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USACE / NAVFAC / AFCEC **UFGS-22 33 30 (August 2025)**

Preparing Activity: NAVFAC **Superseding**
UFGS-22 33 30.00 10 (August 2020)
UFGS-48 14 13.00 20 (May 2015)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated October 2025
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SOLAR WATER HEATING EQUIPMENT

08/25

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****

SECTION 22 33 30

SOLAR WATER HEATING EQUIPMENT
08/25

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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)**.**
****

****

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: Show the following information on the project drawings:

1. Control equipment operation matrix.

2. Control operations sequence.

3. Details of soft-drawn copper-tubing connectors

to top and bottom headers of solar-collector panel.

4. System diagram.

5. Panel array layout and locations.

6. System equipment locations.

7. Equipment piping details.

8. Mounting details.

9. Schedules in accordance with UFC 3-440-01, "Facility Scale Renewable Energy Systems".
****

PART 1 GENERAL

****
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.
****

1.1 REFERENCES

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

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

use the Reference Wizard's Check Reference feature to update the issue dates.

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

****

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

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

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

AMERICAN SOCIETY OF CIVIL ENGINEERS (ASCE)

ASCE 7-16 (2017; Errata 2018; Supp 1 2018) Minimum Design Loads and Associated Criteria for Buildings and Other Structures

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

ASHRAE 90.1 - IP (2019) Energy Standard for Buildings Except Low-Rise Residential Buildings

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

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

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME A13.1 (2023) Scheme for the Identification of Piping Systems

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 B16.1 (2020) Gray Iron Pipe Flanges and Flanged Fittings Classes 25, 125, and 250

ASME B16.15 (2024) 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 B16.24	(2022) Cast Copper Alloy Pipe Flanges, Flanged Fittings, and Valves Classes 150, 300, 600, 900, 1500, and 2500
ASME B16.26	(2024) Cast Copper Alloy Fittings for Flared Copper Tubes
ASME B16.39	(2025) Malleable Iron Threaded Pipe Unions; Classes 150, 250, and 300
ASME B31.1	(2024) Power Piping
ASME B40.100	(2022) Pressure Gauges and Gauge Attachments
ASME BPVC SEC VIII	(2015) Boiler and Pressure Vessel Codes: Section VIII Rules for Construction of Pressure Vessel
ASME BPVC SEC VIII D1	(2023) BPVC Section VIII-Rules for Construction of Pressure Vessels Division 1
ASME PTC 19.3 TW	(2016) Thermowells Performance Test Codes

AMERICAN SOCIETY OF SANITARY ENGINEERING (ASSE)

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

AMERICAN WELDING SOCIETY (AWS)

AWS A5.8/A5.8M	(2019) Specification for Filler Metals for Brazing and Braze Welding
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 A193/A193M	(2025) Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service and Other Special Purpose Applications
ASTM A194/A194M	(2024) Standard Specification for Carbon Steel, Alloy Steel, and Stainless Steel

	Nuts for Bolts for High-Pressure or High-Temperature Service, or Both
ASTM B32	(2020) Standard Specification for Solder Metal
ASTM 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 B117	(2019) Standard Practice for Operating Salt Spray (Fog) Apparatus
ASTM B152/B152M	(2019) Standard Specification for Copper Sheet, Strip, Plate, and Rolled Bar
ASTM B168	(2019; E 2022) Standard Specification for Nickel-Chromium-Iron Alloys, Nickel-Chromium-Cobalt-Molybdenum Alloy, and Nickel-Iron-Chromium-Tungsten Alloy Plate, Sheet, and Strip
ASTM B209	(2014) Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate
ASTM B209M	(2014) Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate (Metric)
ASTM 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 D3667	(2016) Standard Specification for Rubber Seals Used in Flat-Plate Solar Collectors
ASTM D3832	(1979; R 2011) Standard Specification for Rubber Seals Contacting Liquids in Solar Energy Systems
ASTM E1	(2014; R 2025) Standard Specification for ASTM Liquid-in-Glass Thermometers
ASTM E822	(1992; R 2009) Standard Practice for Determining Resistance of Solar Collector Covers to Hail by Impact With Propelled Ice Balls

ASTM E1160	(2013; R 2021) Standard Guide for On-Site Inspection and Verification of Operation of Solar Domestic Hot Water Systems
ASTM F1199	(2021) Standard Specification for Cast (All Temperatures and Pressures) and Welded Pipe Line Strainers (150 psig and 150 degrees F Maximum)

INTERNATIONAL CODE COUNCIL (ICC)

ICC IBC	(2024) International Building Code

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

MSS SP-25	(2018) Standard Marking System for Valves, Fittings, Flanges and Unions
MSS SP-58	(2025) 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 250	(2020) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA MG 00001	(2024) Motors and Generators

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 780	(2026) Standard for the Installation of Lightning Protection Systems

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

SMACNA 1981	(2024) Seismic Restraint Manual Guidelines for Mechanical Systems, 3rd Edition

SOLAR RATING AND CERTIFICATION CORPORATION (SRCC)

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

SRCC OG-300	(2015) Solar Thermal System Certification Program
SRCC STD 300	(2015) Solar Thermal System Standard

U.S. DEPARTMENT OF DEFENSE (DOD)

UFC 3-301-01	(2023; with Change 4, 2025) Structural Engineering

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

CID A-A-59617	(Basic, Notice 1) Unions, Brass or Bronze, Threaded Pipe Connections and Solder-Joint Tube Connections
CID A-A-60001	(Rev A) Traps, Steam
FS F-T-2907	(Rev A; Notice 1) Tanks, Portable Hot Water Storage

UL SOLUTIONS (UL)

UL 873	(2007; Reprint Feb 2015) Standard for Temperature-Indicating and -Regulating Equipment
UL Electrical Construction	(2012) Electrical Construction Equipment Directory

1.2 SOLAR ENERGY SYSTEM

****

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.

