
USACE / NAVFAC / AFCEA / NASA UFGS-48 14 13.00 20 (April 2006)

Preparing Activity: NAVFAC Replacing without change
UFGS-13610N (September 1999)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated January 2009

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DIVISION 48 - ELECTRICAL POWER GENERATION

SECTION 48 14 13.00 20

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04/06

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SECTION 48 14 13.00 20

SOLAR LIQUID FLAT PLATE COLLECTORS

04/06

NOTE: This guide specification covers the requirements for solar liquid-flat-plate collector loop systems, heat storage tanks, pumps, controls and related equipment and materials.

Edit this guide specification for project specific requirements by adding, deleting, or revising text. For bracketed items, choose applicable items(s) or insert appropriate information.

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

Comments and suggestions on this guide specification are welcome and should be directed to the technical proponent of the specification. A listing of technical proponents, including their organization designation and telephone number, is on the Internet.

Recommended changes to a UFGS 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. Trouble shooting instructions.

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

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 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 (2007) Energy Standard for Buildings
Except Low-Rise Residential Buildings, I-P
Edition

ASHRAE 90.1 - SI (2004; Addendas a through p, r through v,
x,ak 2006; Supp to Addendas 2006; Errata
2007; Interpretations 8 - 15:2007; Errata
2008; INT 16-21 2008; Errata 2008; INT
22-26 2008) Energy Standard for Buildings
Except Low-Rise Residential Buildings, SI
Edition

ASHRAE 93 (2003; Errata 2003) 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 SANITARY ENGINEERING (ASSE)

ASSE 1003 (2001; Errata, 2003) Performance Requirements for Water Pressure Reducing Valves

AMERICAN WELDING SOCIETY (AWS)

AWS A5.8/A5.8M (2004; Errata 2004) Specification for Filler Metals for Brazing and Braze Welding

ASME INTERNATIONAL (ASME)

ASME B16.22 (2001; R 2005) Standard for Wrought Copper and Copper Alloy Solder Joint Pressure Fittings

ASME B16.24 (2006) Cast Copper Alloy Pipe Flanges and Flanged Fittings: Classes 150, 300, 400, 600, 900, 1500, and 2500

ASME B16.39 (1998; R 2006) Standard for Malleable Iron Threaded Pipe Unions; Classes 150, 250, and 300

ASME B31.1 (2007; Addenda 2008) Power Piping

ASME B40.100 (2005) Pressure Gauges and Gauge Attachments

ASME BPVC SEC VIII (2007; Addenda 2008) Boiler and Pressure Vessel Codes: Section VIII Rules for Construction of Pressure Vessels, Division 1

ASTM INTERNATIONAL (ASTM)

ASTM A 193/A 193M (2008b) Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service

ASTM A 194/A 194M (2008b) Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High-Pressure or High-Temperature Service, or Both

ASTM B 168 (2008) Standard Specification for Nickel-Chromium-Iron Alloys (UNS N06600, N06601, N06603, N06690, N06693, N06025, and N06045) and Nickel-Chromium-Cobalt-Molybdenum Alloy (UNS N06617) Plate, Sheet, and Strip

ASTM B 209 (2007) Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate

ASTM B 209M (2007) Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate (Metric)

ASTM B 32	(2008) Standard Specification for Solder Metal
ASTM B 88	(2003) Standard Specification for Seamless Copper Water Tube
ASTM B 88M	(2005) Standard Specification for Seamless Copper Water Tube (Metric)
ASTM C 1048	(2004) Standard Specification for Heat-Treated Flat Glass - Kind HS, Kind FT Coated and Uncoated Glass
ASTM D 3667	(2005) Rubber Seals Used in Flat-Plate Solar Collectors
ASTM E 1	(2007) Standard Specification for ASTM Liquid-in-Glass Thermometers

COPPER DEVELOPMENT ASSOCIATION (CDA)

CDA A4015	(1994; R 1995) Copper Tube Handbook
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MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-110	(1996) Ball Valves Threaded, Socket-Welding, Solder Joint, Grooved and Flared Ends
MSS SP-25	(2008) Standard Marking System for Valves, Fittings, Flanges and Unions
MSS SP-58	(2002) Standard for Pipe Hangers and Supports - Materials, Design and Manufacture
MSS SP-69	(2003; R 2004) Standard for Pipe Hangers and Supports - Selection and Application
MSS SP-72	(1999) Standard for Ball Valves with Flanged or Butt-Welding Ends for General Service
MSS SP-80	(2008) Bronze Gate, Globe, Angle and Check Valves
MSS SP-89	(2003) Pipe Hangers and Supports - Fabrication and Installation Practices

