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SOLAR LIQUID FLAT PLATE AND EVACUATED TUBE COLLECTORS

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SOLAR LIQUID FLAT PLATE AND EVACUATED TUBE COLLECTORS
05/15

NOTE: This guide specification covers the requirements for medium-temperature (38-82 degrees C 100-180 degrees F), liquid-flat-plate or evacuated tube collector loop systems, heat storage tanks, pumps, controls and related equipment and materials.

Adhere to UFC 1-300-02 Unified Facilities Guide Specifications (UFGS) Format Standard when editing this guide specification or preparing new project specification sections. Edit this guide specification for project specific requirements by adding, deleting, or revising text. For bracketed items, choose applicable item(s) or insert appropriate information.

Remove information and requirements not required in respective project, whether or not brackets are present.

Comments, suggestions and recommended changes for this guide specification are welcome and should be submitted as a Criteria Change Request (CCR).

NOTE: Applications of the solar systems may be domestic hot water, space heating, swimming pool heating, process fluid heating, spa water heating, air conditioning for solar cooling and heating, agricultural process heating, or other commercial and industrial uses.

NOTE: The following information shall be shown on the project drawings:

1. Control equipment operation matrix.

2. Control operations sequence.

3. Details of soft-drawn copper-tubing connectors to top and bottom headers of solar-collector panel.

4. System diagram.

5. Panel array layout and locations.

6. System equipment locations.

7. Equipment piping details.

8. Mounting details.

9. Schedules in accordance with UFC 3-400-01, "Renewable Energy Systems - Facility".

****

PART 1 GENERAL

1.1 REFERENCES

****

NOTE: This paragraph is used to list the publications cited in the text of the guide specification. The publications are referred to in the text by basic designation only and listed in this paragraph by organization, designation, date, and title.

Use the Reference Wizard's Check Reference feature when you add a Reference Identifier (RID) outside of the Section's Reference Article to automatically place the reference in the Reference Article. Also use the Reference Wizard's Check Reference feature to update the issue dates.

References not used in the text will automatically be deleted from this section of the project specification when you choose to reconcile references in the publish print process.

****

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)

ASHRAE 90.1 - IP	(2019) Energy Standard for Buildings Except Low-Rise Residential Buildings
ASHRAE 90.1 - SI	(2019) Energy Standard for Buildings Except Low-Rise Residential Buildings
ASHRAE 93	(2010; Errata 2013l Errata 2014) Methods of Testing to Determine the Thermal

	Performance of Solar Collectors
ASHRAE 96	(1980; R 1989) Methods of Testing to Determine the Thermal Performance of Unglazed Flat-Plate Liquid-Type Solar Collectors

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME A13.1	(2020) Scheme for the Identification of Piping Systems
ASME B16.1	(2020) Gray Iron Pipe Flanges and Flanged Fittings Classes 25, 125, and 250
ASME B16.22	(2021) Wrought Copper and Copper Alloy Solder Joint Pressure Fittings
ASME B16.24	(2022) Cast Copper Alloy Pipe Flanges, Flanged Fittings, and Valves Classes 150, 300, 600, 900, 1500, and 2500
ASME B16.39	(2020) Standard for Malleable Iron Threaded Pipe Unions; Classes 150, 250, and 300
ASME B31.1	(2022) Power Piping
ASME B40.100	(2022) Pressure Gauges and Gauge Attachments
ASME BPVC SEC VIII	(2010) Boiler and Pressure Vessel Codes: Section VIII Rules for Construction of Pressure Vessel

AMERICAN SOCIETY OF SANITARY ENGINEERING (ASSE)

ASSE 1003	(2020) Performance Requirements for Water Pressure Reducing Valves for Domestic Water Distribution Systems - (ANSI approved 2010)
ASSE 1017	(2023) Performance Requirements for Temperature Actuated Mixing Valves for Hot Water Distribution Systems - (ANSI approved 2010)

AMERICAN WELDING SOCIETY (AWS)

AWS A5.8/A5.8M	(2019) Specification for Filler Metals for Brazing and Braze Welding

ASTM INTERNATIONAL (ASTM)

ASTM A193/A193M	(2023) Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service and Other Special Purpose Applications

