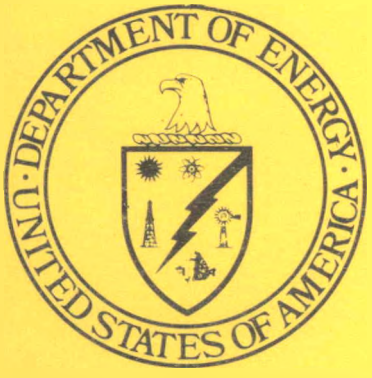
Lh. 6050

SOLAR/2056-79/50

Solar Project Description

INGHAM COUNTY MEDICAL CARE FACILITY
Okemos, Michigan
August 1979



U.S. Department of Energy
National Solar Heating and Cooling Demonstration Program

National Solar Data Program

Solar/2056-79/50
Distribution Category UC-59

SOLAR PROJECT DESCRIPTION
FOR
INGHAM COUNTY MEDICAL CARE FACILITY

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

Under Contract Number
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The Ehrankrantz Group
PRC Energy Analysis Company

In Cooperation with
IBM Corporation, Federal Systems Division

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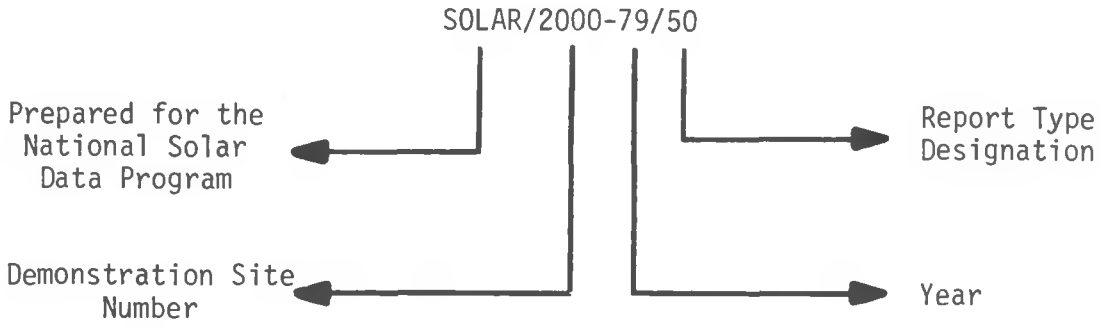
NATIONAL SOLAR DATA PROGRAM REPORTS

Reports prepared for the National Solar Data Program are numbered under a specific format. For example, a report for an XYZ Corporation project site could be designated as SOLAR/2000-79/50. 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 the use of fossil fuel 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 such topics as:

- Solar Project Description,
- Design/Construction Contractor Final Report,
- Project Costs,
- Maintenance and Reliability,
- Operational Experience,
- System Performance Evaluation,
- Monthly Performance Reports, and
- Solar Life-Cycle Cost 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 Ingham County Medical Care Facility solar installation in Okemos, Michigan. Major features of this system include:

- Collector - Liquid, flat plate
- Freeze protection - Antifreeze/warm water recirculation
- Application - Domestic hot water preheat/Process hot water preheat
- Storage - Liquid interior, on-grade
- New/Retrofit - Retrofit
- Performance Evaluation Instrumentation - Yes
- Site-Specific Features - Parallel/series collector piping, warm water recirculation back-up freeze protection

Domestic hot water preheating is provided by a solar energy system utilizing 9,425 square feet of liquid flat plate collectors.

The collectors are ground mounted in 14 rows on steel supports in groups of six. The steel supports are mounted on 6 x 8 timbers. Each row has 6 groups of 6 panels. The collectors are double-glazed with tempered glass, have copper absorber plates and a non-selective black coating. A 50 percent propylene glycol/water solution protects the collectors from freezing down to -20^{o} F. A steam-fired heat exchanger and circulation pump with an emergency generator provide heat to protect the collectors below -20^{o} F.

A 5,000 gallon, currently uninsulated, steel storage tank, is located in the existing mechanical room. The preheated water in the tank is provided directly to a steam-fired hot water heater for use in the laundry facility. A heat exchanger provides preheated water to a steam-fired domestic hot water heater. A gas/oil fired boiler provides steam to the hot water heaters.

The system is fully instrumented for performance evaluation and integrated into the National Solar Data Network. It has been operational since August 1979.

III. SITE AND BUILDING DESCRIPTION

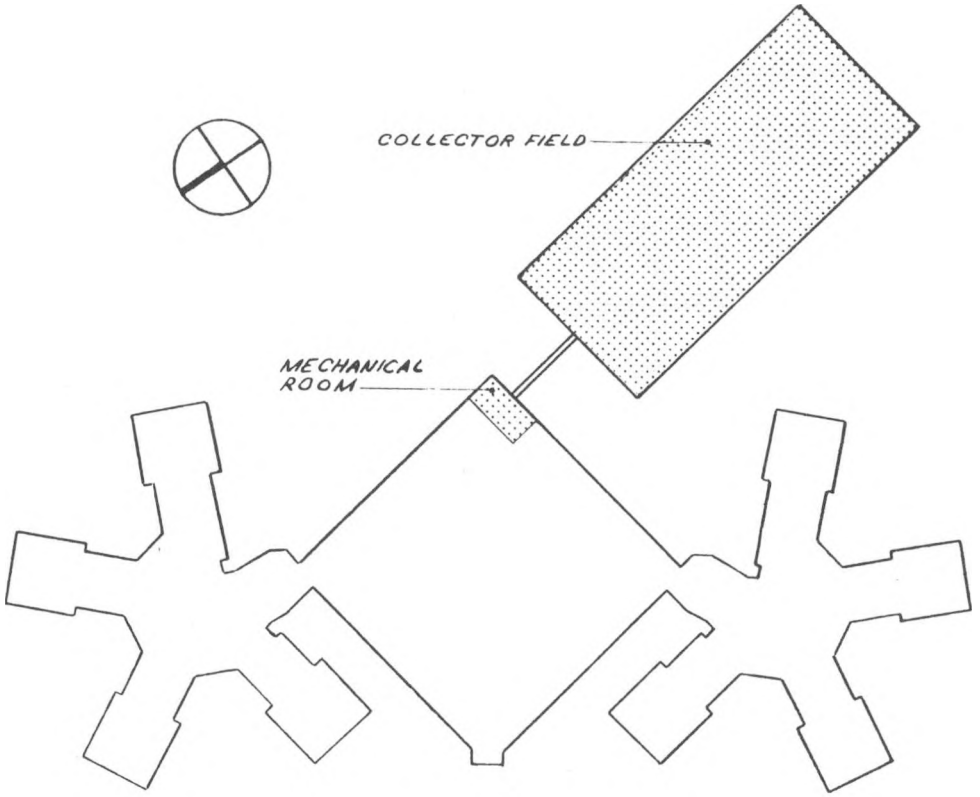


Figure III-1. Site Plan

Site Description

- Special Topographic or climatic conditions - None
- Latitude - 43^{o} N
- Annual Degree days (65^{o} F base)
  - Heating - 6,801
  - Cooling - 575
  - Data location - Grand Rapids, Michigan
  - Data reference - "Input Data For Solar Systems", U.S. Department of Energy, Interagency Agreement No. E(49-26)-1041, November, 1978.
- Average horizontal insolation
  - January - 370 Btu/ft^2/day
  - July - 1,914 Btu/ft^2/day
  - Data location - Grand Rapids, Michigan

- Data reference - "Input Data For Solar Systems", U.S. Department of Energy, Interagency Agreement No. E(49-26)-1041, November, 1978.
- Site topographic description - Flat
- Shading - None

Building Description

- Occupancy - Geriatric facility
- Total area - Not applicable to hot water preheat system
- Height - One story
- Special features - Emergency electric generator
- Structure - Not applicable to hot water preheat system

Mechanical System

- Domestic Hot Water
  - Daily hot water demand - 22,000 gallons
  - Auxiliary - Gas/oil fired steam boiler

IV. SOLAR SYSTEM DESCRIPTION

A. General Overview

The solar energy commercial demonstration project for the Ingham Medical Facility in Okemos, Michigan, is represented in figure IV-A-1. The major components of the solar system include 9,425 square feet of double glazed, flat black, flat plate collectors, a 5,000 gallon solar storage tank, a 2,883 gallon laundry hot water storage tank, and a 1,872 gallon domestic hot water storage tank.

