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USACE / NAVFAC / AFCEC **UFGS-22 33 30.00 10 (August 2020)**

Preparing Activity: USACE **Superseding**
UFGS-22 33 30.00 10 (April 2008)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated July 2024
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SOLAR WATER HEATING EQUIPMENT

08/20

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SECTION 22 33 30.00 10

SOLAR WATER HEATING EQUIPMENT
08/20

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NOTE: This guide specification covers the requirements for solar domestic and service water heating equipment.

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)**.**

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PART 1 GENERAL

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NOTE: In accordance with the design guidance presented in UFC 3-440-01, the system is designed around the properties of a particular collector. The designer should indicate the design methodology used on the drawings. This ensures that equipment shown on detail drawings (if different from the equipment assumed by the designer) is properly sized. It is particularly important for the designer to indicate on the drawings the collector parameters used in the design. Detail drawings returned should also be so noted, particularly if the collector chosen has properties different from those used in the original design. UFC 3-440-01 provides the designer, project manager, and quality

assurance personnel a checklist of required drawings and information called out by this guide specification to appear on the drawings.

Minimize the risk of legionellosis in building water system by following guidance in the U.S. Army Corps of Engineers (USACE) Engineer Manual (EM) 200-1-13, Environmental Quality: Minimizing the Risk of Legionellosis Associated with Building Water Systems on Army Installations.

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1.1 REFERENCES

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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.

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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 NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI Z21.22/CSA 4.4 (2015; R 2020) Relief Valves for Hot Water Supply Systems

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

ASHRAE 93 (2010; Errata 2013l Errata 2014) Methods of Testing to Determine the Thermal Performance of Solar Collectors

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B1.20.1 (2013; R 2018) Pipe Threads, General Purpose (Inch)

ASME B1.20.2M (2006; R 2011) Pipe Threads, 60 Deg. General Purpose (Metric)

ASME B16.15	(2018) Cast Copper Alloy Threaded Fittings Classes 125 and 250
ASME B16.18	(2021) Cast Copper Alloy Solder Joint Pressure Fittings
ASME B16.22	(2021) Wrought Copper and Copper Alloy Solder Joint Pressure Fittings
ASME B16.26	(2018) Standard for Cast Copper Alloy Fittings for Flared Copper Tubes
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 D1	(2019) BPVC Section VIII-Rules for Construction of Pressure Vessels Division 1
ASME PTC 19.3 TW	(2016) Thermowells Performance Test Codes

AMERICAN WELDING SOCIETY (AWS)

AWS B2.1/B2.1M	(2021) Specification for Welding Procedure and Performance Qualification
AWS D1.2/D1.2M	(2014; Errata 1 2014; Errata 2 2020) Structural Welding Code - Aluminum

ASTM INTERNATIONAL (ASTM)

ASTM B32	(2020) Standard Specification for Solder Metal
ASTM B62	(2017) Standard Specification for Composition Bronze or Ounce Metal Castings
ASTM B75/B75M	(2020) Standard Specification for Seamless Copper Tube
ASTM B88	(2022) Standard Specification for Seamless Copper Water Tube
ASTM B88M	(2020) Standard Specification for Seamless Copper Water Tube (Metric)
ASTM B152/B152M	(2019) Standard Specification for Copper Sheet, Strip, Plate, and Rolled Bar
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 B828	(2023) Standard Practice for Making Capillary Joints by Soldering of Copper and Copper Alloy Tube and Fittings
ASTM C1048	(2018) Standard Specification for Heat-Strengthened and Fully Tempered Flat Glass
ASTM F1199	(2021) Standard Specification for Cast (All Temperatures and Pressures) and Welded Pipe Line Strainers (150 psig and 150 degrees F Maximum)

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

MSS SP-58	(2018) Pipe Hangers and Supports - Materials, Design and Manufacture, Selection, Application, and Installation
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 MG 1	(2021) Motors and Generators

U.S. DEPARTMENT OF DEFENSE (DOD)

UFC 3-301-01	(2023; with Change 1, 2023) Structural Engineering

1.2 SOLAR ENERGY SYSTEM

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NOTE: For systems located in an area subject to freezing, a closed-loop antifreeze system may be used. This system requires the propylene-glycol based heat transfer fluid, pumps, heat exchanger, and an expansion tank. A drain back system with either potable water or a propylene-glycol based heat transfer fluid in a closed loop may also be used. For systems at locations in which freezing temperatures do not occur, a direct circulation system may be used. UFC 3-440-01 provides further information on these system types and their appropriate uses. The Solar Collectors Manufacturer's factory designed systems, applicable to the specific location and use, may be utilized.

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a. Provide a solar energy system arranged for preheating of service (domestic and/or process) water using flat plate liquid solar collectors or evacuated tube collectors. Solar systems may be pressurized glycol systems[or drain back systems]. Include in the system components the solar collector array, storage tank[s], pump[s], automatic controls, instrumentation, interconnecting piping and fittings, [uninhibited food-grade propylene-glycol and water heat transfer fluid in a closed loop], [potable water heat transfer fluid in an open loop], [heat exchanger], [expansion tank], [drain back tank] and all accessories required for the fully functional operation of the system. Provide all appurtenances required by a manufacturer designed system for a full and functional operation.

b. Submit manufacturer's descriptive and technical literature; performance chart and curves; catalog cuts; installation instructions; proposed diagrams, instructions, and other sheets prior to posting. A copy of the posted instructions proposed to be used, including a system schematic, wiring and control diagrams, and a complete layout of the entire system. Include with the instructions, in typed form, condensed operating instructions explaining preventive maintenance procedures, methods of checking the system for normal safe operation and procedures for safely starting and stopping the system, methods of balancing and testing flow in the system, and methods of testing for control failure and proper system operation.

c. Submit drawings containing a system schematic; a collector layout and roof plan noting reverse-return piping for the collector array; a system elevation; an equipment room layout; a schedule of operation and installation instructions; and a schedule of design information including collector height and width, recommended flow rate and pressure drop at that flow rate, and number of collectors to be grouped per bank.

d. Include on the drawings complete wiring and schematic diagrams and any other details required to demonstrate that the system has been coordinated and will properly function as a unit. Show proposed layout and anchorage of equipment and appurtenances, and equipment relationship to other parts of the work, including clearances for maintenance and operation.

1.3 SUBMITTALS

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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 and Air Force 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.
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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. Submittals not having a "G" or "S" classification are 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 System

As-Built Drawings

SD-03 Product Data

Spare Parts

Solar Energy System

Welder Qualifications

SD-06 Test Reports

Inspection and Testing

SD-10 Operation and Maintenance Data

Operation and Maintenance Procedures; G, [_____]

1.4 WELDER QUALIFICATIONS

Qualify procedures and welders in accordance with the code under which the welding is specified to be accomplished. Submit, prior to welding operations, [_____] copies of qualified procedures and lists of names and identification symbols of qualified welders and welding operators.

1.5 DELIVERY, STORAGE, AND HANDLING

Protect all equipment delivered and placed in storage from the weather, excessive humidity and excessive temperature variation, and dirt and dust or other contaminants.

1.6 WARRANTY

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NOTE: Most flat plate collector manufacturers provide a minimum 10-year warranty. In the past, the solar energy field attracted a large number of disreputable manufacturers, many of whom were out of business long before their warranty expired. Any manufacturer that meets this collector specification should provide a quality collector that is capable of surviving the warranty.

