must meet or exceed the following requirements:

- Systems shall not exceed the ability of the existing structure to support the entire solar thermal system and withstand increased wind uplift and seismic loads. The capability of the existing structure to support proposed solar systems shall be verified by Design-Builder prior to design approval.
- Roof penetrations, if part of the mounting solution, shall be kept to a minimum.
- Design-Builder shall perform all work so that existing roof warranties shall not be voided, reduced, or otherwise negatively impacted.
- No work shall compromise roof drainage, cause damming or standing water or cause excessive soil build-up.
- All materials and/or sealants must be chemically compatible.
- Thermal movement that causes scuffing to the roof must be mitigated as part of the mounting solution.
- All penetrations shall be waterproofed.
- Detail(s) for the sealing of any roof penetrations shall be approved in writing to the Purchaser-Owner, as well as the manufacturer of the existing roofing system, as part of system design review and approval – prior to Design-Builder proceeding with work. The Purchaser-Owner will make available the roofing manufacturer for each building for consultation with Design-Builder as part of the design process.
- All roofing penetrations and waterproofing shall be performed or overseen by a licensed roofing contractor who is certified by the roofing materials manufacturer for the specific materials or systems comprising each roof upon which a solar system will be installed. The roofing contractor shall also be safety prequalified by the Purchaser-Owner.
- As part of the design submittals, Design-Builder shall include signed certificates from the roofing manufacturer stating:
 - The roofing contractor is certified installer of Complete Roofing System.
 - The manufacturer's Technical Representative is qualified and authorized to approve project.
 - Project Plans and specs meet the requirements of the warranty of the Complete Roofing System for the specified period.
 - Existing warranty incorporates the new roofing work and flashing work.
- Any damage to roofing material during installation of solar systems must be remedied by Design-Builder.
- The installation of panels and other equipment on building roofs will be designed to minimize visibility of the equipment from the ground.

MONITORING SYSTEMS

Design-Builder shall design, build, activate and ensure proper functioning of the necessary Data Acquisition Systems (DAS) that enable the Purchaser-Owner to track the performance of the Solar Systems as well as environmental.

Metering and monitoring equipment installed shall include, but is not limited to a data acquisition system, a BTU meter, i.e. a flow meter, a temperature sensor pair, and a calculator. Btu meters must satisfy maximum permissible errors of OIML R75 Class 1 accuracy. Assembled Btu meters are allowable if Btu calculations are only performed when there is flow.

Data must be collected in 15-minute intervals that will be available on a daily basis. Data collected must include date, time, solar Btu delivered, cold water supply temperature, solar hot water delivery temperature, collector temperature, run time of pump(s) and log data which will include alarms, system messages, system events and trends.

The monitoring system must have remote communication capability whereby performance data can be collected, accessed remotely and uploaded for processing by a Performance Data Provider (PDP). The PDP provider must retain performance data for five years from the data collection end date.

A Monitoring Manual shall be provided to the Purchaser-Owner in printed or on-line form that describes how to use the monitoring system, including the export of data and the creation of custom reports.

FREEZE AND STAGNATION PROTECTION

Design-Builder is responsible for designing and installing a solar system that meets freeze protection requirements set forth by SRCC and IAMPO for the appropriate climate zone of the site.

Closed loop recirculation systems must have a minimum of two separate freeze protection mechanisms on each system. In addition to manual intervention, a separate freeze protection mechanism must be designed to function in the event of a power failure during freezing conditions.

Design-Builder is responsible for designing and installing a solar system that meets stagnation and overheat protection requirements set forth by SRCC or IAPMO.

Closed loop drainback systems must have a controller which will shut down a pump when the storage tank temperature limit has been reached.

For closed loop systems, acceptable stagnation control measures include, but are not limited to advanced controller with thermal cycling function, heat dump radiator, steam back, pressure stagnation protection.