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

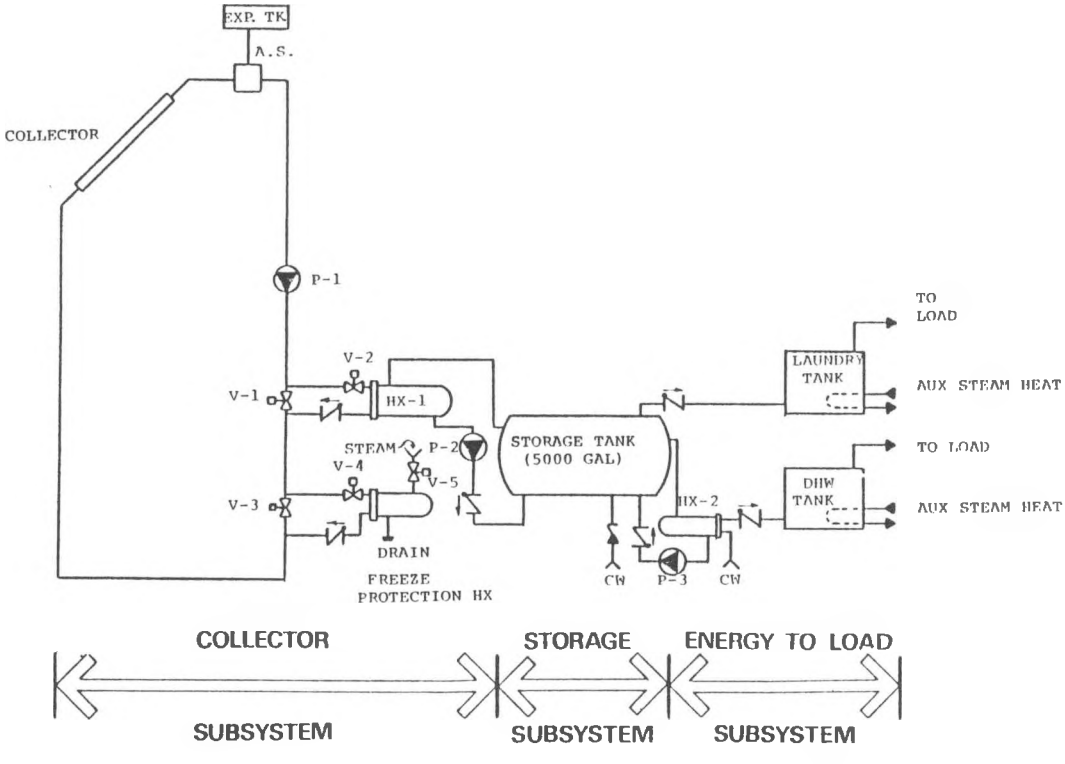


Figure IV-A-1. Overall System Schematic

B. Collector Subsystem

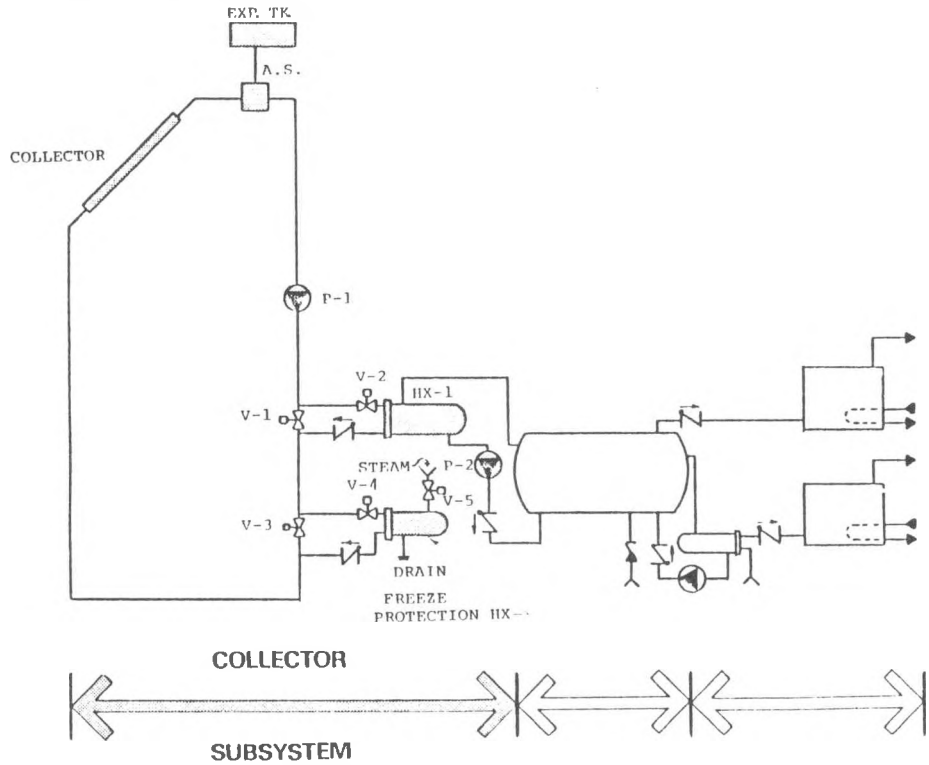


Figure IV-B-1. Collector Subsystem

General Description

The collectors are ground mounted in a sawtooth type array of 14 rows, one collector high. The collectors are supported by a steel frame in groups of six with six groups in each row. Each group is piped in reverse return with each group in series. The rows are piped in parallel with separate balancing and shut-off valves. The collectors are mounted a nominal 10 in. above the group which is covered with a neutral colored gravel.