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Provide a minimum 10-year warranty against the following: failure of manifold or riser tubing, joints or fittings; degradation of absorber plate selective surface; rusting or discoloration of collector hardware; and embrittlement of header manifold seals. Include in the warranty full repair or replacement of defective materials or equipment.

1.7 SPARE PARTS

Submit data for each different item of material and equipment listed, including a complete list of parts and supplies, with current unit prices and source of supply; a list of parts and supplies that are either normally furnished at no extra cost with the purchase of equipment, or specified to be furnished as part of the contract; and a list of additional items recommended by the manufacturer to ensure efficient operation for a period of 120 days.

PART 2 PRODUCTS

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NOTE: To comply with Public Law 109-58 (Energy Policy Act of 2005) design new federal buildings to achieve energy consumption levels that are at least 30 percent below the level required by ASHRAE 90.1-2004. As a minimum, all energy consuming products and systems must meet or exceed the requirements of ASHRAE 90.1.

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2.1 GENERAL EQUIPMENT REQUIREMENTS

2.1.1 Standard Products

Provide materials and equipment which are the standard products of a manufacturer regularly engaged in the manufacture of such products and that essentially duplicate items that have been in satisfactory use for at least 5 years prior to bid opening. Provide equipment supported by a service organization that is, in the opinion of the Contracting Officer, reasonably convenient to the site.

2.1.2 Nameplates

For each major item of equipment, secure a plate containing the manufacturer's name, address, type or style, model or serial number, and catalog number to the item of equipment.

2.1.3 Identical Items

Ensure items of the same classification are identical, including equipment, assemblies, parts, and components.

2.1.4 Equipment Guards [and Access]

Fully enclose or guard belts, pulleys, chains, gears, couplings, projecting set-screws, keys, and other rotating parts so located that any person may come in close proximity. Properly guard or cover high-temperature equipment and piping located so as to endanger personnel or where it creates a potential fire hazard with insulation of a type specified. [Provide catwalk, ladder, and guard rails where shown and in accordance with Section 05 50 13 MISCELLANEOUS METAL FABRICATIONS.]

2.1.5 Special Tools

Provide one set of special tools, calibration devices, and instruments required for operation, calibration, and maintenance of the equipment.

2.2 PIPING SYSTEM

Provide complete piping system with pipe, pipe fittings, valves, strainers, expansion loops, hangers, inserts, supports, anchors, guides, sleeves, and accessories. Provide system materials conforming to the following:

2.2.1 Copper Tubing

ASTM B88M ASTM B88, Type K where buried, Type L otherwise. Collector risers Type L or M.

2.2.2 Solder

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NOTE: The solders referenced are necessary for compatibility with the fluids and metals contained in solar energy systems and also required for piping containing potable water.
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ASTM B32, Type Sb5, Sn94, Sn95, or Sn96. Lead solders are not allowed in any portion of the potable water system.

2.2.3 Joints and Fittings for Copper Tubing

Provide wrought copper and bronze solder-joint pressure fittings conforming to ASME B16.22 and ASTM B75/B75M. Provide cast copper alloy solder-joint pressure fittings conforming to ASME B16.18 and ASTM B828. Provide cast copper alloy fittings for flared copper tube conforming to ASME B16.26 and ASTM B62. Brass or bronze adapters for brazed tubing may be used for connecting tubing to flanges and to threaded ends of valves and equipment. Provide ast bronze threaded fittings conforming to ASME B16.15. Extracted brazed tee joints produced with an acceptable tool and installed as recommended by the manufacturer may be used. Do not use grooved mechanical joints and fittings.

2.2.4   Dielectric Waterways and Flanges

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NOTE: Since all wetted surfaces are required to be nonferrous, the only location for dielectric waterways to be considered is the penetrations to the storage tank.

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Provide waterways and flanges conforming to the requirements of ASME B16.39. Provide dielectric waterways with metal connections at both ends suited to match connecting piping. Thread or solder ends to match adjacent piping. Line dielectric waterways internally with an insulator specifically designed to prevent current flow between dissimilar metals. Provide dielectric waterways and flanges suitable for the temperatures, pressures, and antifreeze encountered. Ensure dielectric flanges meet the performance requirements described herein for dielectric waterways.

2.2.5   Bronze Gate, Globe, Angle, and Check Valves

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NOTE: MSS SP-80 shows standard practice for check valves. Of the check valves listed, only the metal to metal lift check valve (Type 1) may be used. However, spring loaded check valves (also called "nonslam" check valves) are available and are similar to the lift check valve referenced. These spring loaded check valves are preferred and should be used whenever practical.

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MSS SP-80, Type 1 (or nonslam, spring type), Class 125 or 150.

2.2.6   Ball Valves

[MSS SP-72] [or] [MSS SP-110], Class 125 or 150.

2.2.7   Relief Valves, Pressure and Temperature

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NOTE: The system should be used with 862 kPa 125 psig pressure relief and 99 degrees C 210 degree F temperature relief whenever possible. In the event of overpressure, the pressure relief valves located at the low points in the system (usually on the expansion tank in the equipment room) should open first due to the elevation head of the system. This prevents fluid release at the collector level and serves to alert maintenance personnel of a problem.

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ANSI Z21.22/CSA 4.4. Locate pressure relief valves on the solar collector array upper manifold and on the expansion tank to open and discharge the collector fluid [into drain indicated] [into drain tank] when fluid pressure rises above 862 kPa 125 psig. Locate pressure and temperature relief valves on the solar storage tank to open and discharge water [into drain indicated] [into drain tank] when fluid pressure rises above [862] [_____] kPa [125] [_____] psig or when fluid temperature rises above [99] [_____] degrees C [210] [_____] degrees F.

2.2.8 Calibrating Balancing Valves

Provide calibrated balancing valves suitable for 862 kPa 125 psig and 121 degrees C 250 degrees F service, of bronze body/brass ball construction with seat rings compatible with system fluid, and with differential readout ports across valve seat area. Fit readout ports with internal insert of compatible material and check valve. Ensure calibrated balancing valves have memory stop feature to allow valve to be closed for service and reopened to set point without disturbing balance position and calibrated nameplate to assure specific valve settings.

2.2.9 Vacuum Breakers

Install atmospheric type anti-siphon vacuum breaker where indicated on the plans. Include lightweight disc float with silicone disc for tight seating. Construct the vacuum breaker of lead free materials.

2.2.10 Air Vents

[Provide manual air vents that are 10 mm 3/8 inch brass or bronze globe valves or cocks suitable for 862 kPa 125 psig service. Provide air vents with threaded plugs or caps.]

[Provide automatic air vents consisting of ball-float construction. Provide vent inlet no less than 12 mm 1/2-inch and outlet no less than 8 mm 1/4-inch. Provide corrosion-resistant steel. Ensure vent discharges air at any pressure up to 1034 kPa 150 psig.]

2.2.11 Strainers

ASTM F1199, removable basket and screen, Y pattern, cast iron strainer with pressures to 862 kPa 125 psig, simplex type; or a combination elbow-strainer with straightening vanes and strainer arranged for horizontal flow.

