SOLAR/2008-78/50

Solar Project Description

Aratex Services, Inc.
Industrial Laundry
Fresno, California

June 7, 1978

Contracts EG-77-C-01-4049
EG-77-C-01-2522

United States Department of Energy

National Solar Heating and Cooling Demonstration Program

National Solar Data Program

NOTICE

SOLAR/2008-78/50
Distribution Category UC-59

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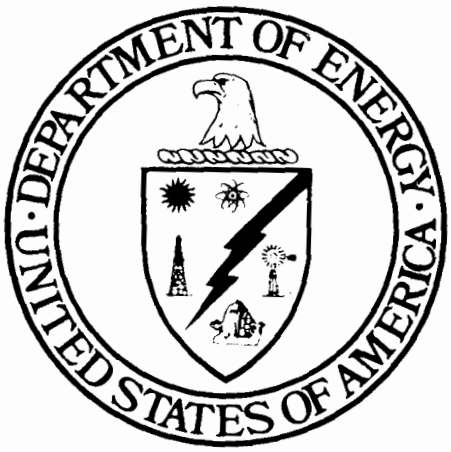
IBM Corporation
Huntsville, AL 35805



United States Department of Energy

National Solar Heating and Cooling Demonstration Program

National Solar Data Program

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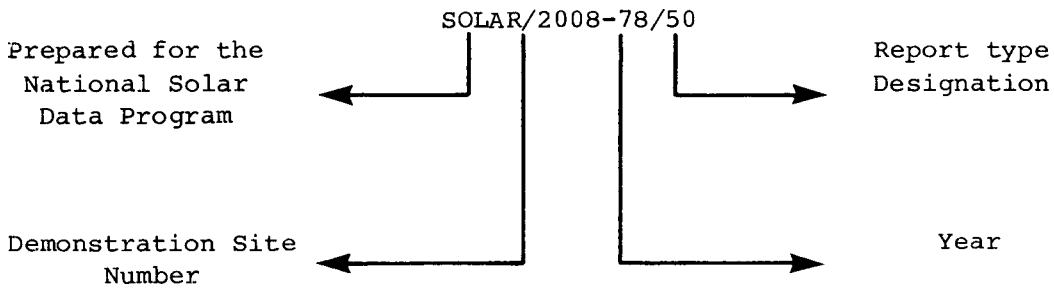
NATIONAL SOLAR DATA PROGRAM REPORTS

Reports prepared for the National Solar Data Program are numbered under a specific format. For example, this report for the Aratex Services, Inc. project site is designated as SOLAR/2008-78/50. 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 are designated by the numbers 01 (for January) through 12 (for December)
  - Solar Energy System Performance Evaluations are designated by the number 14
  - Solar Project Descriptions are designated by the number 50
  - Solar Project Cost Reports are 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, manufacturer 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 Aratex solar installation. Highlights of this site include:

- COLLECTOR TYPE: Flat plate, liquid
- FREEZE PROTECTION: Draindown
- APPLICATION: Laundry process water heating
- STORAGE TYPE: Exterior tank
- NEW OR RETROFIT: Retrofit
- INSTRUMENTED FOR PERFORMANCE EVALUATION: Yes
- SITE SPECIFIC FEATURES: Waste water heat recovery unit, hot water holding tank that is steam preheated and steam condensate heated.

The solar energy is used to heat the process water in a large commercial laundering plant in Fresno, California. The solar system was retrofitted to the building during the Winter and Spring of 1977.

The system utilizes 140 Ying, flat plate, lexan glazed collectors which provide an effective aperture area of 6500 square feet. The collectors are mounted in 24 rows on the flat roof of the building.

All collectors are connected in parallel, with hoses and clamps, to the copper manifold. The water is pumped between the collectors and the atmospherically vented storage tank. The 12,500 gallon insulated fiberglass storage tank is located above ground on the concrete floor of a covered area of the building which is open to the outside.

All of the pumps for the system are located near the storage tank. All solar energy system piping is copper. All exterior piping is insulated with fiberglass, covered by an aluminum jacket.

The solar energy system is used in conjunction with a heat recovery system. Softened cold water is first pumped through a heat exchanger which recovers heat from the laundry wastewater. The water then flows into the solar storage tank and circulates through the collectors. It is then pumped through another heat exchanger which boosts the water to the required temperature of 170°F. Steam from the building heating boiler is used as the auxiliary energy source.

The hot water is stored in a 4000 gallon holding tank to which an immersed heat exchanger adds heat from the steam condensate.

The solar system has been fully instrumented for data acquisition and is included in the National Solar Data Network.

III. SITE AND BUILDING DESCRIPTION (See Figure III-1)

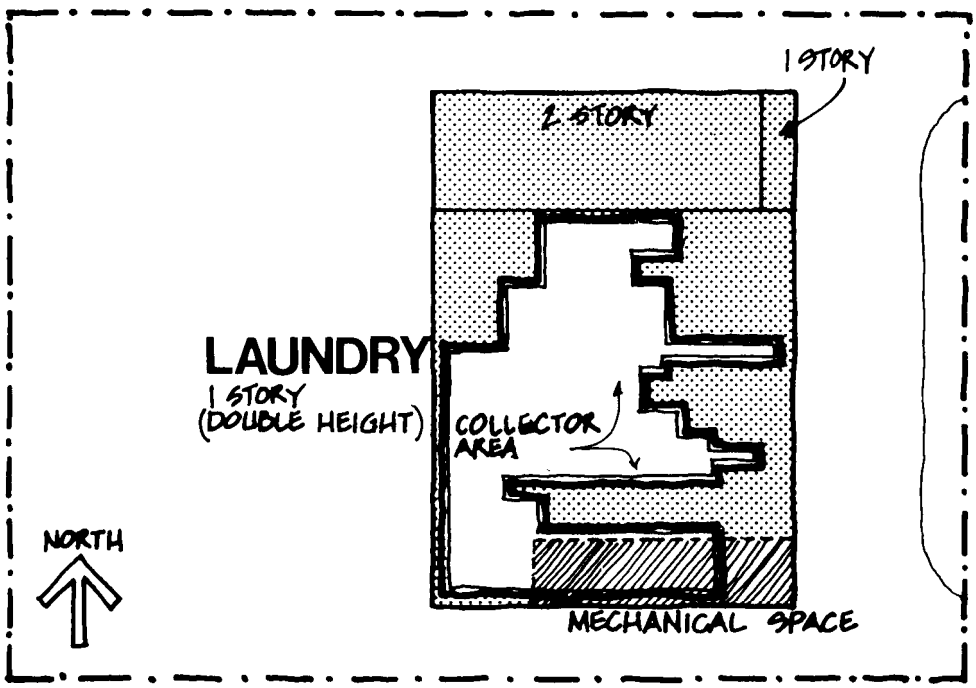


Figure III-1
Site Plan

Site Description

- Special topographic and climatic conditions - None
- Area topographic description - None
- Latitude - 37° N
- Annual degree days (65°F base)
  - o Heating - 2699
  - o Cooling - 1437
  - o Data location - Fresno, California
  - o Data source - "Local Climatological Data, Annual Summaries for 1976," U.S. Department of Commerce, National Oceanic and Atmospheric Administration

- Average horizontal insolation
  - January - 685 BTU/FT^2-DAY
  - July - 2459 BTU/FT^2-DAY
  - Data location - Fresno, California
  - Data reference - Solar Heating Design By The F-Chart Method, Beckman, Klein, Duffie, Wiley-Interscience Publication, 1977.
- Site topographic description - Flat
- Shading - None

Building Description

- Occupancy - Industrial laundry
- Total building area - 32,500 FT^2
- Solar conditioned space - None
- Number of stories - One story, approximately 20 FT high in laundry area, and about 20% of total floor area has a second story (above office space)
- Roof slope - Flat
- Special features - Combined solar hot water and waste heat recovery system - large single collector area

Structure

- Walls
  - Frame - Concrete tilt-up panels
  - Exterior finish - Painted concrete
  - Insulation - None
  - Interior finish - Painted concrete
  - Windows - None
  - Doors - About 60% of rear wall of laundry section opens with motorized overhead roll-up doors (12 FT x 14 FT), approximately 1000 FT^2 overall
- Roof
  - Frame - Steel beams, metal joists, corrugated metal roofing

- Exterior finish - 3 layers built-up roof with gravel
- Insulation - R-8, 2 IN of rigid insulation
- Interior finish - Paint
- Roofing protection - Additional strip of rolled roofing laid between collectors

- Floor - Concrete slab on grade

Mechanical System

- Heating - Non-solar
- Cooling - Non-solar
- Processed hot water (Commercial laundry)
  - Daily water demand - 65,000 GAL at 180°F
  - Solar - Preheat
  - Backup - Gas-fired boiler; steam heat with heat recovery from wastewater and steam condensate

IV. SOLAR SYSTEM DESCRIPTION

A. General Overview

The Aratex solar hot water installation is shown in Figure IV-A-1. The major components of this solar energy system include 140 Ying flat plate collectors, a 12,500 GAL solar storage tank, a wastewater heat recovery system, a steam heat exchanger, a hot water holding tank with an immersed steam condensate coil, pumps, valves, and a gas-fired auxiliary boiler.

Subsequent sections describe the collector, storage, energy-to-load, and auxiliary subsystems. A following section describes the controls. A glossary and a legend of symbols are presented in Appendices A and B, respectively.

