SECTION 23 56 00
SOLAR ENERGY HEATING SYSTEM

SPEC WRITER NOTES:
1. Delete between // --- // if not applicable to project. Also delete any other item or paragraph not applicable in the section and renumber the paragraphs.
2. Provide the year of latest edition to each publication given in Article 1.6 APPLICABLE PUBLICATIONS.

PART 1 - GENERAL

1.1 DESCRIPTION

A. The requirements of this Section apply to all sections of Division 23 related to Solar Energy Heating Systems.

B. Solar energy heating systems: The system includes solar energy collectors, associated circulation pumps, collection tanks, and heat exchangers for the generation of //building heating water// //and// //potable hot water//.

1.2 RELATED WORK

A. Section 01 00 00, GENERAL REQUIREMENTS: General construction practices.

B. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES: Submittals.

C. Section 07 60 00, FLASHING AND SHEET METAL: Flashing products and procedures.

D. Section 22 21 23, DOMESTIC WATER PUMPS: Circulators on solar domestic water heating systems.

E. Section 23 05 93 TESTING, ADJUSTING AND BALANCING FOR HVAC.

F. Section 23 07 11, HVAC AND BOILER PLANT INSULATION: Insulation products and procedures for tanks and piping.

//G. Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC: Control system components. //

H. Section 23 21 13, HYDRONIC PIPING

I. Section 31 00 00, EXCAVATION: Excavating and backfilling.

1.3 DEFINITIONS

A. Unless otherwise specified or indicated, solar energy conversion terms used in these specifications, and on the drawings, shall be as defined in ASTM E772.

1.4 QUALITY ASSURANCE

A. For brazing and soldering procedure qualification, conform to ASME B31.1.

B. For preparation and procedures for joints, conform to ASME B31.1 and CDA A4015.

C. Contractor shall make all necessary field measurements and investigations to assure that the equipment and assemblies will meet contract requirements.

D. Warranties: The solar energy heating system shall be subject to the terms of FAR Clause 52.246-21, except that the warranty period shall be as noted for the items below:

1. Polyethylene piping: 25 year manufacturer’s warranty against defects in materials and workmanship.

1.5 SUBMITTALS

A. Submit six copies in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.

B. If equipment submitted differs in arrangement from that shown on the submittals, provide drawings that show the rearrangement of all associated systems. Approval will be given only if all features of the equipment and associated systems, including accessibility, are equivalent to that required by the contract and acceptable to the //COR//.

C. Prior to submitting shop drawings for approval, contractor shall certify in writing that manufacturers of all major items of equipment have each reviewed drawings and specifications from the applicable other manufacturers, and have jointly coordinated and properly integrated their equipment and controls to provide a complete and efficient installation.

D. Submittals and shop drawings for independent items, containing applicable descriptive information, shall be furnished together and complete in a group. Coordinate and properly integrate materials and equipment in each group to provide a completely compatible and efficient installation. Final review and approvals will be made only by groups.

E. Shop Drawings: Include collector structural supports, solar collector control sequences, instrument mounting and interconnections, and all other components, parts and pieces required to complete the functioning assembly. Where applicable, include shop drawings for foundations or other support structures.

F. Product Data: Include detailed information for components of the solar energy system.

1. Piping
2. Instrumentation
3. Valves
4. Piping specialties
5. Pumps: For each pump, include manufacturer's data including pump speed and characteristic impeller performance curves. Indicate capacity versus heat, efficiency, and brake power for the full range from shut-off to free delivery.
6. Solar storage tanks
7. Solar collectors
8. Heat exchangers
9. Compression tanks
10. Solar-boosted domestic water heater
11. Collector heat transfer fluid
12. Insulation around piping and storage tanks.

G. Test Reports - Underground Solar Storage Tanks Holiday Test: Submit a factory holiday test certificate for each tank.

H. Certificates: Submit technical representative's certification that the solar energy system installation has been done as recommended by the manufacturer.

I. Manufacturer's Instructions

J. Operation and Maintenance Solar Energy Systems Data Package:

1. Safety precautions
2. Operator restart
3. Startup, shutdown, and post-shutdown procedures
4. Normal operations
5. Emergency operations
6. Environmental conditions
7. Lubrication data
8. Preventive maintenance plan and schedule
9. Cleaning recommendations
10. Troubleshooting guides and diagnostic techniques
11. Wiring diagrams and control diagrams
12. Maintenance and repair procedures
13. Removal and replacement instructions
14. Spare parts and supply list
15. O&M submittal data
16. Parts identification

17. Warranty information
18. Testing equipment and special tool information
19. Testing and performance data
20. Contractor information

K. Closeout Submittals: Posted operating instructions for solar energy system that provide for piping identification codes and diagrams of solar energy systems, operating instructions, control matrix, and troubleshooting instructions.

SPEC WRITER NOTE: Insert the year of approved latest edition of the applications between the brackets //----// and delete the brackets if applicable to this project.

1.6 APPLICABLE PUBLICATIONS

A. Publications listed below (including amendments, addenda, revisions, supplements and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by the basic designation only.