Collectors

- Type - Flat plate liquid collectors
- Number - 504 collectors
- Collector orientation - 10^{o} east of south
- Angle - 42^{o} from horizontal

- Gross collector area - 9,425 ft^2
- Net collector area - 8,669 ft^2
- Array configuration - 14 rows of 6 collector modules, each collector module has 6 collector panels
- Manufacturer - Revere
- Model Name - Sun-Aid
- Model Number - 79211
- Collector enclosure
  - Frame material - 0.086 in. aluminum extruded side frame with 0.020 in. aluminum sheet backing
  - Gross area - 18.7 ft^2
  - Net aperture area - 17.2 ft^2
  - Overall size - 77 in. long x 35 in. wide x 4.5 in. thick
  - Filled weight - 123 lbs.
- Glazing
  - Number - Double glazed
  - Material - Low iron tempered glass
  - Thickness - 1/8 in.
  - Transmittance - 81 percent
- Absorber plate
  - Type - Tube-In-Strip panel
  - Material - Copper
  - Thickness - 0.032 in.
  - Coating - Black matte paint
  - Absorptance - 96 percent
  - Emittance - 89 percent

- Insulation
  - Material - Fiberglass (0.6 lb/ft^3 density)
  - Thickness - 3 in.
  - R-value - R-10

Collector Piping (see figure IV-B-2)

- Piping between collector and manifold
  - Material - Copper
  - Diameter - 1/2 in.
  - Approximate length per collector - 6 in.
  - Installation - Soldered
  - Insulation - 2 in. rigid fiberglass
  - Waterproofing - Aluminum jacket
- Manifold and branch piping (see figure IV-B-4)
  - Piping configuration - Reverse return for each module, 6 modules in series, each row direct return
  - Material - Steel
  - Size - Varies 3 in to 1 in.
  - Approximate total length - 4,200 ft.
  - Insulation - 2 in. fiberglass
  - Waterproofing - Aluminum jacket
  - Supply and return piping support - Roller support (See figure IV-B-3)

Collector Support (See figure IV-B-5)

General Description

A module of six collector is supported by a welded box frame of 8 in. channel iron. Collectors are held in the frame by a welded plate at the

