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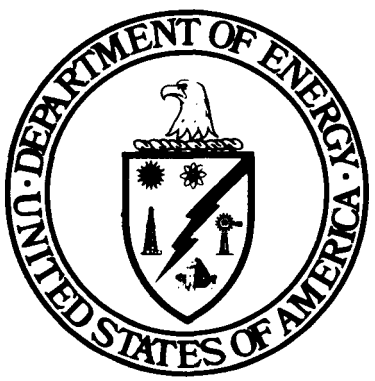
SOLAR/2028-78/50

Solar Project Description

HOGATE'S RESTAURANT
Washington, D.C.
May 9, 1978



U.S. Department of Energy

National Solar Heating and Cooling Demonstration Program

National Solar Data Program

NOTICE

Solar/2028-78/50
Distribution Category UC-59

SOLAR PROJECT DESCRIPTION FOR HOGATE'S RESTAURANT

Prepared for the
Department of Energy
Office of Assistant Secretary for
Conservation and Solar Applications

Under Contract Number
EG-77-C-01-2522

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By

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In Cooperation with
IBM Corporation, Federal Systems Division
Mueller Associates, Incorporated
The Ehrenkrantz Group

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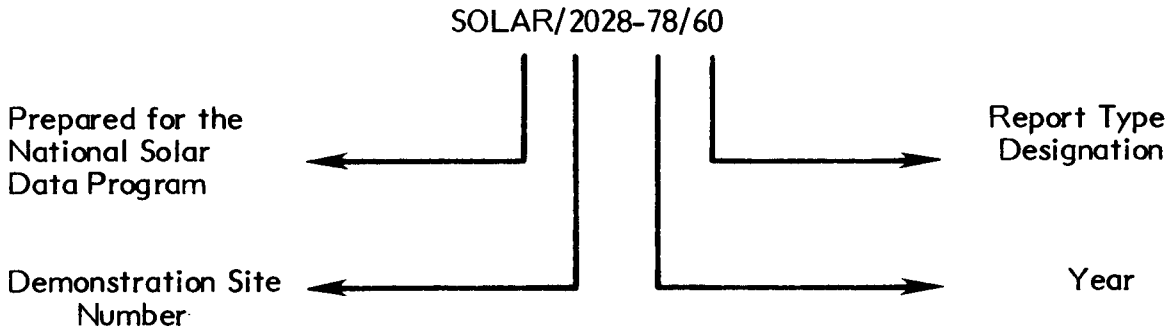
NATIONAL SOLAR DATA PROGRAM REPORTS

Reports prepared for the National Solar Data Program are numbered under a specific format. For example, this report for the Hogate's Restaurant project site is designated as SOLAR/2028-78/60. The elements of this designation are explained in the following illustration:



Demonstration Site Number:
Each project site has its own discrete number - 1000 through 1999 for residential sites and 2000 through 2999 for commercial sites.

Report Type Designation:
This number identifies the type of report, e.g.,

- Monthly Performance Reports — designated by the numbers 01 (for January) through 12 (for December);
- Solar Energy System Performance Evaluations — designated by the number 14;
- Solar Project Descriptions — designated by the number 50;
- Solar Project Cost Reports — designated by the number 60.

These reports are disseminated through the U.S. Department of Energy, Technical Information Center, P.O. Box 62, Oak Ridge, Tennessee 37830.

I. FOREWORD

The National Program for Solar Heating and Cooling is being conducted by the Department of Energy as mandated by the Solar Heating and Cooling Demonstration Act of 1974. The overall goal of the Federal Demonstration Program is to assist in the establishment of a viable solar industry and to achieve a substantial reduction in fossil fuel use through widespread use of solar heating and cooling applications. An analysis and synthesis of the information gathered through this program will be disseminated in site-specific reports and summary documents as products of the National Solar Data Program. These reports will cover topics such as:

- Solar Project Description
- Design/Construction Contractor Final Report
- Project Costs
- Maintenance and Reliability
- Operational Experience
- System Performance Evaluation
- Monthly Performance Reports

The Solar Project Description is prepared for the purpose of documenting the project description in the "as-built" state. Information contained herein has been extracted from data collected during site visits and from reference documents such as the project proposal, designer specifications, contractor submittals, manufacturers literature, photographs, "as-built" drawings and other project documentation as available. The remaining reports in this series will rely on the Solar Project Description for specific site details.

II. EXECUTIVE SUMMARY

The following is a brief summary of the Hogate's Restaurant solar installation. Major features of this system include:

- Collector Type -- Liquid, flat plate
- Freeze Protection -- Antifreeze
- Application -- Restaurant, process hot water
- Storage -- Liquid, exterior, on-grade
- New or Retrofit -- Retrofit
- Performance Evaluation Instrumentation -- Yes
- Site-Specific Features -- Two heat exchangers in series

Solar energy is used to preheat process water for this 900 seat restaurant on the north bank of the Potomac River in Washington, D.C. The solar energy system was retrofitted to the building during the summer and autumn of 1977.

The system utilizes 300 Sunworks collectors with a total effective aperture area of 5,840 square feet. The collectors face 45° west of south at a tilt angle of 55° from the horizontal because of building constraints. The collectors are mounted in two banks, each two collectors high on a steel I-beam support structure that runs parallel to the sloped lines of the two existing mansard roofs.

All collectors are piped in parallel, and balancing valves are used for flow balancing. A propylene glycol and water mixture is used in the collectors, and the fluid is pumped through two heat exchangers in series. On the other side of the heat exchangers, duplex pumps circulate water from the storage tanks and back to the heat exchangers. On demand for hot water in the restaurant, preheated water flows from the tanks to a gas-fired boiler as cold water make-up is fed to the tanks. All the pumps, heat exchangers, and controls are located in a mechanical equipment room in the penthouse at the same level as the collectors. The two 5,000 gallon pressurized storage tanks are located two floors below the equipment room in a parking garage. All system piping is copper insulated

with fiberglass. A canvas jacket is used as interior piping and an aluminum jacket is used on exterior piping.

The system has been fully instrumented for performance evaluation and has been integrated into the National Solar Data Network. It has been in operation since August 1977.

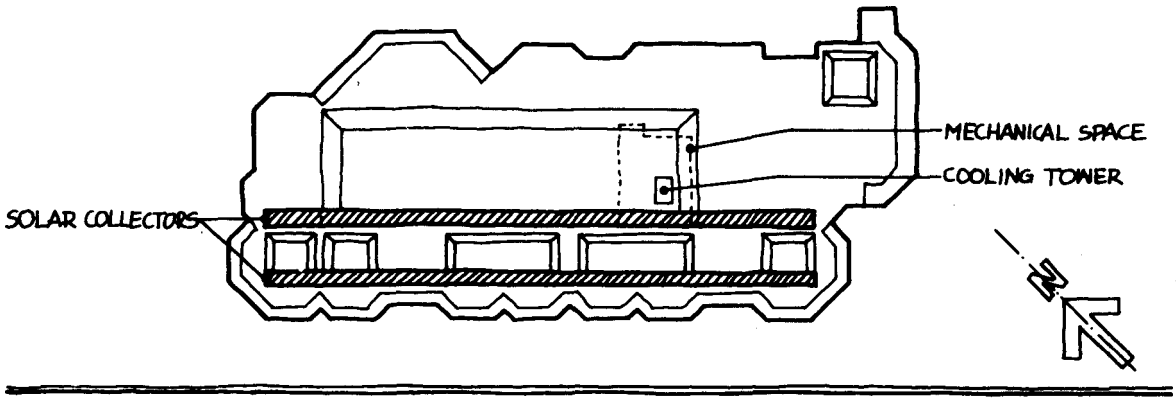


Figure III-1. Site Plan

Site Description

- Special topographic or climatic conditions - Located on the northern bank of the Potomac River Tidal Basin
- Latitude - 39° N
- Annual degree days (65° F base)
  - Heating - 4,087
  - Cooling - 1,554
  - Data location - Washington, D.C.
  - Data reference - Local Climatological Data Annual Summaries for 1976, Department of Commerce, National Oceanic and Atmospheric Administration
- Average horizontal insolation
  - January - 586 Btu/ft^2/day

- July - 1,948 Btu/ft^2/day
- Data location - Washington, D.C.
- Data reference - Duffie, Klein, Beckman, Solar Heating Design by the F-Chart Method, Wiley-Interscience Publication, 1977.

- Site topographic description - Flat, with the Potomac River Tidal Basin to the south
- Shading - None

Building Description

- Occupancy - Restaurant with 900 seats
- Total area - Approximately 45,000 ft^2
- Solar conditioned area - None, solar energy system preheats domestic water for the kitchens
- Height - 2-story
- Roof slope - Flat
- Roof
  - Structural frame
    - Flat section - Steel frame with metal deck
    - Mansard roof section - Steel frame with metal edge and gypsum plank
  - Exterior finish
    - Flat section - Built-up roof with crushed stone finish
    - Mansard roof section - Ribbed metal siding
  - Protection for roof - None

Domestic Hot Water

- Daily water demand - 10,000 gal at 140° F
- Solar - The solar system supplies about 55% of demand
- Auxiliary - Boiler fired by natural gas

IV. SOLAR SYSTEM DESCRIPTION

A. General Overview

The solar energy system for Hogate's preheats service water for the kitchen facilities and is represented in figure IV-A-1. The major components include 6,213 ft^2 of Sunworks double-glazed solar collectors, two 5,000 gallon storage tanks, pumps, and a conventional gas-fired boiler.

Subsequent sections describe the collector, storage, storage-to-load, auxiliary energy, and control subsystems. Figures V-B-1 and V-B-2 show detailed system schematics. Appendices A and B present a glossary and legend of symbols.