ASTM A194/A194M	(2023) Standard Specification for Carbon Steel, Alloy Steel, and Stainless Steel Nuts for Bolts for High-Pressure or High-Temperature Service, or Both
ASTM B32	(2020) Standard Specification for Solder Metal
ASTM B88	(2022) Standard Specification for Seamless Copper Water Tube
ASTM B88M	(2020) Standard Specification for Seamless Copper Water Tube (Metric)
ASTM B168	(2019; E 2022) Standard Specification for Nickel-Chromium-Iron Alloys, Nickel-Chromium-Cobalt-Molybdenum Alloy, and Nickel-Iron-Chromium-Tungsten Alloy Plate, Sheet, and Strip
ASTM B209	(2014) Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate
ASTM B209M	(2014) Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate (Metric)
ASTM C1048	(2018) Standard Specification for Heat-Strengthened and Fully Tempered Flat Glass
ASTM D3667	(2016) Standard Specification for Rubber Seals Used in Flat-Plate Solar Collectors
ASTM D3832	(1979; R 2011) Standard Specification for Rubber Seals Contacting Liquids in Solar Energy Systems
ASTM E1	(2014) Standard Specification for ASTM Liquid-in-Glass Thermometers
ASTM E822	(1992; R 2009) Standard Practice for Determining Resistance of Solar Collector Covers to Hail by Impact With Propelled Ice Balls
ASTM E1160	(2013; R 2021) Standard Guide for On-Site Inspection and Verification of Operation of Solar Domestic Hot Water Systems

COPPER DEVELOPMENT ASSOCIATION (CDA)

CDA A4015	(2016; 14/17) Copper Tube Handbook

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-25	(2018) Standard Marking System for Valves, Fittings, Flanges and Unions

MSS SP-58	(2018) Pipe Hangers and Supports - Materials, Design and Manufacture, Selection, Application, and Installation
MSS SP-69	(2003; Notice 2012) Pipe Hangers and Supports - Selection and Application (ANSI Approved American National Standard)
MSS SP-72	(2010a) Ball Valves with Flanged or Butt-Welding Ends for General Service
MSS SP-80	(2019) Bronze Gate, Globe, Angle and Check Valves
MSS SP-110	(2010) Ball Valves Threaded, Socket-Welding, Solder Joint, Grooved and Flared Ends

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	(2020) Enclosures for Electrical Equipment (1000 Volts Maximum)

SHEET METAL AND AIR CONDITIONING CONTRACTORS' NATIONAL ASSOCIATION (SMACNA)

SMACNA 1981	(2008) Seismic Restraint Manual Guidelines for Mechanical Systems, 3rd Edition

SOLAR RATING AND CERTIFICATION CORPORATION (SRCC)

SRCC CRIS	(ongoing online) Certification Ratings Information Service (CRIS)
SRCC OG-100	(2015) Solar Thermal Collector Certification Program
SRCC OG-300	(2015) Solar Thermal System Certification Program
SRCC STD 300	(2015) Solar Thermal System Standard

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

CID A-A-50561	(Basic) Pumps, Rotary, Power-Driven, Viscous Liquids
CID A-A-50568	(Basic; Notice 1) Gages, Liquid Level Measuring, Tank
CID A-A-59617	(Basic, Notice 1) Unions, Brass or Bronze, Threaded Pipe Connections and Solder-Joint Tube Connections
CID A-A-60001	(Rev A) Traps, Steam
FS F-T-2907	(Rev A; Notice 1) Tanks, Portable Hot Water Storage

UNDERWRITERS LABORATORIES (UL)

UL 873	(2007; Reprint Feb 2015) Standard for Temperature-Indicating and -Regulating Equipment

1.2 RELATED REQUIREMENTS

Section 23 03 00.00 20 BASIC MECHANICAL MATERIALS AND METHODS, applies to this section with additions and modifications specified herein.

1.3 SUBMITTALS

****

NOTE: Review Submittal Description (SD) definitions in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list, and corresponding submittal items in the text, to reflect only the submittals required for the project. The Guide Specification technical editors have classified those items that require Government approval, due to their complexity or criticality, with a "G." Generally, other submittal items can be reviewed by the Contractor's Quality Control System. Only add a "G" to an item if the submittal is sufficiently important or complex in context of the project.