SHADING

Design-Builder shall adhere to the following requirements in order to avoid excessive shading on panels. For any object near an array that is higher than the lowest point of that array by height H, Design-Builder shall locate the array farther from the object than:

- 2H to the North of the object
- 2H to the East or West of the object
- 2H to any non-cardinal direction of the object

Any Design-Builder whose system design does not adhere to these rules shall perform a shading analysis justifying the basis for their design, including any proposed tree removal, and explaining why shading does not create an adverse performance and/or economic impact.

Any trees that are in the footprint of systems to be installed by the Design-Builder shall be removed by the Design-Builder at their expense, subject to the approval of the Purchaser-Owner. A tree shall be considered to be in the footprint of a system if its canopy would extend over any part of the system, including structural components or modules. The Design-Builder shall be responsible for any required tree remediation efforts resulting from tree removal that is deemed the Design-Builder's responsibility.

WARRANTIES

Design-Builder shall provide for the following warranties:

All solar collectors must have a minimum of a 10 year manufacturer's performance warranty to protect against defects and a 15% performance degradation. Additionally, the Design-Builder shall provide a 20-year warranty option if commercially available.

All systems must have a minimum 10 year performance warranty to protect the host against more than a 15% degradation of system performance over the 10 year period that may occur as a result of faulty installation.

All systems must have a minimum 1 year warranty on installation labor and workmanship not otherwise covered by the manufacturer's performance warranty.

The mounting system shall have a 20-year warranty covering at least structural integrity and corrosion.

Design-Builder shall provide a comprehensive ten (10) year warranty on all system components against defects in materials and workmanship under normal application, installation, and use and service conditions.

All warranties must be documented in advance and be fully transferable to Purchaser-Owner.

All work performed by Design-Builder must not render void, violate, or otherwise jeopardize any preexisting Purchaser-Owner facility or building warranties or the warranties of system components.

CONSTRUCTION

SCOPE OF SUPPLY

Design-Builder shall provide all necessary labor, materials, equipment, and services required to install complete integrated turnkey solar thermal systems. Design-Builder shall supply all solar collectors, mounting equipment, piping, pumps, controls, metering, related wiring, monitoring equipment, and all ancillary equipment necessary to install the solar system and interconnect it to the Purchaser-Owner hot water system. The solar system installations shall comply with all contract requirements, technical specifications, approved design documents, and applicable regulatory codes and requirements. Design-Builder shall submit As-Built Construction Drawings in hard copy with two (2) sets and an electronic copy in DWG format on compact disc to the Purchaser-Owner after completion of the Proving Period for each system at each site.

MATERIALS AND EQUIPMENT

Materials and equipment incorporated in the Work shall be new and suitable for the use intended. No material or equipment shall be used for any purpose other than that for which it is designed, specified or indicated.

Design-Builder shall use means necessary to protect the materials and equipment before, during and after installation. Design-Builder shall promptly replace lost or damaged materials and equipment with equal, or Purchaser-Owner-approved, replacements, or repair them, at no additional cost to the Purchaser-Owner

LINE LOCATION

Design-Builder will be responsible for locating, identifying and protecting existing underground utilities conduits, piping, substructures, etc. and ensuring that no damage is inflicted upon existing infrastructure. In addition to USA Dig and utility line-locating, a private line-locator must be used for any project requiring underground work.

TREE REMOVAL

Any trees that are in the footprint of systems to be installed by the Design-Builder shall be removed by the Design-Builder at their expense, subject to the approval of the Purchaser-Owner. A tree shall be considered to be in the footprint of a system if its canopy would extend over any part of the system, including structural components or collectors. The Purchaser-Owner will remove or prune, at its discretion, trees planted outside of the work area that shade collectors (at present time or in the foreseeable future), provided the Design-Builder identifies these trees during the design process. The Design-Builder shall be responsible for any required tree remediation efforts resulting from tree removal that is deemed the Design-Builder's responsibility.