B. American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE):

90.1-IP-//2016//.....Energy Standard for Buildings Except Low-Rise Residential Buildings

93-//2010(RA 2014)//....Methods of Testing to Determine the Thermal Performance of Solar Collectors

96-//2018//.....Methods of Testing to Determine the Thermal Performance of Unglazed Flat-Plate Liquid-Type Solar Collectors

C. American Society of Sanitary Engineering (ASSE):

1003-//2009//.....Performance Requirements for Water Pressure Reducing Valves for Domestic Water Distribution Systems

D. American Welding Society (AWS):

A5.8/A5.8M-//2011//.....Specification for Filler Metals for Brazing and Braze Welding

E. American Society of Mechanical Engineers (ASME):

B16.22-//2018//.....Wrought Copper and Copper Alloy Solder Joint Pressure Fittings

B16.24-//2016//.....Cast Copper Alloy Pipe Flanges and Flanged Fittings: Classes 150, 300, 600, 900, 1500, and 2500

B16.39-//2014//.....Malleable Iron Threaded Pipe Unions; Classes 150, 250, and 300

B31.1-//2018//.....Power Piping

B40.100-//2013//.....Pressure Gauges and Gauge Attachments

BPVC SEC VIII-//2019//..Boiler and Pressure Vessel Codes: Section VIII Rules for Construction of Pressure Vessels

F. American Society for Testing and Materials (ASTM):

A193/A193M-//2017//.....Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service and Other Special Purpose Applications

A194/A194M-//2018//.....Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High-Pressure or High-Temperature Service, or Both

B168-//2019//.....Standard Specification for Nickel-Chromium-Iron Alloys (UNS N06600, N06601, N06603, N06690, N06693, N06025, N06045, and N06696), Nickel-Chromium-Cobalt-Molybdenum Alloy (UNS N06617), and Nickel-Iron-Chromium-Tungsten Alloy (UNS N06674) Plate, Sheet, and Strip

B209-//2014//.....Standard Specification for Aluminum and Aluminum-Alloy Sheet and PlateB209M-14Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate (Metric)

B32-//2014//.....Standard Specification for Solder Metal

B88-//2016//.....Standard Specification for Seamless Copper Water Tube

B88M-//2018//.....Standard Specification for Seamless Copper Water Tube (Metric)

C1048-//2018//.....Standard Specification for Heat-Treated Flat Glass – Kind HS, Kind FT Coated and Uncoated Glass

D3667-//2016//.....Standard Specification for Rubber Seals Used in Flat-Plate Solar Collectors

D3771-//2015//.....Standard Specification for Rubber Seals Used in Concentrating Solar Collectors

D3832-//2017//.....Standard Specification for Rubber Seals Contacting Liquids in Solar Energy Systems

E1-//2014//.....Standard Specification for ASTM Liquid-in-Glass Thermometers

E772-//2015//.....Standard Terminology of Solar Energy Conversion

E822-//2015//.....Standard Practice for Determining Resistance of Solar Collector Covers to Hail by Impact with Propelled Ice Balls

E905-//2013// .....Standard Test Method for Determining Thermal Performance of Tracking Concentrating Solar Collectors

G. Copper Development Association (CDA):

A4015-//14/16//.....Copper Tube Handbook

H. Manufacturers Standardization Society of the Valve and Fittings Industry (MSS):

SP-25-//2018//.....Standard Marking System for Valves, Fittings, Flanges and Unions

SP-58-//2018//.....Pipe Hangers and Supports – Materials, Design, Manufacture, Selection, Application, and Installation (ANSI-Approved American National Standard)

SP-72-//2010//.....Ball Valves with Flanged or Butt Welding Ends for General Service

SP-80- //2013//.....Bronze Gate, Globe, Angle, and Check Valves

SP-110-//2010//.....Ball Valves Threaded, Socket-Welding, Solder Joint, Grooved and Flared Ends

I. National Electrical Manufacturer’s Association (NEMA):

250- //2014//.....Enclosures for Electrical Equipment (1,000 Volts Maximum)x

J. NSF International (NSF):

5-//2016//.....Water Heaters, Hot Water Supply Boilers, and Heat Recovery Equipment

61-//20118//.....Drinking Water System Components – Health Effects

372-//2018//.....Drinking Water System Components – Lead Content

K. Sheet Metal and Air Conditioning Contractors' National Association (SMACNA):

1981-//2008//.....Seismic Restraint Manual Guidelines for Mechanical Systems, 3rd Edition

L. Solar Rating and Certification Corporation (SRCC):

100- //2015//.....Solar Thermal Collector Standard

300-//2015//.....Solar Thermal System Standard

M. U.S. Department of Defense (DOD):

MIL-STD-101-//2014 //...Color Code for Pipelines & for Compressed Gas Cylinders

N. U.S. General Services Administration (GSA):

CID A-A-59617-//2002//..Unions, Brass or Bronze, Threaded Pipe Connections and Solder-Joint Tube Connections

CID A-A-60001-//2017//..Traps, Steam

FS F-T-2907-//2006//....Tanks, Potable Hot Water Storage

PART 2 - PRODUCTS

2.1 GENERAL

A. SRCC OG-300 listed, constructed of materials defined in this section.

SPEC WRITER NOTE: Either reference the applicable Section or specify products herein.