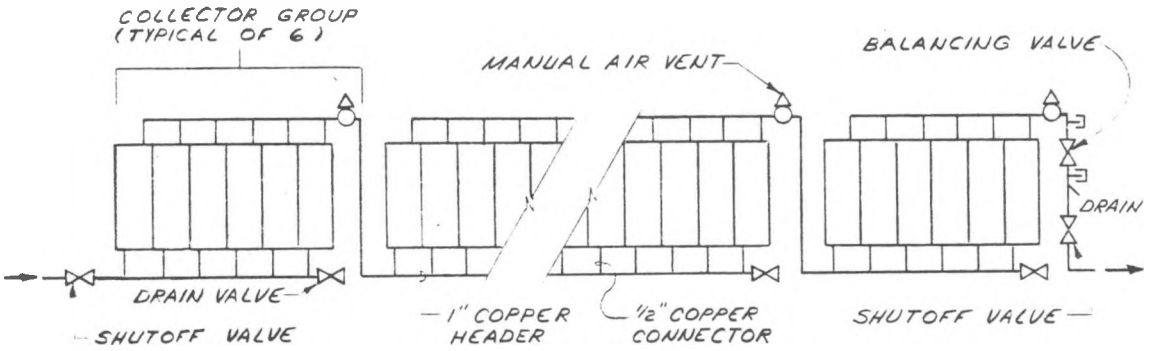


Figure IV-B-2. Collector Piping

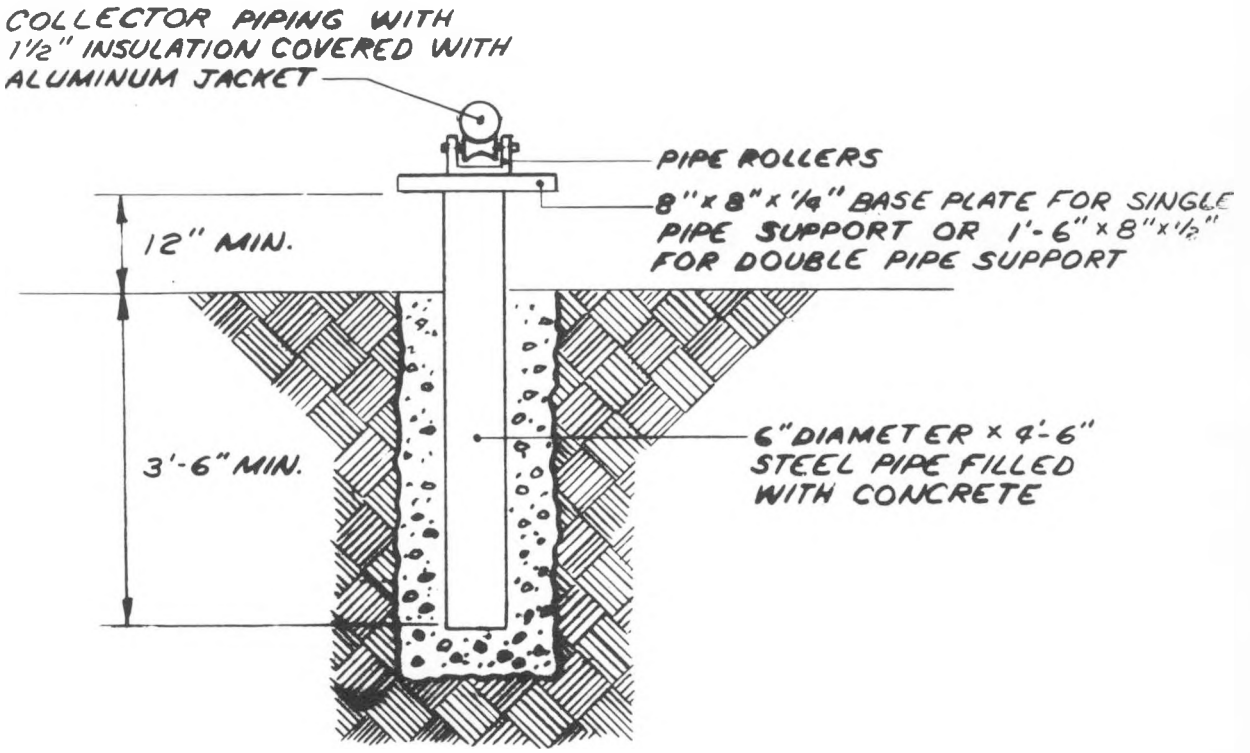


Figure IV-B-3. Pipe Support Detail

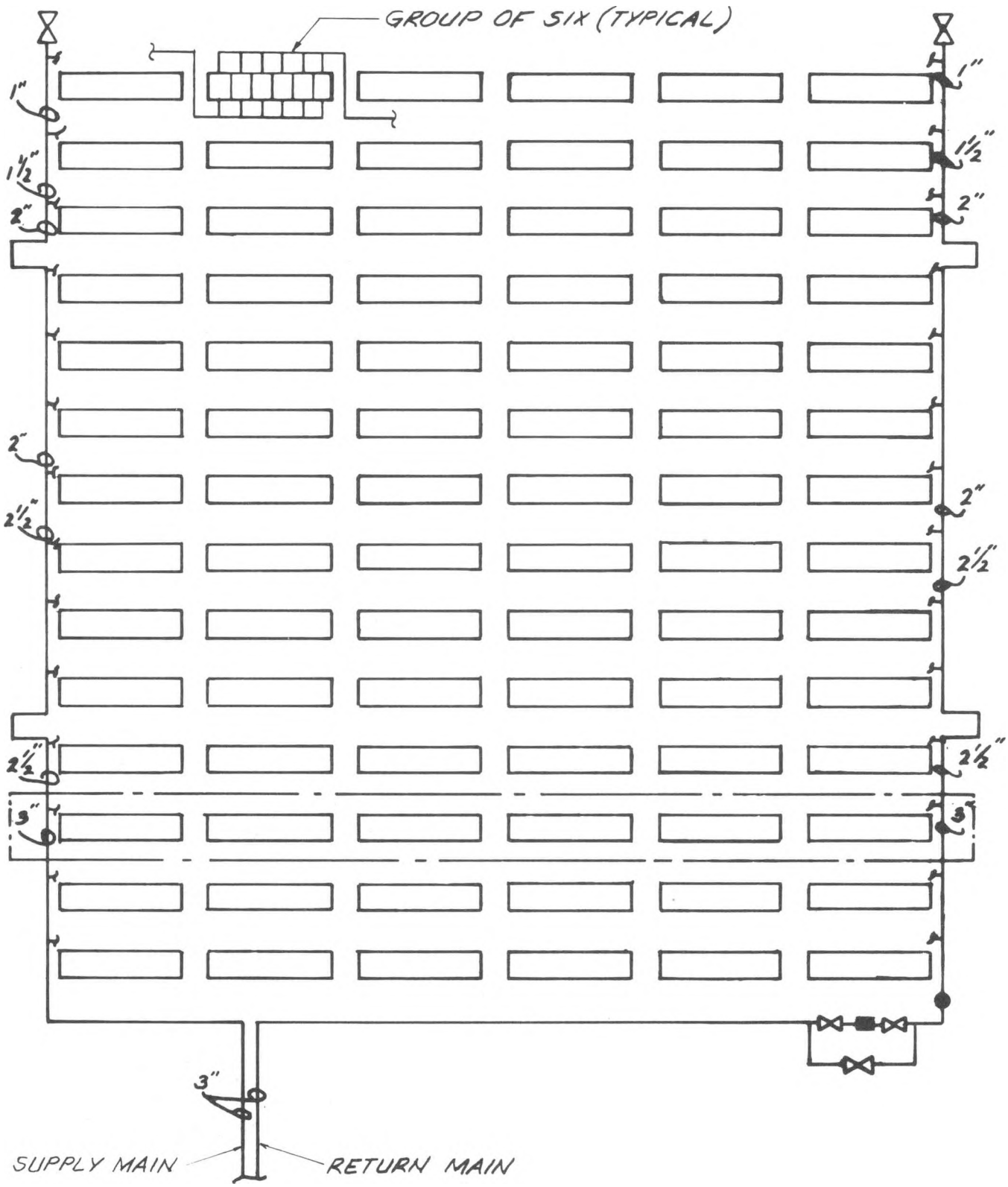


Figure IV-B-4. Manifold and Branch Piping

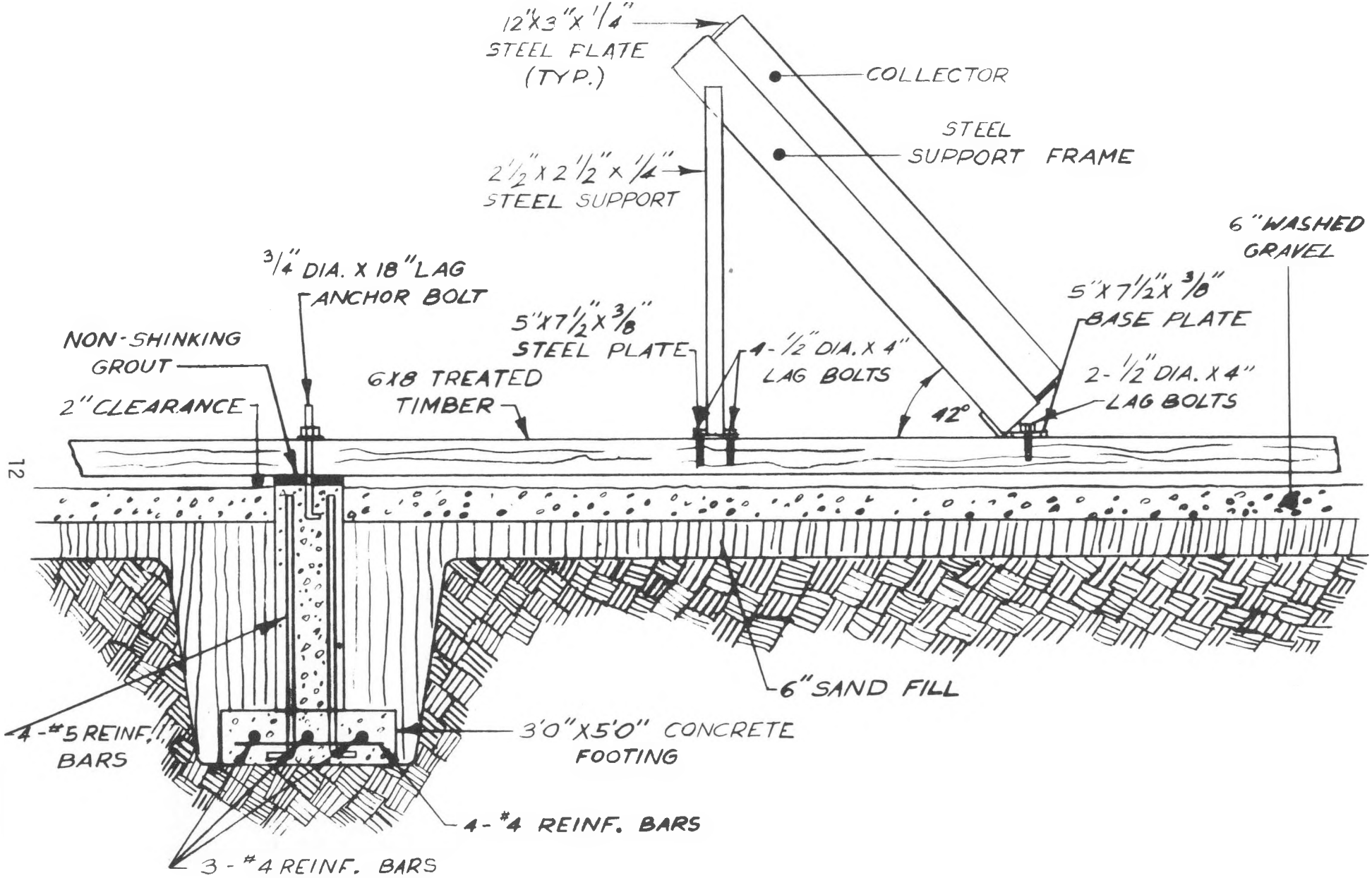


Figure IV-B-5. Collector Support

Heat Transfer Medium

- Type - Water/Antifreeze
- Antifreeze
  - Type - Propylene glycol
  - Concentration - 50 percent

Mechanical Equipment

- Pump (P-1)
  - Type - Base-mounted centrifugal
  - Manufacturer/Model No. - Taco
  - Horsepower - 7 1/2 hp
  - Flow - 100 gal/min
  - Head - 90 ft
- Pump (P-2)
  - Type - Close-coupled centrifugal
  - Manufacturer/Model No. - Taco/120-12-179
  - Horsepower - 1 1/2 hp
  - Flow - 155 gal/min
  - Head - 20 ft
- Expansion Tank
  - Material - Steel
  - Capacity - 144 gal
- Heat Exchanger - 1
  - Type - Tube-in-shell
  - Manufacturer/Model No. - Taco/B10418-84LA
- Freeze Protection Heat Exchanger
  - Type - Tube-in-shell
  - Manufacturer/Model No. - Taco/B-10410-SA

top and bottom of the frame to which the collectors are bolted. The frame is supported at its proper inclination by two 2 1/2 in. tubular steel legs. The legs are welded to the frame and each leg is bolted to a 6 x 8 in. treated timber that runs in a north-south direction through the entire array. The front of the frame is bolted to the timber with a welded base plate. The timbers are held in place by concrete footings.