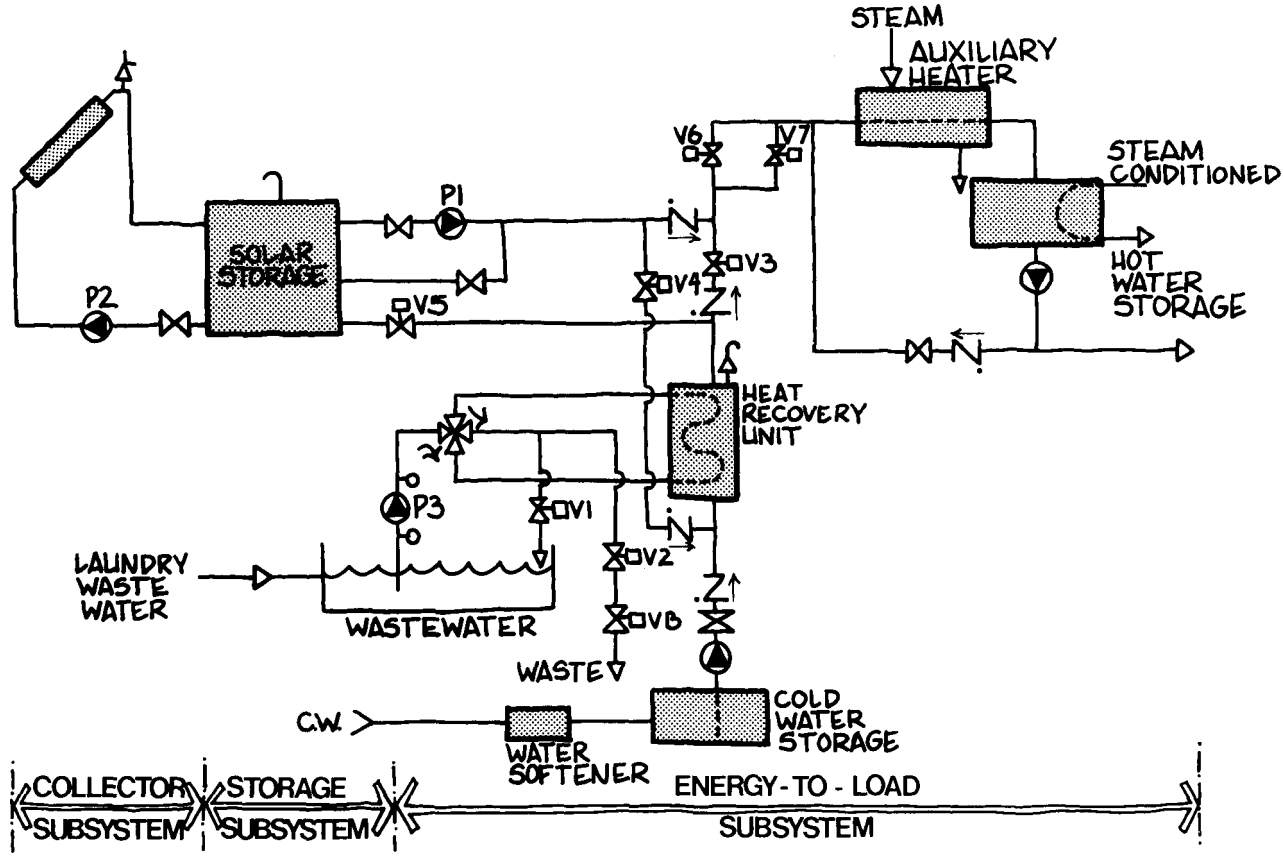


Figure IV-A-1
Overall Solar Energy System Schematic

B. Collector Subsystem

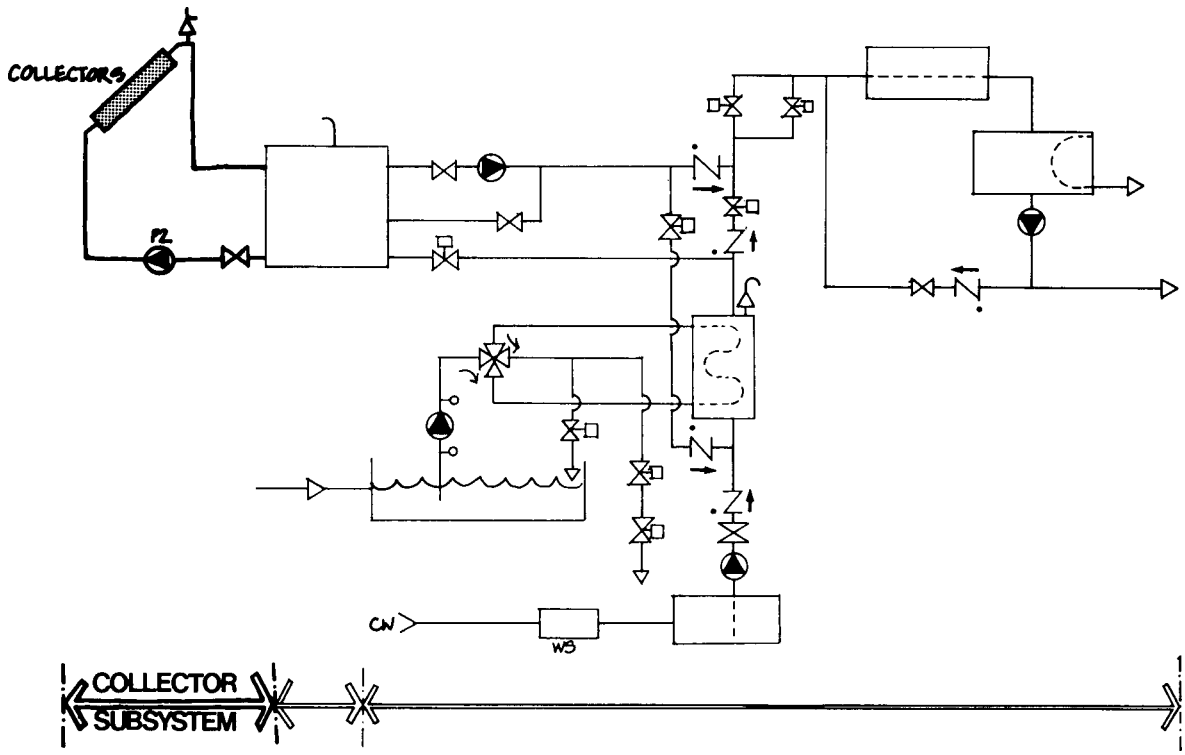


Figure IV-B-1
Collector Subsystem

General Description

The flat plate, solar collectors have a single glazing of UV stabilized, clear polycarbonate sheets. The aluminum absorber plate, painted flat black, is mechanically fastened to 1/2 IN OD stainless steel piping. The exterior manifolding is 1 IN OD stainless steel. The backs of the collectors are insulated with 3 IN of polyurethane foam, while the collector sides are insulated with 1 IN of polyurethane foam. An aluminum frame holds the collector intact.

The collectors are mounted to 1-1/2 IN x 1-1/2 In galvanized steel angles supported by traingular bracing. There is no cross-bracing between triangles. The angles rest on 4 x 4 wood beams supported by wood blocks, bolted to roof trusses. The wood blocks are holes are covered with pitch. The wood is weatherproofed.

The collectors in each row are piped in reverse-return. The collector rows are piped in parallel.

Collectors

- Type - Flat plate
- Number - 140
- Collector orientation - Due south
- Angle - 30° from horizontal
- Total gross collector area - 7392 FT^2
- Total net collector area - 6350 FT^2
- Array configuration - 24 rows, one collector high
- Manufacturer/Model No. - Ying Manufacturing Company/SP4120
- Collector enclosure
  - Frame material - Aluminum
  - Gross area - 48 FT^2
  - Net area - 45.3 FT^2
  - Overall size - 4 FT x 12 FT/panel
  - Filled weight - 2.4 LBS/FT^2
- Glazing
  - Number - One
  - Material - UV stabilized, clear polycarbonate
  - Thickness - 0.02 IN
  - Transmittance - 0.91
- Absorber plate
  - Type - Flat plate, discontinuous sections wedged between collector piping
  - Material - Aluminum
  - Thickness - 0.03 to 0.04 IN
  - Coating - Black paint
  - Absorptance - 0.93
  - Emittance - 0.90

- Fluid passage
  - Material
    - Collector piping - 1/2 IN OD stainless steel
    - Manifold piping - 1 IN OD stainless steel
  - Bond to absorber - Held by edges of absorber plates that are bent to form brackets
  - Protective coating - None
  - Manifold - Exterior
- Insulation
  - Material - ICBO approved polyurethane, foamed in place with foil backing
  - Thickness
    - Back - R-19, 3 IN
    - Sides - R-6, 1 IN

Collector Piping (Above roof) (See Figure IV-B-2)

- Collector to manifold
  - Material - Silicon hose and copper pipe
  - Size - 1 IN ID
  - Length per collector - Approximately 1 FT
  - Installation technique - Unprotected metal clamps with screw fasteners
  - Insulation - R-4, 1 IN fiberglass only on copper pipe
  - Waterproofing - Lapped and bonded corregated aluminum. Plastic sleeve at elbows
- Manifold and branch piping (See Figure IV-B-3)
  - Piping configuration - Reverse-return in each row; rows are piped in parallel
  - Material - Copper
  - Size - 1 IN OD