CLEANING

Clean and disinfect potable-water distribution piping as follows:

- Purge new piping and parts of existing water piping that have been altered, extended, or repaired before using. Use purging and disinfecting procedure prescribed by authorities having jurisdiction or, if method is not prescribed, procedure described in either AWWA C651 or AWWA C652. Submit water samples in sterile bottles to authorities having jurisdiction. Repeat procedure if biological examination shows contamination.

Clean the non-potable solar thermal side of the system including the solar thermal collectors and heat exchanger according to manufacturer's recommendations. Clean all piping by flushing the piping system with clean, potable water until dirty water does not appear at outlets.

QUALITY ASSURANCE AND QUALITY CONTROL

Design-Builder shall implement a Quality Assurance / Quality Control (QA/QC) plan for construction activities on Purchaser-Owner sites. At least 30 days prior to the planned commencement of construction, Design-Builder shall submit a copy of the QA/QC Plan for review and approval by the Purchaser-Owner.

To ensure the highest quality of the installation, Design-Builder shall:

- Implement policies and procedures to ensure proper oversight of construction work, verification of adherence to construction documents and contractual requirements, and rapid identification and mitigation of issues and risks.
- Utilize best practice methods for communicating progress, performing work according to the approved Project schedule, and completing the Project on-time.
- Keep the Site clean and orderly throughout the duration of construction. All trash and rubbish shall be disposed of off-site by licensed waste disposal companies and in accordance with applicable Law.
- Provide equipment marking, as well as labeling and signage for the Project that shall be removed after Project completion.
- Fully comply with all applicable notification, safety and Work rules (including Purchaser-Owner safety standards) when working on or near Purchaser-Owner facilities.

- Provide Special Inspection for trenching, rebar, concrete, welding, and roof attachment work, according to AHJ requirements.
- Route all electrical collection system wiring and conduits in a neat and orderly fashion and in accordance with all applicable code requirements. All cable terminations, excluding module-to-module and module-to-cable harness connections, shall be permanently labeled.
- Torque all mechanical and electrical connections and terminations according to manufacturer specifications, with marking/sealing of all electrical terminations at appropriate torque point.
- Provide all temporary road and warning signs, flagmen or equipment as required to safely execute the Work. Street sweeping services shall also be provided as required to keep any dirt, soil, mud, etc. off of roads. Comply with all state and local storm water pollution prevention (SWPP) ordinances.

REMOVAL AND REMEDIATION

Design-Builder shall remove all construction spoils, abandoned footings, utilities, construction equipment and other byproducts of construction. All disturbed areas including landscaping, asphalt, and concrete shall be remediated to be in equal or better condition than found. Parking lots shall be re-striped if affected by construction operations.

The site shall be left clean and free of debris or dirt that has accumulated as a result of construction operations.

TESTING AND COMMISSIONING

Following completion of construction, Design-Builder shall provide the following services related to startup and performance testing of the systems:

- Acceptance Testing
- System Startup
- Proving Period

A detailed Testing Plan covering each of the phases above shall be submitted and approved by the Purchaser-Owner prior to substantial completion of construction. A detailed description of each phase is provided below.

ACCEPTANCE TESTING

Design-Builder shall perform a complete acceptance test for each System. The acceptance test procedures include component tests as well as other standard tests, inspections, safety and quality checks. All testing and commissioning shall be conducted in accordance with the manufacturer's specifications.

The section of the Testing Plan that covers Acceptance Testing cover at least the following:

- Detailed test methods, including sample calculations and reference to standards as required or applicable, and list of tested equipment.
- Pre-test checklist to ensure readiness and any safety measures are in-place.
- Detailed list of all items to be inspected and tests to be conducted.
- Acceptance Criteria: For each test phase, specifically indicate what is considered an acceptable test result.