- Structural framing material - Steel
- Framing finish - Red oxide paint
- Fasteners - Welded
- Collector attachment - Bolts
- Frame support - Treated wood timbers

Piping (interior)

- Material - Steel
- Size - 3 in.
- Insulation - None (currently)
- Valving
    - Balance
        - Type - Circuit Setter
        - Size - 3 in.
    - Shutoff
        - Type - Gate
        - Size - 3 in.
    - Check
        - Type - Swing
        - Size - 3 in.

- Automatic Valves
  - o Type - Gate
  - o Actuator - Pneumatic

Storage Subsystem (see figure IV-C-1 and IV-C-2)

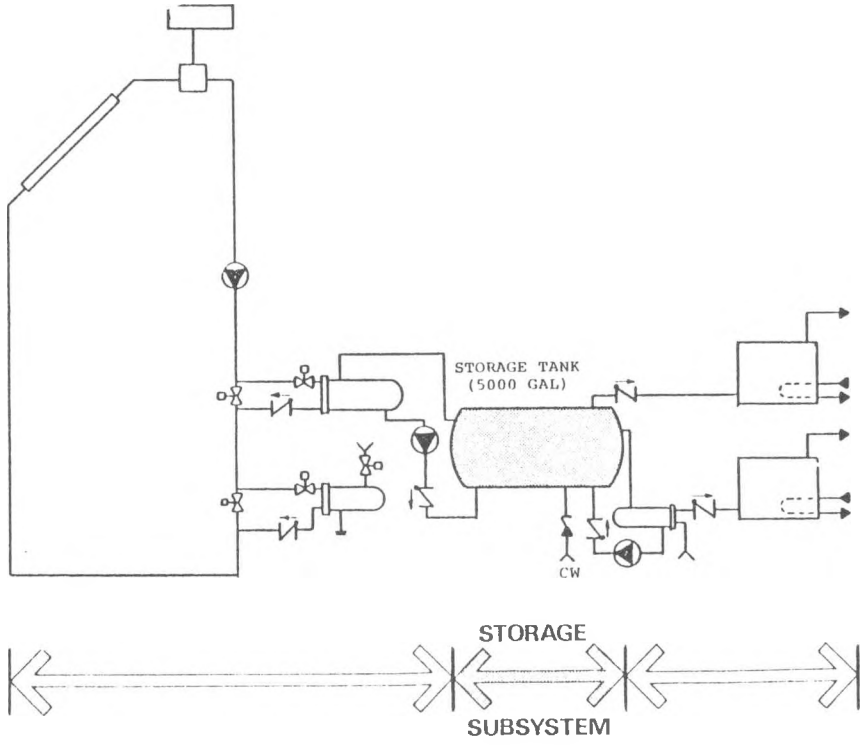


Figure IV-C-1. Storage Subsystem

General Description

The storage system consists of a 5000 gal carbon steel plate tank located in the existing mechanical room. The tank is currently uninsulated.

Tank (see figure IV-C-2)

- Location - Interior, located in existing mechanical room
- Capacity - 5000 gal
- Size - 24 ft long, 6 ft diameter
- Construction - 3/8 in. thick carbon steel
- Manufacturer - Plymouth Tank of West Michigan
- Rated working pressure - 60 psig
- Test pressure - 100 psig
- Insulation - None (currently)
- Waterproofing - None
- Installation - Mounted on concrete floor, supported by four steel saddles
- Piping connections - NPT threaded connections
- Sensor probe installation - 1/2 in. NPT bosses