2.2.12 Pressure Gauges

ASME B40.100. Provide pressure gauges with throttling type needle valve or a pulsation dampener and shutoff valve. Provide minimum dial size of 90 mm 3-1/2 inch.

2.2.13 Thermometers

ASME PTC 19.3 TW, Type I, Class 3. Supply thermometers with wells and separable bronze sockets.

2.2.14 Pipe Threads

ASME B1.20.2MASME B1.20.1.

2.2.15 Pipe Supports

MSS SP-58. Provide stainless steel metal insulation shield.

2.2.16 Aluminum Sheets

ASTM B209M ASTM B209, Alloy 3003.

2.2.17 Copper Sheets Copper Alloy 110

ASTM B152/B152M.

2.3 ELECTRICAL WORK

Provide electric motor-driven equipment specified complete with motor, motor starters, and controls. Provide electrical equipment and wiring in accordance with Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Specify or indicate electrical characteristics. Provide motor starters complete with thermal overload protection and other appurtenances necessary for the motor control specified. Ensure each motor is of sufficient size to drive the equipment at the specified capacity without exceeding the nameplate rating of the motor. Provide manual or automatic control and protective or signal devices required for the operation specified, and any control wiring required for controls and devices but are not shown. Ensure integral size motors are the premium efficiency type in accordance with NEMA MG 1.

2.4 COLLECTOR SUBSYSTEM

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NOTE: As discussed in UFC 3-440-01, the design of a solar energy system is heavily dependent on the choice of a collector. It is important that the collector around which the system is designed be described as thoroughly as possible on the designer's drawings. Of particular interest are the length and width of the collector (for spacing and roof layout reasons), the recommended flow rate of the collector, and the rated pressure drop at that flow rate. The designer should verify that the values of the following parameters are indicated in schedules on the drawings:

1. Type of collectors
2. Number of collectors
3. Gross area and net aperture area
4. Collector height and width
5. Collector fluid volume
6. Collector filled weight
7. Collector manufacturer's warranty period
8. Recommended collector flow rate
9. Pressure drop across the collector at recommended flow rate.

Flat plate collectors should be utilized in ASHRAE Climate Zones 1-3. Evacuated tube collectors should be used in ASHRAE Climate Zones 4 and above or within zones 1-3 when water heating above 140 degrees F (60 degrees C) is required.

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2.4.1 Flat Plate Collector Construction

Provide liquid, internally manifolded type flat plate solar collectors. Provide each collector with cover glazing, an absorber plate, heat transfer liquid flow tubes, internal headers, weep holes, insulation, and a casing. Collectors must be of weather-tight construction. Ensure solar collectors withstand a stagnation temperature of 177 degrees C 350 degrees F and a working pressure of 862 kPa 125 psig without degrading, out-gassing, or warping. Provide collector net aperture area as shown and is a minimum of 2.3 square meters 24.5 square feet. Provide collector length, width, and volume as shown on the drawings.

2.4.1.1 Absorber Plate and Flow Tubes

Provide copper absorber sheet or plate. Ensure top of absorber plate is coated with selective surface of black chrome and has an emissivity less than 0.2 and absorptivity greater than 0.9. Provide Type L or Type M copper flow tubes that are soldered, brazed, or mechanically bonded to the absorber plate. Install tubes on the absorber plate so that they drain by gravity.

2.4.1.2 Cover Glazing

Ensure each collector has a single layer of cover glazing made of clear float, water white or low iron type tempered glass. Provide glass meeting ASTM C1048. Provide cover glazing which is completely replaceable from the front of the collector without disturbing the piping or adjacent collectors. Ensure cover glazing is separated from the collector by a continuous gasket made of EPDM rubber.

2.4.1.3 Insulation

Insulate back and sides of the absorber plate. Fill space between absorber plate and casing with insulation that has an R value of 4 minimum. Use insulation conforming to EPA requirements in accordance with Section 01 33 29 SUSTAINABILITY REQUIREMENTS AND REPORTING which is fibrous glass, polyisocyanurate, urethane foam, or other material suitable for the intended purpose, and capable of withstanding the moisture, sun exposure, and stagnation temperature limitations of the solar collector. Do not allow polyisocyanurate insulation to come in contact with the absorber plate.

2.4.1.4 Casing

Provide aluminum casing. Provide mill finish or factory applied baked enamel, embossed or bronze anodized aluminum. Separate cover glazing from the casing by an EPDM rubber gasket or equivalent material. Make allowance for thermal expansion between the cover and absorber plates and the casing, and for drainage of moisture through weep holes.

2.4.2 Evacuated Tube Collectors

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NOTE: There are several types of solar collectors that utilize evacuated tubes. The most prominent being heat pipe collectors and direct flow collectors. Heat pipe collectors are highly efficient and recommended for use for domestic hot water. The tubes are easily removed and replaced without disabling the entire system. The tubes are suitable for cold climates. Correct Orientation of the pipes is imperative for proper operation. Direct flow collectors are wet systems, utilizing a "pipe within a pipe" design. The interior pipe has an integral heat absorber mechanically attached to

the pipe. These tube collectors can be mounted horizontal or vertical and are suitable for all weather conditions. The direct flow collectors are recommended for commercial and industrial applications. These collectors are very flexible and can be utilized when the ideal installation position is not available. For both types, the tubes are under a vacuum, providing excellent insulation.

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Ensure evacuated tube collectors incorporate the use of borosilicate glass tubes. Utilize [heat pipe] [direct flow] collectors in the system design. Ensure tubes are resistant to thermal shock and designed to resist hail damage.

[Heat pipe systems are a dry system that does not utilize water within the collector tubes. Incorporate an inner sealed copper tube containing a non-toxic heat transfer medium into the system. The heat-pipe principle will transfer heat, via the heat pipe, from the evacuated glass tube to the receptor in the manifold. Design the system to allow the removal of the tubes without draining the system. Install systems that are extremely dependent on the correct mounting arrangements precisely as recommended by the manufacturer to insure correct operation.]

[Utilize direct flow systems, which are a fully pumped wet system, if ideal installation arrangements are not possible. Enclose a copper pipe, circulating water, within the evacuated tube. Connect the ends of the pipe to the cold or hot water header within the panel assembly. Direct flow systems are pressurized and can be mounted both horizontally and vertically. Manufacture the system to allow replacement of a single evacuated tube without draining the entire collector loop.]

2.4.2.1 Operating Conditions

[Provide direct flow collectors capable of withstanding a stagnation temperature of 300 degrees C 595 degrees F] [Provide heat pipe collectors capable of withstanding a stagnation temperature of 165 degrees C 330 degrees F]. Ensure evacuated tubes incorporate "plug and play" design where tubes can be removed or replaced without disabling the entire system.

2.4.3 Mounting and Assembly Hardware

Provide stainless steel mounting frame with stainless steel or aluminum mounting clips. Provide stainless steel assembly hardware including all bolts, washers, and nuts.

2.4.4 Solar Collector Performance

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NOTE: The maximum number of collectors per bank allowed by the manufacturer should be investigated. This number is dependent on the header and riser diameters, flow rates, and thermal expansion characteristics of the collector. It is expected that most 1.2 m 4 foot wide collectors can be grouped into banks of at least seven, and this is the largest bank size allowed.