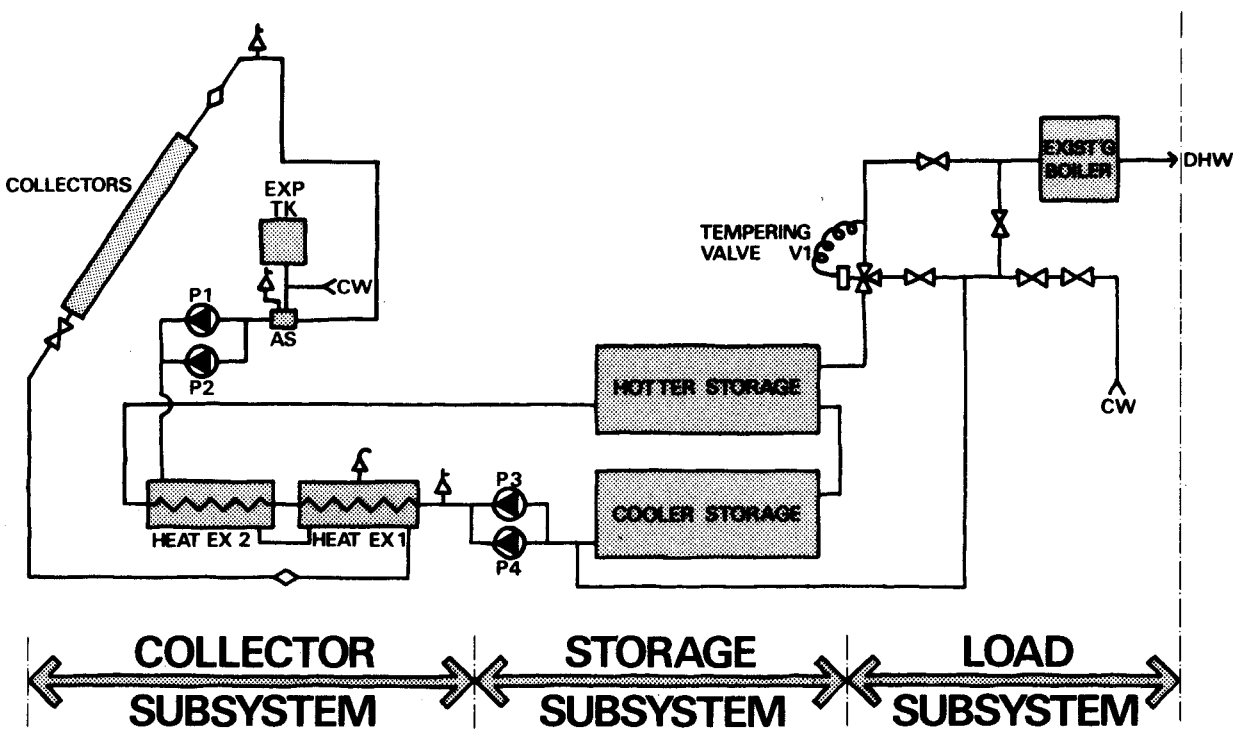


Figure IV-A-1. General Overview

B. Collector Subsystem

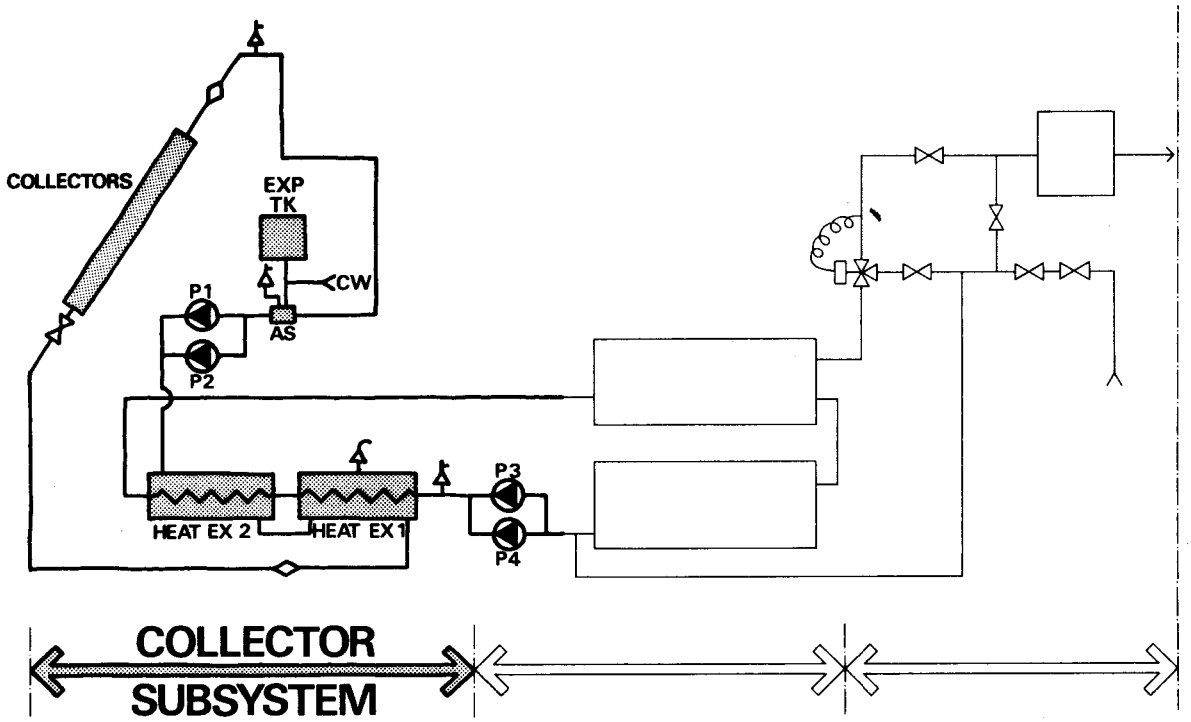


Figure IV-B-1. Collector Subsystem

General Description

The 5,840 square feet of solar collectors are mounted in two banks on the roof at a 55^{o} tilt angle to the horizon. These banks are piped in parallel and are supported by welded steel beams. Due to the orientation of the existing building, the collectors face 45^{o} west of south.

The collectors have double-glazed tempered glass and copper absorber plates that are covered with a selective coating. Freeze protection is provided by a water/propylene glycol solution.

Collectors

- Type - Flat plate
- Manufacturer - Sunworks

- Number - 300
- Collector orientation - 45^{o} west of south
- Angle - 55^{o} from horizontal
- Total gross collector area - 6,213 ft^2
- Total net collector area - 5,840 ft^2
- Collector Enclosure
    - Frame material - Bronze anodized aluminum
    - Gross collector - 20.71 ft^2
    - Effective absorber area - 18.68 ft^2
    - Overall size - 7 ft long x 2 ft 11½ in. wide by 4 in. thick
    - Filled weight - 141 lb

Collector Piping--above roof (see figure IV-B-2)

- Piping between collector to manifold
    - Material - Copper, type M
    - Diameter - 1 in.
    - Approximate length per collector - 7 in.
    - Installation technique - Sweated joints
    - Insulation - 1 in. isocyanurate, R-6
    - Waterproofing - Aluminum cover
- Manifold and branch piping
    - Piping configuration - Reverse return
    - Material - Copper, type L
    - Size - Varies from 1 in. to 2½ in.
    - Approximate total length - 1,200 ft
    - Insulation - 2 in. of fiberglass, R-8

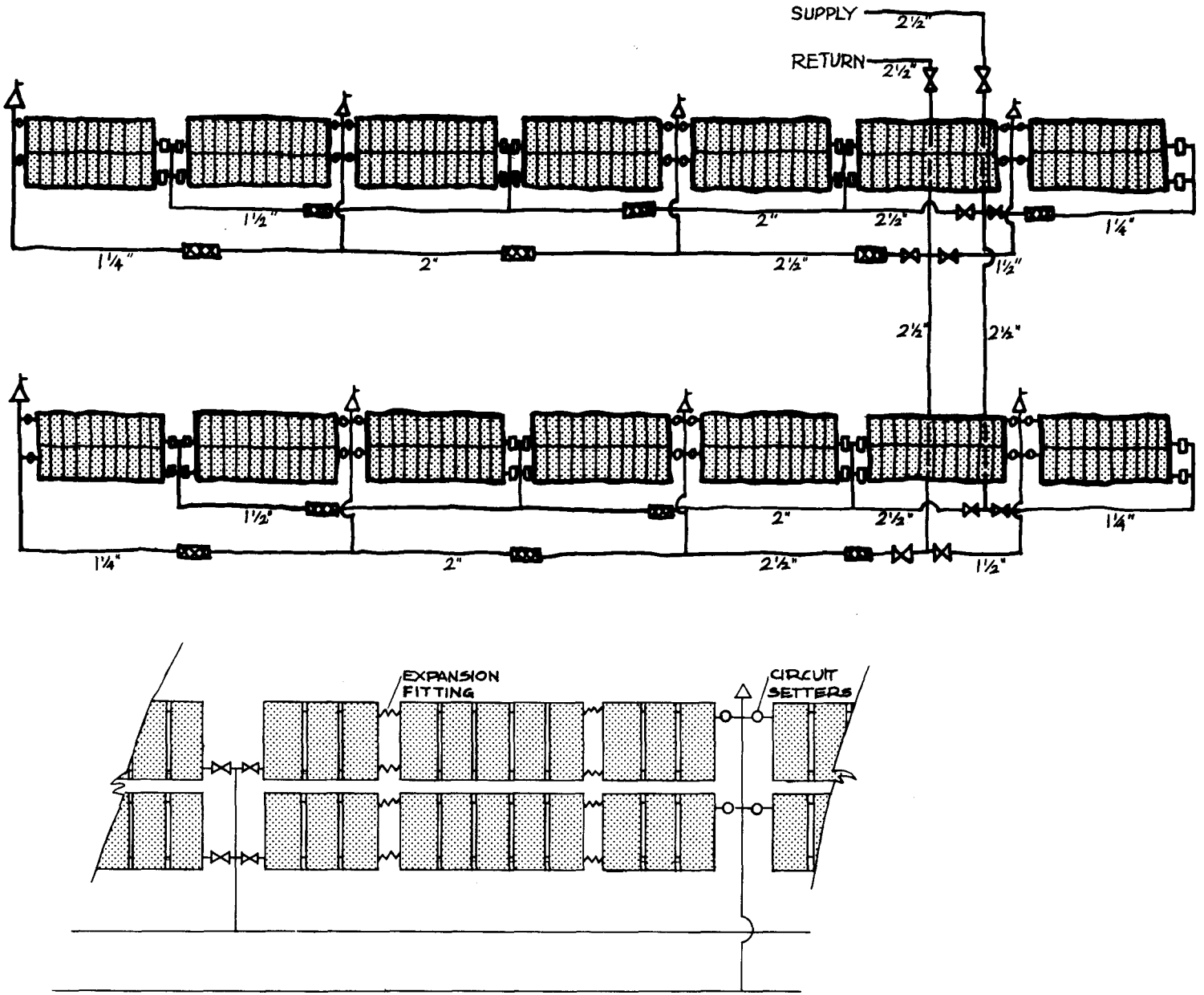


Figure IV-B-2. Collector Array Configuration

- o Waterproofing - Aluminum covers which snap together along long joints and sealed between layers at the ends (manufactured by Johns-Mansville)

- o Supply and return piping support - Rollers with galvanized sheet metal support over rollers. No galvanic protection is provided.