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

SMACNA 1650	(1998; Addendum 2000) Seismic Restraint Manual Guidelines for Mechanical Systems - Second Edition
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SOLAR RATING AND CERTIFICATION CORPORATION (SRCC)

SRCC CSCWHSR (2004) Summary of SRCC Certified Solar Collector and Water Heating System Ratings

SRCC OG-100 (1995) Operating Guidelines for Certifying Solar Collectors

U.S. DEPARTMENT OF DEFENSE (DOD)

MIL-STD-101 (Rev B) Color Code for Pipelines & for Compressed Gas Cylinders

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

CID A-A-59617 (Basic) Unions, Brass or Bronze, Threaded Pipe Connections and Solder-Joint Tube Connections

FS A-A-50560 (Basic) Pumps, Centrifugal, Water Circulating, Electric-Motor-Driven

FS A-A-50561 (Basic) Pumps, Rotary, Power-Driven, Viscous Liquids

FS A-A-50562 (Basic) Pump Units, Centrifugal, Water, Horizontal; General Service and Boiler-Feed: Electric-Motor- or Steam-Turbine-Driven

FS A-A-50568 (Basic) Gages, Liquid Level Measuring, Tank

FS A-A-60001 (Basic) Traps, Steam

FS F-T-2907 (Basic) Tanks, Portable Hot Water Storage

FS WW-S-2739 (Basic) Strainers, Sediment: Pipeline, Water, Air, Gas, Oil, or Steam

1.2 RELATED REQUIREMENTS

Section 23 03 00.00 20 BASIC MECHCNICAL 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 to reflect only the submittals required for the project. Submittals should be kept to the minimum required for adequate quality control.

A "G" following a submittal item indicates that the submittal requires Government approval. Some submittals are already marked with a "G". Only delete an existing "G" if the submittal item is not complex and can be reviewed through the Contractor's Quality Control system. Only add a "G" if the

submittal is sufficiently important or complex in context of the project.

For submittals requiring Government approval on Army projects, a code of up to three characters within the submittal tags may be used following the "G" designation 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.

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" designation; submittals not having a "G" designation are [for Contractor Quality Control approval.] [for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government.] The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Solar energy systems

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

SD-03 Product Data

Piping

Instrumentation

Valves

Piping specialties

Pumps

Solar storage tanks

Solar collectors

Heat exchangers

Compression tanks

Solar-boosted domestic water heaters

Collector heat transfer fluid

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

Underground solar storage tanks [holiday test](#)

Submit a factory holiday test certificate for each tank.

SD-07 Certificates

Solar energy system [installation](#)

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](#)

SD-10 Operation and Maintenance Data

[Solar energy systems](#), Data Package 3

Submit in accordance with Section [01 78 23](#) OPERATION AND MAINTENANCE DATA.

SD-11 Closeout Submittals

[Posted operating instructions](#) for solar energy system

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

NOTE: The warranty clause for solar collectors in this guide specification has been approved by NAVFACENGCOM HQ in accordance with the requirements of NAVFAC P-68. This clause may be used without any HQ approval or request for waiver.

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

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.

1.5 SOLAR COLLECTOR WARRANTY

NOTE: The warranty clause for solar collectors in this guide specification has been approved by NAVFACENGCOM HQ in accordance with the requirements of NAVFAC P-68. This clause may be used without any HQ approval or request for waiver.

Furnish five 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 trouble shooting instructions.

PART 2 PRODUCTS

2.1 SOLAR ENERGY SYSTEMS

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.

2.2 PIPING

2.2.1 Copper Pipe

ASTM B 88, 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 B 168] [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, 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

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

FS 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 A 193/A 193M for bolts and ASTM A 194/A 194M 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 D 3667, Type C.

[Fluorinated elastomers, ethylene-propylene-diene-terpolymer (EPDM) or
silicone] [ASTM D 3667, 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 B 32, Alloy Grade Sb5, Sn95, or Sn96, with minimum melting 221 degrees
C 430 degrees F.

2.4.5 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 1/2 inches and larger.

2.4.6 Piping Identification Labels

Plastic slip-on or adhesive backed labels conforming to MIL-STD-101.

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.

[FS A-A-50560, in-line centrifugal] [FS A-A-50562 non-self-priming,
horizontally mounted, centrifugal] [FS 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.

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. 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 mm5/8 inch] [or] [20 mm3/4 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, 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 lightening 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.

[ASHRAE 93] [ASHRAE 96] [SRCC OG-100 and SRCC CSCWHSRlisted] [or] [Florida Solar Energy Center (FSEC) certified]; liquid flat-plate 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." For further details and unit measurements, read ASHRAE 93 and ASHRAE 96.