The Acceptance Testing section of the Testing Plan shall include (but not be limited to) the following tests:

- Testing performance of the collectors relative to insolation, ambient temperature and inlet temperature

- Testing of all sensors of the DAS
- Temperature sensor diagnostics
- Testing of the Data Presentation interface of the DAS
- Piping hydraulic pressure test
- Water potability test

After Design-Builder conducts all Acceptance Testing based on the Testing Plan approved by the Purchaser-Owner prior to substantial completion, Design-Builder shall submit a detailed Acceptance Test Report to the Purchaser-Owner for review.

The Acceptance Test Report shall document the results of the tests conducted following the Testing Plan, and include additional information such as the date and time each test was performed. It shall also make reference to any problem and deficiencies found during testing. If there was troubleshooting done, the Report shall describe the troubleshooting methods and strategy. Design-Builder shall be responsible for providing the labor and equipment necessary to troubleshoot the System.

SYSTEM STARTUP

Following Purchaser-Owner approval of the Acceptance Test Report, Design-Builder shall conduct tests over twenty-four (24) hours and at a time resolution of fifteen (15) minutes, recording the following data:

- Thermal output (Btu)
- In-plane irradiance
- Ambient temperature
- Collector inlet temperature
- Thermal energy storage temperatures

These data points shall be presented in a manner that best depicts the actual performance of the system for Purchaser-Owner review and approval and shall be submitted as part of the Startup Test Report.

PROVING PERIOD (30 DAYS)

Upon completion of Acceptance Testing and System Startup, and approval by the Purchaser-Owner, Design-Builder shall monitor the system during a thirty (30) day Proving Period and submit a report for Purchaser-Owner review and approval prior to final acceptance by the Purchaser-Owner. This includes monitoring system output and ensuring the correct functioning of system components over this time. The values for the following data shall be acquired every fifteen (15) minutes over thirty (30) days:

- Date and Time of data points
- Thermal output (Btu)
- Total Btu's delivered (per tank if system has multiple tanks)
- In-plane irradiance
- Ambient temperature
- Collector inlet temperature
- Thermal energy storage temperatures
- Quantity of back-up fuel consumption
- System availability

Design-Builder shall utilize calibrated test instruments and DAS and monitoring system to collect the test data described above, which shall be made available to the Purchaser-Owner for access throughout the Proving Period. Design-Builder shall determine through analysis of data from the Proving Period whether the solar thermal system delivers the expected production as determined by the final approved design (i.e., Construction Documents). Actual production shall be compared against expected production using actual weather data and other system inputs for calculating expected production.

All data and reports required in system testing shall be fully functional and available to the Purchaser-Owner at the commencement of the Proving Period. Data and reporting requirements are included in the testing scope of the Proving Period and deficiencies in these areas (including missing data, inaccurate reports, and other issues that make validation of system performance inconclusive) shall be grounds for denying approval of the Proving Period Report.

If the solar thermal system does not perform to design specifications, diagnostic testing shall be performed by Design-Builder, deficiencies shall be identified with proposed corrective actions submitted to the Purchaser-Owner, and the Proving Period test repeated. Design-Builder shall be responsible for providing the labor and equipment necessary to troubleshoot the system. The Proving Period Report shall be submitted after the successful completion of this phase and submitted to the Purchaser-Owner for review and approval. The report shall contain, but not be limited to, the following information; calculations shall be provided in Excel format with formulas visible to allow for peer review:

- System description
- Test period
- Test results
- Anomalies identified during test
- Corrective action performed
- Actual measured performance
- Calculations detailing expected performance under TMY conditions

CLOSE-OUT DOCUMENTATION REQUIREMENTS

Close-Out documents prepared by Design-Builder must include at minimum, but not limited to, the following items:

- Final As-Built Drawing Set, provided in (2) hard copy sets and an electronic copy in DWG format (or as desired by Purchaser-Owner)
- Owner's Manual and component warranties
- Signed inspections cards from AHJ and required Special Inspections
- O&M Manuals – Design-Builder shall provide two (2) copies of O&M Manuals. Updated editions of O&M Manuals shall be sent electronically to the Purchaser-Owner as they become available.