2.2 PIPING

//A. Comply with Section 23 21 13, HYDRONIC PIPING.//

//A. Copper Pipe: ASTM B88M/ASTM B88, minimum Type L, hard drawn copper tubing, except that the connection tubes of collectors may be soft-drawn.//

B. Bronze Flanges and Flanged Fittings: ASME B16.24.

C. Solder-Joint Fittings: ASME B16.22, wrought copper.

D. Unions: CID A-A-59617, solder joint.

E. Dielectric Union: Provide insulated union with a galvanized steel female pipe-threaded end and a copper solder joint end conforming to ASME B16.39, Class 1. Provide a dry insulation barrier, impervious to water and capable of withstanding a 600 Volt breakdown test and limiting galvanic current to one percent of the short circuit current in a corresponding bimetallic joint.

SPEC WRITER NOTE: In corrosive atmospheric conditions such as oceanic air, use only nickel-chromium-iron alloy bellows.

F. Expansion Joints:

1. Bellow Expansion Joints: Corrugated, //unreinforced// //or// //with //reinforcing// //or// //equalizing// rings//, and //single-bellow// //double-bellow// expansion joints. Construct bellows of //copper alloy// //nickel-chromium-iron alloy, conforming to ASTM B168// //or// //stainless steel//.
2. Guided Slip-Tube Expansion Joints: //Ring packing with seal to allow repacking under pressure// //Permanent packless seal//, //internally// //internally and externally// guided, and //single// //double// slip-tube. Provide drain port in the housing. //For packless seal, provide a Type 304 or 321 stainless steel bellows with laminated or multi-ply construction.// //

SPEC WRITER NOTE: Either reference the applicable Section or specify products herein.

2.3 VALVES

//A. Comply with Section 23 21 13, HYDRONIC PIPING.//

//A. Asbestos packing is not acceptable.//

B. General: //Provide end connections as indicated.// Valves shall open when turned counterclockwise.

C. Gate Valves: MSS SP-80, bronze, Class 150; //Type 1, solid wedge non-rising stem// //or// //Type 2, solid wedge, inside screw rising stem//; with solder, threaded, or flanged ends.

D. Globe and Angle Valves: MSS SP-80, bronze, Class 150; //Type 1, metal disc integral seat// //or// //Type 2, non-metallic disc, integral seat//; with solder, threaded, or flanged ends.

E. Ball Valves: MSS SP-72 for flanged or butt-welding ends or MSS SP-110 for threaded, socket-welding, solder joint, grooved and flanged ends.

F. Balancing Cocks, Flow Rate Control and Meter: Bronze, solder, threaded, or flanged ends. Provide square head, flow indicator arc or check pressure ports for differential flow metering device. Provide valve construction with rating of 116°C at 862 kPa [240°F at 125 psi]. //Provide a readout kit including flow meter, readout probes, hoses, flow charts or calculator, and carrying case.//

G. Check Valves: MSS SP-80, bronze, Class 150; //Type 3, swing check, metal disc to metal seat// //or// //Type 4, swing check, non-metallic disc to metal seat//. //Provide spring-loaded construction with elastomer seals.//

SPEC WRITER NOTE: When thermal siphon is a problem, use only spring-loaded check valves with elastomer seals.

H. Water Pressure-Reducing Valves: ASSE 1003 with ASSE seal, self contained, direct acting, and single seat diaphragm.

I. Control Valves: UL listed. Provide valves actuated by electric motors. Construct valves to permit replacing valve seals without draining the system. Provide bronze body construction and stainless steel valve stems, with rating of 4 to 166° C at 862 kPa [40 to 240°F at 125 psi]. Include external position indicators and steel enclosures to protect operating components.

1. Shutoff and Diverting Control Valves: Bronze valves with 100 percent shutoff, stainless steel butterfly or ball, and elastomer seats and seals.
2. Non-Shutoff Mixing Valves: MSS SP-25 marking modulating, //bronze// //or// //brass// body construction, stainless steel valve stems, and thermostatically controlled.
3. Valve Operators: Provide electric //two-position// //or// //proportioning// operators, with oil-immersed gear trains. Two-position operators may be single-direction with //spring-return// //or// //reversing// construction. //For //reversing// //and// //proportioning// operators, provide limit switches to limit the lever in either direction unless the operator is the stalling type.// Operators shall function properly with a 10 percent plus or minus change in the line voltage feeding the equipment. Totally enclose operators and gear trains in dustproof housings of pressed steel or metal castings with rigid conduit connections. Equip valve operators with a spring yield device so that when in the closed position it will maintain on the valve disc a pressure equivalent to the pressure rating of the valve.

J. Air Vents and Relief Valves

1. Air Vents: CID A-A-60001, float construction for pressures up to 862 kPa [125 psi]. Air outlet shall be piped to the nearest //floor drain// //glycol recovery unit//.
2. Relief Valves: ASME labeled valves with a relief setting 200 percent higher than the normal operating pressure. Provide nonferrous or stainless steel valve seats and moving parts exposed to fluid,

compatible with the operating conditions. //Relief valve shall be piped to the nearest glycol recovery unit.// //

SPEC WRITER NOTE: Either reference the applicable Section or specify products herein.