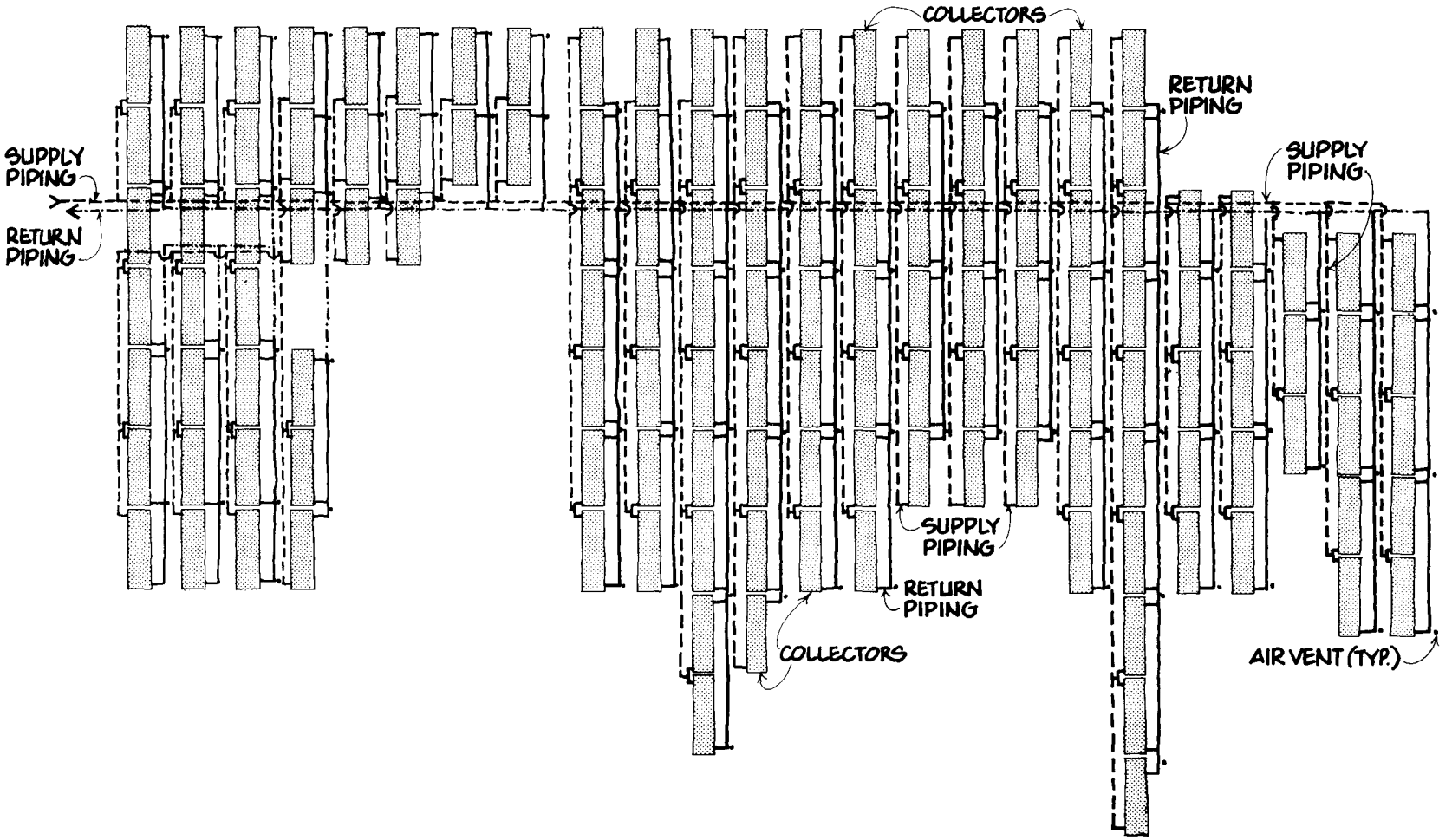
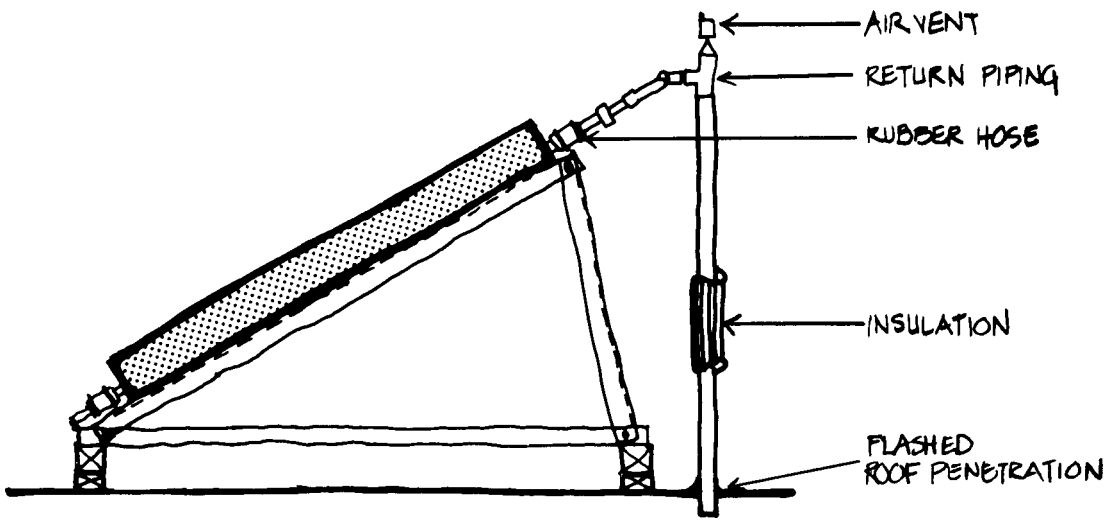


Figure IV-B-2
Collector Subsystem-Above Roof Piping Diagram



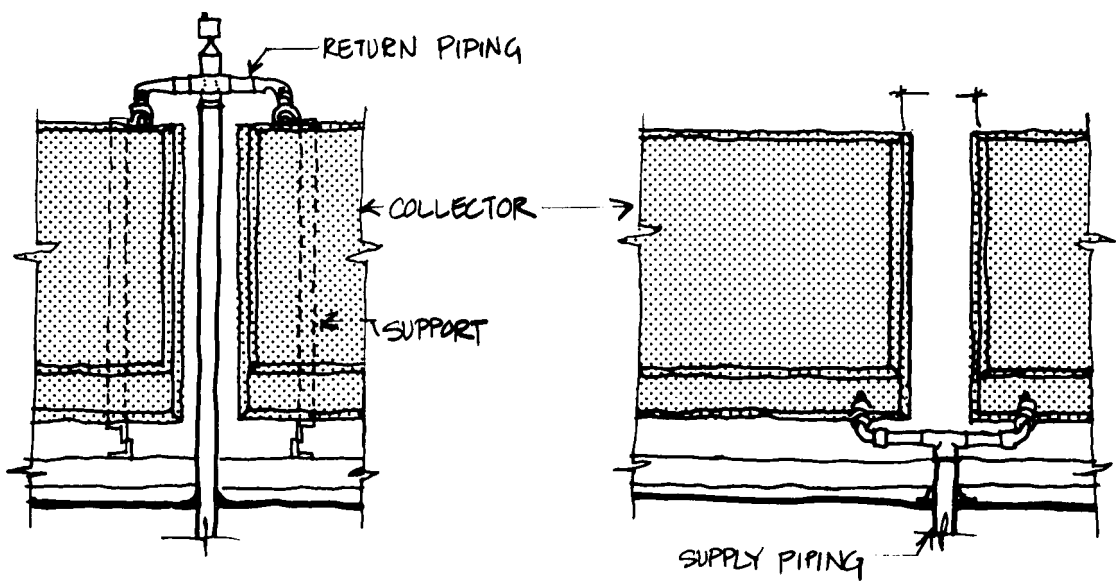


Figure IV-B-3
Collector Manifold Details

- o Insulation - R-4, 1 IN fiberglass
- o Waterproofing - Lapped and bonded corrugated aluminum, plastic sleeve at elbows
- o Supply piping support - None required since pipe is flashed directly into roof
- o Return piping support (See Figure IV-B-4) - 1-1/2 IN x 1-1/2 IN galvanized steel angle supported horizontally by collector frame, with pipe support hung from 3/16 IN steel bolt, pipe supported on outside of waterproofing
- o Roof support - None

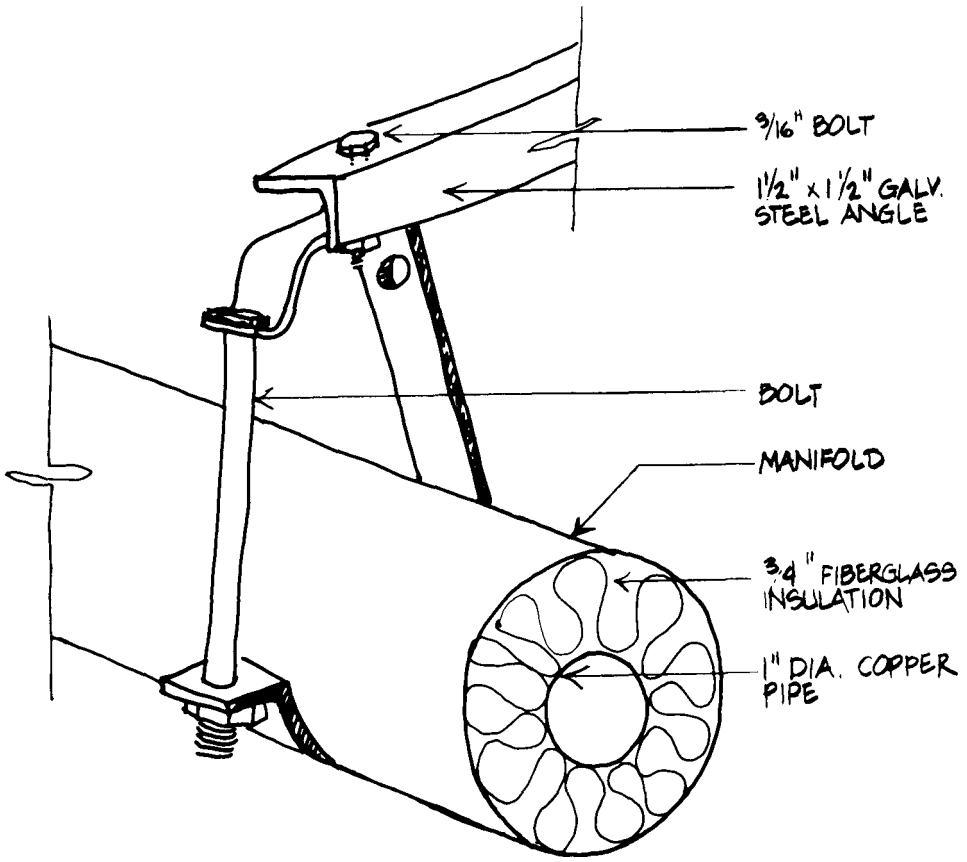


Figure IV-B-4
Return Piping Support Detail

- Roof penetration (See Figure IV-B-5) - Pipe waterproofing flashed directly to roofing