For Army projects, fill in the empty brackets following the "G" classification, with a code of up to three characters to indicate the approving authority. Codes for Army projects using the Resident Management System (RMS) are: "AE" for Architect-Engineer; "DO" for District Office (Engineering Division or other organization in the District Office); "AO" for Area Office; "RO" for Resident Office; and "PO" for Project Office. Codes following the "G" typically are not used for Navy, Air Force, and NASA projects.

The "S" classification indicates submittals required as proof of compliance for sustainability Guiding Principles Validation or Third Party Certification and as described in Section 01 33 00 SUBMITTAL PROCEDURES.

Choose the first bracketed item for Navy, Air Force, and NASA projects, or choose the second bracketed item for Army projects.

****

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Solar Energy Systems; G[, [_____]]

Include collector structural supports, solar collector control sequences, and instrument mounting and interconnections.

SD-03 Product Data

Piping; G[, [_____]]

Instrumentation; G[, [_____]]

Valves; G[, [_____]]

Piping Specialties; G[, [_____]]

Pumps; G[, [_____]]

Solar Storage Tanks; G[, [_____]]

Solar Collectors; G[, [_____]]

For the selected collectors, include test results per ASHRAE 93.

Heat Exchangers; G[, [_____]]

Compression Tanks; G[, [_____]]

Solar-Boosted Domestic Water Heaters; G[, [_____]]

Collector Heat Transfer Fluid; G[, [_____]]

Insulation Around Piping and Storage Tanks; G[, [_____]]

For each pump, include manufacturer's data including pump speed and characteristic impeller performance curves. Indicate capacity versus head, efficiency, and brake power for the full range from shut-off to free delivery.

SD-06 Test Reports

****

NOTE: Underground tanks are not a recommended method for thermal storage. A design with thermal storage within a building is more ideal for efficiency.

****

[Underground Solar Storage Tanks Holiday Test; G[, [_____]]

Submit a factory holiday test certificate for each tank.]

SD-07 Certificates

Solar Energy System Installation; G[, [_____]]

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

SD-08 Manufacturer's Instructions

Solar Energy Systems; G[, [_____]]

SD-10 Operation and Maintenance Data

Solar Energy Systems, Data Package 3; G[, [_____]]

Submit in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA.

SD-11 Closeout Submittals

Posted Operating Instructions for Solar Energy System; G[, [_____]]

1.4 QUALITY ASSURANCE

For brazing and soldering procedure qualification, conform to ASME B31.1; for preparation and procedures for joints, conform to ASME B31.1 and CDA A4015.

1.4.1 Operation and Maintenance Data

Submit Solar Energy Systems data package for the following items in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA.

a. Troubleshooting guide for solar energy systems

b. Solar collector warranty

c. Operation instructions

d. Preventive maintenance and inspection data, including a schedule for system operators.

e. Project drawings.

1.5 SOLAR COLLECTOR WARRANTY

****

NOTE: Warranties on Navy construction: Warranties for equipment, materials, or design furnished, or workmanship performed by the Contractor or any subcontractor or supplier, has a duration of one year from the date of final acceptance of the work. An exception is in normal commercial practice longer warranty period for particular construction are given.

A warranty duration of longer than a year, and not covered normally by the industry, requires a Level III Contracting Officer's written determination documenting that the extra warranty protection is needed.

The warranty clause for solar collectors in this guide specification has been approved by NAVFACENGCOM HQ in accordance with the requirements of the Naval Facilities Acquisition Supplement (NFAS). NFAS can be found at the following link:

https://portal.navfac.navy.mil/portal/page/portal/navfac/navfac_forbusinesse

This clause may be used without any HQ approval or request for waiver.

****

Furnish ten year manufacturer's warranty against defects in materials and workmanship.

1.6 POSTED OPERATING INSTRUCTIONS

Provide for piping identification codes and diagrams of solar energy systems, operating instructions, control matrix, and troubleshooting instructions.

1.7 HEALTH AND SAFETY RECOMMENDATIONS

Section 01 35 26 GOVERNMENTAL SAFETY REQUIREMENTS, applies to this section with additions and modifications specified herein.

PART 2 PRODUCTS

2.1 SOLAR ENERGY SYSTEMS

****

NOTE: SRCC OG-300 applies to residential and light commercial systems of 119 gallons or less. SRCC OG-100 applies to the collectors only.