- o Piping wall penetration - Sleeve filled with oakum and caulked

- Automatic vents - Manufactured by Sarco, 1 for each collector group

- Valves

  - o Balance

    -Type - Bell and Gossett Circuit Setter

    -Location - 1 each return per unit for a group of 11 collectors

    -Number - 28

  - o Shut off

    -Type - Gate

    -Location - 1 at each supply per unit for a group of 11 collectors

    -Number-28

- Collector Support (see figures IV-B-3 and IV-B-4)

  - o General Description - The flat section has triangular steel supports that are welded to the existing steel roof structure and support three horizontal steel beams that are attached to the collectors. Roof penetrations are protected by pitch pockets. The sloped section has short steel beams that are welded to the existing steel roof structure and support a sloped steel member. The member supports horizontal steel beams that are attached to the collectors. The ribbed siding penetrations are first sealed by 16-ounce lead-coated copper molding around the opening to conform to ribbed siding and then caulked.

- Structural framing material - Steel

- Framing finish - Paint

- Fasteners - Welded

- Collector attachment - Power-screwed through collector flange to steel supporting beam with an 1/8 in. acrylic plastic spacer to separate the aluminum collector from the steel beams (see figure IV-B-5)

Piping (below roof)

- Material - Copper, type L
- Size - 2 1/2 in.
- Insulation - 2 in. of fiberglass wrapped by canvas, R-8
- Balance valves-Manufactured by Bell and Gossett, located by the collector pump

Mechanical Equipment

- Pumps (P-1 and P-2)
  - Location - Mechanical room
  - Manufacturer/Model Number - Taco/1641
  - Type - Centrifugal
  - Power - 3 hp
  - Flow rate - 130 gal/min
  - Head - 55 ft
- Pumps (P-3 and P-4)
  - Location - Mechanical room
  - Manufacturer/Model Number - Taco/1632
  - Type - Inline, centrifugal
  - Power - 3/4 hp
- Expansion tank
  - Material - Copper bearing steel
  - Capacity - 60 gal

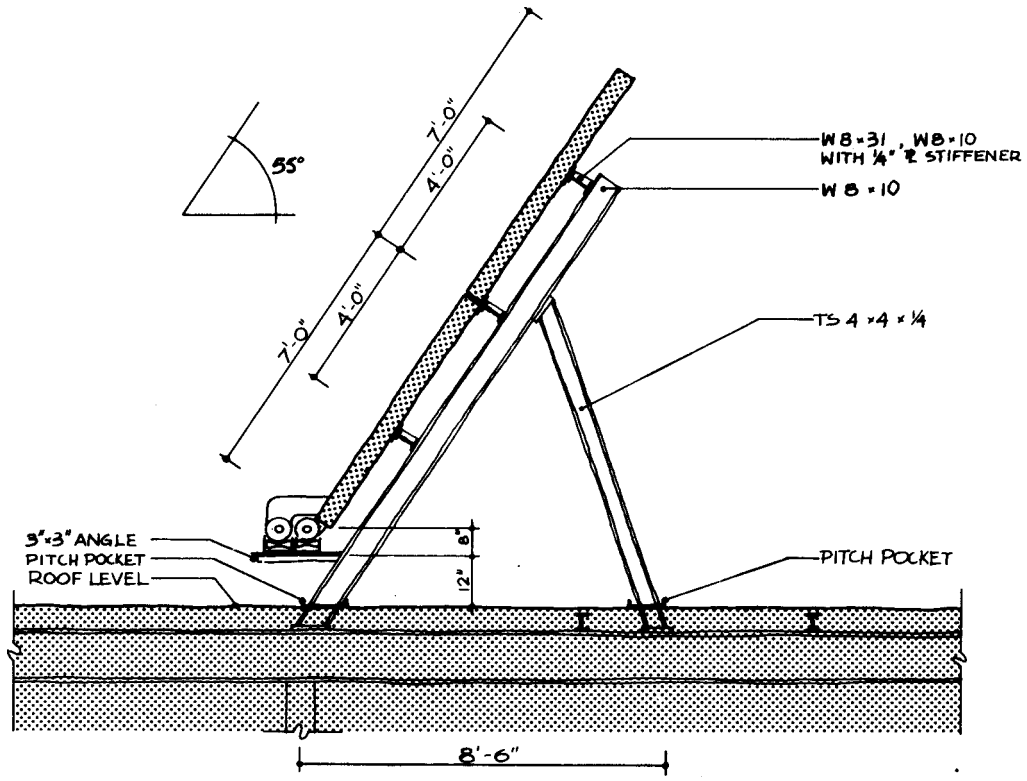


Figure IV-B-3. Collector Support on Flat Section of Roof

- o Fittings
  - Air control by Bell and Gossett, AFT

- Heat Exchanger
  - o Location - In the mechanical room
  - o Type - Shell and tube
  - o Manufacturer/Model Number - Bell and Gossett/WV 106-45
  - o Number - 2, in counter-flow series
  - o Capacity
    - Rating - 1,165,000 Btu/hr at design condition
    - Shell flow rate - 130 gal/min

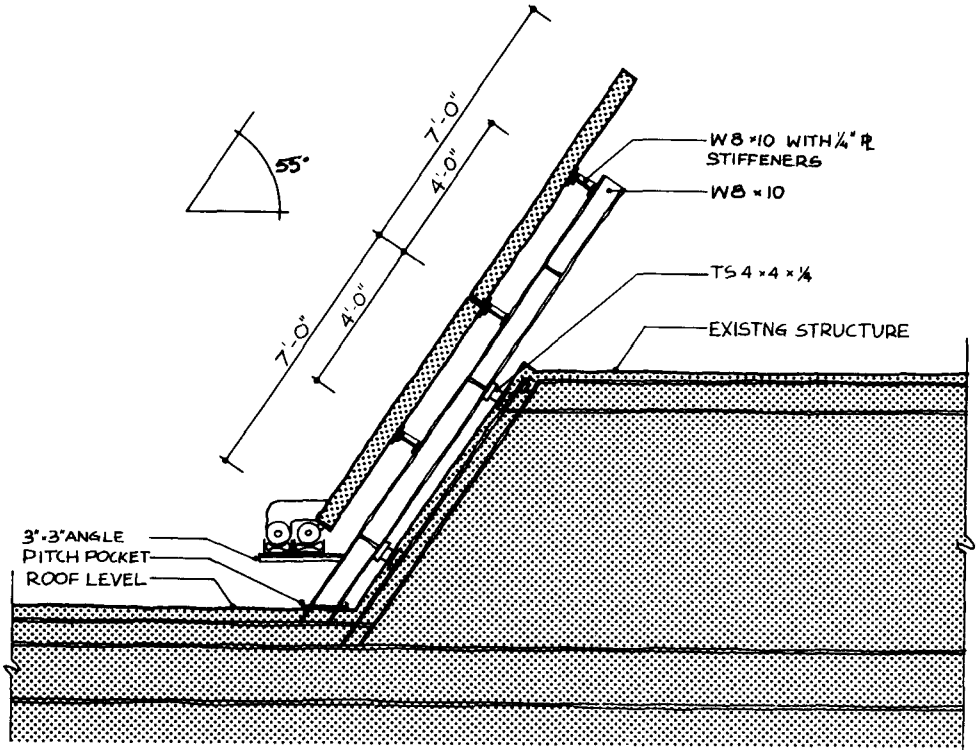


Figure IV-B-4. Collector Support on Mansard Section of Roof

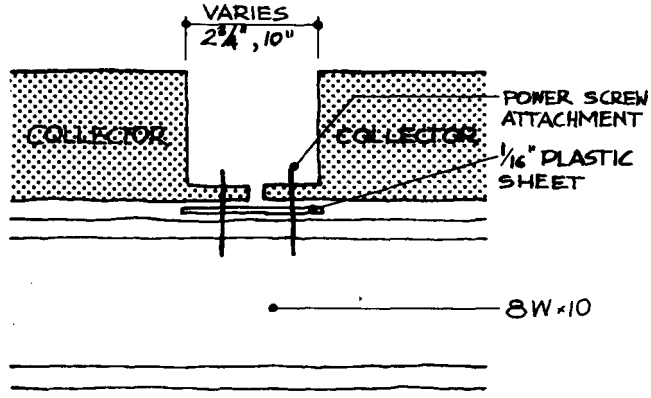


Figure IV-B-5. Collector Attachment

- Tube flow rate - 80 gal/min
- Shell inlet temperature - 130° F
- Shell outlet temperature - 110° F
- Tube inlet temperature - 81° F
- Tube outlet temperature - 110° F

- Miscellaneous Equipment
  - Low level sensor-Manufacturer by McDonnell No. 764

Visual Monitoring Equipment

- Sight glass for expansion tank
- Thermometers - Weksler
- Pressure gage - Weksler

Heat Transfer Medium

- Base material - Water
- Antifreeze
  - Type - Propylene glycol, "Sun Sol," manufactured by Sunworks
  - Concentration - 40%
- Glazing
  - Number - Double
  - Material - No iron content, tempered glass
  - Thickness - 3/16 in.
  - Transmittance - 85%
- Absorber plate
  - Type- Continuous flat plate, soldered to the absorber tubes at 6 in. centers
  - Material - Copper
  - Thickness - 0.010 in.