2.4 PIPING SPECIALTIES

//A. Comply with Section 23 21 13, HYDRONIC PIPING.//

//A. Bolts and Nuts: Stainless steel; ASTM A193/A193M for bolts and ASTM A194/A194M for nuts.//

B. Gaskets: //Fluorinated elastomers, ethylene-propylene-diene-terpolymer (EPDM) or silicone// //ASTM D3667, Type C rubber// //ASTM D3771, Type C rubber//, compatible with flange faces.

SPEC WRITER NOTE: For cold weather region of below -10°C [+14°F], consider gaskets made of rubber in accordance with ASTM D3667 (for flat-plate solar collectors) or ASTM D3771 (for concentrating solar collectors), Type C.

C. Brazing Metal: AWS A5.8/A5.8M, 15 percent silver-base alloy, minimum melting point 816°C [1,500°F], for copper pipes rated at maximum 862 kPa and 177°C [125 psi and 350°F]. Provide cadmium free filler metals.

D. Solder Metal: ASTM B32, Alloy Grade Sb5, Sn95, or Sn96, with minimum melting 221°C [430°F].

E. Strainers: FS WW-S-2739, Class 125; Style Y pattern; Type I, threaded or soldered ends, for 50 mm [2 inches] and smaller; and Type II, flanged ends, for 65 mm [2.5 inches] and larger.

F. Piping Identification Labels: Plastic slip-on or adhesive-backed labels conforming to MIL-STD-101.

G. Hangers and Supports: MSS SP-58, as required by MSS SP-69.//

2.5 //BOOSTER// //AND// //CIRCULATING// PUMPS

SPEC WRITER NOTE: Use the first pump option below (A) for non-potable systems. Use the second pump option below (A-C) for potable systems. For use of both booster and circulation pumps with multiple types, repeat the below paragraphs as needed.

SPEC WRITER NOTE: If silicone based fluids are used, rotary pumps shall be used to avoid seepage problems.

//A. //CID A-A-50560, in-line centrifugal// //CID A-A-50562 non-self-priming, horizontally mounted, centrifugal// //CID A-A-50561, rotary// //; pump styles as indicated//. Provide flanged inlets and outlets, mechanical seals, flexible couplings, and electric motors. Select pumps to operate not more than 5 percent below and on the shut-off side of the maximum efficiency point of the impeller curve. Provide bronze or cast iron body construction, bronze or stainless steel fitted.//

//A. See Section 22 21 23 DOMESTIC WATER PUMPS as well as the additional requirements below.

B. Provide with flanged inlets and outlets.

C. Select pumps to operate not more than 5 percent below and on the shut-off side of the maximum efficiency point of the impeller curve.//

2.6 COMPRESSION TANKS FOR NON-POTABLE SYSTEMS

A. ASME BPVC SEC VIII, steel construction with ASME label for 862 kPa (gage) [125 psig] working pressure. Hot-dip galvanized interior and exterior surfaces of tanks after fabrication. Provide cast iron or steel saddles or supports. Provide tanks with drain, fill, air charging and system connections, and liquid level gage.

2.7 SOLAR STORAGE TANKS

A. Except as modified herein, FS F-T-2907; //stone lined (cement lined)// //glass lined// //stainless steel// //Type 18-8 stainless steel lined// //or// //baked-on phenolic// steel tank with ASME label for //862 kPa (gage) [125 psig]// //_____//. Do not use baffles or perforated pipes in tank construction. For the steel tank, include //collector loop heat-exchanger bundle// //and// //domestic hot water// //and// //space heating// heat-exchanger bundle.

SPEC WRITER NOTE: Small mixing pumps and shrouds to enhance tube bundle heat exchanger performance in the tanks are an exception and shall be used only where required. The corrosive nature of some water supplies may require a stainless-steel tank or a stainless-steel lining. For better stratification (hot water on the top, cold water on the bottom), vertical solar tanks shall be used. Up to 18,950 liters [5,000 gallons] capacity, solar storage tanks may be unpressurized, internally stainless-steel-lined, factory insulated, and covered with enamel steel outer jackets for indoor applications or fiberglass jackets for outer and underground applications. Solar storage tanks, if intended for a usable life in

excess of 5 years, shall not be pressurized. Unpressurized stainless steel tanks shall last in excess of 20 years; other unpressurized tanks should last up to 15 years; pressurized steel tanks with copper heat exchangers may last only 3 to 8 years, due to galvanic corrosion. Recommend 122 liters [3 gallons] of storage capacity for each square meter [foot] of collector surface facing the sun.

B. Underground Tanks: UL listed, //double walled// fiberglass coated steel tanks. Provide exterior surfaces of steel tanks with a glass reinforced isophthalic polyester resin of sufficient thickness to resist 35,000-volt Holiday test. Provide automatic monitoring system with audible alarms to continuously monitor leaks.

