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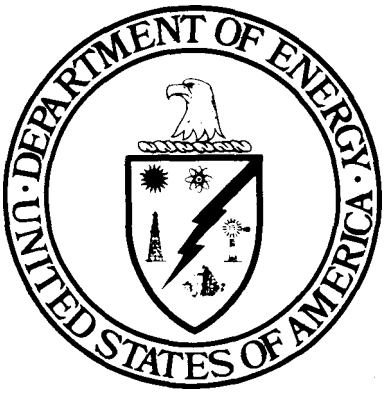
SOLAR 2021-79/50
DISTRIBUTION CATEGORY UC-59

MASTER

Solar Project Description

IRVINE ELEMENTARY SCHOOL
Irvine, California
April 11, 1979



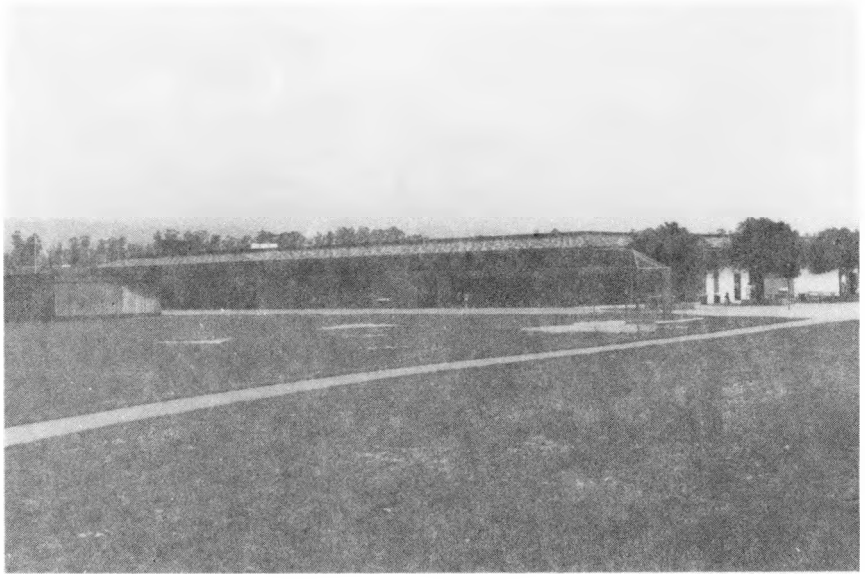
U.S. Department of Energy

National Solar Heating and Cooling Demonstration Program

National Solar Data Program

Solar/2021-79/50
Distribution Category UC-59

SOLAR PROJECT DESCRIPTION FOR IRVINE ELEMENTARY SCHOOL



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

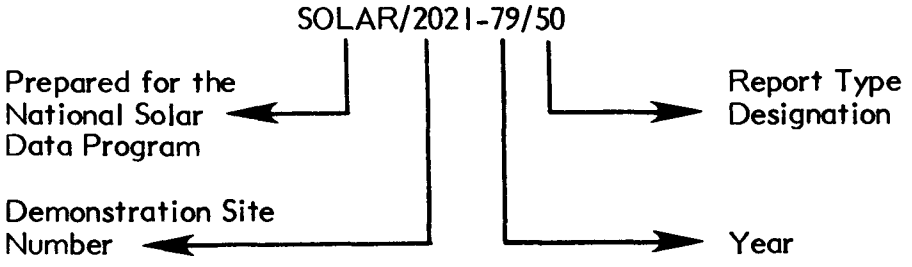
TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

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 Irvine School project site is designated as SOLAR/2021-79/50. 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.:

  - o Monthly Performance Reports are designated by the numbers 01 (for January) through 12 (for December);
  - o Solar Energy System Performance Evaluations are designated by the number 14;
  - o Solar Project Descriptions are designated by the number 50;
  - o 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 El Camino Real School solar installation in Irvine, California. Major features of this system include:

- Collector - Evacuated, glass tube, high temperature performance
- Freeze protection - Circulation of warm water
- Application - Heating and cooling
- Storage - None
- New/Retrofit - Retrofit
- Performance evaluation instrumentation - Yes
- Site specific features - Evacuated tubes, no storage

The El Camino Real School in Irvine, California, has a solar energy system for space heating and cooling for the 40,000 square foot school building. Since heating demands are low due to the moderate climate and most of the load demand occurs during the day, no solar energy storage is provided.