- Coating and application - Selective black nonelectrolytic thin-film oxide
- Absorptance - 0.87/0.92
- Emittance - 0.07/0.35

- Fluid passage
  - Material - 1/4 in. inside diameter (3/8 in. outside diameter) Type N copper
  - Bond to absorber - High temperature solder
  - Manifold location - Internal, 1 in. inside diameter (1.125 in. outside diameter)

- Insulation
  - Material - Fiberglass
  - Thickness - 2.5 in.
  - R Value - 10

C. Storage Subsystem (see figures IV-C-1 and IV-C-2)

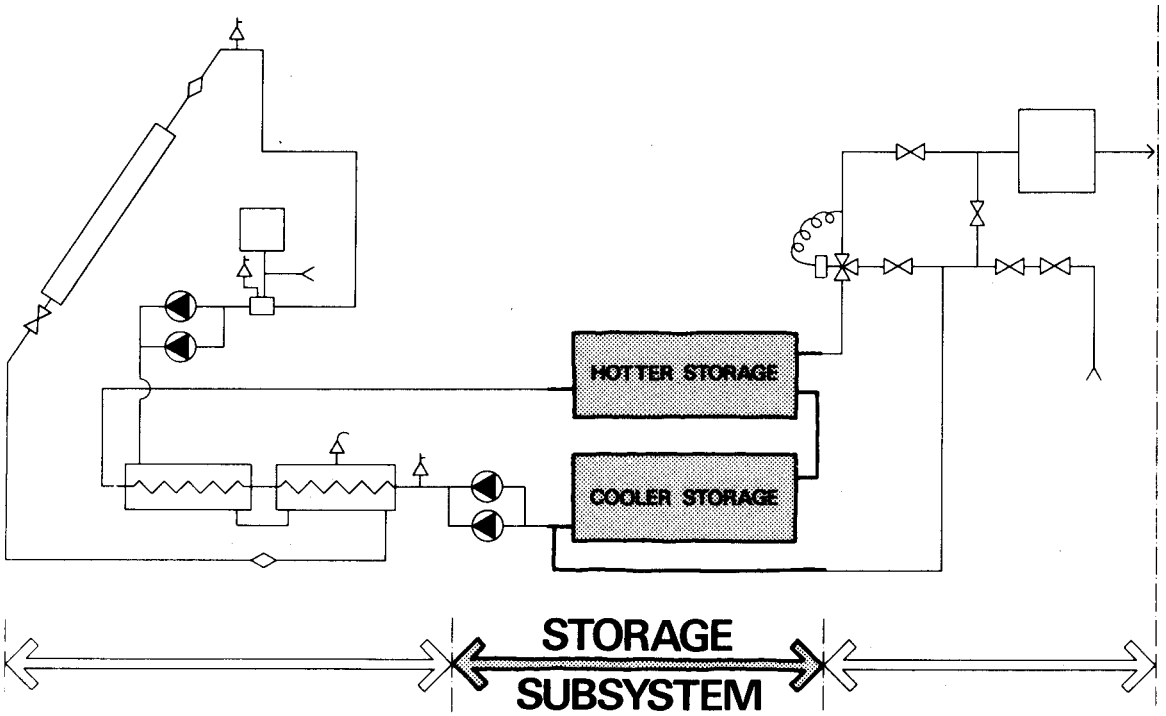


Figure IV-C-1. Storage Subsystem

General Description - Two ASME-rated 5,000 gallon steel storage tanks, piped in series, are located in the parking garage of the restaurant, one floor below the kitchen area. The tanks are covered with 6 inches of glass fiberboard sheathed with aluminum. Both tanks are lined with phenolic epoxy. A wire partition surrounds the tanks which are laid side by side horizontally. Space for water expansion is provided inside one tank. The tanks are piped in series to enhance the temperature differential/stratification effects between the two.

Tanks (see figures IV-C-2 and IV-C-3)

- Location - Parking garage, one floor beneath kitchen level, two floors below mechanical equipment room
- Capacity - Two tanks, 5,000 gal each
- Size - Each tank 6 ft diameter by 24 ft long

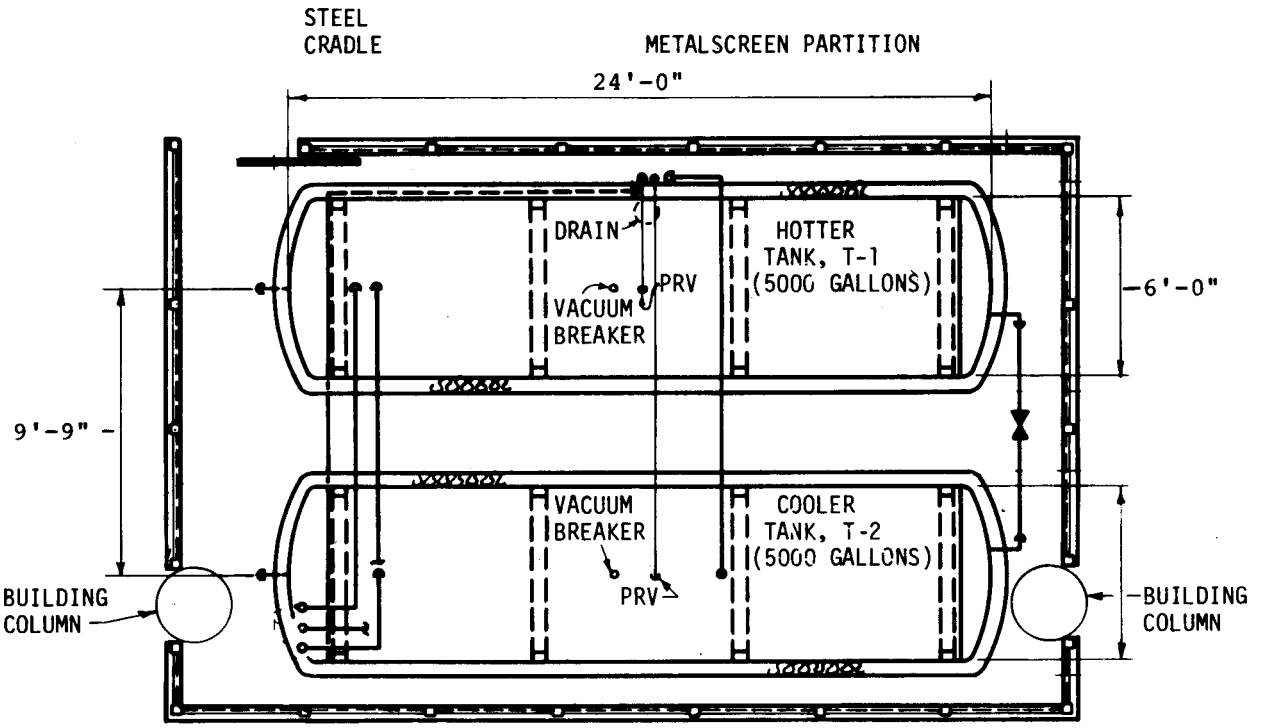


Figure IV-C-2. Plan of Solar Storage Tanks

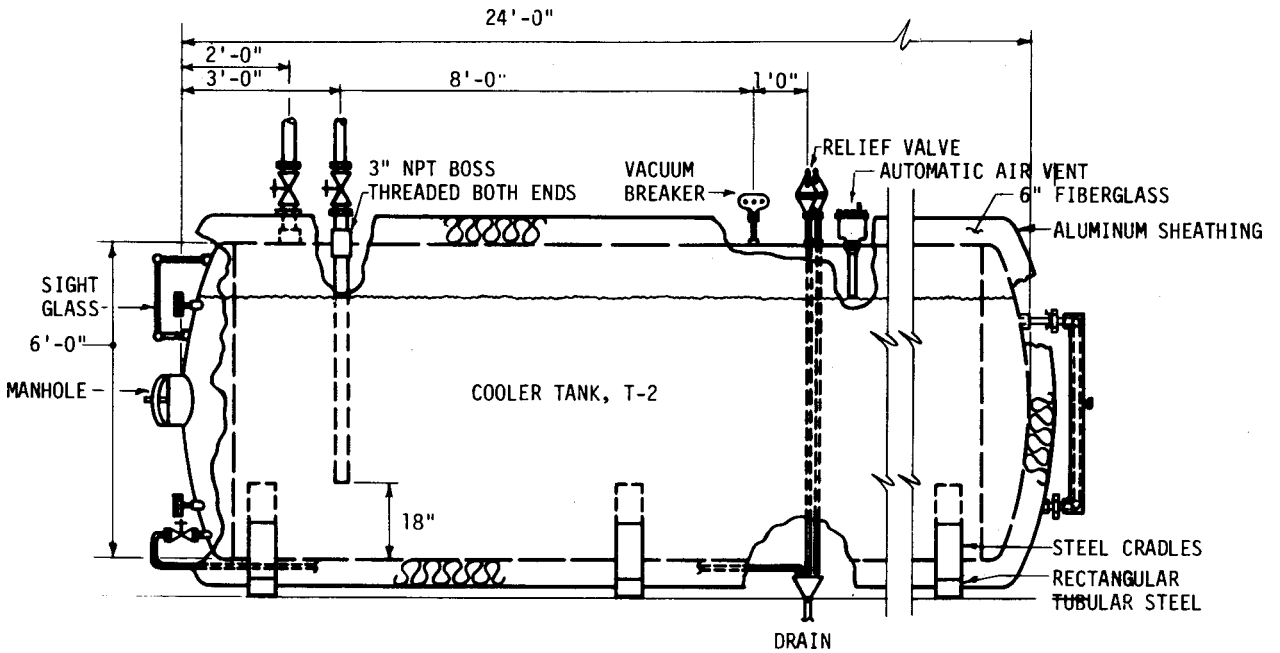


Figure IV-C-3. Storage Tank Elevation

- Construction - Steel, manufactured by RECO, Inc.
- Rated working pressure - 125 psig
- Test pressure - 188 psig
- Insulation - R-26, 6 in. glass fiberboard sheathed with .016 in. aluminum sheet
- Waterproofing - None required
- Installation - Each tank resting horizontally on three steel saddles which are elevated above the concrete floor by rectangular tubular steel pipe
- Immersed Coils - None
- Piping connection - NPT threaded fittings
- Sensor probe installations - NPT threaded fittings
- Lining - Phenolic epoxy, Wisconsin Protective Coatings #1264, 5-7 mil thick