****

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

****

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.

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

Valves; G, [_____]

Instrumentation; G, [_____]

Solar Energy Systems; G, [_____]

Installation; G, [_____]

SD-03 Product Data

Spare Parts

Solar Energy System

Quality Assurance; G, [_____]

Commissioning Plan; G, [_____]

Commissioning Schedule; G, [_____]

Piping; G, [_____]

Instrumentation; G, [_____]

Valves; G, [_____]

Pumps; G, [_____]

Solar Storage Tanks; G, [_____]

Solar Collectors; G, [_____]

Heat Exchangers; G, [_____]

Compression Tanks; G, [_____]

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

Collector Heat Transfer Fluid; G, [_____]

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

Piping System; G, [_____]

SD-06 Test Reports

Inspection and Testing

****

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

****

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

SD-07 Certificates

Welder qualification; G, [_____]

[Cybersecurity Equipment Certification; G, [_____]

] Seismic Certification; G, [_____]

Wind Certification; G, [_____]

Shop Painting System Certification; G, [_____]

SD-08 Manufacturer's Instructions

Solar Energy Systems; G, [_____]

SD-10 Operation and Maintenance Data

Operation and Maintenance Procedures; G[, [_____]]

Solar Energy Systems, Data Package 3; G,

SD-11 Closeout Submittals

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

1.4 QUALITY ASSURANCE

1.4.1 Welder Qualification

Qualify procedures and welders in accordance with with Section 40 05 13.96 WELDING PROCESS PIPING unless a specific welding code is specified 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.

1.4.2 Material And Equipment

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship. Provide products with satisfactory commercial or industrial use for years prior to bid opening, and past performance documentation with consistent design and bill of materials. Include applications of equipment and materials under similar circumstances and of similar size. Where or more items of the same class of equipment are required, products will be from a single manufacturer; the component parts of the item must be the products of the same manufacturer unless stated in the technical section. Submit proof of compliance with requirements of UL, where material or equipment is specified to comply. The label of or listing in UL Electrical Construction will be acceptable evidence. In lieu of the label or listing, a written certificate from an approved nationally recognized testing laboratory (NRTL) equipped to perform such services, stating that the items have been tested and conform to the requirements and testing methods of Underwriters Laboratories may be submitted.

1.4.3 Operation and Maintenance Data

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

a. Troubleshooting guide for solar energy systems[with as-built plans displaying systems components coordinated with activity to organize as required].

b. Solar collector warranty

c. Operation instructions

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

e. Project[as-built] drawings.

1.4.4 "As-Built" and Record Drawings

After completion of construction, submit "As-Built" drawings prepared and certified by the construction contractor, showing in red ink, on-site changes to the original construction details and all underground utilities measured from field benchmarks, accurate to within 25 mm1 inch of centerline of the utility. Immediately record for inclusion into the "As-Built" drawings all modifications to original drawings made during installation. Indicate adequate clearance for operation, maintenance, and replacement of operating equipment devices. After submittal and approval of "As-Built" drawings, submit Record Drawings, prepared and by the project engineer(s) and architect(s), of the original design drawings reflecting all design changes and contractor noted changes in the "As-Built" drawings.

[1.5 CYBERSECURITY EQUIPMENT CERTIFICATION

****

NOTE: Select this option if the solar water heating system includes remote control or remote access capability even if the system is separate from an energy management control system. Exercise a Risk Management Framework (RMF) for implementing cybersecurity. Refer to Section 25 05 11 CYBERSECURITY FOR FACILITY-RELATED CONTROL SYSTEMS and UFC 4-010-06 Cybersecurity of Facility-Related Control Systems (FRCS) for requirements on

incorporating cybersecurity into control system and for general information on the Risk Management Framework (RMF) process as it applies to control system. Coordinate equipment certification with Government's cybersecurity requirements and interpretations.

****

Furnish a certification that control systems are designed and tested in accordance with DoD Instruction 8500.01, DoD Instruction 8510.01, and as required by individual Service Implementation Policy.

]1.6 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.

1.7 WARRANTY

****

NOTE: Warranties on Navy construction: Warranties for equipment, materials, or design, furnished, or workmanship performed by the Contractor, or any subcontractor or supplier, has a duration of one year from the date of final acceptance of the work. An exception is in normal commercial practice, longer warranty periods for particular construction are given. A warranty duration of longer than a year, and not covered normally by the industry, requires a Level III Contracting Officer's written determination documenting that the extra warranty protection is needed.

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.

****

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. Include warranty information, names, addresses, telephone numbers, and procedures for filing a claim and obtaining warranty services. The equipment items must be supported by service organizations which are reasonably convenient to the equipment installation in order to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.[Provide mounting system warranty of minimum 15 years.]