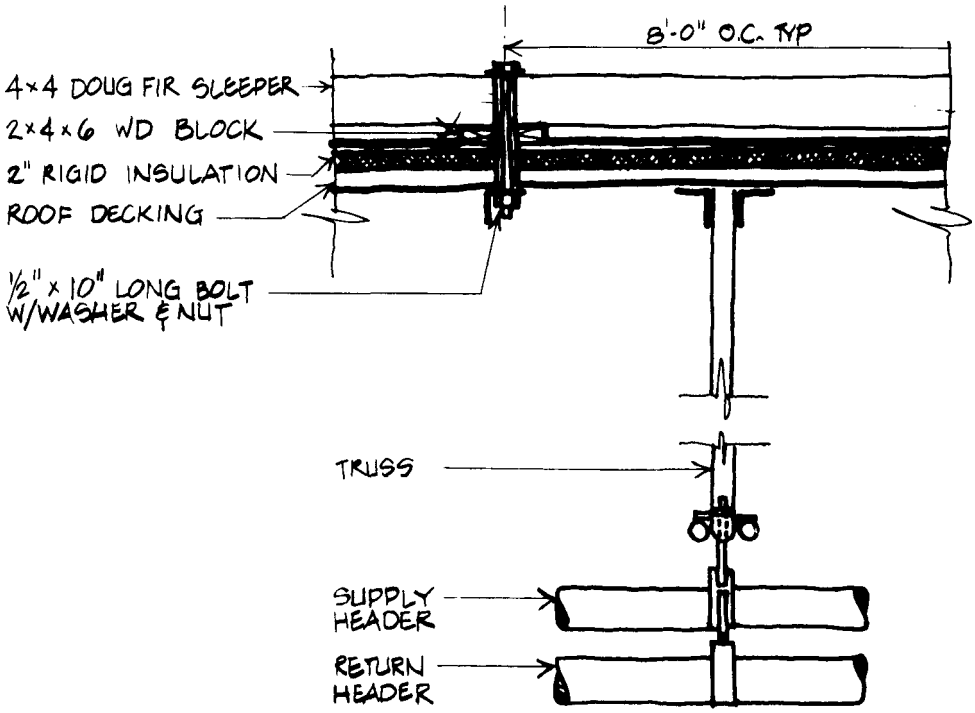


Figure IV-B-5
Roof Penetration/Piping Support

- Vents
  - Automatic - No. 66 Auto-Vent, as manufactured by Maid-O-Mist
- Valves
  - Balance
    - Location - Flow control valves in each bank, in manifold
    - Manufacturer - Aqua-Duct

Collector Support (See Figure IV-B-6)

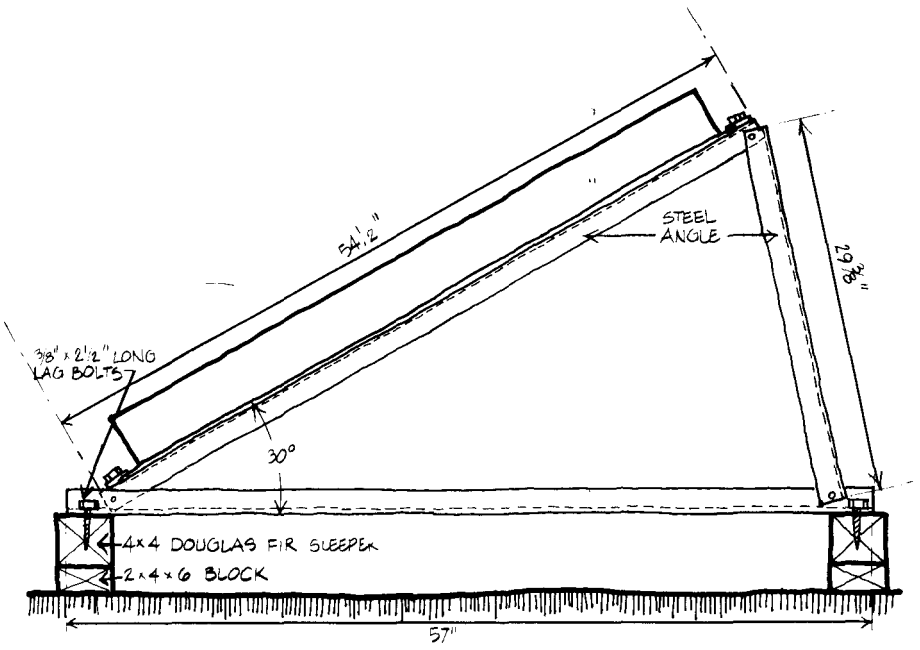


Figure IV-B-6
Collector Support Section

- Structural framing material - 1-1/2 IN x 1-1/2 IN galvanized steel angles bolted together to form vertical triangles which are attached to collectors. These triangles rest on 4 x 4 wood supports which rest on wood blocks.
- Fasteners - Nuts, bolts, and washers
- Collector attachment - Metal edge of collector is slid between metal angle and washer, and secured by bolts

Piping (Below roof)

- Material - Copper, type M

Mechanical equipment

- Pump (P2)
  - Type - Duplex pump, one casting has 2 motors and 2 impellers
  - Location - Next to storage tank
  - Manufacturer - Grundfos

- Horsepower - 1-1/2 HP for each motor
- Flow rate - 200 GPM

Heat Transfer Fluid

- Fluid - Water
- Treated - Water softener

C. Storage Subsystem (See Figure IV-C-1)

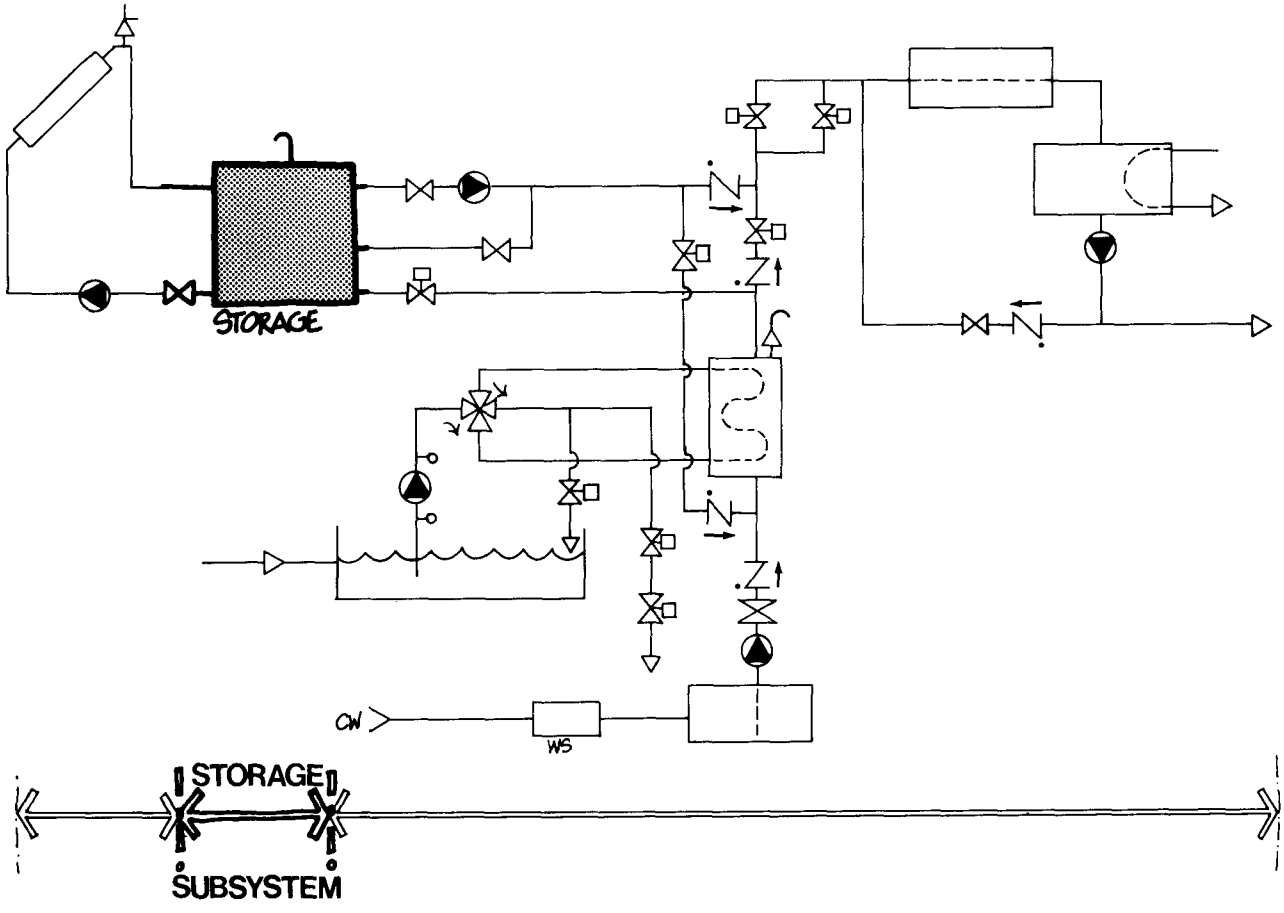


Figure IV-C-1
Storage Subsystem

General Description

The 12,500 GAL storage tank is located at grade level in a porch-like enclosure adjacent to the laundry. The tank, which is exposed to the outdoor environment, is protected overhead by a roof. The tank is covered with 3 IN of urethane foam insulation. The exposed insulation is protected by corrugated aluminum. The tank is mounted vertically and rests on a concrete slab at grade level.