****

Plot thermal performance on the thermal efficiency curve in accordance with ASHRAE 93. Ensure the y-intercept is equal to or greater than 0.68, and the numerical value of the slope of the curve (FRUL) is between 0 and minus 5.7 watts per square meter per degree K (0 and minus 1.0 Btu per hour per square foot per degree F) 0 and minus 1.0 Btu per hour per square foot per degree F. Ensure manufacturer's recommended volumetric flow rate and the design pressure drop at the recommended flow rate is as shown. Ensure manufacturer's recommendations allow at least seven collectors to be joined per bank while providing for balanced flow and for thermal expansion considerations.

2.5 Solar Collector Array

2.5.1 Net Absorber Area and Array Layout

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NOTE: The minimum array aperture area allowed for the project is that collector array area associated with the highest LCC savings by the SOLFEAS solar feasibility study computer program. The array layout should be completed according to the methods discussed in UFC 3-440-01. For flow balancing purposes, each bank must have the same number of collectors. Banks must contain between 4 and 7 collectors each. Generally, the array should follow building lines, but must keep within 20 degrees of due south. Care should be taken to distinguish between magnetic and due south for the project location. Row spacing is a function of the collector height and projection location; methodology for determining this spacing is given in UFC 3-440-01. It is imperative to proper construction of the system that the array layout be accurately shown on the drawings. Items to be shown on the drawings must include:

a. SOLFEAS result for minimum array size
b. Total array size to be installed
c. Bank size (4, 5, 6, or 7 collectors) and number of banks
d. Minimum row spacing in event of multiple rows of collection
e. Array orientation with respect to true south.

****

Provide array consisting of an assembly of solar collectors as shown with a minimum total array aperture area of [_____] square meters square feet. Assemble solar collectors as shown in banks of equal number of collectors. Banks consist of no less than 4 and no more than 7 collectors each. Orient collector array so that all collectors face the same direction and are oriented within 20 degrees of true south and with respect to true south as indicated. Space collectors arranged in multiple rows so that no shading from other collectors is evident between 1000 hours and 1400 hours solar time on December 21.

Use minimum spacing between rows as recommended by the manufacturer for the specific location.

2.5.2 Piping

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NOTE: The reverse-return strategy is important to proper array operation. Because this strategy results in what may be initially perceived by the Contractor as excess piping, it is important that the array piping be shown and indicated on the drawing as satisfying this requirement. Rules, methodology, and examples of the reverse-return strategy are given in UFC 3-440-01. Collector loop flow rate should be determined by multiplying the recommended flow rate per collector by the number of collectors to be installed. Collector headers must be located such that there is no possibility of air pockets. Items to be shown on the drawings must include:

a. Flow rate through collector loop based on recommended flow per collector
b. Reverse-return piping shown and noted
c. Valves, strainers, automatic controls, and all accessories
d. Pipe pitch for draining.

****

The array piping includes interconnecting piping between solar collectors, and connect in a reverse-return configuration as indicated with approximately equal pipe length for any possible flow path. Provide flow rate through the collector array as indicated. Provide automatic pressure relief valves in the array piping system as indicated, and adjust to open when the pressure within the solar array rises above 862 kPa 125 psig. Ensure each collector bank is capable of being isolated by valves, and each bank capable of being separated has a pressure relief valve installed and is capable of being drained. Locate manually operated air vents at system high points, and pitch all array piping a minimum of 21 mm/meter 0.25 inch/foot as shown so that piping can be drained by gravity. Supply calibrated balancing valves at the outlet of each collector bank as indicated.

2.5.3 Supports for Solar Collector Array

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NOTE: The support structure for the solar array is to be constructed from stainless steel to minimize cost and maintenance of painting a system. For the majority of solar projects, this structure will be constructed as a support rack on a flat roof. Design loads for solar arrays include the filled weight of the collectors, weight of filled piping, wind, seismic and snow loads, and the weight of the support structure itself. Of these, the wind imposed on solar collector arrays may require the most attention. Provide seismic details, if a Government designer (either Corps office or A/E) is the Engineer of Record, and show on the drawings. Delete the bracketed phrase if seismic details are not provided. Pertinent portions of UFC 3-301-01 and Sections 13 48 73 and 23 05 48.19 must be

included in the contract documents. Support structures provided by the collector manufacturer may be used if they meet the stated specification.
****

Provide stainless steel support structure for collector array in accordance with Section [05 50 13 MISCELLANEOUS METAL FABRICATIONS][05 50 14STRUCTURAL METAL FABRICATIONS]. Use support structure to secure collector array at the tilt angle with respect to horizontal and orientation with respect to true south as shown. Ensure support structure withstands static weight of filled collectors and piping, wind, snow, seismic, and other loads as indicated. Ensure seismic details [conform to UFC 3-301-01 and Sections 13 48 73 SEISMIC CONTROL FOR MISCELLANEOUS EQUIPMENT and 23 05 48.19 [SEISMIC] BRACING FOR HVAC] [be as shown on the drawings]. Ensure support structure allows access to all equipment for maintenance, repair, and replacement.

2.6 STORAGE TANK

****
NOTE: Storage tank volume should be between 61 to 81 liters per square meter 1.5 to 2 gallons per square foot of collector area. This range of acceptable values should be inserted in the blanks provided based on the array area inserted in paragraph Net Absorber Area and Array Layout. Storage volume outside of this range becomes undesirable from a system performance point of view. Items to be shown on the drawings must include:

a. Range of acceptable storage tank volumes
b. Number of liters gallons of storage provided per square meter square foot of collector area for given tank
c. Minimum R value of tank insulation
d. Type of lining in tank.
****

[Provide solar indirect water heater type storage tank, having integral coil heat exchanger for connection to the collector array (see Heat Exchanger in Transport Subsystem paragraph below).] Ensure solar system hot water storage tank has a storage volume between [_____] and [_____] liters gallons and is as shown. Provide solar system storage tank conforming to specifications for hot water storage tanks in Section 22 00 00 PLUMBING, GENERAL PURPOSE. Provide insulation in accordance with Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS, except that insulation must have an R value of not less than 30. Design tank penetrations to allow for connections to copper piping without risk of corrosion due to dissimilar metals, and factory install as indicated.

2.7 TRANSPORT SUBSYSTEM

2.7.1 Heat Exchanger

****
NOTE: Although solar energy system performance is not strongly dependent on the effectiveness of the particular heat exchanger used, it is very important

to ensure that it is sized properly. Use of the approach and return temperatures stated in this paragraph ensures that the effectiveness of the heat exchanger is within acceptable limits. The hot side return temperature can be less than 49 degrees C 120 degrees F if the designer feels that the effectiveness should be greater than 0.5. When multi-plate heat exchangers are used, the effectiveness can be significantly increased above 0.5 for a small increase in heat exchanger cost. Both shell-and-tube and multi-plate or plate-and-frame heat exchangers are allowable for solar systems. Although the shell-and-tube exchangers are more common, multi-plate heat exchangers are becoming readily available from a variety of manufacturers. The multi-plate heat exchanger has the advantages over shell-and-tube of being more compact, more efficient, easier to clean, and it is commonly produced from superior materials. They can also be easily expanded to larger sizes if necessary, and many require little or no insulation. The designer should consider use of these exchangers whenever practical. Because of the wide variety of configurations used by these heat exchangers, they must often be sized by the individual manufacturers. In accordance with UFC 3-440-01, the flow rate on the storage side of the heat exchanger should be 1.25 times that on the collector side. Items to be shown on the drawings must include:

a. Type of heat exchanger and heat exchanger materials
b. Flow rates on both sides of heat exchanger
c. Plate or tube heat transfer area.
****

Perform heat exchanger construction and testing in accordance with ASME BPVC SEC VIII D1and list for use on potable water systems. Use minimum design pressure rating of 862 kPa 125 psig. Ensure heat exchanger is capable of returning a hot-side exit temperature of [49] [_____] degrees C [120] [_____] degrees F or less given a hot-side approach temperature of 60 degrees C 140 degrees F and a cold-side approach temperature of 38 degrees C 100 degrees F. Ensure heat exchanger is capable of withstanding temperatures of at least 116 degrees C 240 degrees F. Provide heat exchanger that is capable of operation at the flow rates as shown.