1.7.1 Warranty Exclusion

The warranty must cover all system malfunctions and failures except those resulting from misuse, abuse, neglect, fire, vandalism, acts of nature, or other causes beyond the control of the Contractor or manufacturer.

[1.7.2 Cybersecurity During Warranty Period

****
NOTE: Select this option if the solar water heating system includes remote control or remote access capability.
****

All work performed on the control system after acceptance must be performed using Government Furnished Equipment or equipment specifically and individually approved by the Government.

]1.8 CALCULATION

If construction is approved to deviate from design, provide relevant calculations to demonstrate that new design is satisfactory.

1.9 POSTED OPERATING INSTRUCTIONS

Provide for piping identification codes and diagrams of solar energy systems, operating instructions, control matrix, and troubleshooting instructions. Instructions are to be posted at a place agreed to by the Government.

1.9.1 Maintenance and Accessibility

Collector design must allow for rapid replacement of glass covers. Pumps, pipes, valves, and controls must be accessible to allow for repair or replacement. Water pumps must be located so that leakage does not cause serious damage. The operations and maintenance manual must be developed for the specific design of the solar system and include a valve maintenance schedule. Comply with CFR 1910 Subpart E, Exit Routers and Emergency Planning requirements. Maintenance access must follow OSHA fall protection requirements.

1.10 CERTIFICATIONS

Provide seismic certification and wind certification, prepared by a licensed professional engineer or National Recognized Testing Laboratory, (NRTL) for all components and assembled systems in accordance with ASCE 7-16, ICC IBC, state and local building codes. Seismic and wind certifications must demonstrate system must withstand wind and seismic requirements as installed and remain online and functional after a seismic or wind event.

1.11 HEALTH AND SAFETY RECOMMENDATIONS

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

1.12 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 which must provide efficient operation for a period of 120 days.

PART 2 PRODUCTS

****

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 the latest ASHRAE 90.1.

****

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

Items of the same classification must be 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.] Comply with CFR 1910 Subpart O, Machinery and Machine Guarding requirements.

2.1.5 Solar Energy Systems

****

NOTE: SRCC OG-300 applies to residential and light commercial systems of 450 liters119 gallons or less. SRCC OG-100 applies to the collectors only.

****

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

2.1.6 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

****
NOTE: 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 Bolts and Nuts

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

2.2.2 Gaskets

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

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

2.2.3 Copper Tubing

****
NOTE: Underground tanks which require buried copper tubing are not a recommended method for thermal storage. A design with thermal storage within a building is more ideal for efficiency.

The following paragraphs are tailored for ARMY and AIR FORCE, and NAVY. Select the applicable tailoring option for the project.
****

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

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

2.2.4   Solder-Joint Fittings

ASME B16.22, wrought copper.

2.2.5   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.

2.2.6   Piping Identification Labels

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

2.2.7   Unions

CID A-A-59617, solder joint.

2.2.8   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.

2.2.9   Dielectric Waterways and Flanges

****

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.

****

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. Dielectric flanges must meet the performance requirements described herein for dielectric waterways.

2.2.10   Expansion Joints

2.2.10.1   Bellow Expansion Joints

****

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

****

Corrugated,[unreinforced][or][with[reinforcing][or][equalizing] rings], and[single-bellow][double-bellow] expansion joints. Construct bellows of[copper alloy][nickel-chromium-iron alloy, conforming to

ASTM B168][or][stainless steel].

2.2.10.2 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.]

2.2.11 Pipe Supports

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

2.2.12 Pipe Threads

ASME B1.20.2MASME B1.20.1.

2.2.13 Solder

****

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.

****

ASTM B32, Type Sb5, Sn94, Sn95, or Sn96, with minimum melting 221 degrees C 430 degrees F. Lead solders are not allowed in any portion of the potable water system.

2.2.14 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 cast 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.

2.2.14.1 Bronze Flanges and Flanged Fittings

****

NOTE: This paragraph is tailored for NAVY. Use for Navy projects.

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ASME B16.24.

2.3 VALVES

[Provide end connections as indicated.]Valves must open by turning 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][or][MSS SP-110], Class 125 or 150.

2.3.4   Water Pressure-Reducing Valves

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

2.3.5   Bronze Gate, Globe, Angle, and Check Valves

****

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.

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

****

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

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   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.

2.3.7   Control Valves

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

2.3.7.1 Shutoff and Diverting Control Valves

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

2.3.7.2 Non-Shutoff Mixing Valves

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

2.3.7.3 Valve Operators

Provide electric[two-position][or][proportioning] operators, with oil-immersed gear trains. Two-position operators may be single-direction with[spring-return][or][reversing]construction.[For[reversing][and][proportioning] operators, provide limit switches to limit the lever in either direction unless the operator is the stalling type.] Operators must 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, Pressure and Temperature

2.3.8.1 Air Vents

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NOTE: Locate manual air vents at the high point(s)of the system where air will accumulate.

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[CID A-A-60001, float construction for pressures up to 862 kPa 125 psi.][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. Vent discharges air must be at any pressure up to 1034 kPa 150 psig.

]2.3.8.2 Relief Valves

****

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.

****

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.

[Provide 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.

2.3.9 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. Calibrated balancing valves must 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.

2.4 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.