****

[SRCC OG-300 listed] [SRCC OG-100 Collector certification], and provide necessary materials to fabricate solar energy systems in accordance with this section. At the Contractor's option, provide factory-prefabricated solar equipment packages which include heat exchanger, compression and storage tanks, pumps and controls and which meet the requirements of this section or are certified by an ANSI-accredited certification body to SRCC STD 300 or other applicable ANSI standard.

2.2 PIPING

2.2.1 Copper Pipe

ASTM B88MASTM B88, minimum Type L, hard drawn copper tubing, except that the connection tubes of collectors may be soft-drawn.

2.2.2 Bronze Flanges and Flanged Fittings

ASME B16.24.

2.2.3 Solder-Joint Fittings

ASME B16.22, wrought copper.

2.2.4 Unions

CID A-A-59617, solder joint.

2.2.5 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.

2.2.6 Expansion Joints

2.2.6.1 Bellow Expansion Joints

****

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

****

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].

2.2.6.2 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.]

2.3 VALVES

[Provide end connections as indicated.] Valves shall open when turned counterclockwise.

2.3.1 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.

2.3.2 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.

2.3.3 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.

2.3.4 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 degrees C at 862 kPa 240 degrees F at 125 psi.

2.3.5 Check Valves

****
NOTE: When thermal siphon is a problem, such as an active flow indicator during nighttime or poor system performance, use only spring-loaded check valves with elastomer seals.
****

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.]

2.3.6 Water Pressure-Reducing Valves

ASSE 1003 with ASSE seal, self contained, direct acting, and single seat diaphragm.

2.3.7 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 degrees C at 862 kPa 40 to 240 degrees F at 125 psi. Include external position indicators and steel enclosures to protect operating components.

2.3.7.1 Shutoff and Diverting Control Valves

Bronze valves with 100 percent shutoff, stainless steel butterfly or ball, and elastomer seats and seals.

2.3.7.2 Non-Shutoff Mixing Valves

ASSE 1017,MSS SP-25 marking modulating, [bronze] [or] [brass] body construction, stainless steel valve stems, and thermostatically controlled.

2.3.7.3 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.

2.3.8 Air Vents and Relief Valves

2.3.8.1 Air Vents

CID A-A-60001, float construction for pressures up to 862 kPa 125 psi.

2.3.8.2 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.

2.4 PIPING SPECIALTIES

2.4.1 Bolts and Nuts

Stainless steel; ASTM A193/A193M for bolts and ASTM A194/A194M for nuts.

2.4.2 Gaskets

****
NOTE: For cold weather region of below minus 10 degrees C 14 degrees F, consider gaskets made of rubber in accordance with ASTM D3667 (for flat plate solar collectors) or ASTM D3832 (for evacuated tube solar collectors), Type C.
****

[Fluorinated elastomers, ethylene-propylene-diene-terpolymer (EPDM) or silicone][ASTM D3667, Type C rubber][ASTM D3832, Type C rubber], compatible with flange faces.

2.4.3 Brazing Metal

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

2.4.4 Solder Metal

ASTM B32, Alloy Grade Sb5, Sn95, or Sn96, with minimum melting 221 degrees C 430 degrees F.

2.4.5 Strainers

Class 125; Style Y pattern; threaded or soldered ends, for 50 mm 2 inches and smaller; and flanged ends in accordance with ASME B16.1, for 65 mm 2 1/2 inches and larger.

2.4.6 Piping Identification Labels

Plastic slip-on or adhesive backed labels conforming to ASME A13.1.

2.4.7 Hangers and Supports

MSS SP-58, as required by MSS SP-69.

2.5 [BOOSTER] [AND] [CIRCULATING] PUMPS

****
NOTE: If silicone based fluids are used, rotary pumps should be used to avoid seepage problems.
****

[Section 23 21 23 HYDRONIC PUMPS, centrifugal] [CID A-A-50561, rotary][; pump styles as indicated]. Provide flanged inlets and outlets, mechanical seals, flexible couplings, and electronically commutated motors (ECM). 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.

2.6 COMPRESSION TANKS

ASME BPVC SEC VIII, steel construction with ASME label for 862 kPa (gage) 125 psig working pressure. Hot-dip galvanize 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

****

NOTE: Small mixing pumps and shrouds to enhance tube bundle heat exchanger performance in the tanks are an exception and should be used only where required. The corrosive nature of some water supplies may require copper lining. For better stratification (hot water on the top, cold water on the bottom), vertical solar tanks should be used. Up to 18,950 liters 5,000 gallon 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 an usable life in excess of 5 years, should not be pressurized. Unpressurized stainless steel tanks should 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.