2.7.1.1 Plate Heat Exchanger

Construct heat exchanger of multiple plates of 316 stainless steel, titanium, copper, copper-nickel, or brass. Provide plates that are frame-mounted, mechanically bonded, welded, or brazed at edges. Ensure plate-type heat exchanger is able to be cleaned. Provide gaskets consisting of EPDM rubber or Viton. Ensure all plate heat exchanger characteristics are as indicated.

2.7.1.2 Tube-in-Shell Heat Exchanger

Provide [fixed] [removable] bundle, shell-and-tube type heat exchanger. Construct shell, tube sheets, and end plates of nonferrous, brass, copper-nickel, or 316 stainless steel. Provide shell insulation in accordance with Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS, except that insulation must have a minimum R value of no less than 12. Provide tubes that are seamless copper or copper alloy and mechanically bonded, welded, or brazed to the end tube plates. Ensure tubes are straight and supported by tube sheets which maintain the tubes in alignment. [Arrange straight tube heat exchanger for mechanical cleaning.] Provide all tube-in-shell heat exchanger characteristics as indicated.

2.7.1.3 Coil Heat Exchanger

Ensure heat exchanger is integral to the storage tank. Construct heat exchanger of nonferrous, stainless steel, copper nickel, or copper. Provide all coil heat exchanger characteristics as shown. If a freeze protection fluid circulates in the heat exchanger, ensure heat exchanger piping consists of double wall construction.

2.7.2 Pumps

****

NOTE: In closed loop systems, the use of a standard base mounted or inline pump is acceptable. If the system utilizes an open loop or drain down tank where the pump may drain, incorporate a means to prime the pump or the use of a self-priming pump.

****

Provide circulating pumps that [are listed for use in a potable water system and]are the electrically-driven, single-stage, centrifugal, base mounted or inline type.[Provide self-priming pumps.] Support pumps [on a concrete foundation] [or] [by the piping on which installed]. Ensure pumps have a capacity no less than that indicated and are either integrally-mounted with the motor or direct-connected by a flexible-shaft coupling on a cast-iron or steel sub-base. Construct pump shaft of corrosion resistant alloy steel, sleeve bearings and glands of bronze designed to accommodate a mechanical seal. Provide pumps with bronze or stainless steel impellers and casings of cast iron or bronze. Ensure motors have sufficient power for the service required, are of a type approved by the manufacturer of the pump, are suitable for the available electric service and for the heat transfer fluid used, and conform to the requirements specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Control motors by suitable switches that can be activated by either the differential temperature controller or by manual override (Hand-Off-Automatic). Provide each pump suction and discharge connection with a pressure gauge as specified.

2.7.3 Pipe Insulation

Apply pipe insulation and coverings in accordance with Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS as called out for steam piping to 103 kPa 15 psig. Provide array piping insulation capable of withstanding 121 degrees C 250 degrees F, except provide piping within 450 mm 1.5 feet of collector connections capable of withstanding 204 degrees C 400 degrees F.

2.7.4 Expansion Tank

****

NOTE: Care should be taken by the designer to properly size the expansion tank according to the guidance in UFC 3 440-01. This expansion tank sizing criteria requires the expansion tank to be able to accept an amount of fluid equal to the fluid volume of the collectors plus piping at the same height or above the collectors. This is in contrast to the conventional method of sizing the expansion tank to account for thermal expansion of the heat transfer fluid. The method described above allows for the large volume increase corresponding to the vaporization of fluid in the collectors during stagnation. This "oversizing" provides a fail-safe means of system pressure control during stagnation conditions, and prevents heat transfer fluid discharge by keeping the system pressure below the maximum 862 kPa 125 psig relief value. A bladder-type expansion tank is required to separate the heat transfer fluid from the metal tank material. Use of a precharged tank allows the overall tank size to be smaller. Care should be taken to ensure that the expansion tank precharge pressure is less than the fill pressure at the expansion tank. Items to be shown on the drawings must include:

a. Expansion tank acceptance and total volume
b. Expansion tank and bladder materials
c. Maximum relief, system cold fill, and precharge pressures.

****

Construct and test expansion tank in accordance with ASME BPVC SEC VIII D1 and as applicable for a working pressure of 862 kPa 125 psig. Provide tank with an elastomeric EPDM bladder which separates the system fluid from the tank walls and is suitable for a maximum operating temperature of 116 degrees C 240 degrees F. Size the expansion tank to accept a volume equal to the fluid volume of the collectors plus the associated piping. Ensure tank volume is a minimum of [_____] liters gallons as shown. If the system is modified from the construction documents, recalculate the system volume and modify the expansion tank volume as required. Provide total tank size and arrangement as shown. Provide tank with 862 kPa 125 psi pressure relief valve. Provide tank with precharge pressure of [_____] kPa psi as shown.

2.7.5 Heat Transfer Fluid

****

NOTE: Where freezing temperatures at the project location and the system design dictate, the use of an uninhibited propylene-glycol/water solution will be utilized. USP/food-grade uninhibited propylene-glycol is a nontoxic, noncorrosive fluid used by the food industry, and has been approved for use with single isolation heat exchangers in

closed-loop military solar energy systems by the Office of the Surgeon General (DASG) in coordination with the Toxicology Division of the Army Environmental Hygiene Agency. The concentration to be used is a function of the climate where the system is to be located. The concentration should be either 30 or 50 percent, with climates that commonly attain freezing temperatures (those above approximately 2,222 heating Kelvin days 4000 heating degree F days) receiving the 50 percent solution. Although inhibited propylene-glycol is often used in mechanical systems, uninhibited propylene-glycol is specified for solar systems to eliminate fluid maintenance requirements. Indicate in equipment schedules on drawings the heat transfer fluid used, the concentration, and the maximum operating temperature to assure proper equipment and materials compatibility. Items to be shown on the drawings regarding the heat transfer fluid must include, if applicable:

a. Use of uninhibited, food-grade propylene- glycol and distilled water solution
b. 30 or 50 percent concentration
c. Note of tamper resistant seal requirement.

****

[Ensure solar collector loop fluid is uninhibited USP/food-grade propylene-glycol and mixed with distilled or demineralized water to form a [30] [50] percent by volume propylene-glycol solution as shown]. [Solar collector loop fluid must be potable water.]