2.5 STRAINERS

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NOTE: Locate a strainer before the pump to test for system flush.
****

ASTM F1199, removable basket and screen, Style Y pattern, cast iron strainer with pressures to 862 kPa 125 psig, simplex type,threaded or soldered ends, for 50 mm 2 inches and smaller,and flanged ends in accordance with ASME B16.1, for 65 mm 2 1/2 inches and larger; or a combination elbow-strainer with straightening vanes and strainer arranged for horizontal flow.

2.5.1 Combination Strainer and Pump Suction Diffuser

Angle type body with removable strainer basket and internal straightening vanes, a suction pipe support, and a blowdown outlet and plug. Strainer must be in accordance with ASTM F1199, except as modified and supplemented by this specification. Unit body must have arrows clearly cast on the sides indicating the direction of flow.

Casing must have connection sizes to match pump suction and pipe sizes, and be provided with adjustable support foot or support foot boss to relieve piping strains at pump suction. Provide unit casing with blowdown port and plug. Provide a magnetic insert to remove debris from system.

2.6 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. Each gauge range must be selected so that at normal operating pressure, the needle is within the middle-third of the range.

2.7 THERMOMETERS

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

2.8 COPPER SHEETS COPPER ALLOY 110

ASTM B152/B152M.

2.9 ALUMINUM SHEETS

ASTM B209, Alloy 3003.

2.10 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.

2.11 STORAGE TANKS

****

NOTE: Storage tank volume must 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 must 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 paragraph HEAT EXCHANGER below).]Solar system hot water storage tank must have 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. For domestic use, heat the water in the storage tank to a minimum of 60 degrees C 140 degrees F in order to avoid any potential source of Legionnaire's disease.

2.11.1 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), use vertical solar tanks. 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 12 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. Tank design must meet ASHRAE 90.1 - IP standby loss criteria.

2.11.2 Underground Tanks

****

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

****

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. Tank design must meet ASHRAE 90.1 - IP standby loss criteria.

2.11.3 Tank Insulations and Jackets

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

2.11.4 Dielectric Waterways and Flanges

****

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.

****

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 waterway with a water impervious insulation barrier capable of limiting galvanic current between dissimilar metals to 1 percent of short circuit current in a corresponding bimetallic joint.] Provide dielectric waterways and flanges suitable for the temperatures, pressures, and antifreeze encountered. Dielectric flanges must meet the performance requirements described herein for dielectric waterways.

2.12 SUPPLEMENTARY HEAT

****

NOTE: UFC 3-440-01 requires the Supplementary Heat.

The designer should consider a control strategy that prioritizes solar heat and minimizes supplementary energy use, such as a lockout for supplementary heat, when solar output is sufficient

****

Provide supplementary heat source which must supply 100 percent of the system required loads. The auxiliary heater must operate automatically. Common heat delivery system must be shared with the solar system.[Include the supplementary heat design in the solar system design package.]

2.13 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. Each motor must be 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. Integral size motors must be the premium efficiency type in accordance with NEMA MG 00001 or electronically commutated motor (ECM) for improved energy efficiency at low speeds.

2.14 COLLECTOR SUBSYSTEM

****

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 0-3. Evacuated tube collectors should be used in ASHRAE Climate Zones 4 and above or within zones 1-3 when water heating above 60 degrees C 140 degrees F is required.

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NOTE: In accordance with ASHRAE 93 and ASHRAE 96, a solar collector is "a device designed to absorb incident solar radiation and to transfer the energy to a liquid passing through it." Use the liquid flat-plate collector for system design, including cooling applications up to 141 kW 40 tons. Use ASHRAE 93 for glazed collectors and ASHRAE 96 for unglazed collectors. The State of Florida requires all solar collectors to be certified by FSEC (Florida Solar Energy Center). If the project site is not in Florida and the state and local regulations do not prohibit FSEC certified collector, the use of FSEC collector may be considered as an option. Provide lightning protection as required by the local environment. A collector in which the internal risers and headers are in a reverse return arrangement will have uniform flow and uniform heating, but it will be too restrictive to limit only this arrangement. When inlet and outlet tubes are not located conveniently on the collector, the collector will take up additional space, resulting in more exposed roof area between the collector.

****

Liquid flat-plate collectors and evacuated tube collectors[must be][SRCC OG-100 and SRCC CRIS listed][or][Florida Solar Energy Center (FSEC) certified][and][must be tested in accordance with][ASHRAE 93][and][ASHRAE 96]. 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:

2.14.1 Collector Sizes

Maximum filled weight not to exceed 24.40 kg per square meter 5 pounds per square foot of gross collector area.

2.14.1.1 Minimum Performance Parameters

****

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

****

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

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

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

IFP = (A - B)/C

Where:

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

2.14.2   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. Solar collectors must 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.

2.14.2.1   Absorber Plate and Flow Tubes

****

NOTE: The full sheet absorber plates offer the highest performance of absorptive coatings. While the IR reflective coating ensures low thermal emissivity, the oxidic absorption and anti-reflective coatings ensure the maximum level of solar absorption.

The following paragraph is tailored for ARMY and AIR FORCE, and NAVY. Select the applicable tailoring option for the project.

****

Provide copper absorber sheet or plate. Top of absorber plate must be 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. Fabricate of[aluminum][stainless-steel][copper tubes on copper sheet or aluminum][or][copper tubes with copper or aluminum fins]. Provide the absorber rated for [1034 kPa (gage)] [150 psig] [_____] with working pressure of [862 kPa (gage)] [125 psig] [_____]. Provide selective or semi-selective absorber coating with minimum absorptivity 0.90, maximum emissivity 0.12, and minimum breakdown temperature at [204 degrees C] [400 degrees F] [_____].