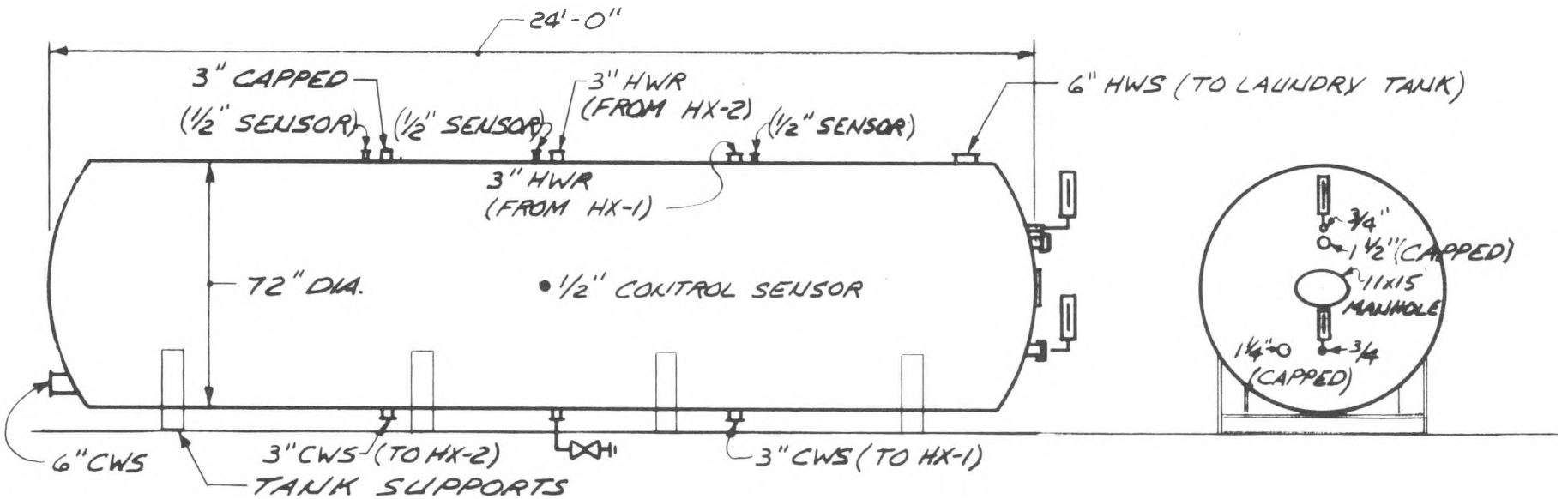


Figure IV-C-2. Storage Tank Detail

D. Energy-to-Load Subsystem (see figure IV-D-1)

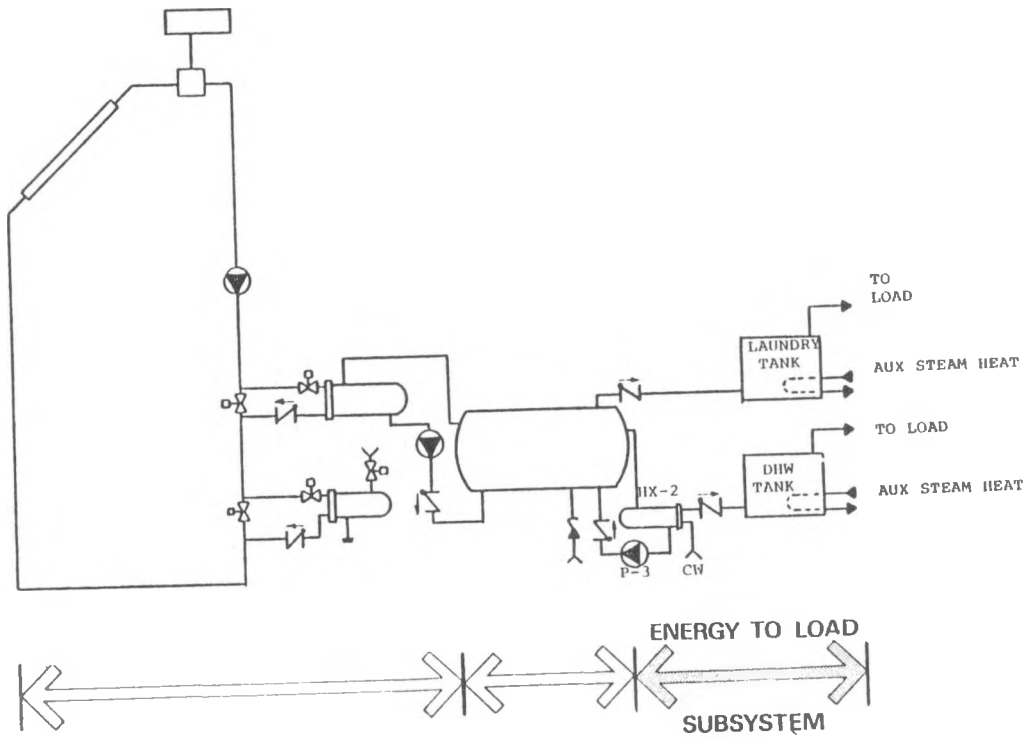


Figure IV-D-1. Energy-to-Load Subsystem

General Description

The energy-to-load subsystem provides preheated process and domestic water to two steam-fired hot water heaters. The domestic hot water is preheated by a tube-in-shell heat exchanger supplied by hot water from the storage tank. Hot water from the storage tank is supplied directly to the process water heater. The two heaters supply two recirculation loops in the building space. A thermostatic mixing valve limits exiting water temperature from the domestic hot water heater to 110^{o} F.

Domestic Hot Water

- Piping
  - Material - 2 1/2 in. black steel
- Insulation - None
- Pump (P-3)
  - Type - Close-coupled centrifugal
  - Manufacturer/Model No. - Weinman/4007CV
  - Horsepower - 1/8 hp
  - Flow - 28 gal/min
- Heat Exchanger
  - Type - Tube-in-shell
  - Manufacturer/Model No. - Taco/B10418-84LA
- Valving
  - Type - Pneumatic
  - Manufacturer - ITT Barton
- Transfer fluid - Water
- Domestic Water Heater
  - Type - Tank with immersed heat exchanger
  - Capacity - 1,872 gal
  - Insulation - 1 1/2 in. fiberglass (R = 3.5)
  - Heating surface - 30 ft^2
  - Manufacturer - Richmond Eng. Co., Inc.

Process Hot Water

- Piping
  - o Material - 6 in. black steel
  - o Insulation - None
- Valving - same as DHW
- Transfer fluid - Same as DHW
- Process Hot Water Heater
  - o Type - Same as DHW heater
  - o Capacity - 2,883 gal
  - o Insulation - Same as DHW heater
  - o Heating surface - 51 ft^2
  - o Manufacturer - Same as DHW heater

Auxiliary Boilers (Typical of 2)

- Type - Gas/oil fired steam boiler
- Capacity - 6.7 mmBtu/hr
- Manufacturer/Model No. - Cleaver-Brooks/CB-200-200

E. Control System

The solar system control equipment is shown in figure IV-E-1. The operating modes are described as follows:

- Solar Energy Collection - When collector fluid temperature sensor TS-1 reaches at temperature 20^{o} F higher than the storage tank temperature sensor TS-2, solar collector loop pump P-1 activates. When TS-1 is 3^{o} F higher than TS-2 pump P-1 deactivates.
- Recirculation freeze protection - When collector loop fluid temperature sensor TS-3 reaches -20^{o} F, pump P-1 is activated. Valve V-4 and V-5 open and V-3 closes, allowing steam from the auxiliary boilers to heat the collector

loop fluid. Valve V-1 opens and valve V-2 closes preventing subfreezing collector fluid from entering the solar to storage heat exchanger. When TS-3 exceeds -20° F pump P-1 deactivates and valves V-1, V-4, V-5 close and V-2, V-3 open.

- Heat rejection - When storage tank temperature exceeds a set maximum, valve V-6 opens draining hot water from the domestic water heater and permitting cool water to enter the storage to load heat exchanger HX-3 cooling the water in the storage tank.

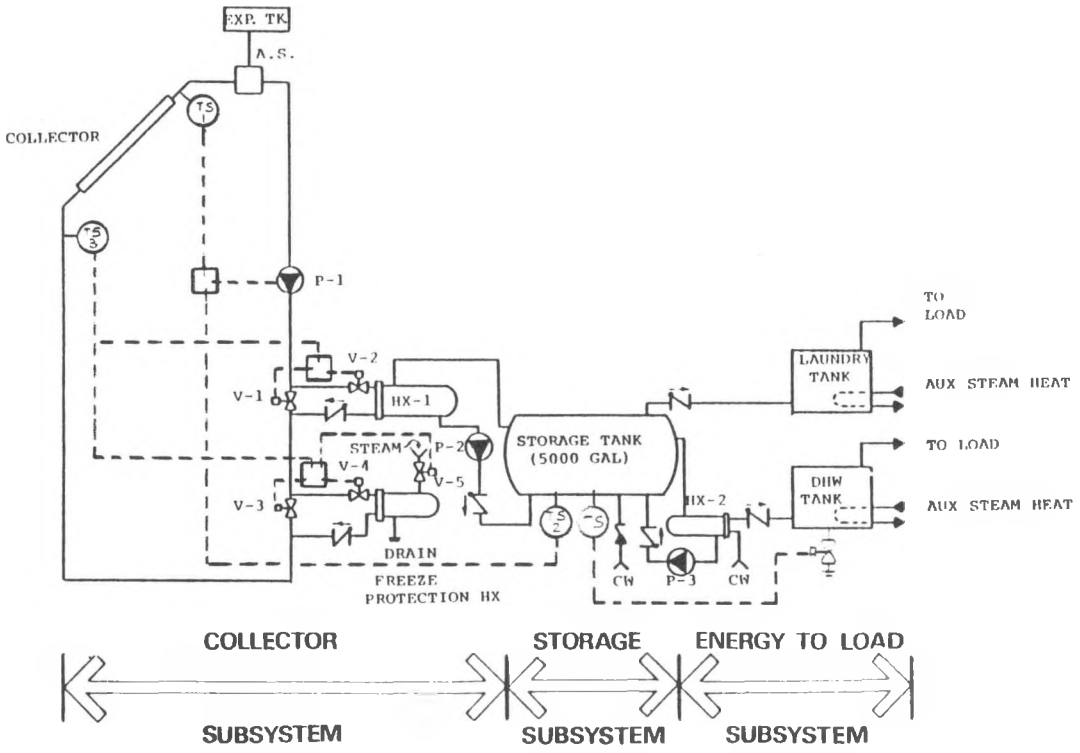


Figure IV-E-1. Control System

V. PERFORMANCE EVALUATION INSTRUMENTATION

A. The National Solar Data Network

The National Solar Data Network (see figure V-A-1) 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 performances factors that describe the behavior of the solar system (see NBSIR 76-1137, National Bu eau of Standards). Additional instrumentation may also be included a: result of site-specific requirements. Typically, the instrumentation includes sensors that monitor the following:

- Total insolation in the plate 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 are 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 date 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 is presented in tables V-B-1 through V-B-4, respectively. Sensor locations are shown in figure V-B-1.