2.7.6 Drain Back Tank

Provide drain back tank that is constructed by one manufacturer, ASME stamped for working pressure, has ASME registration, and is sized in accordance with the requirements of the manufacturer. Construct tank of stainless steel type 304 alloy. Provide tank connection fittings that are 12 mm 1/2 inch female NPT type fittings. Ensure maximum operating pressure is no less than 50 PSI. Maximum temperature less than 95 degrees C 200 degrees F is unacceptable.

2.8 CONTROL AND INSTRUMENTATION SUBSYSTEM

2.8.1 Differential Temperature Control Equipment

****

NOTE: The guidance contained in UFC 3-440-01 discusses desired control and diagnostic capabilities of control equipment.

****

Supply differential temperature control equipment as a system by a single manufacturer. Ensure controller is compatible with the building automation system (BAS). Provide solid-state electronic type controller complete with an integral transformer to supply low voltage, which allows a minimum adjustable temperature differential (on) of 4 to 11 degrees C 8 to 20 degrees F, a minimum adjustable temperature differential (off) of 2 to 3 degrees C 3 to 5 degrees F, and includes a switching relay or solid state output device for pump control. Thermostat must operate in the on-off mode. Controller accuracy must be plus or minus 0.5 degree C 1 degree F. Provide controller that is compatible with 10-kOhm thermistor temperature sensors. Use differential control to provide direct digital temperature readings of all temperatures sensed. Control must indicate visually when pumps are energized. Control ambient operating range must be a minimum of 0 to 49 degrees C 32 to 120 degrees F. At a minimum, system control points must include:

a. Collector temperature sensor

b. Storage tank temperature sensor

c. Heat exchanger temperatures inlet and outlet

d. Pump inlet and discharge pressure

e. Heat exchanger inlet and outlet pressure

f. Storage tank pressure

g. Flow indicator in the collector loop

h. Flow indicator in the storage loop

i. BTU meter to measure and record the thermal energy stored.

2.8.2 Thermistor Temperature Sensors

Provide 10-kOhm thermistor temperature sensors supplied by the differential temperature controller manufacturer, with an accuracy of plus or minus 1 percent at 25 degrees C 77 degrees F. Model supplied must have passed an accelerated life test conducted by subjecting thermistor assemblies to a constant temperature of 204 degrees C 400 degrees F or greater for a period of 1000 hours minimum. Maintain accuracy within plus or minus 1 percent as stated above. Provide hermetically sealed glass type thermistors. Use operating range of minus 22 to plus 204 degrees C minus 40 to plus 400 degrees F. Provide immersion wells or watertight threaded fittings for temperature sensors.

2.8.3 Sensor and Control Wiring

18 AWG minimum twisted and shielded 2, 3, or 4 conductor to match analog function hardware. Provide control wiring with 600 volt insulation. Provide multi-conductor wire with an outer jacket of PVC.

2.8.4 Flowmeters

****

NOTE: Venturi pressure differential is dependent on the flow rates to be measured. System flow rates are dependent on recommended collector flow rates. UFC 3 440-01 and paragraphs Piping and Heat Exchanger should be used to determine both the collector side and storage side flow rates.

****

Provide flowmeters consisting of a venturi, 150 mm 6 inch dial differential pressure meter, valved pressure taps, and bar stock needle valves. Provide venturi flow nozzle with threaded bronze ends for pipe sizes up to 50 mm 2 inches and flanged ends for pipe sizes 65 mm 2-1/2 inches and above. Ensure venturi length is not less than 1.6 times the pipe size. Select venturi to read differential pressure corresponding to 0.5 to 1.5 times the system flow rate. Provide venturi with an accuracy of plus or minus 1 percent of the range. Provide meter with an accuracy of plus or minus 2 percent of the full scale range.

2.8.5 Sight Flow Indicators

Provide sight flow indicators consisting of a clear glass window or cylinder and a nonferrous or 316 stainless steel body and impeller. Provide indicator with threaded ends for pipe sizes up to 50 mm 2 inches and flanged ends for pipe sizes 65 mm 2-1/2 inches and above. Ensure maximum operating pressure is no less than 862 kPa 125 psi. Ensure maximum operating temperature is no less than 121 degrees C 250 degrees F.

2.9 PAINTING AND FINISHING

Equipment and component items, when fabricated from ferrous metal and located inside the building, must be factory finished with the manufacturer's standard finish.

PART 3 EXECUTION

3.1 EXAMINATION

After becoming thoroughly familiar with all details of the work, verify all dimensions in the field, and advise the Contracting Officer of any discrepancy before performing any work.

3.2 INSTALLATION

3.2.1 Collector Subsystem

3.2.1.1 Collector Array

****

NOTE: UFC 3-440-01 discusses installation design guidelines for solar collector arrays. The tilt angle of the collectors off horizontal should be near the site latitude within plus or minus 10 degrees. Items to be shown on the drawings with regard to the installation of the array must include:

a. Tilt angle of collectors from horizontal
b. Elevation of bottom or back of collectors off of flat or pitched roof
c. Location and elevation of piping with regard to array supply and return.

****

Install solar collector array at the tilt angle, orientation, and elevation above roof as indicated. [Install collectors per the manufacturer's instructions.] [For installation on flat roofs with rack type collector mounting or for ground mounted collectors, bottom of collector must be a minimum of 450 mm 18 inches from roof or ground surface.] [For mounting on pitched roofs, install back of collectors a minimum of 50 mm 2 inches above roof surface.] Each solar collector must be removable for maintenance, repair, or replacement. Solar collector array must not impose additional loads on the structure beyond the loads scheduled on the structural drawings.

3.2.1.2 Array Piping

Install collector array piping in a reverse-return configuration so that path lengths of collector supply and return are of approximately equal length. All piping must be coded with fluid type and flow direction labels in accordance with Section 09 90 00 PAINTS AND COATINGS.

3.2.1.3 Array Support

Install array support in accordance with the recommendations of the collector manufacturer. Weld structural members requiring welding in accordance with AWS D1.2/D1.2M for aluminum and welders should be qualified according to AWS B2.1/B2.1M.

3.2.2 Storage Subsystem

Install solar storage tank penetrations as shown so that cold water inlet to storage tank and outlet from storage tank to collector array are located near the bottom of the tank, and inlet from collector array and outlet to load are located near the top of the tank. Where practicable, install hot water storage tanks with access hatches in order to facilitate annual cleaning and inspections.

3.2.3 Transport Subsystem

3.2.3.1 Flow Rates

****

NOTE: The reverse-return strategy is important to proper array operation. Because this strategy results in what may be initially perceived by the Contractor as excess piping, it is important that the array piping be shown and indicated on the drawing as satisfying this requirement. Rules, methodology, and examples of the reverse-return strategy are given in UFC 3 440-01. Collector loop flow rate should be determined by multiplying the recommended flow rate per collector by the number of collectors to be installed. Collector headers must be located such that there is no possibility of air pockets. Items to be shown on the drawings must include:

a. Flow rate through collector loop based on recommended flow per collector
b. Reverse-return piping shown and noted
c. Valves, strainers, automatic controls, and all accessories
d. Pipe pitch for draining.