Tank (See Figure IV-C-2)

- Location - At southern end of building in covered area at grade level, exposed to the outdoor environment
- Capacity - 12,500 GAL

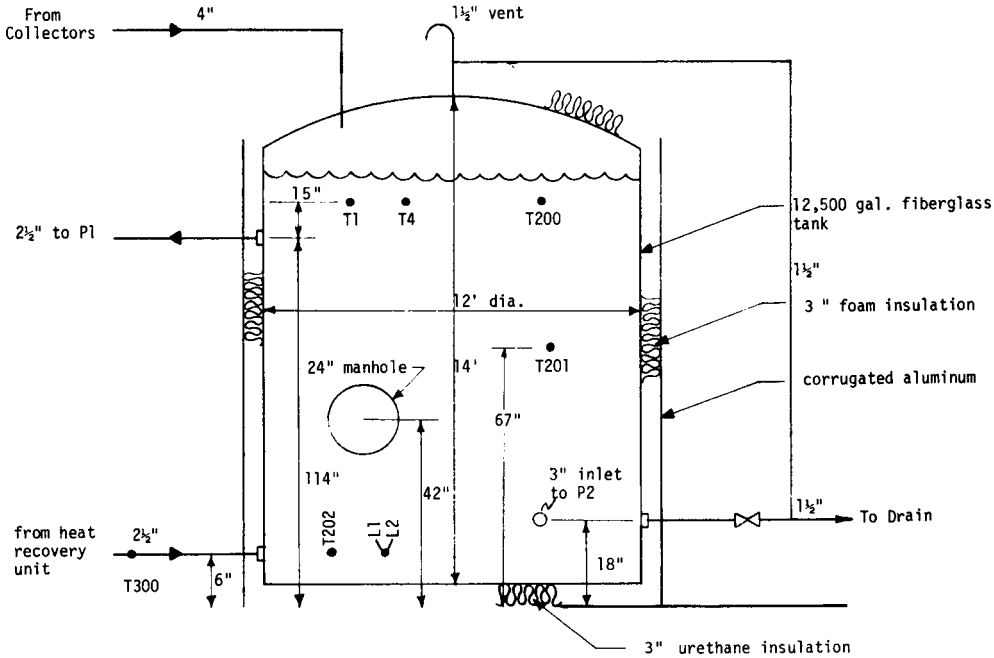


Figure IV-C-2
Storage Tank

- Size - 12 FT diameter x 14 FT high
- Construction - Fiberglass as manufactured by Century Plastics, Los Angeles, California
- Rated working pressure - Atmospheric
- Test pressure - N/A
- Insulation - R-17, 3 IN polyurethane on top, sides, and bottom field installed
- Waterproofing - None required; sides are sheathed with corrugated aluminum for mechanical damage resistance
- Installation - Resting vertically on concrete floor at grade level
- Immersed coils - None
- Piping connections - Threaded pipe tappings, welded
- Sensor probe installations - Same as above

D. Energy-To-Load Subsystem (See Figure IV-D-1)

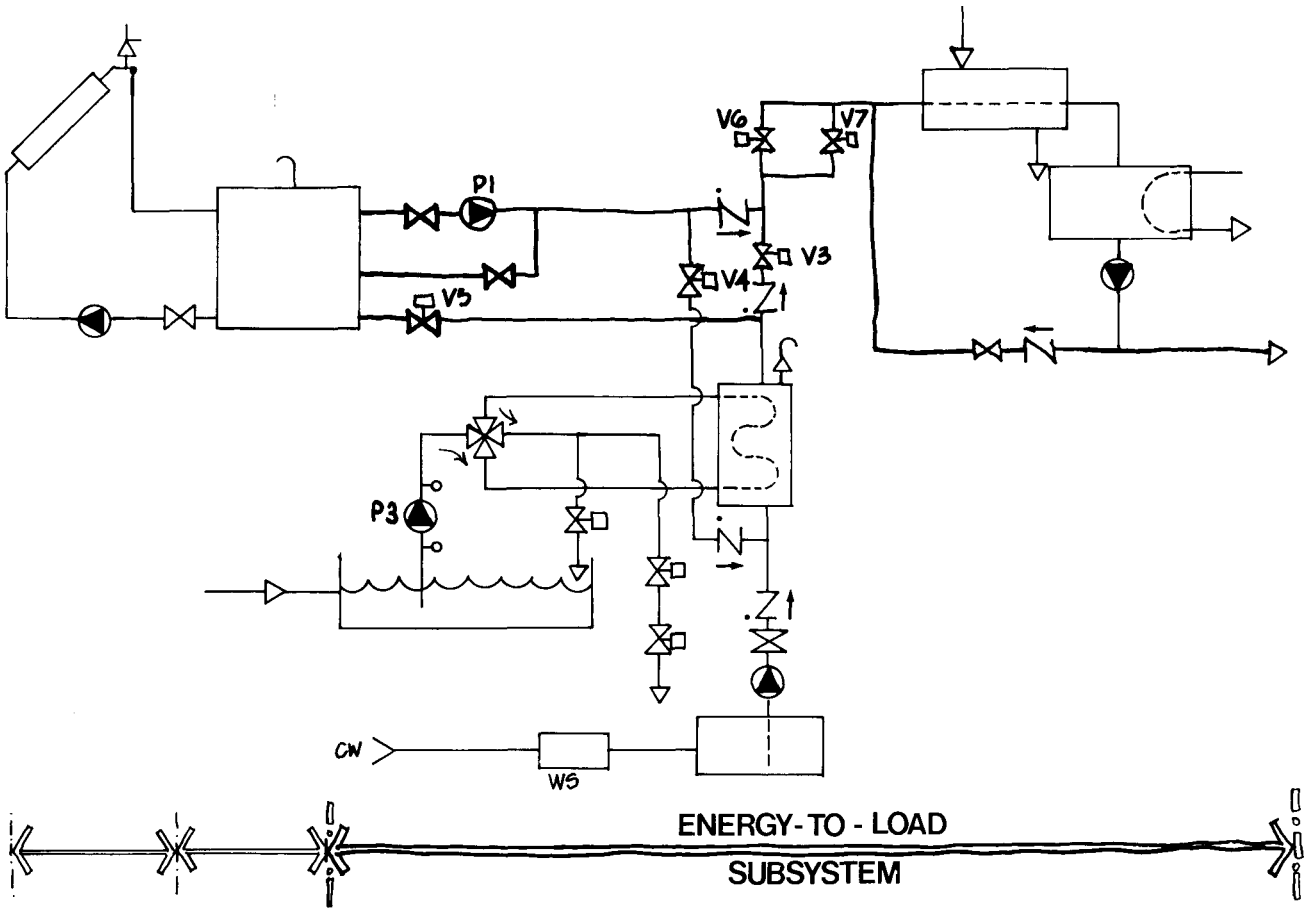


Figure IV-D-1
Energy-To-Load Subsystem

1. Weekday Mode

- General Description - Hot water is processed for laundry use in the following manner. Softened city water is circulated through a heat exchanger for heat recovery from the laundry wastewater and then pumped to the solar storage tank. The water is heated further by the solar collectors.

  The laundry process water is passed through a steam heat exchanger to boost the water temperature to the required level of 170°F and then sent to a hot water holding tank. The steam is provided by a conventional boiler which is used for space heating. The hot water holding tank has a capacity of 4000 GAL. Steam condensate is circulated through an immersed heat exchanger in the hot water holding tank to recover waste heat from the condensate.

2. Weekend Mode

- General Description - During periods when the laundry is not in operation, the solar energy is used to elevate the stored water to a high limit temperature of 180°F for use when the laundry operations start up again. Then the 16,5000 gallon wastewater sump is put to use as additional thermal storage capacity. In this mode, when the main storage tank temperature exceeds 180°F with valves V6 and V7 closed, and valve V4 open, and pump P1 recirculates storage tank water through the heat recovery unit. At the same time, valve V1 is open, valve V2 is closed and the temperature of the sump water is raised when it is recirculated through the heat recovery unit by pump P3. (See Figure IV-F-1 for valve location).

  Valve VA performs the function of reversing the flow direction through the heat recovery unit for flushing the tubes. Valve VA is reversed automatically every 30 minutes by a timer.

Piping

- Type
  - o Steel in wastewater heat recovery system
  - o Copper (Type M) in solar energy system

Wastewater Heat Recovery Units

- Type - Water-to-water, Ludell Shell
- Shell inlet water temp. - ±80°F (observed)
- Shell water flow - 150 GPM (pump rating)
- Tube inlet temp. - ±125°F (observed)
- Tube water flow - 200 GPM (pump rating)
- Rating - 3,500,000 BTU/HR (calculated)

Pump (P-1)

- Type - Centrifugal base mounted
- Location - Beside storage tank
- Manufacturer - Taco
- Horsepower - 5 HP
- Flow rate - 150 GPM
- Head - 85 FT

Pump (P3)

- Type - Centrifugal base mounted, self-priming
- Location - 15 FT from storage tank
- Manufacturer - Hydro-Matic
- Horsepower - 5 HP
- Flow rate - 200 GPM
- Head - 50 FT