2.14.2.2   Cover Glazing

****

NOTE: The following paragraph is tailored for ARMY and AIR FORCE, and NAVY. Select the applicable tailoring option for the project.

****

Each collector must have 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. Cover glazing must be Kind FT (fully tempered), Condition A (uncoated surfaces), Type I (transparent flat type), Class 1 (clear), Quality q3 - glazing select; [3][5][or][4] mm[1/8][3/16][or][5/32] inch float glass, conforming to ASTM C1048. Cover glazing must be separated from the collector by a continuous gasket made of EPDM rubber.

2.14.2.3 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.

2.14.2.4 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.

2.14.2.5 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.]

2.14.2.6 Hail Protection

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

2.14.2.7 Casing

****

NOTE: The following paragraph is tailored for ARMY and AIR FORCE, and NAVY. Select the applicable tailoring option for the project.

****

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. Fabricate from at least 20 gage[galvanized steel][or][ASTM B209M ASTM B209 alloy or equivalent aluminum]. Paint collector box with durable baked enamel or powder coat. In the back of case, provide insulation with a heat transfer factor of maximum 0.57 watts per degree C per square meter 0.1 BTU per hour per degree F per square foot. Use only insulation without out-gassing or other breakdown at or under stagnation temperature, such as rigid mineral fiber panels. Fabricate cover frame and glazing channel of[galvanized sheet steel][stainless steel][or][extruded aluminum]. Provide preformed gaskets of EPDM or silicone as specified.

2.14.3   Evacuated Tube Collectors

****

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.

****

Evacuated tube collectors must 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.

]2.14.3.1   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.]Evacuated tubes must incorporate "plug and play" design where tubes can be removed or replaced without disabling the entire system.

2.14.4   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.

2.14.5 Solar Collector Performance

****

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. The y-intercept must be 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.

Manufacturer's recommended volumetric flow rate and the design pressure drop at the recommended flow rate must be as shown. Manufacturer's recommendations must allow at least seven collectors to be joined per bank while providing for balanced flow and for thermal expansion considerations.

2.15 SOLAR COLLECTORS ARRAY

2.15.1 Net Absorber Area and Array Layout

****

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. Flow through the array must be in balance at the proper flow rates, while maintaining a maximum velocity limit of 1.5 m/s 5 ft/s. 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 four and no more than seven 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.

2.15.2 Piping

****
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.

Each collector bank must be 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.

2.15.3 Supports for Solar Collector Array

****

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 SEISMIC CONTROL FOR NONSTRUCTURAL COMPONENTS and 23 05 48.19 SEISMIC BRACING FOR MECHANICAL SYSTEMS must be included in the contract documents. Support structures provided by the collector manufacturer may be used if they meet the stated specification.

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NOTE: In hostile environments, the additional cost of stainless steel components may be justified. Manufacturer's standard construction material is acceptable only in noncoastal and noncorrosive environments defined as Environmental Severity Classification Category C1 and C2 as determined by Tables A-1 and A-2, Appendix A, UFC 1-200-01 DOD Building Code. All fasteners for collector aluminum frames must be stainless steel. Galvanized fasteners must not contact roof mounted collector frames or racking. Ground mounted system must withstand the expected wind loads for the location. Coordinate with the structural engineer. Coordinate the ground mounted system foundation type with the geotechnical report.

****

[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.][Use a stainless steel, galvanized steel, or aluminum support structure. Do not use wood or plastic components for support.][Provide stainless steel support structure for collector array in accordance with Section[05 50 13 MISCELLANEOUS METAL FABRICATIONS][05 50 14STRUCTURAL METAL FABRICATIONS].] Use array mounting hardware compatible with the site considerations and environment. Select mechanical hardware for corrosion resistance and durability. Use support structure to secure collector array at the tilt angle with respect to horizontal and orientation with respect to true south as shown. Support structure must withstands static weight of filled collectors and piping, wind, snow, seismic, and other loads as required by ASCE 7-16 and ICC IBC. Submit calculations provided by the licensed professional structural engineer for the array mounting system and its attachment to the structure. Seismic details must[conform to UFC 3-301-01 and Sections 13 48 73 SEISMIC CONTROL FOR NONSTRUCTURAL COMPONENTS and 23 05 48.19 SEISMIC BRACING FOR MECHANICAL SYSTEMS][be as shown on the drawings]. Support structure must allow access to all equipment for maintenance, repair, and replacement. Design must include fall protection prevention systems compatible with the job tasks and work environment.

[2.16 LIGHTNING PROTECTION SYSTEM

****

NOTE: Provide a lighting risk assessment calculation in accordance with UFC 3-501-01 Electrical Engineering and UFC 3-575-01 Lightning and Static Electricity Protection Systems requirements, and if lighting protection is a design requirement, include this paragraph in the Specification.

****

Provide Lightning Protection for electrical and mechanical systems in accordance with Section 26 41 00 LIGHTING PROTECTION SYSTEM and NFPA 780.

]2.17 TRANSPORT SUBSYSTEM

2.17.1 Heat Exchangers

****

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 determines 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.

****

****

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. Use titanium or nickel-brazed stainless steel heat exchangers in spas due to high temperature water and high chlorination.