Although solar energy system performance is not strongly dependent on the effectiveness of the particular heat exchanger used, it is very important to ensure that it is sized properly. Use of the approach and return temperatures stated in this

paragraph ensures that the effectiveness of the heat exchanger is within acceptable limits. The hot side return temperature can be less than 49 degrees C 120 degrees F if the designer feels that the effectiveness should be greater than 0.5. When multi-plate heat exchangers are used, the effectiveness can be significantly increased above 0.5 for a small increase in heat exchanger cost. Both shell-and-tube and multi-plate or plate and frame heat exchangers are allowable for solar systems. The multi-plate heat exchanger has the advantages over shell-and-tube of being more compact, more efficient, easier to clean, and it is commonly produced from superior materials. They can also be easily expanded to larger sizes if necessary, and many require little or no insulation. The designer should consider use of these exchangers whenever practical. Because of the wide variety of configurations used by these heat exchangers, they must often be sized by the individual manufacturers. In accordance with UFC 3-440-01, the flow rate on the storage side of the heat exchanger should be 1.25 times that on the collector side. Items to be shown on the drawings must include:

a. Type of heat exchanger and heat exchanger materials
b. Flow rates on both sides of heat exchanger
c. Plate or tube heat transfer area.
****

[Base flow rate in the collector loop on recommended collector flow rate, and as shown. Ensure storage loop flow rate is 1.25 times the collector loop flow rate.] [Base system flow rate on recommended collector flow rate, and as indicated.] Ensure all flow rates are below 1.5 meters/second 5 feet/second.

3.2.3.2 Pumps

[Install pumps on foundations, leveled, grouted, and realigned before operation in accordance with manufacturers' instructions.] [Provide additional pipe supports for close-coupled in-line pumps.] [Provide a straight pipe between the suction side of the pump and the first elbow for all base mounted pumps. The length of this pipe must be a minimum of five times the diameter of the pipe on the suction side of the pump, or attach a suction diffuser of the proper size to the suction side of the pump.] [Provide straight pipe between the suction side of the pump and the first elbow for all in-line pumps. The length of this pipe must be a minimum of five times the diameter of the pipe size on the suction side of the pump.] Ensure drain line sizes from the pumps are not less than the drain trap or the pump dirt pocket, but in no case must the drain line be less than 13 mm 1/2 inch iron pipe size. Terminate drain lines to spill over the nearest floor or open sight drain.

3.2.3.3 Expansion Tank

Install expansion tank on suction side of pump.

3.2.3.4   Piping, Valves, and Accessories

****

NOTE: In freezing temperatures at the project , the use of an uninhibited propylene-glycol/water solution may be required. USP/food-grade uninhibited propylene-glycol is a nontoxic, noncorrosive fluid used by the food industry, and has been approved for use with single isolation heat exchangers in closed-loop military solar energy systems by the Office of the Surgeon General (DASG) in coordination with the Toxicology Division of the Army Environmental Hygiene Agency. The concentration to be used is a function of the climate where the system is to be located. The concentration should be either 30 or 50 percent, with climates that commonly attain freezing temperatures (those above approximately 2,222 heating Kelvin days 4000 heating degree F days) receiving the 50 percent solution. Although inhibited propylene-glycol is often used in mechanical systems, uninhibited propylene-glycol is specified for solar systems to eliminate fluid maintenance requirements. Indicate in equipment schedules on drawings the heat transfer fluid used, the concentration, and the maximum operating temperature to assure proper equipment and materials compatibility. Water should only be used as a heat transfer fluid when the direct circulation system is specified, or when the system is designed with inherent freeze protection. Items to be shown on the drawings regarding the heat transfer fluid must include, if applicable:

a. Use of uninhibited, food-grade propylene- glycol and distilled water solution
b. 30 or 50 percent concentration
c. Note of tamper resistant seal requirements.

****

Install piping in accordance with Section 22 00 00 PLUMBING, GENERAL PURPOSE, except where noted otherwise. Code piping with fluid type and flow direction labels in accordance with Section 09 90 00 PAINTS AND COATINGS. When a food-grade uninhibited propylene-glycol solution is used to heat potable service water, tamper resistant seals must be attached to all fill ports. All propylene-glycol circuits must be labeled "CONTAINS UNINHIBITED FOOD-GRADE PROPYLENE-GLYCOL: INTRODUCTION OF ANY NONAPPROVED FLUID MAY CONSTITUTE A HEALTH HAZARD." All tamper resistant seals must carry the name of the registered engineer or licensed plumber who certifies that only a [30] [50] percent food-grade uninhibited propylene-glycol and water solution has been installed in the system. Install air vents at the high points of the collector array and in the equipment room.

3.2.3.5   Pipe Expansion

Provide expansion of supply and return pipes for changes in the direction of the run of pipe or by expansion loops as indicated. Use expansion loops to provide adequate expansion of the main straight runs of the system within the stress limits specified in ASME B31.1. Provide cold-sprung loops and install where indicated. Provide pipe guides as indicated. Do not use expansion joints in system piping.

3.2.3.6 Valves

****
NOTE: Calibrated balancing valves are required at the outlet of each bank in addition to the ball valve required at this outlet. If the reverse-return piping strategy is properly adhered to, this valve may prove unnecessary. It is specified, however, to allow the array to be flow balanced in the event of improper construction or modification of the array at some later time. The ball valves are required to enable the array to be disconnected for maintenance or repair. Check valves at pump discharges are required to prevent back flow into pumps and are required on the collector loop to prevent fluid cooled in the collectors at night from migrating around the loop to the heat exchanger.
****

Install valves at the locations indicated and where required for the proper functioning of the system. Install valves with their stems horizontal or above. Install gate or ball valves at the inlet and outlet of each bank of internally manifolded collectors. Install calibrated balancing valves with integral pressure taps at the outlet of each bank and at the pump discharge. Mark final setting for each valve on each valve. Install ball valves with a union immediately adjacent. Install gate valves at the inlet and outlet of each pump and also at the inlet and outlet of each heat exchanger. Install a check valve at pump discharges. Pipe discharges of relief valves [where required for high temperature or pressure]to the nearest floor drain or as indicated on system drawings. Give consideration to the fluid temperature and pressure when locating the relief valve discharges. Additionally, evaluate the pipe material of the receiving pipe for high temperature fluids.

3.2.3.7 Foundations

Construct concrete foundations or pads for storage tanks, heat exchangers, pumps, and other equipment covered by this specification in accordance with manufacturer's recommendations and be a minimum of 150 mm 6 inches high with chamfered edges.

3.2.3.8 Grooved Mechanical Joints

Do not utilize grooved mechanical joints.

3.2.4 Control Subsystem

3.2.4.1 Differential Temperature Controller

Install automatic control equipment at the location shown in accordance with the manufacturer's instructions. Install control wiring and sensor wiring in conduit. [Mount collector temperature sensor in a temperature sensor well in the fluid stream along the top manifold of a bank between two adjacent collector units.] [Provide collector temperature sensor by differential temperature controller manufacturer and mount directly on the absorber plate by the manufacturer.] Unless otherwise indicated, provide operators, controllers, sensors, indicators, and like devices when installed on equipment casings and pipe lines with stand-off mounting brackets, bases, nipples, adapters, or extended tubes to provide clearance, not less than the thickness of the insulation, between the surface and the device. Ensure these stand-off mounting items are integral with the devices or standard accessories of the controls manufacturer unless otherwise approved. Clamp-on devices or instruments where direct contact with pipe surface is required are exempt from the use of the above mounting items. Color code and identify all control wiring with permanent numeric or alphabetic codes.