E. Auxiliary Energy System (See Figure IV-E-1)

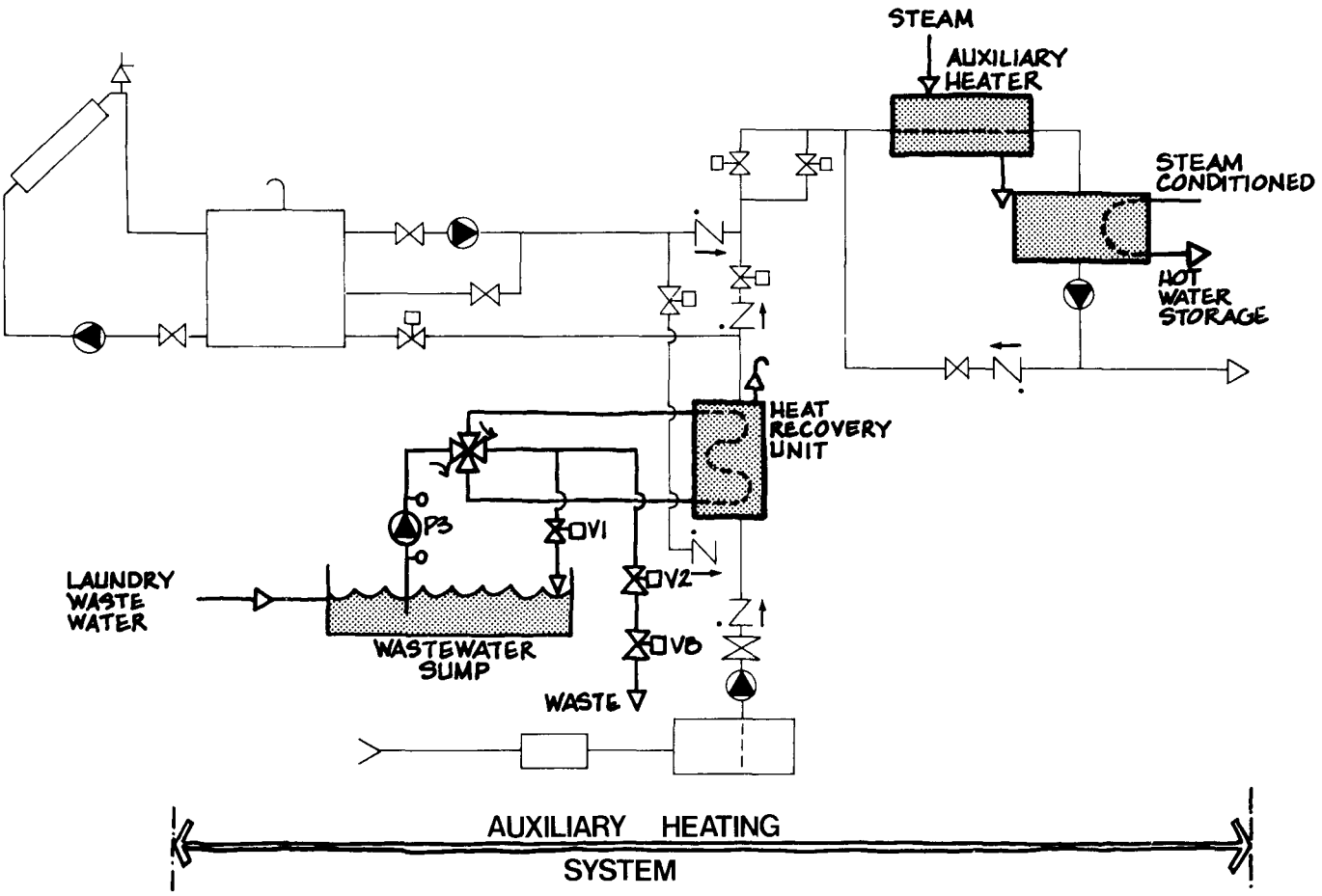


Figure IV-E-1
Auxiliary Energy System

General Description

The auxiliary energy used in heating the laundry process water is provided by a steam-generation boiler. The solar heated water is pumped by P1 from the storage tank on command from level controller L3 which also opens V6. The water passes through the steam-to-water heat exchanger on its way to the hot water holding tank. The steam heat exchanger provides supplemental heating to raise the laundry process water temperature to the required setting for the laundry process. In the holding tank, further heating is supplied by circulation steam condensate from the plant through an immersion bundle in the base of the holding tank. Low level controller L4 opens valve V7 which allows a greater flow into the holding tank. From the holding tank the process water is pumped on demand to the laundry machines by a 500 GPM base mounted pump.

Hot Water Holding Tank

- Type - Stand mounted, horizontal
- Material - Steel
- Capacity - 4000 GAL
- Specifics
    - 3 IN insulation around tank
    - Immersed bundle heater in one end

Steam-To-Water Heat Exchanger

- Manufacturer - Ludell
- Size (IN) - 12 diameter x 70 long

F. Control Operation (See Figure IV-F-1 and Tables IV-F-1 and IV-F-2)

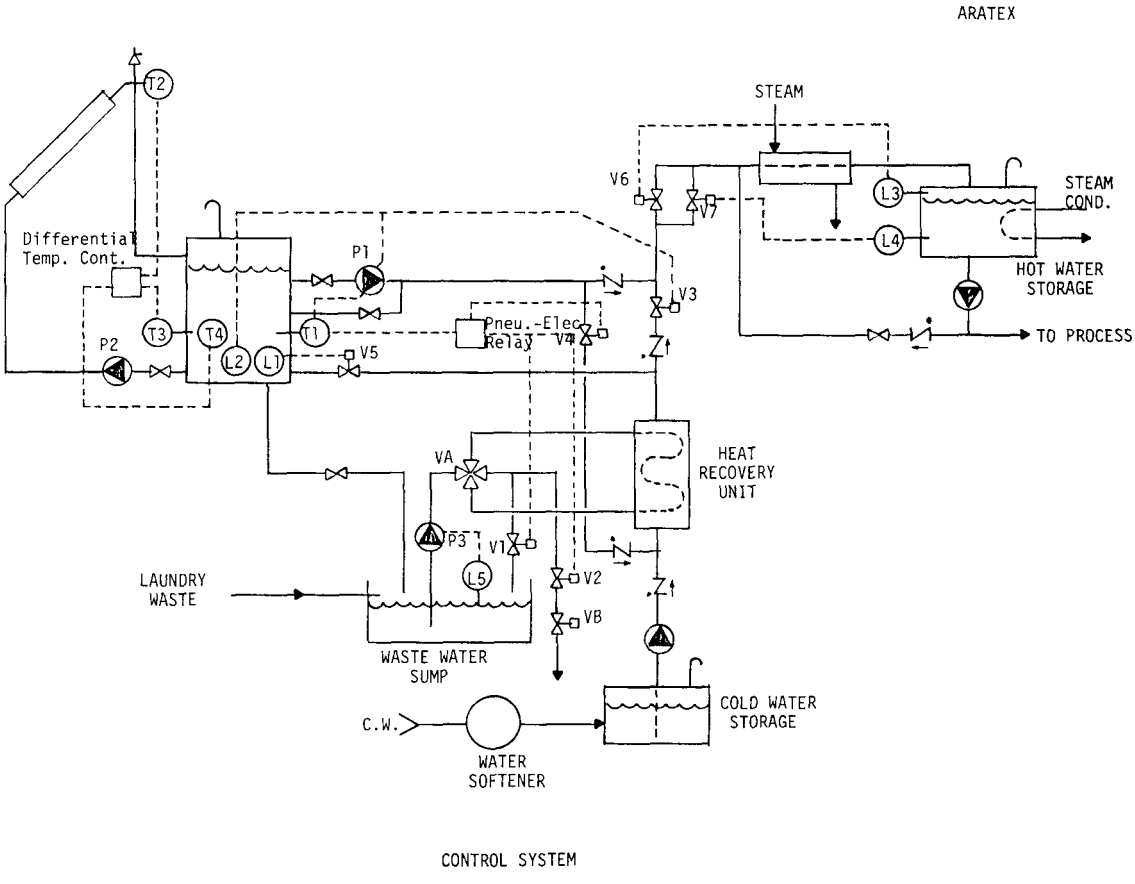


Figure IV-F-1
Controls Diagram

General Description

The collector loop operates independently of all other systems, and it is able to operate at all times subject to the controller demands. The main storage tank is vented to the atmosphere, and thus the collector loop is an open system. When the collector circulator pump P2 is not running, the water in the collectors drains down to the tank for freeze protection. Whenever the temperature of the water leaving the collector is at least 4.5°F above the storage tank temperature, the collector circulator runs for a predetermined time. The reset timer prevents rapid pump cycling during scattered cloud conditions. When the water temperature in the storage tank is within 1.5°F of the water temperature leaving the collector, the circulation pump P2 is turned off. Excessive storage tank temperatures are prevented by de-energizing the collector circulator pump P2 if the water in the storage tank becomes 190°F or greater.

1. Weekday Mode (Laundry Operating)

   - General Description - In normal operational mode, city water enters the heat recovery unit at 80°F where its temperature is raised to 115°F by circulating 125°F laundry wastes from the wastewater sump. The water enters the main storage tank and mixes with water being heated by the solar collectors. The water is then pumped to a holding tank by P1 through a steam heat exchanger where its temperature is raised to the process requirements. A 500 GPM circulates the water in the holding tank to raise its temperature to 180°F and also distributes hot water to the laundering equipment on demand.

2. Weekend Mode (Laundry Not Operating)

   - General Description - During periods when there is no requirement for process water and no flow of wastewater, the 16,500 gallon wastewater sump is used as additional storage capacity. Valves V6 and V7 are closed and valve V4 is opened to allow pump P1 to circulate the main storage tank water through the heat exchanger. At the same time, pump P-3 recirculates the water in the 16,500 gallon waste sump through the heat exchanger and thus raises its temperature throughout the weekend. The wastewater sump is therefore as warm as possible for the start of laundry operations on the following Monday morning.

Valving (See Table IV-F-1)

- Automatic valve (VA)
  - Type - 4-way, 2-position, air operated
  - Manufacturer - Dezurik
- Automatic plug valves
  - Type - 2-position, electric
  - Manufacturer - Dezurik
- Automatic globe valves
  - Type - Pneumatic operated
  - Manufacturer - Grinnell

- Automatic solenoid valve
  - Type - 2 position
  - Manufacturer - Asco
- Butterfly valves - Manufactured by Grinnell
- Gate valves
  - Manufacturer - Nibco
  - Material - Bronze
- Check valves
  - Manufacturer - Kennedy
  - Material
    - Heat recovery system - Iron
    - Solar energy system - Bronze

TABLE IV-F-1
AUTOMATIC VALVE TYPES

	Operation		Control		Type		Manufacturer			
	Electric	Pneumatic	Modulating	2 Position	Plug	Globe	Dezurik	Grinnell	Asco	Marfed
V1		X		X		X		X		
V2		X		X		X		X		
V3		X		X	X		X			
V4		X		X	X		X			
V5	X			X	X				X	
V6	X			X	X					X
V7	X			X	X					X
VA		X		X	X			X		
VB		X				X		X		

TABLE IV-F-1
TRUTH TABLE FOR PUMPS

	WEEKDAY MODE			WEEKEND MODE		
	P1	P2	P3	P1	P2	P
Collector water 4.5°F above storage water		on			on	
Storage water 1.5°F above collector water		off			off	
Storage water $\geq$ 190°F		off			off	
Level low in holding tank	on					
Level sufficient in holding tank	off					
Level low in wastewater sump			off			
Level sufficient in wastewater sump			on			
Storage water $\geq$ 180°F				on		c
Storage water $\leq$ 170°F				off		c

TABLE IV-F-2
TRUTH TABLE FOR VALVES

	V1	V2	V3	V4	V5	V6	V7
Weekday Mode	X	0	⊠	X	⊠	⊠	⊠
Weekend Mode	0	X	X	0	⊠	X	X

KEY

0 = Open X = Closed ⊠ = Open/Closed on Demand

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. Products from the Network include 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 which describe the behavior of the solar system (See NBSIR 76-1137, National Bureau of Standards). Additional instrumentation may also be included as a result of site-specific requirements. Typically, the instrumentation include 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 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.