C. Tank Insulations and Jackets: Comply with Section 23 07 11 HVAC AND BOILER PLANT INSULATION. Separate aboveground tanks from supports with insulation.

2.8 HEAT EXCHANGERS

SPEC WRITER NOTE: Where potable fluids are not used, double wall and vented construction provides fail-safe leak detection without attendance by any operator. If the operator is not present, sound alarms may not be heard, and visual indicators may not be observed in some cases. For many years, industrial applications commonly used shell-and-tube or tube-in-tube heat exchangers. In recent years, some industrial applications use plate-and-frame heat exchangers as options. Plate-and-frame construction requires much less space, i.e., from one tenth to one half of the space required by shell-and-tube construction. Plate-and-frame heat exchangers generally have high heat transfer rates. Electropolished stainless steel plates may be specified to minimize fouling. Stainless steel heat exchangers shall be used in spas due to high temperature water and high chlorination.

SPEC WRITER NOTE: For use with potable water sources, coordinate materials and certifications to suit requirements.

A. ASME BPVC SEC VIII, construction with ASME label for 1034 kPa (gage) [150 psig] working pressure and 2068 kPa (gage) [300 psig] factory-

rating pressure. Heat exchanger shall be of counterflow design. //Provide automatic monitoring system with audible alarms to continuously monitor leaks.// //Provide relief vent with a visual indicator to detect leaks by the change of coloring in the heat transfer fluid.//

B. Plate-and-Frame Construction: //Stainless steel// //or// //monel// //single// //vented, double// wall plates and carbon steel frames, with baked epoxy-enamel, and shroud. Provide stainless steel side bolts and nozzles. Provide one piece molded //nitrile rubber// //ethylene-propylene rubber viton// //neoprene// //or// //butyl// gaskets. Fabricate heat exchangers with design results of heat transfer coefficients greater than 5680 watts per square meter degree C [1,000 Btu per square foot per hour per degree F].

SPEC WRITER NOTE: Shell and tube heat exchangers are also specified in Section 22 35 00 for potable sources and in Section 23 21 13 for non-potable sources. Either retain and edit the requirements herein or reference the applicable section.

//C. Shell and Tube: Comply with //Section 22 35 00, DOMESTIC HEAT EXCHANGERS// //Section 23 21 13, HYDRONIC PIPING//.

//C. //Shell and Tube// //or// //Tube in Tube// Construction: //Double wall vented//, //straight tube// //or// //"U" tube// //as indicated//. //Heat exchanger shall comply with NSF 61 and NSF 372.// Low temperature water //mixture// shall pass through tubes. High temperature water //mixture// shall pass through shells. Fabricate tubes from //16 mm [5/8 inch]// //or// //20 mm [3/4 inch]// //stainless steel// //or// //seamless No. 20 BWG cupro-nickel (90-10)//. Provide tube bundles removable through flanged openings.//

2.9 SOLAR COLLECTORS

SPEC WRITER NOTE: In accordance with ASHRAE 93 and ASHRAE 96, a solar collector is “a device designed to absorb incident solar radiation and to transfer the energy to a liquid passing through it.” Use the liquid flat-plate collector for system design, including cooling applications up to 141 kW [40 tons]. Use ASHRAE 93 for glazed collectors and ASHRAE 96 for unglazed collectors. The State of Florida requires all solar collectors to be certified by FSEC (Florida Solar Energy Center). If the

project site is not in Florida and the state and local regulations do not prohibit FSEC certified collector, the use of FSEC collector may be considered as an option. Provide lightning protection as required by the local environment. A collector in which the internal risers and headers are in a reverse return arrangement will have uniform flow and uniform heating, but it will be too restrictive to limit only this arrangement. When inlet and outlet tubes are not located conveniently on the collector, the collector will take up additional spaces, resulting more exposed roof area between the collector and greater likelihood of leaking at joints.

A. //ASHRAE 93// //ASHRAE 96// //SRCC OG-100 listed// //or// //Florida Solar Energy Center (FSEC) certified//; liquid flat-plate collectors, evacuated tube collectors, and concentrated solar collectors. Provide factory fabricated and assembled, //single-glazed// //double-glazed// //triple-glazed// //or// //unglazed// panels. //Internal manifold collectors may be used if manufacturer standard.// Include the following design features:

1. Collector Sizes: Maximum filled weight not to exceed 24.40 kg per square meter [five pounds per square foot] of gross collector area.
2. Minimum Performance Parameters: Provide total collector flow rate in accordance with manufacturer's recommendations. Provide instantaneous collector efficiency as follows:

SPEC WRITER NOTE: In accordance with ASHRAE 93 and ASHRAE 96, instantaneous collector efficiency is “the amount of energy removed by the transfer liquid per unit of gross collector area during the specified time period divided by the total solar radiation incident on the collector per unit area (solar flux) during the same time period, under steady-state or quasi-steady-state (the state of the solar collector test when the flow rate and temperature of the liquid entering the collector are constant but the exit liquid temperature changes gradually due to the normal change in irradiation that occurs with time for clear sky conditions) conditions.” Read ASHRAE 93 and ASHRAE 96 for further details and unit measurements.