3.2.4.2 Sequence of Operation

****

NOTE: The following on/off set differentials are common for liquid systems:

Pump on = 7 to 11 degrees C 12 to 20 degrees F.
Pump off = 2 to 4 degrees C 3 to 8 degrees F.

****

The differential temperature controller sensing temperature difference between the fluid in a solar collector and water in the storage tank must start solar collector loop [and storage loop] pumps[s] when the temperature differential (Delta T - ON) rises above [8] [_____] degrees C [15] [_____] degrees F, and must stop the pump when the differential (Delta T - OFF) falls below [3] [_____] degrees C [5] [_____] degrees F.

3.3 INSPECTION AND TESTING

Submit an independent testing agency's certified reports of inspections and laboratory tests, including analysis, position of flow-balancing equipment, and interpretation of test results. Properly identify each report. Describe test methods used and compliance with recognized test standards.

3.3.1 Inspection

Make system available for inspection at all times.

3.3.2 Testing Prior to Concealment

3.3.2.1 Hydrostatic Test

Demonstrate to Contracting Officer that all piping has been hydrostatically tested, at a pressure of 862 kPa 125 psi for a period of time sufficient for inspection of every joint in the system and in no case less than 2 hours, prior to installation of insulation. Isolate expansion tank and relief valves from test pressure. Loss of pressure is not allowed. Repair leaks found during tests by replacing pipe or fittings and retest the system. Caulking of joints is not permitted.

3.3.2.2 Cleaning of Piping

Flush system piping with clean, fresh water prior to concealment of any individual section and prior to final operating tests. Prior to flushing piping, isolate or remove relief valves. Cover solar collectors to prevent heating of cleaning fluid, unless cleaning is performed during hours of darkness. Circulate the solution through the section to be cleaned at the design flow rate for a minimum of 2 hours.

3.3.3 Posting Framed Instructions

Post framed instructions under glass or in laminated plastic where directed. Include a system schematic, and wiring and control diagrams showing the complete layout of the entire system. Prepare condensed operating instructions explaining preventative maintenance procedures, balanced flow rates, methods of checking the system for normal safe operation, and procedures for safely starting and stopping the system in typed form, frame as specified above, and post beside the diagrams. Submit proposed diagrams, instructions, and other sheets for approval prior to posting. Post framed instructions before acceptance testing of the system.

3.3.4 Acceptance Testing and Final Inspection

Notify the Contracting Officer 7 calendar days before the performance and acceptance tests are to be conducted. Perform tests in the presence of the Contracting Officer. Furnish all instruments and personnel required for the tests. Electricity and water will be furnished by the Government. Maintain a written record of the results of all acceptance tests to be submitted in booklet form. The tests are as follows:

3.3.4.1 As-Built Drawings

Submit, as a condition of final acceptance, a complete set of as-built system drawings. Clearly indicate the actual condition of the installed solar energy system at the time of the final test.

3.3.4.2 Final Hydrostatic Test

Demonstrate to Contracting Officer that all piping has been hydrostatically tested at a pressure of 862 kPa 125 pounds per square inch for a period of time sufficient for inspection of every joint in the system and in no case less than 2 hours. Isolate expansion tank and relief valves from test pressure. Use gauges in the test that have been calibrated within the 6-month period preceding the test. Test must be witnessed by Contracting Officer. Loss of pressure is not allowed. Repair leaks found during tests by replacing pipe or fittings and retest the system. Caulking of joints is not permitted.

3.3.4.3 System Flushing

For the final inspection, flush the system thoroughly, in no case for less than 2 hours, of all foreign matter until a white linen bag installed in a strainer basket shows no evidence of contamination. Keep the white linen bag in the strainer basket during the entire flushing operation prior to its being presented to the Contracting Officer for approval. The Contracting Officer will inspect the linen bag prior to completion of flushing and approve the flushing operation. Drain system prior to final filling.

3.3.4.4 System Filling

Fill system through indicated connections with [propylene-glycol solution. Mix solution consisting of [30] [50] percent propylene-glycol and [70] [50] percent distilled water by volume] [distilled water] externally to the solar system. Vent air from the system after filling. Ensure system pressure at the high point on the roof is 69 kPa 10 psig minimum.

3.3.4.5 Operational Test

Perform operational test over a period of 48 consecutive hours with sufficient solar insulation to cause activation of the solar energy system during daylight hours. With system fully charged so that pressure at the high point on the roof or the lowest system pressure is a minimum of 69 kPa 10 psig and with fluid and pump[s] energized, [sight flow indicator must indicate flow] [flowmeter must indicate flow as indicated]. Use calibrated balancing valves with pressure taps to indicate bank flow rate as shown.

3.3.4.6 Control Logic

****

NOTE: The following on/off set differentials are common for liquid systems:

Pump on = 7 to 11 degrees C 12 to 20 degrees F.
Pump off = 2 to 4 degrees C 3 to 8 degrees F.

****

By substituting variable resistors for collector and storage tank temperature sensors, demonstrate the differential temperature controller correctly energizes the system pump[s] when the collector sensor indicates a temperature of [8] [_____] degrees C [15] [_____] degrees F greater than the storage tank temperature, as indicated on the controller display panel. Provide differential temperature controller to de-energize the system pump[s] when the displayed temperature of the solar collectors is [3] [_____] degrees C [5] [_____] degrees F greater than the displayed temperature of the storage tank.

3.3.4.7 Temperature Sensor Diagnostics

Demonstrate that the controller will correctly identify open and short circuits on both the solar collector temperature sensor circuit and the storage tank sensor circuit.

3.3.4.8 Overall System Operations

Demonstrate that the solar energy system will operate properly while unattended for a period of at least 72 hours and that the controller will start pump[s] after being warmed by the sun, and that it will properly shut down during cloudy weather or in the evening over a minimum of three complete cycles. Contractor is permitted to manipulate the temperature of the storage tank by the introduction of cold water at local groundwater temperature.

3.4 FIELD TRAINING

Provide a field training course for designated operating and maintenance staff members. Provide training for a minimum period of [_____] hours of normal working time and start after the system is functionally complete but prior to final acceptance tests. Include discussion of the system design and layout and demonstrations of routine operation and maintenance procedures. This training includes: normal system operation and control; flow balancing; detection of a nonfunctioning system due to sensor, controller, and/or mechanical failure; filling, draining, and venting of the collector array; replacement of sensors, collectors, and collector components; collector cleaning and inspection for leaks; and heat exchanger cleaning and expansion tank charging if applicable. Submit [6] [_____] copies of operation and [6] [_____] copies of maintenance manuals for the equipment furnished. One complete set prior to performance testing and the remainder upon acceptance. Manuals must be approved prior to the field training course. Detail the step-by-step procedures required for system filling, startup, operation, and shutdown in the operating manuals. Include the manufacturer's name, model number, service manual, parts list, and brief descriptions of all equipment and their basic operating features. List routine maintenance procedures, possible breakdowns and repairs, troubleshooting guides, piping and equipment layout, balanced fluid flow rates, and simplified wiring and control diagrams of the system as installed in the maintenance manuals.

-- End of Section --