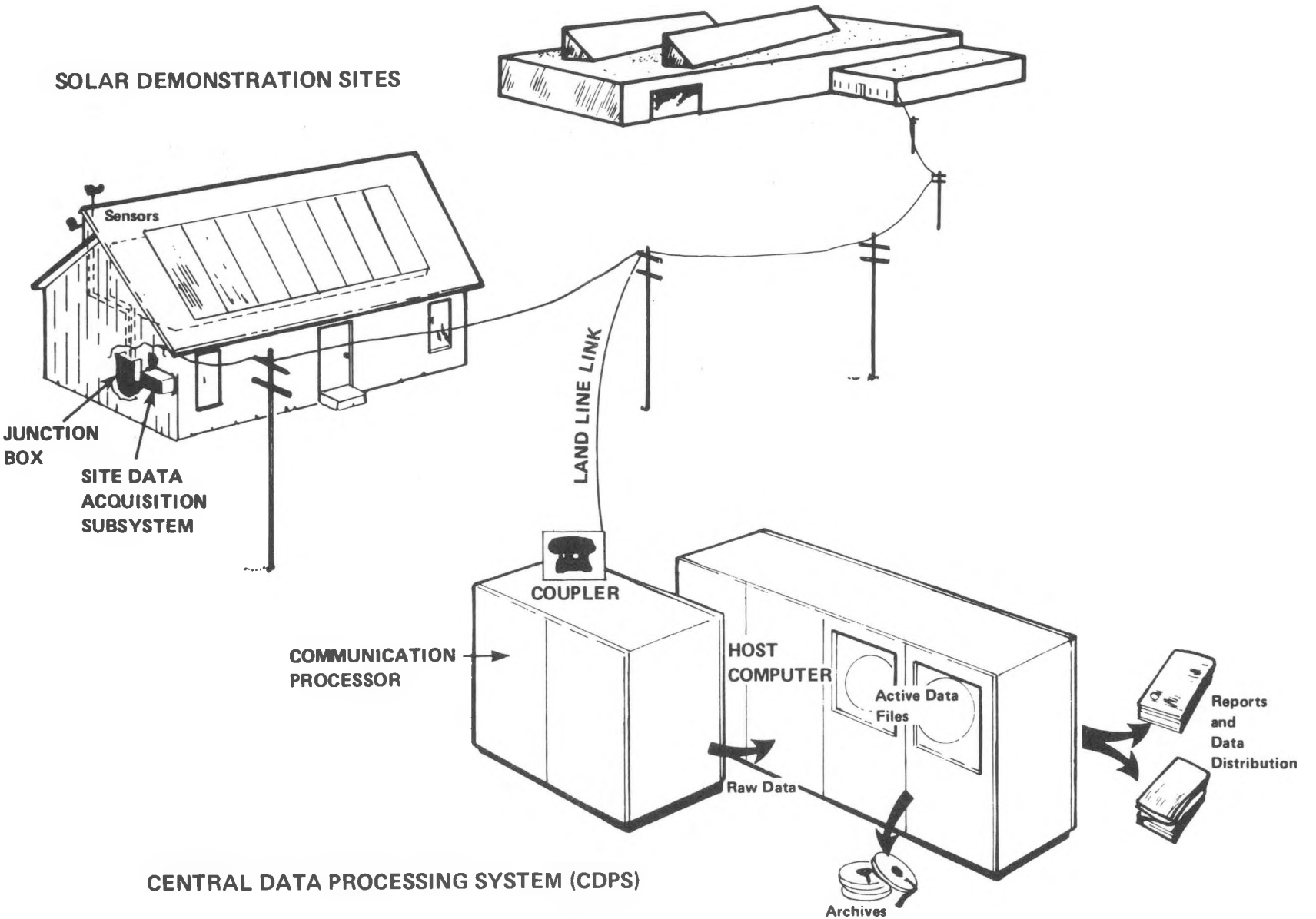


Figure V-A-1. The National Solar Data Network

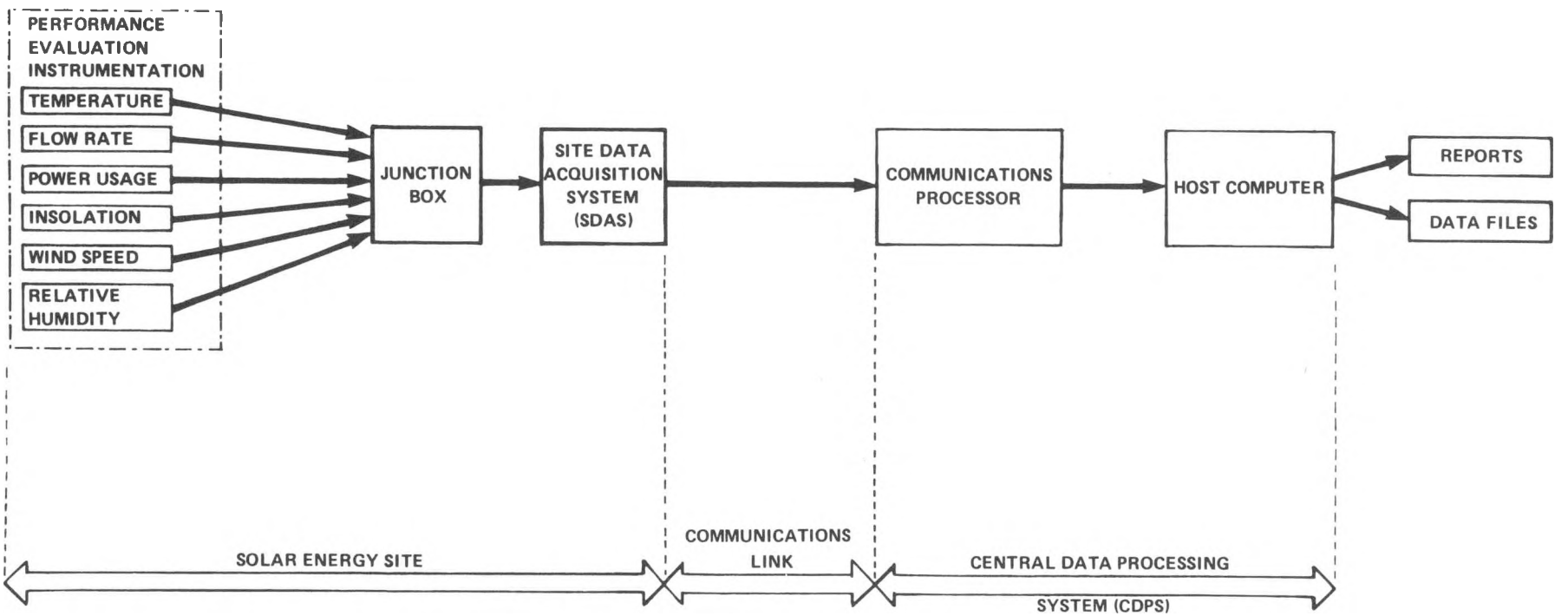


Figure V-A-2. Data Flow Path for the National Solar Data Network

Table V-B-1. Temperature Instrumentation

Sensor	Name	Range (^{O} F) Min.	Range (^{O} F) Max.	Mfgr	Thermowell Part No.	Probe Part No.
T001	Ambient Air Temperature	-20	120	Minco		S53P85Z36
T100	Collector Array Inlet Temperature	30	230	Minco	F203U15	S57P40Z36
T150	Collector Array Outlet Temperature	30	230	Minco	F203U15	S57P40Z36
T102	Collector Absorber Surface Temperature	30	450	Minco	RTD	S34/57301
T101	Heat Exchanger Inlet Temperature (No. 1)	30	230	Minco	F203U15	S57P40Z36
T151	Heat Exchanger Outlet Temperature (No. 1)	30	230	Minco	F203U15	S57P40Z36
T200	Storage Tank - Top Temperature	30	230	Minco	F203U195	S53P225Z36
T201	Storage Tank - Middle Temperature	30	230	Minco	F203U375	S53P405Z36
T202	Storage Tank - Bottom Temperature	30	230	Minco	F203U555	S53P58Z36
T300	Heat Exchanger Inlet Temperature (No. 2)	30	160	Minco	F203U15	S57P40Z36
T350	Heat Exchanger Outlet Temperature (No. 2)	30	160	Minco	F203U15	S57P40Z36
T302	Water Inlet Temperature (Tank No. 2)	30	230	Minco	F203U15	S57P40Z36
T352	Water Outlet Temperature (Tank No. 2)	30	230	Minco	F203U15	S57P40Z36
T301	Cold Water Inlet Temperature (Tank No. 1)	30	160	Minco	F203U15	S57P40Z36
T351	Water Outlet Temperature (Tank No. 1)	30	160	Minco	F203U15	S57P40Z36
T303	Water Inlet Temperature (Tank No. 3)	30	160	Minco	F203U15	S57P40Z36
T353	Water Outlet Temperature (Tank No. 3)	30	160	Minco	F203U15	S57P40Z36
T304	Recirculated Water Temperature (Tank No. 2)	30	230	Minco	F203U4	S53P30Z36
T305	Recirculated Water Temperature (Tank No. 3)	30	160	Minco	F203U4	S53P30Z36

Table V-B-2. Flow Rate Instrumentation

Sensor	Name	Range (gpm)		Mfgr	Model No.