Minimum Instantaneous Collector Efficiency, Percent	Inlet Fluid Parameter
74	0.00
54	0.03
40	0.05

Determine inlet fluid parameter (IFP) in accordance with the following formula:

IFP = (A – B)/C

Where:

a. A = Liquid inlet temperature in collector

b. B = Ambient air temperature

c. C = Solar flux

3. Absorber: Fabricate of //aluminum// //stainless-steel// //copper tubes on copper sheet// //or// //copper tubes with copper fins//. Provide the absorber rated for //1034 kPa (gage)// //[150 psig]// //_____// with working pressure of //862kPa (gage)// //[125 psig]// //_____//.
4. Absorber Plate Coating: Electroplated black chrome with minimum //0.0025 mm [0.0001 inch]// //[1/10 mil]// //_____// thick, flat black undercoating of nickel or baked-silicone-polyester, or equivalent surface coating. Provide coating with minimum absorptivity 0.90, maximum emissivity 0.12, and minimum breakdown temperature at //204°C [400°F]// //_____//.
5. Collector Case: Fabricate from at least 20 gage //galvanized steel// //or// //ASTM B209M ASTM B209 alloy or equivalent aluminum//. Provide collector box with painted durable baked enamel, anodized bronze, or stucco embossed finish. In the back of case, provide insulation with a heat transfer factor of maximum 0.57 watts per degree C per square meter [0.1 Btu per hour per degree F per square foot]. Use only insulation without out-gassing or other breakdown at or under stagnation temperature, such as rigid mineral fiber panels. Fabricate cover frame and glazing channel of //galvanized sheet steel// //stainless steel// //or// //extruded aluminum//. Provide preformed gaskets as specified.
6. Collector Cover (Glazing Material): ASTM C1048, Kind FT, fully tempered glass; Condition A, uncoated surfaces; Type I, transparent

glass; Class 1, clear; Quality q3, glazing select; //3// //5// //or// //4// mm [//1/8// //3/16// //or// //5/32// inch] float glass.

7. Collector Identification: On each collector, provide the following information:
   a. Manufacturer's name or trademark
   b. Model name or number
   c. Certifying agency label and rating.
8. Other Components: Provide collectors for the complete removal of internal moisture which may develop in the collectors. //Collector weep holes or desiccants with air vents may be used. If desiccants are used, provide 8 mesh silica gel with approximately 10,000 cycles of regeneration.//
9. Hail Protection: Manufacturer’s hail protection performance measured according to ASTM E822, or equivalent.
10. Tracking Concentrating Solar Collectors: Manufacturer’s thermal performance of tracking concentrating solar collectors measured according to ASTM E905.

SPEC WRITER NOTE: Delete this paragraph if the project is not for tracking concentrating solar collectors.

2.10 COLLECTOR SUPPORTS

A. //As indicated.// //Provide a commercial integrated structural system, supplied by a single manufacturer, consisting of formed aluminum or galvanized or plated steel channels, perforated with round or square holes, and corrosion resistant brackets, clamps, bolts and nuts.//

2.11 COLLECTOR HEAT TRANSFER FLUID

SPEC WRITER NOTE: In lieu of the collector heat transfer fluid, the use of water in a drain-back concept may be acceptable. Recommend to use only non-toxic heat transfer fluid. For some applications which tolerate low flash point and high toxicity, inhibited ethylene glycol may be used.

A. Conform to the following:
   1. Liquid useful temperature range of -40 to 204°C [-40 to 400°F].
   2. Non-ionic, high dielectric, non-aqueous, non-reactive, stable fluid which does not corrode copper, aluminum, iron, or steel, or attack plastics.
   3. Flash point exceeding 193°C [380°F].

4. Fluid stability of ten years.
5. Maximum acute oral toxicity of 5 grams per kilogram [5000 ppm].

2.12 SOLAR-BOOSTED DOMESTIC WATER HEATERS FOR POTABLE END USE

SPEC WRITER NOTE: Specify domestic water heater here or reference the applicable Division 22 Specification. Double-wall heat exchanger shall be specified here or added to the applicable Division 22 specification.

//A. ASHRAE 90.1 - SI ASHRAE 90.1 - IP and UL listed. Provide built-in //, double wall// heat exchanger and factory insulation jacket. All internal components shall be NSF 5, NSF 61, and NSF 372 compliant.//

//A. Section //22 33 00 ELECTRIC DOMESTIC WATER HEATERS// //22 34 00 FUEL-FIRED DOMESTIC WATER HEATERS//. Provide built-in //, double wall// heat exchanger.//

2.13 INSULATION

A. Section 23 07 11, HVAC AND BOILER PLANT INSULATION.

2.14 INSTRUMENTATION

SPEC WRITER NOTE: Utilize the Section reference(s) or the system specified herein as applicable to project. Where a direct-digital control system exists in the project, use the first option (A). Where no such system is available, the second option may be used (A-I).

//A. Section 23 09 23 DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC.//

//A. Use corrosion resistant materials for wetted parts of instruments.