D. Energy-to-Load Subsystem

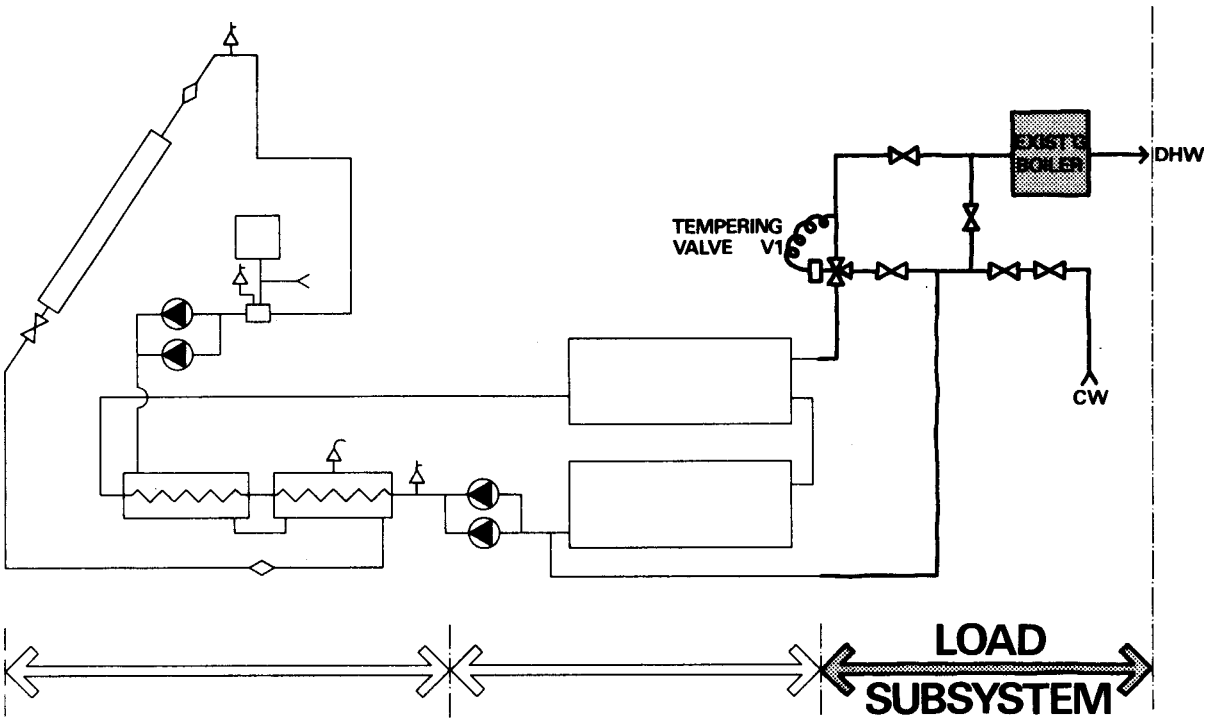


Figure IV-D-1 Energy-to-Load Subsystem

General Description - Cold water enters the cooler storage tank upon demand for hot water from the hotter tank. The water that is drawn from the tank flows through a mixing valve to prevent excessive temperature from reaching the boiler. From the mixing valve, the water flows to the gas-fired boiler which maintains a minimum water temperature of 140° F in a recirculating hot water supply line for the restaurant's fixtures and dishwashers.

- Piping - Copper, type L
- Pipe insulation - Fiberglass, 2 in. with canvas jacket
- Pumps - None
- Valves - See Control Operation

E. Control Operation

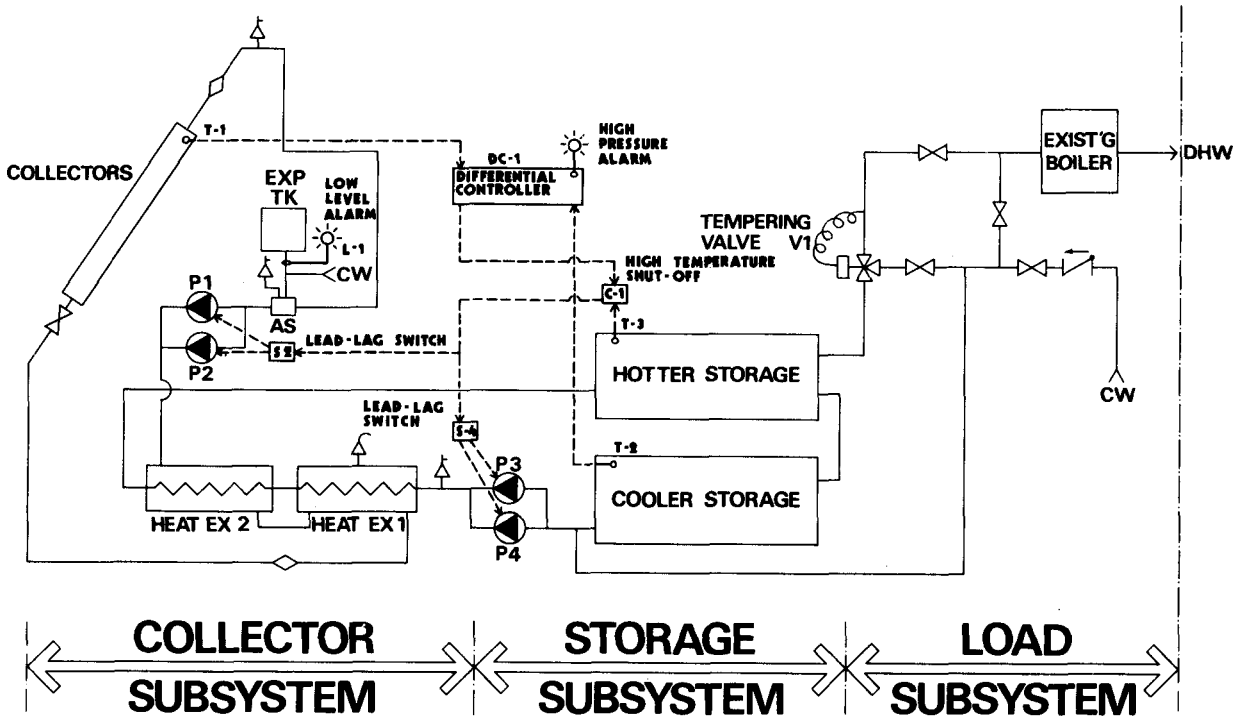


Figure IV-E-1. Controls Diagram

General Description - A differential thermostat controls the operation of the system pumps. Lead-lag pumps are utilized on each side of the heat exchanger to provide redundancy. The only automatic valve is the tempering valve V-1 which prevents excessive water temperatures from reaching the boiler. Alarms sound for low fluid level in the collector system and excessive pressure.

- Pumps P-1 and P-2

  On-off automatic switch S-1 controls pumps P-1 and P-2. In the off position, pumps are off. In the on position, either P-1 or P-2 is on as selected by lead-lag switch S-2. In the automatic position, P-1 or P-2 starts as selected by S-2 when the differential temperature between sensor T-1, located on the solar collector absorber plate, and sensor T-2, located in storage tank T-2, exceeds the "activate" (on) setting of differential controller, DC-1. The lag pump starts automatically if the lead pump fails. Pumps P-1 and P-2 operate alternately and are

interlocked so that both do not operate simultaneously. Pump P-1 or P-2 stops when the differential temperature between sensor T-1 and T-2 is less than the "deactivate" (off) setting of DC-1.

- Pumps P-3 and P-4

  On-off automatic switch S-3 controls pumps P-3 and P-4. In the off position, pumps are off. In the on position, P-3 or P-4 is on as selected by lead-lag switch S-4. In the automatic position, P-3 or P-4 starts as selected by S-4 when the differential temperature between sensor T-1, located on the solar collector absorber plate, and sensor T-2 located in storage tank T-2, exceeds the "activate" (on) setting of differential controller, DC-1. The lag pump starts automatically if the lead pump fails. Pumps P-3 and P-4 operate alternately and are interlocked so that both do not operate simultaneously. Pump P-3 or P-4 stops when the differential temperature between sensor T-1 and T-2 is less than the "deactivate" (off) setting of DC-1.

- Excessive Storage Tank Temperature

  Controller C-1 stops P-1 or P-2 and P-3 or P-4 when temperature at sensor T-3 exceeds 180° F.

- Excessive Collector Pressure

  Audible alarm with manual reset sounds when pressure at sensor P-1 located in the compression/expansion tank exceeds set pressure.

- Fluid Level

  Audible alarm with manual reset sounds when fluid level in the pipe between the compression/expansion tank and air scoop falls below location of sensor L-1.

- Valving

  - V-1, tempering valve - Fully proportioning, mixing valve limiting water temperature to boiler to 140° F

  - Gate valves - Bronze gate valves are provided to permit shutting off the solar preheating system and allowing cold water make-up directly to the boiler.

V. PERFORMANCE EVALUATION INSTRUMENTATION

A. The National Solar Data Network

The National Solar Data Network (see figure V-A-I) has been developed for the Department of Energy to process data collected from specific commercial demonstration sites which were selected for thermal performance evaluation. The data flow in the Network is shown in figure V-A-2. Output from the Network includes monthly and seasonal system performance reports describing the thermal performance of the solar energy system and subsystems.