****

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.

2.7.1 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.

2.7.2 Tank Insulations and Jackets

Comply with Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS. Separate aboveground tanks from supports with insulation.

2.8 HEAT EXCHANGERS

****

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 use 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. Titanium or nickel-brazed stainless steel heat exchangers should be used in spas due to high temperature water and high chlorination.

****

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. [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.]

2.8.1 Plate-and-Frame Construction

[Stainless steel] [or] [monel] 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 watt per square meter degree C 1,000 Btu per square foot per hour per degree F.

2.8.2 [Shell and Tube] [or] [Tube in Tube] Construction

[Double wall vented], [straight tube] [or] ["U" tube] [as indicated]. 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] od [stainless steel] [or] [seamless No. 20 BWG cupro-nickel (90-10)]. Provide tube bundles removable through flanged openings.

2.9 SOLAR COLLECTORS

****

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 space, resulting in more exposed roof area between the collector.

****

[ASHRAE 93] [ASHRAE 96] [SRCC OG-100 and SRCC CRIS listed] [or] [Florida Solar Energy Center (FSEC) certified]; liquid flat-plate collectors and evacuated tube 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:

2.9.1 Collector Sizes

Maximum filled weight not to exceed 24.40 kg per square meter five pounds per square foot of gross collector area.

2.9.2 Minimum Performance Parameters

****

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.

****

Provide total collector flow rate in accordance with manufacturer's recommendations. Provide instantaneous collector efficiency as follows:

Minimum Instantaneous Collector Efficiency, Percent	Inlet Fluid Parameter
74	0
54	0.03
40	0.05

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

IFP = (A - B)/C

Where:

A = Liquid inlet temperature in collector
B = Ambient air temperature
C = Solar flux

2.9.3 Absorber

Fabricate of [aluminum] [stainless-steel] [copper tubes on copper sheet or aluminium] [or] [copper tubes with copper or aluminum fins]. Provide the absorber rated for [1034 kPa (gage)] [150 psig] [_____] with working pressure of [862 kPa (gage)] [125 psig][_____].

2.9.4 Absorber Plate Coating

Provide selective or semi-selective absorber coating with minimum absorptivity 0.90, maximum emissivity 0.12, and minimum breakdown temperature at [204 degrees C] [400 degrees F][_____].

2.9.5 Collector Case

Fabricate from at least 20 gage [galvanized steel] [or] [ASTM B209M ASTM B209 alloy or equivalent aluminum]. Paint collector box with durable baked enamel or powder coat. 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 of EPDM or silicone as specified.

2.9.6 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.

2.9.7 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.

2.9.8 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.]

2.9.9 Hail Protection

Manufacturer's hail protection performance measured according to ASTM E822, or equivalent.

2.10 COLLECTOR SUPPORTS

[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

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NOTE: In lieu of the collector heat transfer fluid, the use of water in a drainback concept may be acceptable. Recommend to use only non-toxic heat transfer fluid.
****

Conform to the following:

a. Liquid useful temperature range of [-40] to [204][_____] degrees C [400][_____] degrees F.

b. Non-ionic, high dielectric, non-aqueous, non-reactive, stable fluid which does not corrode copper, aluminum, iron, or steel, or attack plastics.

c. Flash point exceeding 193 degrees C 380 degrees F.

d. Fluid stability of five years.

e. Maximum acute oral toxicity of 5 grams per kilogram 5000 ppm.

2.12 SOLAR-BOOSTED DOMESTIC WATER HEATERS

ASHRAE 90.1 - SIASHRAE 90.1 - IP and UL listed. Provide built-in [, double wall] heat exchanger and factory insulation jacket. Non-pressurized, vented, drainback systems may use single-wall heat exchanger.

2.13 INSULATION

Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS.

2.14 INSTRUMENTATION

Use corrosion resistant materials for wetted parts of instruments.

2.14.1 Solar Controller

UL listed. Solid-state or electrical only, with overvoltage protection.

2.14.1.1 Differential Temperature Control

Factory assembled and packaged device.