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NOTE: All materials used in the heat exchanger must be compatible with the fluids used.

****

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NOTE: The following paragraph is tailored for ARMY and AIR FORCE, and NAVY. Select the applicable tailoring option for the project.

****

Thermal capacity on the storage side of the heat exchanger must be greater than or equal to the thermal capacity on the collector side of the heat exchanger. The storage sub-system volumetric flow rate must be at least 0.9 times that of the total array volumetric flow rate. Perform heat exchanger construction and testing in accordance with ASME BPVC SEC VIII D1 and list for use on potable water systems. Use minimum design pressure rating of 862 kPa 125 psig. Heat exchanger must be 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. Heat exchanger must be 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. 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.]

2.17.1.1 Plate-and-Frame Construction

****
NOTE: The following paragraphs are tailored for ARMY and AIR FORCE, and NAVY. Select the applicable tailoring option for the project.
****

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. Plate-type heat exchanger must be able to be cleaned. Provide gaskets consisting of EPDM rubber or Viton. All plate heat exchanger characteristics must be as indicated.

[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.

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

****
NOTE: The following paragraph is tailored for ARMY and AIR FORCE, and NAVY. Select the applicable tailoring option for the project.
****

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. Tubes must be 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. [Double wall vented,][Straight tube][or]["U" tube][as indicated]. Low temperature water[mixture] must pass through tubes. High temperature water[mixture] must pass through shells. Fabricate tubes from [16 mm][20 mm] [5/8 inch][3/4 inch] or[stainless steel][or][seamless No. 20 BWG cuprous-nickel (90-10)]. Provide tube bundles removable through flanged openings.

2.17.1.3 Coil Heat Exchanger

Heat exchanger must be 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, heat exchanger piping must consist of double wall construction.

2.17.2 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]. Pumps must 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. Motors must 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.

[2.17.2.1 [Booster][and][Circulating] Pumps

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

[Section 23 21 23 HYDRONIC PUMPS, centrifugal][;][pump styles as indicated]. Provide flanged inlets and outlets, mechanical seals, flexible couplings, and electronically commutated motors (ECM). Select pumps to operate not more than 5 percent below and on the shut-off side of the maximum efficiency point of the impeller curve. Provide bronze or cast iron body construction, bronze or stainless steel fitted.

]2.17.3 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.

2.17.4 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. Tank volume must be 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.

2.17.5 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.
****

[Solar collector loop fluid must be 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.]

2.17.5.1 Collector Heat Transfer FluidHeat Transfer Fluid

****
NOTE: If a glycol mixtures is used, the designer must consider the decrease heat transfer capacity of the system in calculation to address hot water requirements and efficiency.
****

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

Conform to the following:

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

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

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

d. Fluid stability of 5 years.

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

2.17.6 Solar-boosted Domestic Water Heaters

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

2.17.7 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. Maximum operating pressure must be no less than 50 PSI. Maximum temperature less than 95 degrees C 200 degrees F is unacceptable.

2.18 INSULATION

****

NOTE: The following paragraph is tailored for ARMY and AIR FORCE, and NAVY. Select the applicable tailoring option for the project.

****

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 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. Follow Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS requirements.

2.19 CONTROL AND INSTRUMENTATION SUBSYSTEM

Use corrosion resistant materials for wetted parts of instruments.

2.19.1 Solar Controller

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

2.19.1.1 Differential Temperature Control

Factory assembled and packaged device.

2.19.1.2 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.

[2.19.1.3 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.

]2.19.1.4 Controller Enclosure

NEMA 250; Weathertight rated to NEMA 4X.

2.19.2 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. Controller must be 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.

[2.19.3 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.

]2.19.4 Pressure Gages

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

2.19.5 Tank Gages

Provide[buoyant force;][diaphragm;][or][purge, bubble-pipe] type Gage[s].

2.19.6 Thermistor Temperature Sensors

****

NOTE: UFC 3-440-01 allows using platinum resistance temperature detectors (RTDs) also.

****

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.

[2.19.7 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 10 amperes at 120 Vac].][Provide a switch with ON, OFF, and AUTO positions.] Provide weathertight enclosures.

]2.19.8 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.

2.19.9 Thermometers

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

2.19.10 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. Venturi length must be 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.

2.19.11 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.

2.19.12 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. [Solar Differential Controller with]Kilojoule BTU Meter: [Controller conforming to UL 873 with]Sensing and Monitoring device to measure and display the heat energy produced by the solar system, with minimum sensitivity of 0.5 percent over the entire scale. Provide electromechanical kJ BTU counter plus digital-panel meter indicating sensor temperatures, differential temperature, flow rate, and watt BTU per minute or hour.

b. [Water][and][Heat Transfer Fluid]Leak Detection: UL-listed system consisting of a sensor probe, control panel, and LED indicators for[water; yellow,][and][heat transfer fluid; red,] with audible alarm at minimum 75 dB sound level; reference 10 exponential minus 12 watts.

2.19.13 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. Maximum operating pressure must be no less than 862 kPa 125 psi. Maximum operating temperature must be no less than 121 degrees C 250 degrees F.

2.20 SOLAR COLLECTOR CONTROL SEQUENCES

As indicated in paragraph SEQUENCE OF OPERATION.