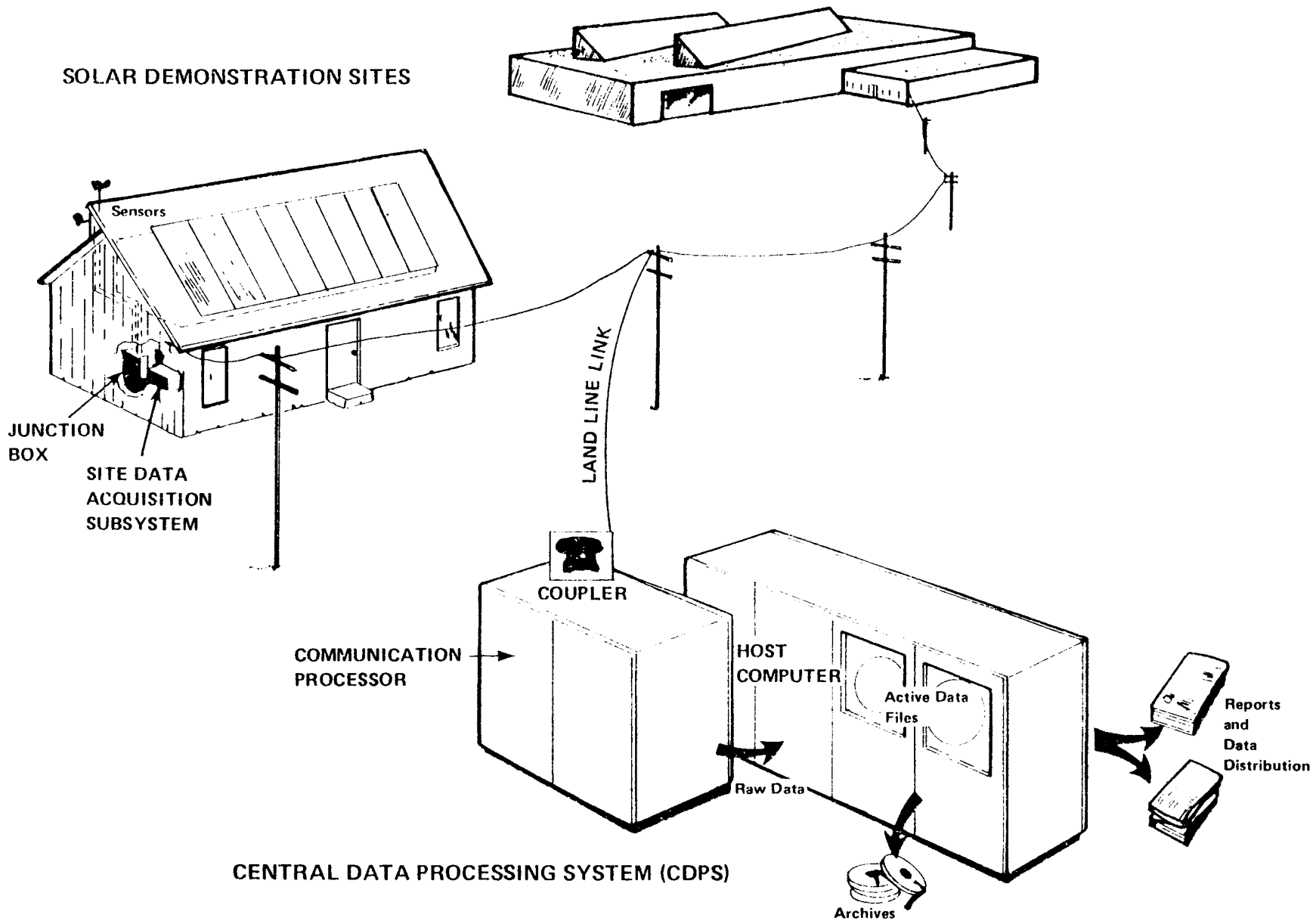


Figure V-A-1. The National Solar Data Network

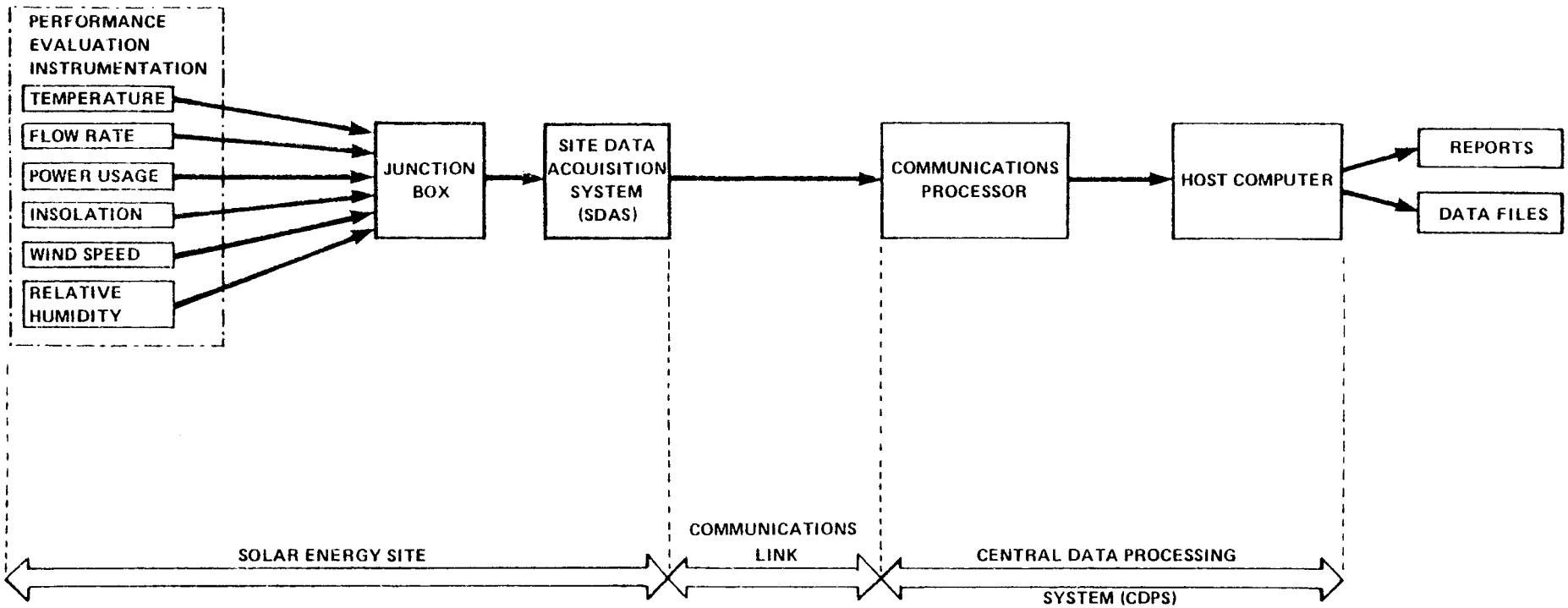


Figure V-A-2. Data Flow Path for the National Solar Data Network

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. On-Site Instrumentation

The on-site instrumentation include sensors to monitor the various parameters of the solar energy system, a junction box, and a Site Data Acquisition System that stores data 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 ARATEX SERVICES, INCORPORATED

SENSOR	NAME	RANGE (F) Min	RANGE (F) Max	MFGR	THERMOWELL PART NO
T001	Ambient air dry bulb temp	-20	120	Minco	
T100	Collector array inlet temp	30	230	Minco	F203U55
T150	Collector array diff. temp	0	50	Minco	F203U55
T101	Solar hot water storage tank outlet temp	30	230	Minco	F203U15
T151	Solar hot water storage tank diff. temp	0	50	Minco	F203U55
T102	Collector absorber temp	30	450	Minco	RTD Adh.
T200	Top of solar hot water storage tank	30	230	Minco	F203U154
T201	Middle of solar hot water storage tank	30	230	Minco	F203U154
T202	Bottom of solar hot water storage tank	30	230	Minco	F203U154
T300	Solar hot water storage tank diff. inlet temp	30	230	Minco	F203U15
T350	Solar hot water storage tank diff. outlet temp	0	50	Minco	F203U15
T351	Storage tank outlet diff. temp	0	50	Minco	F203U15
T302	Steam heat exchanger inlet temp	30	230	Minco	F203U15
T352	Storage tank inlet temp and heat exchanger outlet temp	0	50	Minco	F203U15
T303	Domestic water inlet temp	30	160	Minco	F203U15
T304	Waste water heat exchanger temp	30	230	Minco	F203U15
T354	Waste water heat exchanger temp	0	50	Minco	F203U15

TABLE V-B-2. FLOW RATE INSTRUMENTATION FOR ARATEX SERVICES, INCORPORATED

SENSOR	NAME	RANGE (GPM/CFM)			MFGR	MODEL NO
		Min.	Design.	Max.		
W100	Collector flowrate	20	175	200	Ramapo	MKV-4-W07
W300	Solar hot water storage tank flow	20	140	200	Ramapo	MKV-2-1/2-W07
W301	Hot water flow from storage tank	30		300	Ramapo	MKV-3-W01
W302	Hot water flow to process	20	140	200	Ramapo	MKV-4-W01
W303	City water inlet flow	20	140	200	Ramapo	MKV-3-W01

TABLE V-B-3. POWER INSTRUMENTATION FOR ARATEX SERVICES, INCORPORATED

SENSOR	NAME	PHASE	MFGR	FULL SCALE INPUT		MODEL NO
				Volts	Amps	
EP101	Collector pump power-solar pump P-2	3	Ohio Semi-tronics	230	11	PC5-23F
EP301	Circulator pump power-P1	3	Ohio Semi-tronics	230	13.3	PC5-23F
EP302	Water to process pump	3	Ohio Semi-tronics	230	50	PC5-62F
EP303	Waste water heat recovery pump	3	Ohio Semi-tronics	230	14.4	PC5-23F
EP304	Power used for water flow control, solar flow control and alternate cycling pump control	1	Ohio Semi-tronics	115	15	PC5-1F