B. Solar Controller: UL listed. Solid-state or electrical only, with overvoltage protection.
   1. Differential Temperature Control: Factory assembled and packaged device.
   2. High Limit Control: Provide high temperature cut-off to limit upper half of the storage tank temperature to be //71// //82// //_____// degrees C [//160// //180// //_____// degrees F].
   3. Swimming Pool Control: Provide adjustable thermostatic setting to prevent pool overheating, with range from //13// //_____// to //29// //_____// degrees C [//56// //_____// to //85// //_____// degrees F]. Turn solar heater on when solar collectors are 2.77°C [5°F] hotter than pool temperature. When pool temperature is above the thermostatic setting, drain water from the panels.

SPEC WRITER NOTE: Delete paragraph 3 if the project is not for a swimming pool.

4. Controller Enclosure: NEMA 250; Weathertight rated to NEMA 4X.

C. Differential Thermostat: Provide UL-listed differential thermostat for controlling the magnetic starter, not in the same circuit as pump motor. //For integral collector freeze protection, provide two independent contact relays //, rated ten amperes at 120 VAC.// //Provide a switch with ON, OFF, and AUTO positions.// Provide weathertight enclosures.

SPEC WRITER NOTE: Use this only in large systems, generally not residential. It is recommended that the differential thermostat be 4.40°C [8°F] turn on and 1.70 to 2.80°C [3 to 5°F] turn off.

D. Sensors: Construct sensors to withstand stagnation temperatures of glazed solar collectors. Provide primary and alternate collector sensors attached to an absorber plate. Provide //copper// //brass// wells which can be inserted into the collector tube, storage tank, or //_____//. Sensors may be strapped onto pipes and covered with insulation.

SPEC WRITER NOTE: Delete this paragraph if solar collectors are unglazed.

E. Pressure Gages: ASME B40.100, brass body, and minimum 90 mm [3.5 inches] diameter dial face.

F. Tank Gages: CID A-A-50568; Type //I, buoyant force;// //II, diaphragm;// //or// //III, purge, bubble-pipe//.

G. Thermometers: ASTM E1, //liquid-in-glass type// //dial type, liquid-filled tube and bulb//. For pipe and tank applications, provide separate sockets fabricated of brass, copper, or stainless steel and rated for 862 kPa [125 psi] working pressure.

H. Test Ports: Solid brass, 6 mm [1/4 inch] fitting to receive either a temperature or pressure probe 3 mm [1/8 inch] outside diameter, two valve cores of neoprene, fitted with color coded and marked cap with gasket, and rated for 6894 kPa (gage) [1,000 psig].

I. Monitoring System:

SPEC WRITER NOTE: For small systems such as family housing, do not use monitoring system, due to high initial cost and the labor to maintain it.

1. Kilojoule Btu Meter: Sensing and Monitoring device to measure and display the heat energy produced by the solar system, with minimum sensitivity of 0.5 percent over the entire scale. Provide electromechanical kJ Btu counter plus digital-panel meter indicating sensor temperatures, differential temperature, flow rate, and watt Btu per minute or hour.
2. //Water// //and// //Heat Transfer Fluid// Leak Detection: UL-listed system consisting of a sensor probe, control panel, and LED indicators for //water; yellow,// //and// //heat transfer fluid; red,// with audible alarm at minimum 75 dB sound level; reference 10 exponential minus 12 watts.//

PART 3 – EXECUTION

3.1 INSTALLATION

A. Install the solar collector system in accordance with this section and the printed instructions of the manufacturer. Prior to system start-up, protect collector from direct sunlight.

B. Piping Installation: Accurately cut pipe to measurements established on site and work into place without springing or forcing. Locate piping out of the way of windows, doors, openings, light fixtures, electrical conduit, equipment, and other piping. Provide for expansion and contraction. Do not bury, conceal, or insulate until piping has been inspected, and tested. Locate joints where they may be readily inspected. Provide flexibility in piping connected to equipment for thermal stresses and vibration. Support and anchor piping connected to equipment to prevent strain from thermal movement and weight from being imposed on equipment. //Provide seismic restraints in accordance with SMACNA.// Install hangers and supports in accordance with MSS SP-69 and MSS SP-58, unless otherwise indicated.

1. Fittings: Provide long-radius ells wherever possible to reduce pressure drops. Do not bend pipes, miter pipe to form elbows, use bushings, or notch straight runs to form full-sized tees. Provide union for disconnection of valves and equipment for which a means of disconnection is not otherwise provided. Provide reducing fittings for changes of pipe size.
2. Measurements: Determine and establish measurements for piping at the job site and accurately cut pipe and tubing lengths accordingly. Where possible, install full pipe lengths. Do not use couplings to join random lengths.