2.21 PAINTING AND FINISHING

****

NOTE: For corrosion protection, select the manufacturer's standard finish corresponding to the Environmental Severity Classifications (ESC) and humid locations following UFC 3-190-06 Protective Coatings and Paints and ASHRAE 90.1-2019 requirements. UFC 1-200-01, section titled "Corrosion Prone Locations" identifies Climate Zones 3C, 4C, or 5C as requiring additional corrosion protection. Humid locations are in Climate Zones 0A, 1A, 2A, 3A, 3C, 4C, and 5C. To determine ESC for specific project locations, use the latest ASHRAE United States Climate Zones Map.

****

New equipment painting must be factory applied or shop applied, and must be as specified herein.

2.21.1 Factory Painting System

2.21.1.1 Inside the Building

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

2.21.1.2 Outside the Building

Equipment and component items, when fabricated from ferrous metal and located outside the building, must be factory finished with the manufacturer's standard finish for project location[in Climate Zone [_____]].

2.21.2 Shop Painting System for Metal Surfaces

Clean, pretreated, prime and paint metal surfaces; except aluminum surfaces need not be painted. Apply coatings to clean dry surfaces. Clean the surfaces to remove dust, dirt, rust, oil and grease by wire brushing and solvent degreasing prior to application of paint, except metal surfaces subject to temperatures in excess of 50 degrees C 120 degrees F must be cleaned to bare metal.

Where more than one coat of paint is specified, apply the second coat after the preceding coat is thoroughly dry. Lightly sand damaged painting and retouch before applying the succeeding coat. Color of finish coat must be aluminum or light gray.

a. Temperatures Less Than 50 Degrees C 120 Degrees F: Immediately after cleaning, the metal surfaces subject to temperatures less than 50 degrees C 120 degrees F must receive one coat of pretreatment primer applied to a minimum dry film thickness of 0.0076 mm 0.3 mil, one coat of primer applied to a minimum dry film thickness of 0.0255 mm 1 mil; and two coats of enamel applied to a minimum dry film thickness of

0.0255 mm 1 mil per coat.

b. Temperatures Between 50 and 205 Degrees C 120 and 400 Degrees F: Metal surfaces subject to temperatures between 50 and 205 degrees C 120 and 400 degrees F must receive two coats of 205 degrees C 400 degrees F heat-resisting enamel applied to a total minimum in thickness of 0.05 mm 2 mils.

c. Temperatures Greater Than 205 Degrees C 400 Degrees F: Metal surfaces subject to temperatures greater than 205 degrees C 400 degrees F must receive two coats of 315 degrees C 600 degrees F heat-resisting paint applied to a total minimum dry film thickness of 0.05 mm 2 mils.

2.21.2.1 Certification

Provide certification that the shop painting system applied withstands 125 hours in a salt-spray fog test, except that equipment located outdoors must withstand 500 hours in a salt-spray fog test. Salt-spray fog test must be in accordance with ASTM B117, and for that test the acceptance criteria must be as follows: Immediately after completion of the test, the paint must show no signs of blistering, wrinkling, or cracking, and no loss of adhesion; and the specimen must show no signs of rust creepage beyond 3 mm 0.125 inch on either side of the scratch mark.

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 Solar Collector System

****

NOTE: Disinfect domestic water systems, if connected with solar collector panels. Provide disinfections 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.

3.2.2 Collector Subsystem

3.2.2.1 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 (to favor winter output). 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.
d. Provide a minimum space of 100 mm 4 inches between the collector and the roof.
****

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 4 inches above roof surface.] Keep the collectors out of the shade between 9 a.m. and 3 p.m. when the bulk of the energy collection occurs. Array azimuth angle apples to the direction of the collector faces. Design the array's azimuth angle within plus or minus 20 degrees from due south.[Group internal-manifold collectors into banks ranging from four to seven collectors, with each bank containing the same number of collectors to maintain uniform flow throughout the array and minimize thermal expansion.] 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. Roof penetrations for the array supply and return piping and sensor wiring conduit must be without leaking and allow movement due to temperature expansion. For installation on new roof, coordinate with roof manufacturer of new roof and obtain certificate. For installation on existing roof, coordinate with activity to provide certificate of continued validity of warranty from manufacturer.

3.2.2.2 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.

3.2.2.3 Piping Installation

Accurately cut pipe to measurements established on site and work into place without springing or forcing. Locate piping out of the way of windows, doors, openings, light fixtures, electrical conduit, equipment, and other piping. Provide for expansion and contraction. Do not bury, conceal, or insulate until piping has been inspected, and tested. Locate joints where they may be readily inspected. Provide flexibility in piping connected to equipment for thermal stresses and vibration. Support and anchor piping connected to equipment to prevent strain from thermal movement and weight from being imposed on equipment.[Provide seismic restraints in accordance with SMACNA 1981.] Install hangers and supports in accordance with MSS SP-58, unless otherwise indicated.

3.2.2.3.1   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.

3.2.2.3.2   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.

3.2.2.3.3   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.

3.2.2.3.4   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.

3.2.2.3.5   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.

3.2.2.3.6   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.

3.2.2.3.7   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.

3.2.2.3.8   Flashing

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

3.2.2.3.9   Escutcheons

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

3.2.2.3.10 Drain Lines

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

3.2.2.3.11 Insulation and Identification

Insulate piping in accordance with Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS.[Frostproof air vents by insulating or shielding from night sky reverse radiation.] After piping has been insulated, apply identification labels and arrows in accordance with ASME A13.1. Apply identification over the insulation jacket of piping. Provide two copies of the piping identification code framed under glass and install where directed. Where insulation is exposed to the exterior of a building, sunlight, or the elements, insulation must be shielded from the elements with appropriate aluminum, stainless steel, or UV-inhibited PVC jacketing.