The performance evaluation instrumentation at each selected demonstration site is part of a comprehensive data collection system that allows for valid analyses of the solar system performance. Collected data are both applicable and practical in calculating thermal performance factors that describe the behavior of the solar sytsem (see NBSIR 76-1137, National Bureau of Standards). Additional instrumentation may also be included as a result of site-specific requirements. Typically, the instrumentation includes sensors that monitor the following:

- Total insolation in the plane of the collector array
- Ambient temperature
- Collector subsystem flow rate and temperatures
- Storage inlet flow rate and temperatures
- Storage outlet flow rate and temperatures
- Storage temperature
- Storage-to-load subsystem flow rate and temperatures
- Auxiliary fuel flow rates

Site data are recorded automatically at prescribed intervals by the Site Data Acquisition System (SDAS). The recorded data are transmitted daily to the Communications Processor in the Central Data Processing System (CDPS). The communications link between every SDAS and the CDPS consists of voice-grade

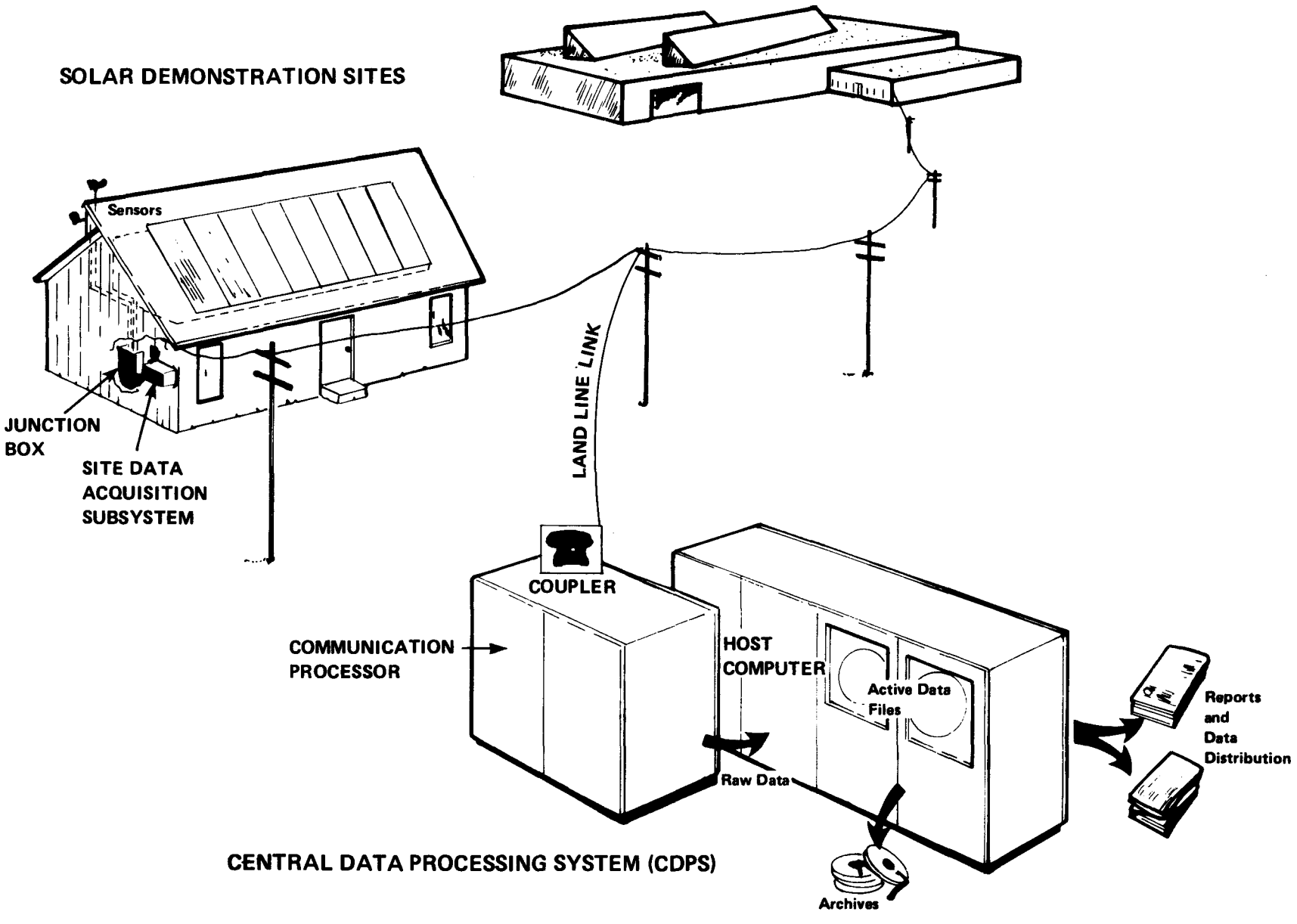


Figure V-A-1. The National Solar Data Network

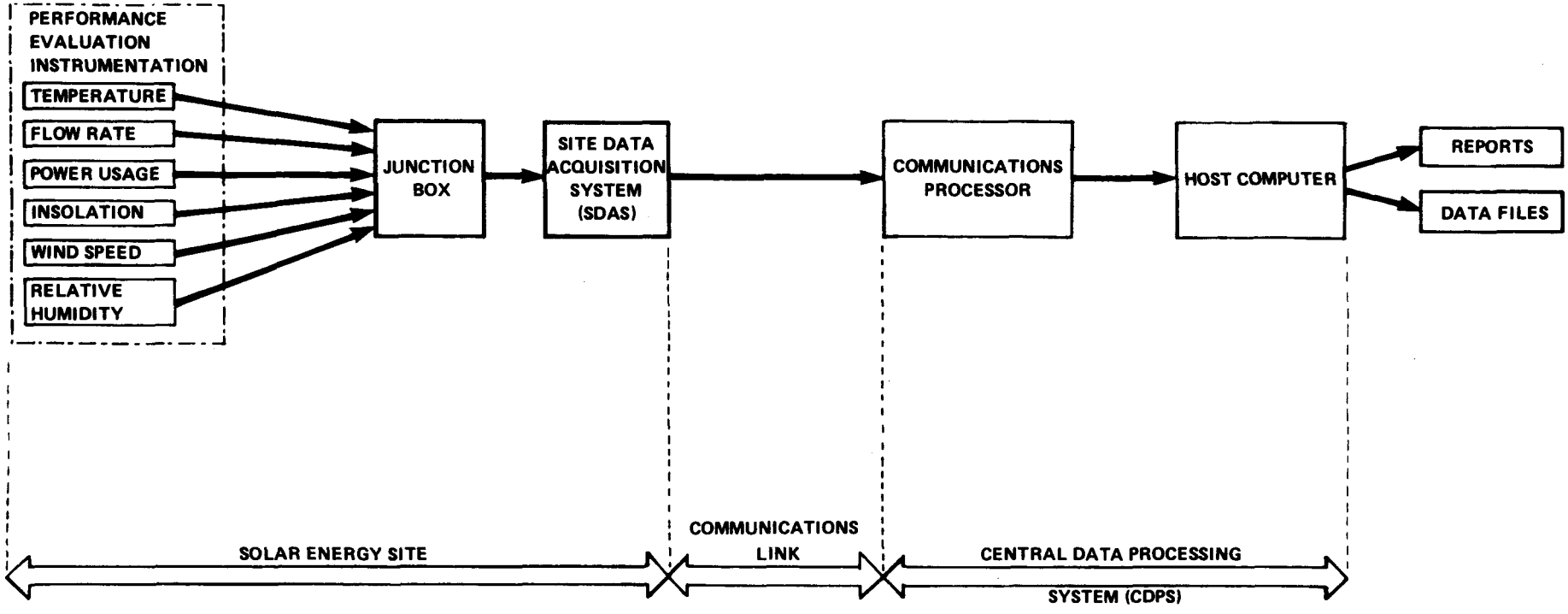


Figure V-A-2. Data Flow Path for the National Solar Data Network

telephone lines and telephone data couplers. A reading is transmitted from the SDAS internal timer with every data sample to ensure that the data are time-tagged correctly.

The Communications Processor scans the receiving data to identify any apparent transmission errors and verifies correct site contact by checking the address code transmitted by the SDAS. Data is stored temporarily in the Communications Processor and processed by the Host Computer. The processing includes measurement checking to ensure that the data are reasonable; that is, that they are not beyond the known instrument limits and that they are not erratic. Data which appear questionable are discarded and are not used in the solar system performance analyses.

Appropriate equations were formulated and programmed to define desired performance factors for the solar energy systems at each selected demonstration site. A performance factor is a number that describes either the efficiency or the quantity of energy lost, gained, or converted by a solar energy system or by a component. All valid data are processed using these performance factor equations to generate hourly performance factors. Hourly performance factors are integrated into daily and monthly performance factors. These hourly, daily, and monthly performance factors are stored in data files in the CDPS. These data files also include measurement data, expressed in engineering units; numerical and textual site identification; and specific site data used in generating the performance factors.

B. Onsite Instrumentation

The onsite instrumentation includes sensors to monitor the various parameters of the solar energy system, a junction box, and a Site Data Acquisition System that stores and transmits data to the Host Computer (see figure V-A-1 and V-A-2). Specific information for temperature, flow, power, and miscellaneous sensors are presented in tables V-B-1 thru V-B-4, respectively. Sensor locations are shown in figures V-B-1 and V-B-2.

Table V-B-1. Temperature Instrumentation for Hogate's Restaurant

SENSOR	NAME	RANGE (F)		MFGR.	THERMOWELL PART NO.
		Min.	Max.		
T301	Cold Water Supply Temperature	30	160	Minco	F203U30
T303	Storage Output Temperature	30	230	Minco	F203U35
T304	Domestic Water Supply Input Temperature	30	160	Minco	F203U30
T102	Collector Absorber Temperature	30	450	Minco	DC732
T001	Outside Ambient Air Temperature	-20	120	Minco	IS4
T100	Collector Array Inlet Temperature	30	230	Minco	F203U30
T150	Collector Array Outlet Temperature	30	450	Minco	F203U35
T200	Hotter Storage Tank—Top Temperature	30	230	Minco	F203U154
T204	Cooler Storage Tank—Middle Temperature	30	230	Minco	F203U154
T201	Hotter Storage Tank—Middle Temperature	30	230	Minco	F203U154
T202	Hotter Storage Tank—Bottom Temperature	30	230	Minco	F203U154
T203	Cooler Storage Tank—Top Temperature	30	230	Minco	F203U154
T205	Cooler Storage Tank—Bottom Temperature	30	230	Minco	F203U154
T300	Collector Heat Exchanger Inlet Temperature	30	230	Minco	F203U30
T350	Collector Heat Exchanger Outlet Temperature	30	230	Minco	F203U35
T302	Domestic Circuit—Water Inlet Temperature	30	230	Minco	F203U30
T352	Domestic Circuit—Water Outlet Temperature	30	230	Minco	F203U35