2.14.1.2 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.

[2.14.1.3 Swimming Pool Control

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NOTE: Delete this paragraph if the project is not for a swimming pool.
****

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 degrees C 5 degrees F hotter than pool temperature. When pool temperature is above the thermostatic setting, drain water from the panels.

]2.14.1.4 Controller Enclosure

NEMA 250; Weathertight rated to NEMA 4X.

[2.14.2 Differential Thermostat

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

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.

][2.14.3 Sensors

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NOTE: Delete this paragraph if solar collectors are unglazed.
****

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.

]2.14.4 Pressure Gages

ASME B40.100, brass body, and minimum 90 mm 3 1/2 inch diameter dial face.

2.14.5 Tank Gages

CID A-A-50568; Type [I, buoyant force;] [II, diaphragm;] [or] [III, purge, bubble-pipe].

2.14.6 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.

2.14.7 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.

[2.14.8 Monitoring System

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

****

a. [Solar Differential Controller with] Kilojoule Btu Meter: [Controller conforming to UL 873 with] 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.

b. [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.

][2.15 SOLAR COLLECTOR CONTROL SEQUENCES

As indicated.

]PART 3 EXECUTION

3.1 INSTALLATION

3.1.1 Solar Collector System

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NOTE: Disinfect domestic water systems, if connected with solar collector panels. Provide disinfection provisions in either Section 22 00 00 PLUMBING, GENERAL PURPOSE or another appropriate project section.
****

Install the solar collector system in accordance with this section and the printed instructions of the manufacturer. [Disinfect domestic water systems, if connected with collector panels, in accordance with Section 22 00 00 PLUMBING, GENERAL PURPOSE.] Prior to system start-up, protect collector from direct sunlight.

3.1.2 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 1981.] Install hangers and supports in accordance with MSS SP-69 and MSS SP-58, unless otherwise indicated.

3.1.2.1 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.

3.1.2.2 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.

3.1.2.3 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.

3.1.2.4 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. Provide 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.

3.1.2.5 Header Thermal Expansion and Contraction

Install slip tube or bellows type expansion joints. Limit thermal

expansion of collector headers to [6] [_____] mm for 93 degrees C [1/4] [_____] inch for 200 degrees F maximum rise.

3.1.2.6 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.

3.1.2.7 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.

3.1.2.8 Flashing

[Section 07 60 00 FLASHING AND SHEET METAL.] Provide watertight flashing for pipe and tubing extending through the roof.

3.1.2.9 Escutcheons

Provide chrome plated steel escutcheons for uninsulated pipe and tubing passing through floors, walls and ceilings.

3.1.2.10 Drain Lines

Provide drain lines from air vents and relief valves to the nearest [roof drains] [floor drains] [disposal points as directed].

3.1.2.11 Insulation and Identification

Insulate piping in accordance with Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS. [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 ASME A13.1. 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 the exterior of a building, sunlight, or the elements, insulation shall be shielded from the elements with appropriate aluminum, stainless steel, or UV-inhibited PVC jacketing.

3.1.2.12 Excavating and Backfilling

Provide in accordance with Section 31 00 00 EARTHWORK. 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.

3.1.3 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] [_____].

3.2 FIELD QUALITY CONTROL

3.2.1 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:

a. Manufacturer's name or trademark

b. Model name or number

c. Certifying agency label and rating.

3.2.2 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 [Contracting Officer] [QC Representative].

3.2.2.1 Piping Test

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NOTE: Use pneumatic test if non-aqueous heat transfer fluid are used, to avoid contamination of fluids with water and to eliminate seepage problems.

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[Pneumatically test new piping for leakage using air at a pressure of 138 kPa (gage) 20 psig or] [Test new water piping for leakage using water at a pressure of at least690 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.

3.2.2.2 Operation Tests

****

NOTE: Insert appropriate Section number and title in blank below using format per UFC 1-300-02.

****

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][_____] and ASTM E1160.

3.2.3 Manufacturer's Field Services

Furnish the services of a technical representative of the collector

manufacturer, at the job site during each phase of inspection, installation, and testing. For solar collectors, furnish the services of a manufacturer's representative to instruct Government personnel for one manday, in the operating and maintenance of equipment. Notify the Contracting Officer in writing, prior to scheduling instructions.

-- End of Section --