3.2.2.4 Excavating and Backfilling

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

****

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

3.2.2.5 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] [_____].

3.2.2.6 Array Support

Install array support in accordance with the recommendations of the collector manufacturer and licensed profession structural engineer. 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. Provide fall protection prevention systems compatible with the job tasks and work environment. Follow the manufacturer required space around the array for maintenance.

3.2.3 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.

3.2.4   Transport Subsystem

3.2.4.1   Flow Rates

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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.

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 determines 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. Storage loop flow rate must be 1.25 times the collector loop flow rate.][Base system flow rate on recommended collector flow rate, and as indicated.]All flow rates must be below 1.5 meters/second 5 feet/second.

3.2.4.2 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.]Drain line sizes from the pumps must be 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.

3.2.4.3 Expansion Tank

Install expansion tank on suction side of pump.

3.2.4.4 Piping, Valves, and Accessories

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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.

3.2.4.5 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.

3.2.4.6 Valves

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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.

Install ASSE 1017 temperature controlled (master mixing valve) to lower temperature per UFC 3-420-01 immediately downstream of the water heater [and][or] storage tank as close to the fixture(s) as possible in order to reduce the amount of stored tempered water in the pipes in accordance with ASSE 1017.

3.2.4.7 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.

3.2.4.8 Grooved Mechanical Joints

Do not utilize grooved mechanical joints.

3.2.5 Control Subsystem

3.2.5.1 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. These stand-off mounting items must be 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.

3.2.5.2 Sequence of Operation

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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

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].

3.3.2.1 Piping Test

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

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Prior to testing, equipment and components that cannot withstand the tests must be properly isolated.[Pneumatically test new piping for leakage using air at a pressure of 138 kPa (gage) 20 psig or][Test new water piping for leakage using water at a pressure of at 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 must be no evidence of leakage, as detected by a reduction in test pressure. Should a reduction occur, locate leaks, repair, and repeat the test.

3.3.2.2 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.

3.3.2.3 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. System pressure at the high point on the roof must be 69 kPa 10 psig minimum.

3.3.4.5 Control Logic

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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.

3.3.4.6 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.

3.3.4.7 Mechanical Systems Tests

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

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Perform tests on mechanical systems, including pumps, controls, controlled valves, and other components in accordance with manufacturer's written recommendations. Test entire system in accordance with[Section 23 05 93 TESTING, ADJUSTING, AND BALANCING FOR HVAC] [_____] and ASTM E1160.

3.3.4.8 Operation 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.

3.4 FIELD QUALITY CONTROL

3.4.1 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.

3.4.2 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 man day, in the operating and maintenance of equipment. Notify the Contracting Officer in writing, prior to scheduling instructions.

3.5 COMMISSIONING

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NOTE: Section 01 91 00.15 BUILDING COMMISSIONING is intended for building systems, however, the basic requirements are applicable to Solar Water Heating Systems commissioning processes. Section 01 91 00.15 will need to be tailored for the Solar Water Heating Systems when compiling project specifications.

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Conduct Commissioning, after the system is installed and is ready for operation, in accordance with Section 01 91 00.15 BUILDING COMMISSIONING.

3.5.1 Commissioning Agent Qualification

Individual qualified in testing (e.g., professional engineer, factory-certified technician) must perform or directly supervise commissioning tests.

3.5.2 Commissioning Plan and Schedule

Develop and implement a commissioning plan and commissioning schedule in accordance with Section 01 91 00.15 BUILDING COMMISSIONING.

3.5.3 Start-up Pre-functional Checklists

Carry out a checklist of startup requirements and conduct a series of safety tests which must show proper installation, safe operation, and performance conforming to specification.

3.5.4 Functional Performance Testing

Prepare test procedures and conduct functional performance testing of the installed system. Coordinate test requirements with a technical representative of the collector manufacturer.

3.5.5 Functional Performance Testing Results

Coordinate, observe and record the results of the functional performance testing. Coordinate retesting as necessary until satisfactory performance is verified. Verify the intended operation of individual components and system interactions under various conditions and modes of operation. Document items of non-compliance in materials, installation or operation. Immediately address observed non-conformance and deficiencies in terms of notification to responsible parties, and provide recommended actions to correct deficiencies.

3.6 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.

3.7 INSTRUCTIONS TO THE GOVERNMENT PERSONNEL

Upon completion of the work and at a time approved by the Contracting Officer, provide instructions by a qualified instructor to the Government personnel in the proper adjustment, system operation, and maintenance of the specified systems and equipment, including pertinent safety requirements as required. Government personnel must receive training comparable to the equipment manufacturer's factory training. Instructor must provide a separate training course for the monitoring system.

3.7.1 Instructor's Qualification Resume

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NOTE: Use the most appropriate and available option to provide the necessary training.

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Instructor(s) must be employee(s) of[installer][manufacturer][certified solar water heating system training program]. Instructors must be thoroughly familiar with all parts of the installation and trained in operating theory as well as practical operation and maintenance work. Submit the name(s)and qualification resume(s)of instructor(s)to the Contracting Officer for approval.

3.8 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 --