Table V-B-2. Flow Rate Instrumentation for Hogate's Restaurant

SENSOR	NAME	RANGE			MFGR.	MODEL NO.
		Min.	Design.	Max		
W301	Cold Water Supply Flow Rate (gal)	0		1000	Niagara	7945116-3
W302	Domestic Water Flow and Recirculation (gpm)	0		20	Ramapo	MKV-2.5-J07
W303	Solar Hot Water Supply Flow Rate (gal)	0		1000	Niagara	7945116-8
W100	Collector Array Flow Rate (gpm)	0		150	Ramapo	MKV-2.5-J07
W300	Storage Heat Exchanger Output Flow Rate (gpm)	0		100	Ramapo	MKV-2.5-J07
F300	Domestic Boiler Fuel Flowrate (ft^3)	0		1000	American Meter	AL-1000

Table V-B-3. Power Instrumentation for Hogate's Restaurant

SENSOR	NAME	PHASE	RANGE (kW)		MFGR.	MODEL NO.
			Min.	Max.		
EP101	Collector Pump Power (P-1 & P-2)		0	4	Ohio Semitronics	PC5-14
EP301	Storage Pump Power (P-3 & P-4)		0	2	Ohio Semitronics	PC5-5
EP302	Domestic Circulating Water Pump Power		0	0.5	Ohio Semitronics	PC5-1

Table V-B-4. Miscellaneous Instrumentation for Hogate's Restaurant

SENSOR	NAME	MFGR.	MODEL NO
J001	Collector Plane Total Insolation	Eppley Laboratories, Inc.	PSP

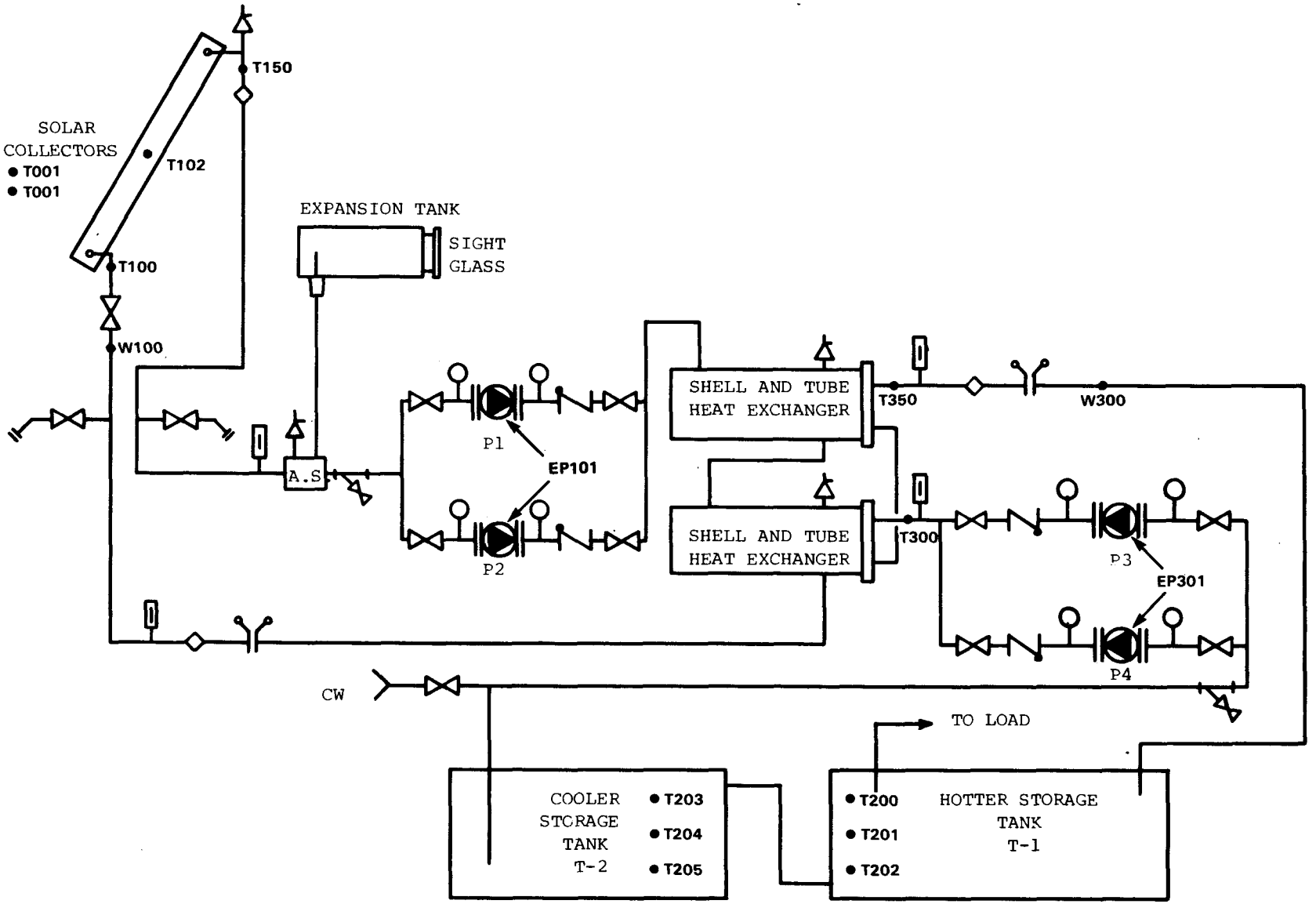


Figure V-B-1. Storage-to-Load Subsystem

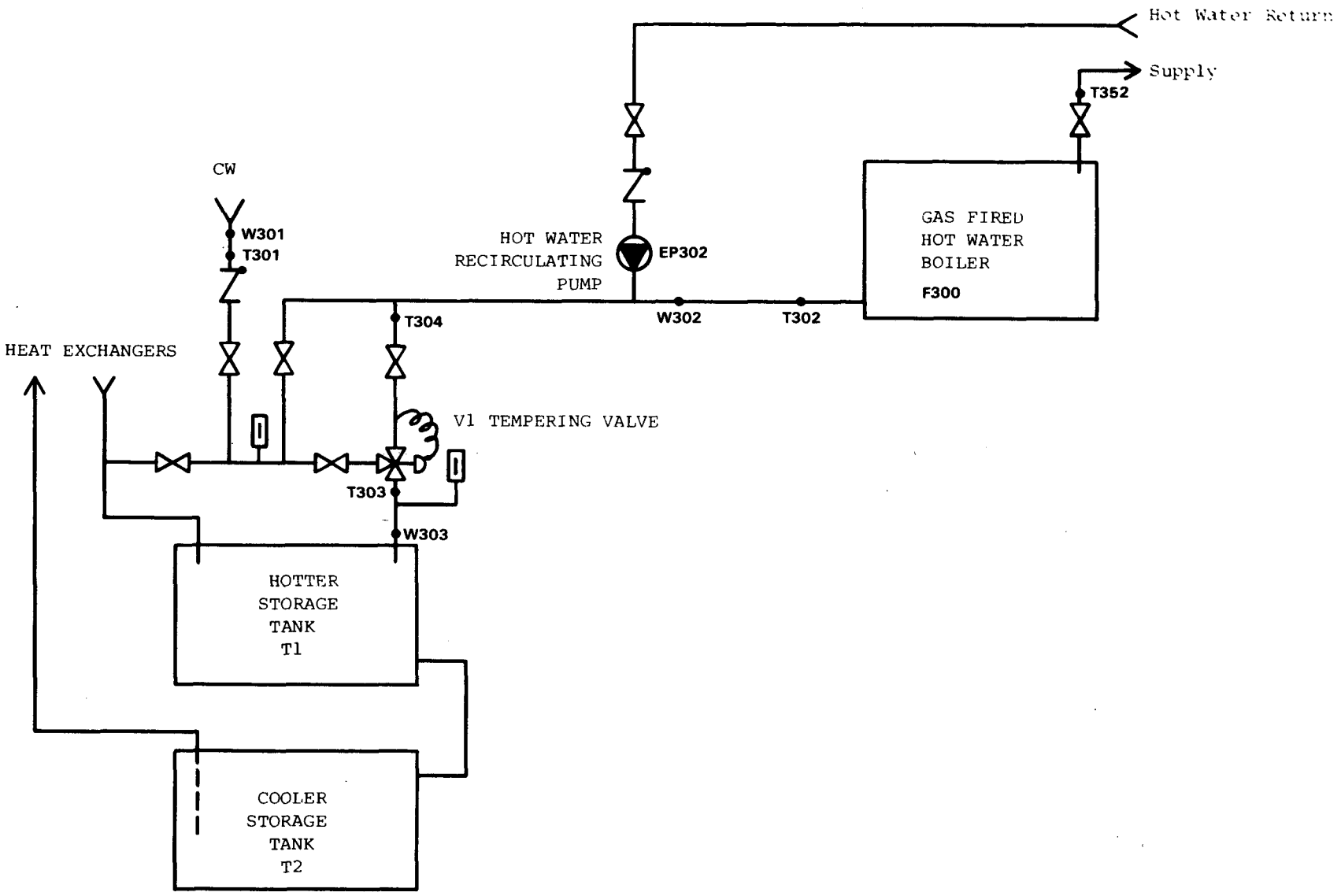


Figure V-B-2. Collector Subsystem

IV. APPENDIX

A. Glossary

ABSORBER PLATE - The surface in a flat-plate collector that absorbs incident solar radiation and transfers the absorbed energy to a heat transfer fluid.

ABSORPTANCE - The ratio of absorbed radiation by a surface to the total incident radiation on that surface.

ABSORPTION SUBSYSTEM - The mechanical equipment that conditions indoor air by an absorption process.

ACTIVE SOLAR SYSTEM - An integrated solar energy system, consisting of collector, storage, solar energy-to-load subsystems, that can condition indoor air or preheat domestic hot water in a controlled manner.

AIR-BASED SOLAR COLLECTOR SYSTEM - A solar energy system in which air is the heat transfer fluid.

AIR CONDITIONING - The process of treating indoor air by controlling the temperature, humidity, and distribution to specified comfort settings as set by the occupants in the conditioned space.

AMBIENT AIR - A term for outdoor air, which may be brought into a building to be conditioned or circulated.

ANTIFREEZE FREEZE PROTECTION SYSTEM - A freeze protection system that uses a solution of water and glycol. This solution depresses its freezing point sufficiently to prevent possible water freeze in solar collectors and exterior piping.