TABLE V-B-4. MISCELLANEOUS INSTRUMENTATION FOR ARATEX SERVICES, INCORPORATED

SENSOR	NAME	MODEL NO.	MFGR.
I001	Collector Plane Total Insolation	PSP	Eppley Laboratories
V001	Wind Speed	W101-P-DC/540	Weathermeasure
D001	Wind Direction	W101-P-DC/540	Weathermeasure

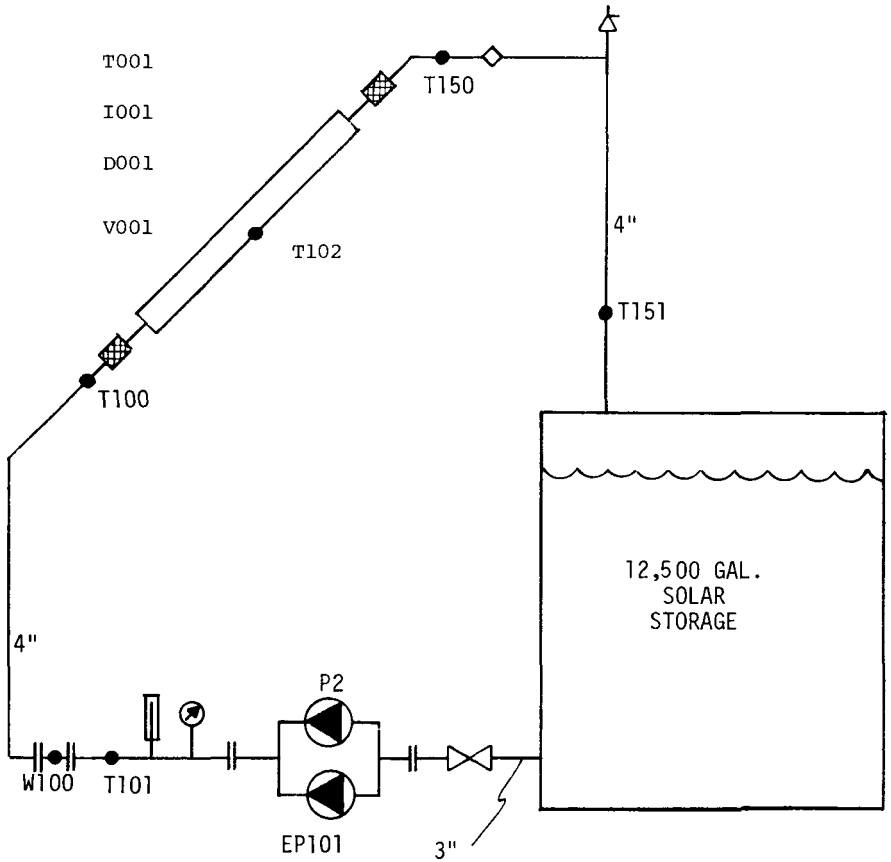


Figure V-B-1
Collector Subsystem

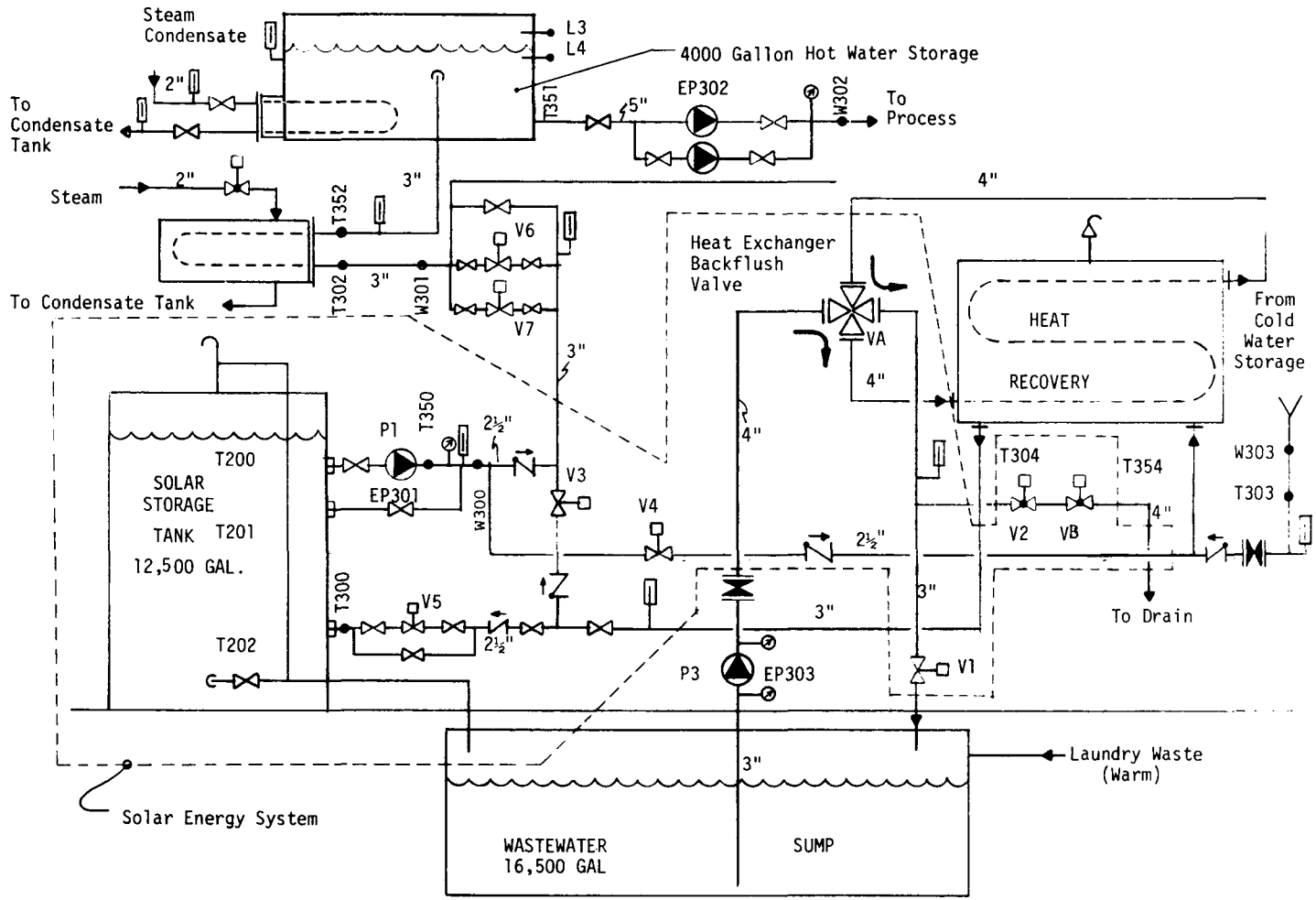


Figure V-B-2
Storage-To-Load Subsystem

VI. 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, and 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 the solar collectors and the exterior piping.

AUXILIARY ENERGY SUBSYSTEM - The equipment, utilizing conventional energy sources, used to supplement the output provided by a solar energy system and used 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° 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 in order 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 incapable of being 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, while others use nitrogen.

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 air stream.

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.

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

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 that is permanently orientated towards the sun and 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 covered by one or more transparent covers. There are no concentrators or focusing aids in a flat plate collector.

FOCUSING COLLECTOR - A solar collector using 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 in 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 a shutdown or a 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. This unit may also include additional components to heat the condition 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 the use of any other 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 for a fraction of the 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, as well as the addition of 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 so that the stored energy can be used for heating, cooling, or heating water during periods 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 the heating and cooling systems for space conditioning or the hot water heater.

TON OF REFRIGERATION - A unit of refrigeration which is equivalent to 12,000 BTU/HR.

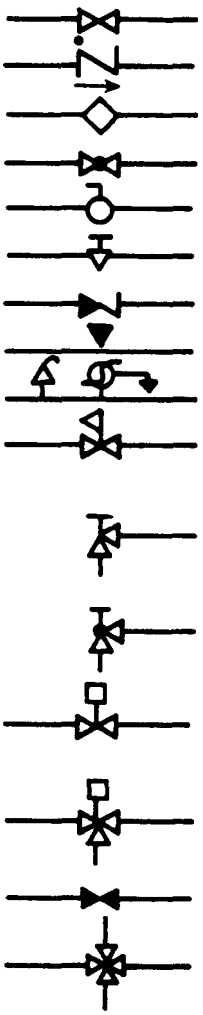
TRACKING COLLECTOR - A solar energy collector that constantly moves to follow the path of the sun.

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

ZONE - A portion of a conditioned space with similar heating and cooling requirements so that a common control is used.

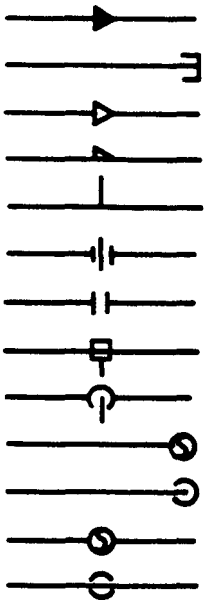
B. LEGEND FOR SOLAR SYSTEM SCHEMATICS

VALVES



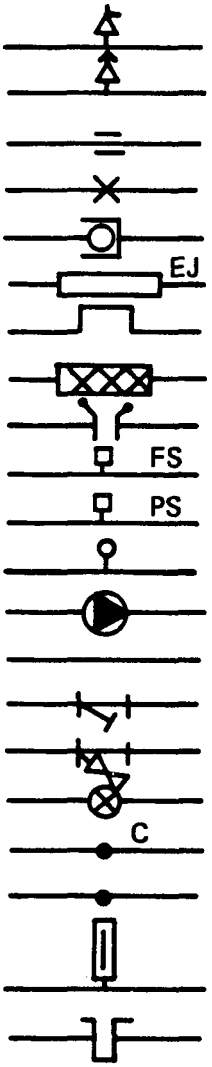
GATE VALVE
CHECK VALVE
BALANCING VALVE
GLOBE VALVE
BALL VALVE
PLUG VALVE
BACKFLOW PREVENTER
VACUUM BREAKER
RELIEF OR SAFETY
PRESSURE REDUCING
ANGLE GATE VALVE
ANGLE GLOVE VALVE
CONTROL VALVE, 2 WAY
CONTROL VALVE, 3 WAY
BUTTERFLY VALVE
4 WAY VALVE

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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