OPERATIONS AND MAINTENANCE

Design-Builder shall offer Operations and Maintenance services for ten (10) years with their Proposal, with an option to extend the Contract for up to an additional ten (10) years. The Purchaser-Owner reserves the right to not execute the Operations and Maintenance services agreement. In offering such services, Design-Builder shall perform all necessary preventive and corrective maintenance, which includes routine maintenance adjustments, replacements, and repairs with supporting documentation delivered to the Purchaser-Owner after the Work has been performed. Maintenance by Design-Builder shall ensure that all warranties are preserved. The frequency and timing of collector wash-downs shall be determined by Design-Builder based on system monitoring data. Environmental sensors such as pyranometers shall be tested and recalibrated at least once every three (3) years.

Design-Builder shall log all maintenance calls and document all maintenance activities. These activities shall be presented in a report, which is to be submitted to the Purchaser-Owner on a minimum quarterly basis.

Design-Builder shall perform the following maintenance services, at a minimum, as described below:

PREVENTATIVE MAINTENANCE

Preventive Maintenance shall be performed at least annually and include:

- Test system performance vs. insolation and ambient temperature to verify continued performance at or near design levels
- System level testing including tests of individual major components
- System visual inspection to include but not be limited to the list below. All discovered issues shall be resolved as needed.
 - Inspect for stolen, broken or damaged collectors, record damage and location. Report to the Purchaser-Owner and wait for the Purchaser-Owner to authorize a course of action.
 - Check mechanical attachments of the collectors and racking system.
 - Inspect all metallic parts for corrosion.
 - Survey entire jobsite for debris or obstructions.
 - Inspect fasteners for proper torque and corrosion.
 - Check for proper operation and reporting of monitoring hardware.
 - Inspect pipe connections for leaks
 - Inspect piping and other hardware for signs of damage from vandalism or animal damage.
 - Inspect storage tank(s) for signs of damage
- Routine system maintenance to include correction of loose water pipe connections, replacement if defective collectors found during testing, other minor maintenance repair work.
- Collector cleaning, at a frequency to be determined by the ongoing monitoring of the system such that effect on production is no more than 5%, but not less often than twice a year.
- Routine DAS maintenance to include sensor calibration and data integrity check

TROUBLESHOOTING AND CUSTOMER SERVICE

- Dispatch of field service resources within two business days of notification (via automated or manual means) for repairs as necessary to maintain system performance.
- Any corrective action required to restore the system to fully operational status shall be completed within 24 hours of the service resources arriving on-site.
- Support telephone line made available to Purchaser-Owner staff to answer questions or report issues.
- Support line shall be staffed during operational hours from 8 am – 6 pm local time. During times outside of this operational period, an urgent call shall be able to be routed to a supervisor for immediate action.

MAJOR COMPONENT MAINTENANCE AND REPAIR

- Pump repair and component replacement and refurbishment as required in the event of pump failure.

- Pump inspection and regular servicing as required under pump manufacturer's warranty specifications. Those include but are not limited to the following annually:
 - Check for corrosion on all fittings
 - Check all connections.
 - Perform a complete visual inspection of all connected systems including expansion tank and back-up water heater.
 - Record all inspections completed.
 - Inform pump manufacturer of all deficiencies identified.
 - Oversee pump manufacturer performance of In-Warranty replacement of failed pump components.
- Customer advocacy with vendors.

TRAINING

The Respondent shall provide four (4) hours of on-site training for Purchaser-Owner personnel in all aspects of operation and shall be scheduled to take place at the jobsite at a time agreeable to both the Purchaser-Owner and Design-Builder. At a minimum, training topics shall include the following:

- System safety, including shut-down procedures
- Solar thermal collector maintenance and troubleshooting
- Calibration and adjustment procedures for flow meter, temperature sensors, pressure gauges
- DAS and monitoring solution, including standard and custom reporting
- Heat transfer fluid changing guide and schedule