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	Zero
54	0.03
40	0.05

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

$$IFP = \frac{A - B}{C}$$

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] [copper tubes with copper fins]. Provide the absorber rated for [1034 kPa (gage)] [150 psig] [_____] with working pressure of [862kPa (gage)] [125 psig] [_____].

2.9.4 Absorber Plate Coating

Electroplated black chrome with minimum [0.0025 mm] [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 degrees C] [400 degrees F] [_____].

2.9.5 Collector Case

Fabricate from at least 20 gage [galvanized steel] [or] [ASTM B 209M ASTM B 209 alloy or equivalent aluminum]. Paint collector box with durable baked enamel. 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.

2.9.6 Collector Cover (Glazing Material)

ASTM C 1048, 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.]

2.10 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

NOTE: In lieu of the collector heat transfer fluid, the use of water in a drainback concept may be acceptable. Currently, there are only a few companies using such drainback concept. Recommend to use only non-toxic heat transfer fluid. For some applications which tolerate low flash point and high toxicity, the inexpensive inhibited ethylene glycol (Union Carbide UCAR 17 at 70 percent volume; useful temperature range: -34 to 149 degrees C -30 to 300 degrees F; specific heat: 3.31 kJ per kg per degree C 0.79 Btu per pound per degree F; viscosity: 60 mPa.S at -23 degrees C and 1.5 mm²/s at 82 degrees C 60 centipoise at -10 degrees F and 1.5 centistokes at 180 degrees F; specific gravity: 1.1 at 15.60 degrees C 60 degrees F) may be used. For example only, the following Table 1 gives the engineering data for three collector fluids which comply with the requirements specified (For further information, see Military Handbook, MIL-HDBK-1003/13, "Solar Heating of Buildings and Domestic Water," Table 2-5):

TABLE 1

COLLECTOR HEAT TRANSFER FLUIDS

Manufacturer	Dow Corning	Resource Technology Corp.	Uniroyal Chemical
Brand Name or Chemical Name	Dow Corning Q2-1132	Sun-Temp	Synthetic Polyalphaole -fine
Viscosity, mm ² /s at degree C	20/25; 7/99		10/93
Viscosity, mPa.S at degree C		89/0.55; 2.1/100	
Useful Temperature, degrees C	-45.55 to 232	-40 to 260	-40 to 204
Flash Point, degrees C	232	193	204
Specific Heat, in kJ/kg/degrees C	1.55/40 1.76/200	2.35/22.22	2.10/93

TABLE 1

COLLECTOR HEAT TRANSFER FLUIDS

Toxicity	Low	None	None
Lot	Drum 208 liters	Drum 208 liters	Drum 208 liters

TABLE 1

COLLECTOR HEAT TRANSFER FLUIDS

Manufacturer	Dow Corning	Resource Technology Corp.	Uniroyal Chemical
Brand Name or Chemical Name	Dow Corning Q2-1132	Sun-Temp	Synthetic Polyalphaole -fine
Viscosity, Centistokes per degree F	20/77; 7/210		10/200
Viscosity, Centipoise per degree F		89/33; 2.1/212	
Useful Temperature, degrees F	-50 to 450	-40 to 500	-40 to 400
Flash Point, degrees F	450	380	400
Specific Heat, in Btu/lb/degrees F	0.37/104 0.42/392	0.56/72	0.5/200
Toxicity	Low	None	None
Lot	Drum 55 Gallon	Drum 55 Gallon	Drum 55 Gallon

Conform to the following:

- Liquid useful temperature range of -40 to 204 degrees C 400 degrees F.
- Non-ionic, high dielectric, non-aqueous, non-reactive, stable fluid which does not corrode copper, aluminum, iron, or steel, or attack plastics.
- Flash point exceeding 193 degrees C 380 degrees F.
- Fluid stability of ten years.
- Maximum acute oral toxicity of 5 grams per kilogram 5000 ppm.

2.12 SOLAR-BOOSTED DOMESTIC WATER HEATERS

ASHRAE 90.1 - SI ASHRAE 90.1 - IP and UL listed. Provide built-in [, double wall] heat exchanger and factory insulation jacket.

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

Solid-state or electrical only.

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

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

Weathertight.

[2.14.2 Differential Thermostat

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

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

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

2.14.6 Thermometers

ASTM E 1, [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

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. KilojouleBtu 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.
- 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

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 1650.] Install hangers and supports in accordance with MSS SP-69 and MSS SP-89, 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 57 13, "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 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.

3.1.2.12 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.

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

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

[Pneumatically test new piping for leakage using air at a pressure of] [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.

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] [_____].

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 --