3. Cleaning: Thoroughly clean interior of water piping before joining by blowing clear with either steam or compressed air. Maintain cleanliness of piping throughout installation. Provide caps or plugs on ends of cleaned piping as necessary to maintain cleanliness.
4. Panel Connections to Headers: Connect panels to top and bottom headers with soft-drawn long bend "S" or "U" copper tubes brazed with 15-percent silver solder. Use tube bender only. Hand-formed tubing will not be acceptable. Install bottom headers behind the panels to protect the header insulation from abuse. For panels with internal headers, provide copper couplings and soldering.
5. Header Thermal Expansion and Contraction: Install slip tube or bellows type expansion joints. Limit thermal expansion of collector headers to //6// //_____// mm for 93°C [//1/4// //_____// inch for 200°F] maximum rise.
6. Flanged Joints: Provide flanged joints for making flanged connections to flanged pumps and other flanged piping components. Install joints so that flanged faces bear uniformly. Engage bolts so that there is complete threading through the nuts and tighten until bolts are equally torqued.
7. Sleeves: Provide schedule 10 galvanized steel sleeves for pipe and tubing passing through floors, roofs, walls and partitions of either concrete or masonry construction, except that sleeves are not required for floor slabs on grade. After piping has been installed, pack oakum into the space between the pipe or tubing and the sleeve and seal both ends with insulating cement.
8. Flashing: //Comply with Section 07 60 00, FLASHING AND SHEET METAL.// Provide watertight flashing for pipe and tubing extending through the roof.
9. Escutcheons: Provide chrome plated steel escutcheons for uninsulated pipe and tubing passing through floors, walls and ceilings.
10. Drain Lines: Provide drain lines from air vents and relief valves to the nearest //roof drains// //floor drains// //disposal points as directed//.
11. Insulation and Identification: Insulate piping in accordance with Section 23 07 11 HVAC AND BOILER PLANT INSULATION. //Frostproof air vents by insulating or shielding from night sky reverse radiation.// After piping has been insulated, apply identification labels and arrows in accordance with MIL-STD-101. Apply identification over the

insulation jacket of piping. Provide two copies of the piping identification code framed under glass and install where directed. Where insulation shall be exposed to sunlight, insulation shall be sunlight resistant.

12. Excavating and Backfilling: Provide in accordance with Section 31 00 00 EXCAVATION. Coordinate provision of utility warning and identification tape with backfill operation. Provide tapes above buried lines at a depth of 200 to 300 mm [8 to 12 inches] below finish grade.

C. Instrumentation: Install instruments as recommended by the control manufacturers. //For the monitoring system to detect //water// //and// //heat transfer fluid//, locate the sensor probe in the lowest corner of double-wall //tank// //and// //heat exchanger//.// Locate control panels //inside mechanical room// //_____//.

D. Meters shall tie into building Utility Monitoring and Control System (UMCS) or Direct Digital Control (DDC) system.

3.2 FIELD QUALITY CONTROL

A. Field Inspection: Prior to initial operation, inspect the piping system for conformance to drawings, specifications and ASME B31.1. Inspect the following information on each collector:

1. Manufacturer's name or trademark
2. Model name or number
3. Certifying agency label and rating.

B. Tests: Provide equipment and apparatus required for performing tests. Correct defects disclosed by the tests and repeat tests. Conduct testing in the presence of the //Resident Engineer// //COR//.

1. Piping Test: //Pneumatically test new piping for leakage using air at a pressure of// 138 kPa (gage) [20 psig] //Test new water piping for leakage using water at a pressure of at least 690 kPa (gage) [100 psig] or// 1.5 times the system pressure. Install a calibrated test pressure gage in the system to indicate loss in pressure occurring during the test. Apply and maintain the test pressure for one hour, during which time there shall be no evidence of leakage, as detected by a reduction in test pressure. Should a reduction occur, locate leaks, repair, and repeat the test.

SPEC WRITER NOTE: Use pneumatic test if non-aqueous heat transfer fluids are used, to avoid contamination of fluids

with water and to eliminate seepage problems.

2. Operation Tests: Perform tests on mechanical systems, including pumps, controls, controlled valves, and other components in accordance with manufacturer's written recommendations. Test entire system in accordance with Section 23 05 93 TESTING, ADJUSTING AND BALANCING FOR HVAC.

3.3 FOLLOW-UP VERIFICATION

A. Upon completion of acceptance checks, settings, and tests, the Contractor shall show by demonstration in service that the solar energy heating system is in good operating condition and properly performing the intended function.

SPEC WRITER NOTE: Where solar energy is used for heating potable utilities, optional paragraph B shall be retained in the project specifications.

//B. Where solar energy heating systems interface with potable water systems, the Contractor shall verify that proper separation has been provided at all points of interface, including heat exchangers, and that no interconnects exist between potable and non-potable systems.//

3.4 INSTRUCTION

A. A complete set of operating instructions for the solar energy heating system shall be laminated or mounted under acrylic glass and installed in a frame near the equipment.

B. Furnish the services of a factory-trained technician for one, 4-hour training period for instructing personnel in the maintenance and operation of the solar energy heating system, on the date requested by the //Resident Engineer// //COR//.

3.5 COMMISSIONING

A. Provide commissioning documentation in accordance with the requirements of //Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS// for all inspection, start up, and Contractor testing required above and required by the System Readiness Checklist provided by the Commissioning Agent.

B. Components provided under this section of the specification will be tested as part of a larger system. Refer to //Section 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS// //and// //Section 23 08 00,

COMMISSIONING OF HVAC SYSTEMS// and related sections for Contractor responsibilities for system commissioning.

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