		Min.	Max.		
W100	Collector Array Flow Rate	15	150	Ramapo	MKV-3-W01
W300	Water Flow Rate to Tank No. 3	5	50	Ramapo	MKV-2-1/2-W07
W301	Water Flow Rate to Tank No. 2	35	350	Ramapo	MKV-6-W01
W302	Recirculated Water Flow Rate (Tank No. 2)	1.5	15	Ramapo	MKV-3/4-J07
W303	Recirculated Water Flow Rate (Tank No. 3)	1.5	15	Ramapo	MKV-3/4-J07
W304	Water Flow to Tank No. 1	1.5	15	Hershey American	MKV-3/4-J07

Table V-B-3. Power Instrumentation

Sensor	Name	Phase	Range (kW)		Mfgr	Model No.
			Min.	Max.		
EP101	Collector Pump Power	3	0	12	Ohio Semitronics	PC5-24F
EP301	Pump Power from Heat Exchanger (No. 1)	1	0	0.5	Ohio Semitronics	PC5-1F
EP302	Pump Power from Heat Exchanger (No. 2)	3	0	4	Ohio Semitronics	PC5-6F
EP303	Circulating Pump from Laundry Power	1	0	1	Ohio Semitronics	PC5-10F
EP304	Circulating Pump from Kitchen Power	1	0	1	Ohio Semitronics	PC5-10F

Table V-B-4. Miscellaneous Instrumentation

Sensor	Name	Range ($Btu/ft^2/hr$)		Mfgr	Model No.
		Min.	Max.		
I001	Total Solar Radiation	0	422.41	Eppley Labs	S/N 16706F3

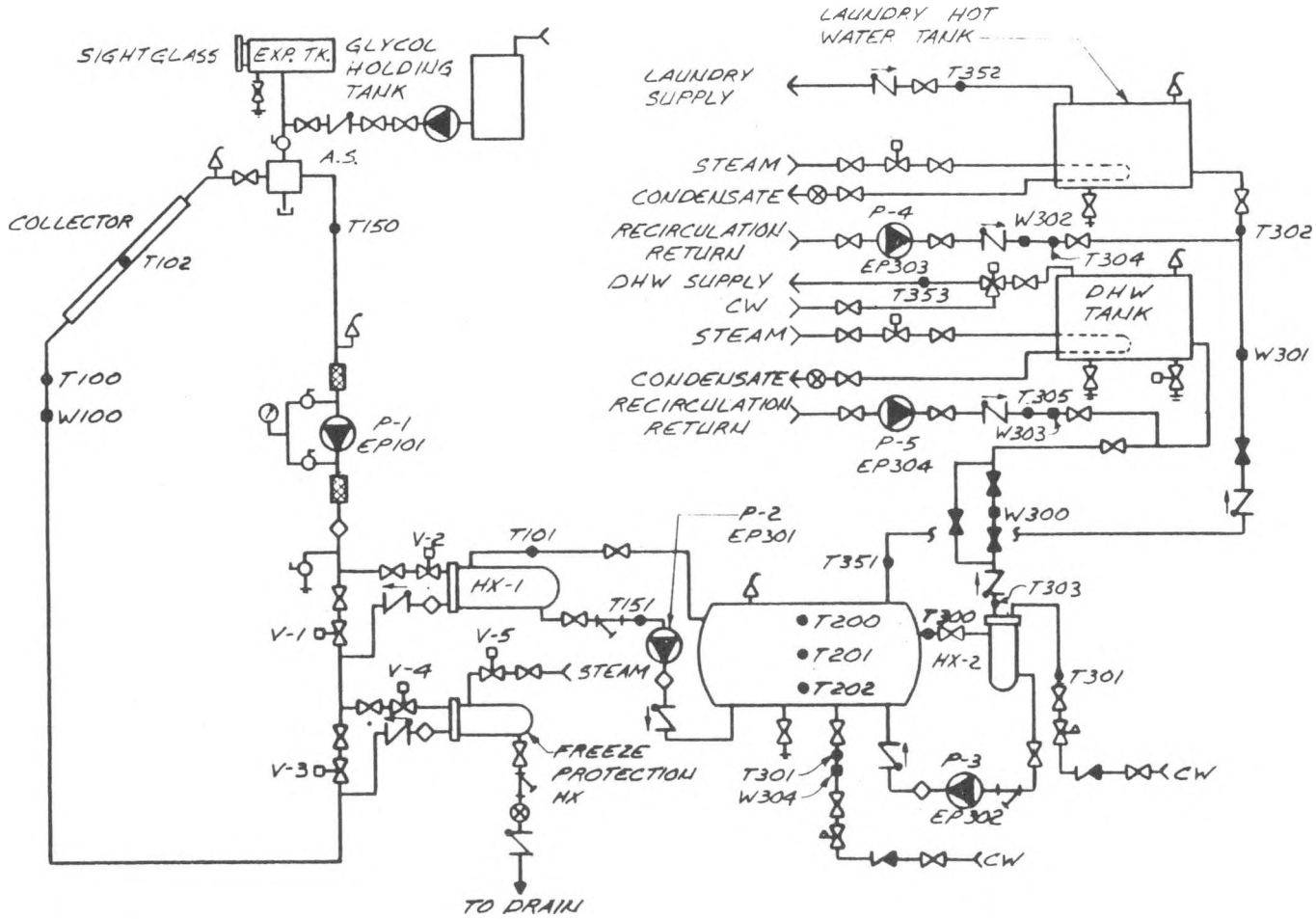


Figure V-B-1. Performance Instrumentation Schematic

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, 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^{o} F to 60^{o} 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 SOLLECTOR - 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 of 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.

DRAINDOWN 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.

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.

FLATE-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 bean 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.

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 GLOBE 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