AUXILIARY ENERGY SUBSYSTEM - The equipment which uses conventional energy sources to supplement the output provided by a solar energy system and to provide a full backup system when the solar system is inoperable.

BACKFLOW - The unintentional reversal of flow in a potable water distribution system by foreign or toxic substances that may contaminate the potable water.

BACKFLOW PREVENTER - A device or means to stop backflow.

BEAM RADIATION - Solar radiation which is not scattered and may be concentrated.

BRITISH THERMAL UNIT (Btu) - A unit of energy that is required to heat one pound of water from 59° F to 60° F.

BUILDING ENVELOPE - The exterior surface of a building that encloses the conditioned space.

CLIMATE - The prevailing or average weather conditions of a specific geographic region as described by temperature and other meteorological data.

COLLECTOR MANIFOLD - The piping that connects the absorber tubes in a collector plate.

COLLECTOR PLATE - A term used for an absorber plate.

COLLECTOR SUBSYSTEM - The assembly that absorbs incident solar radiation and transfers the absorbed thermal energy to a heat transfer fluid.

COMBINED COLLECTORS - An assembly that both collects incident solar radiation and stores the thermal energy in the same unit.

CONCENTRATING SOLAR COLLECTOR - A solar collector which focuses beam radiation onto an absorber to obtain higher energy fluxes than can normally be achieved by flat-plate solar collectors.

CONCENTRATOR - A reflective surface or refracting lens used in directing insolation onto an absorber.

CONDITIONED SPACE - The space in a building that has the air conditioned for heating and cooling.

CONTROL SUBSYSTEM - The assembly of electric, pneumatic, and hydraulic actuated sensing devices used in regulating the solar energy system and the auxiliary energy subsystem.

COOLING TOWER - A heat exchanger that transfers waste heat from an absorption cooling system to ambient air.

DIFFUSE RADIATION - Solar radiation which is scattered by air molecules, dust, or water droplets and cannot be focused.

DRAIN-DOWN FREEZE PROTECTION SYSTEM - A freeze protection system that prevents potential water freeze problems by automatically opening a valve to drain the solar collectors and exterior piping. Air is used for some systems, nitrogen for others.

DUCT HEATING COIL - A liquid-to-air heat exchanger in the duct distribution system used to heat air by passing a hot fluid into a coil in the airstream.

EMITTANCE - The ratio of energy radiated by a body to the energy radiated by a blackbody at the same temperature.

EQUIVALENT FULL LOAD COOLING HOURS - The seasonal cooling load for a building described as the total number of hours that the air conditioning system will operate under full load conditions to meet the required cooling load.

EXPANSION TANK - A tank which will permit water to expand whenever it is heated to prevent excessive pressures on the other system components.

FIXED COLLECTOR - A solar collector permanently oriented toward the sun which cannot track the sun nor be adjusted for seasonal variations.

FLAT-PLATE COLLECTOR - A basic heat collection device used in solar heating systems, which consists of an absorber plate, with insulated bottom and sides, and is covered by one or more transparent covers. There are no concentrators or focusing aids in a flat-plate collector.

FOCUSING COLLECTOR - A solar collector which uses a parabolic mirror, Fresnel lens or other type of focusing device to concentrate solar radiation onto an absorber.

FRESNEL COLLECTOR - A concentrating solar collector which uses a Fresnel lens to focus beam radiation onto an absorber.

GLAZING - The transparent cover(s) on a solar collector used to reduce the energy losses from the top of the collector.

HEAT TRANSFER FLUID - The fluid that transfers solar energy from the solar collector to the storage subsystem or to the load.

INCIDENCE ANGLE - The angle at which the insolation strikes a surface and the normal for that surface.

INSOLATION - The total amount of solar radiation on a surface in a given unit of time.

LAMINATED GLASS - A glazing consisting of multiple glass sheets bonded together by intervening layer or layers of plastic.

LANGLEY - The standard unit of insolation defined as 1 langley = 1 cal/cm^2 (1 langley = 3.69 Btu/ft^2).

LIQUID-BASED SOLAR COLLECTOR SYSTEM - A solar energy system in which either water or an antifreeze solution is the heat transfer fluid.

LOAD - The total space conditioning or domestic water heating requirements that are supplied by both the solar energy system and the auxiliary energy subsystem.

NOCTURNAL RADIATION - The loss of thermal energy by the solar collectors to the sky at night.

NO-FLOW CONDITION - The condition obtained when the heat transfer fluid is not flowing through the collector array due to shutdown or malfunction.

OPAQUE - A surface that is not transparent, thus solar radiation is either reflected or absorbed.

OUTGASSING - The emission of gases by materials and components, usually during exposure to elevated temperature or reduced pressure.

PACKAGE AIR-CONDITIONING UNIT - A factory-made assembly consisting of an indoor coil, a compressor, an outdoor coil, and other components needed for space cooling operations. Unit may also include additional components to heat the conditioned space.

PARABOLIC FOCUSING COLLECTOR - A concentrating collector which focuses beam radiation by a parabolic reflector.

PASSIVE SOLAR SYSTEM - An integrated solar energy system that can provide for space heating needs without use of an energy source other than the sun.

PEBBLE BED - A storage tank using uniform-sized pebbles to store solar energy in air-based solar collector systems.

REFLECTANCE - The ratio of radiation reflected by a surface to the total incident radiation on the surface.

REFLECTED RADIATION - Insolation which is reflected from a surface, such as the ground, and is incident on the solar collector.

SELECTIVE SURFACE - A surface which has a high absorptance for solar radiation and a low emittance for thermal radiation.

SOLAR CONDITIONED SPACE - The area in a building that depends on solar energy to provide a fraction of its heating and cooling needs.

SOLAR HEATING SYSTEM - An integrated assembly of collector, storage, solar energy-to-load, and control subsystems required to convert solar energy into thermal energy for space heating requirements--also includes an auxiliary backup system.

SOLAR RETROFIT - The addition of a solar energy system to an existing structure.

STORAGE SUBSYSTEM - The components used to store solar energy for use in heating or cooling air, or heating water during period of low insolation.

STRATIFICATION - The horizontal layering by a fluid due to temperature differentials, commonly noticed in storage tanks filled with water.

THERMOSTAT - A temperature dependent sensor which controls either the heating and cooling systems for space conditioning or the hot water heater.

TON OF REFRIGERATION - A unit of refrigeration equivalent to 12,000 Btu/hr.

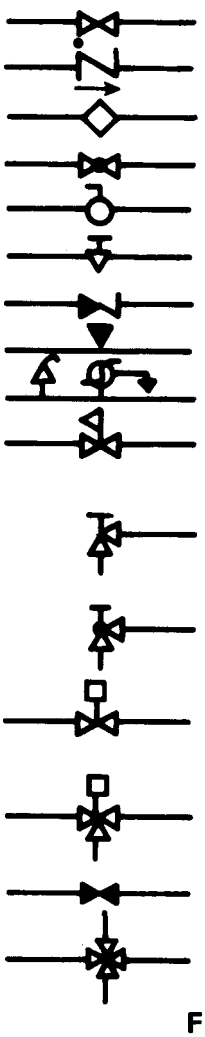
TRACKING COLLECTOR - A solar energy collector that constantly moves to follow the path of the sun.

VAPOR BARRIER - A material which is used to reduce the transmission of water vapor.

ZONE - Portions of a conditioned space which use a common control because of their similar heating and cooling requirements.

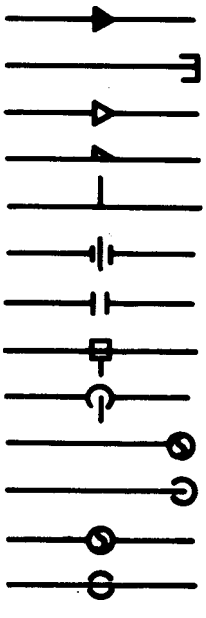
B. Legend for Solar System Schematics

VALVES



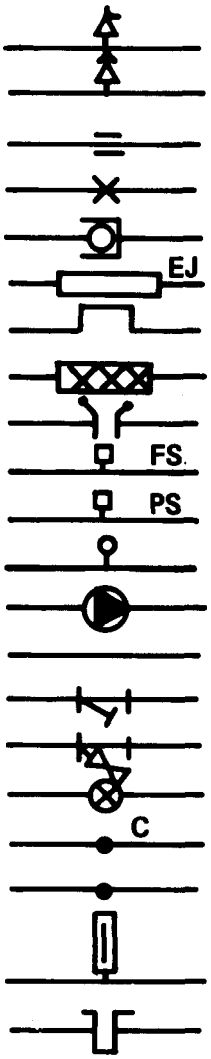
GATE VALVE
CHECK VALVE
BALANCING VALVE
GLOBE VALVE
BALL VALVE
PLUG VALVE
BACKFLOW PREVENTER
VACUUM BREAKER
RELIEF OR SAFETY
PRESSURE REDUCING
ANGLE GATE VALVE
ANGLE GLOVE VALVE
CONTROL VALVE, 2 WAY
CONTROL VALVE, 3 WAY
BUTTERFLY VALVE
4 WAY VALVE

FITTINGS



DIRECTION OF FLOW
CAP
REDUCER, CONCENTRIC
REDUCER, ECCENTRIC
TEE
UNION
FLANGED CONNECTION
CONNECTION, BOTTOM
CONNECTION, TOP
ELBOW, TURNED UP
ELBOW, TURNED DOWN
TEE, OUTLET UP
TEE, OUTLET DOWN

PIPING SPECIALITIES



AUTOMATIC AIR VENT
MANUAL AIR VENT
ALIGNMENT GUIDE
ANCHOR
BALL JOINT
EXPANSION JOINT
EXPANSION LOOP
FLEXIBLE CONNECTION
FLOWMETER FITTING
FLOW SWITCH
PRESSURE SWITCH
PRESSURE GAUGE
PUMP
PIPE SLOPE
STRAINER
STRAINER, W/BLOW OFF
TRAP
CONTROL SENSOR
INSTRUMENTATION SENSOR
THERMOMETER
THERMOMETER WELL ONLY

COLD WATER SUPPLY

AS	AIR SEPARATOR
EXP TK	EXPANSION TANK
WS	WATER SOFTENER
HED	HOSE END DRAIN

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