The 4,932 square feet of Owens-Illinois evacuated tubular glass collectors face south at a 25^{o} angle to the horizontal. The collector modules consist of 24 tubes, 12 up and 12 down in a series flow arrangement. The modules are piped in reverse return with insulated steel branch piping.

Overheat protection is provided by a heat rejector system on the roof of the building. Freeze protection is provided by circulating water through the collectors when the ambient temperature reaches a set minimum.

Space heating is provided by circulating hot water from the collectors through a heat exchanger installed upstream and in series with the existing gas-fired boiler; the energy is transferred to the load via the heat exchanger and then to seven roof-mounted air handling units. A 3,420,000 Btu/hr boiler is used for any additional heating.

Space cooling is provided by circulating hot water from the collectors through a heat exchanger installed upstream and in series with the existing gas-fired boiler; the energy in this load loop is used to power two 100-ton absorption water chillers. The chilled water from the chillers is then delivered to the chilled water coils, and the cool air is then distributed to the different zones via the distribution ducts.

The system has been fully instrumented for performance evaluation and integrated into the National Solar Data Network. It has been operational since September 1978.

III. SITE AND BUILDING DESCRIPTION

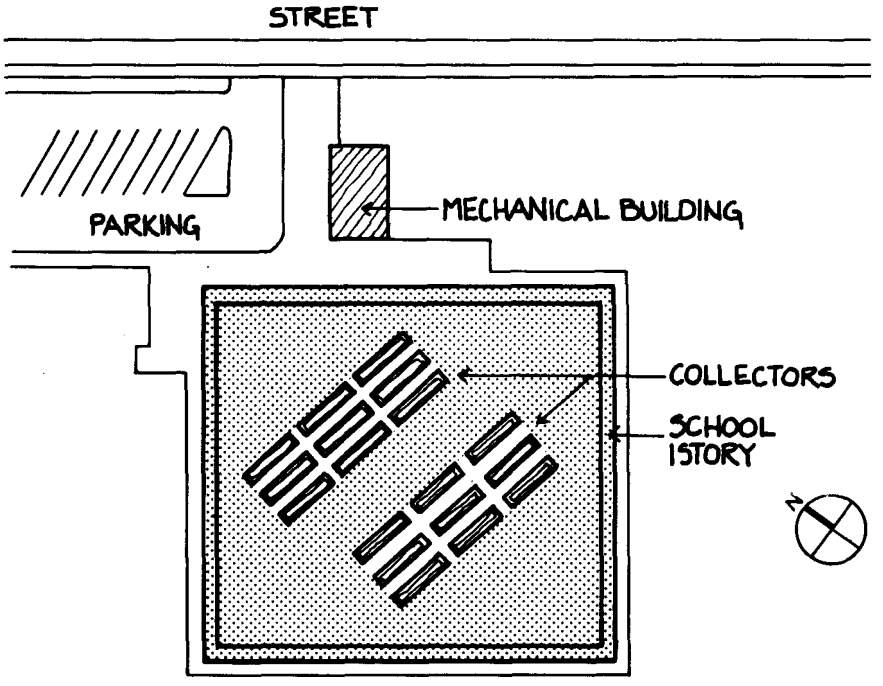


Figure III-1. Site Plan

Site Description

- Special topographical or climatic conditions - Very moderate climate
- Latitude - 34° N
- Annual degree days (65° F base)
  - Heating - 899
  - Cooling - 1,499
  - Data location - Long Beach, California
  - Data reference - Local Climatological Data Annual Summaries for 1976, Department of Commerce, National Oceanic and Atmospheric Administration.
- Average horizontal insolation
  - January - 630 Btu/ft^2/day
  - June - 2,212 Btu/ft^2/day

- Data location - Long Beach, California
- Data reference - Beckman, Klein, Duffie, Solar Heating Design by the F-Chart Method, Wiley-Interscience Publication, 1977.

- Site topographical description - Flat
- Shading - None

Building Description

- Occupancy - Elementary school
- Total area - 40,000 ft^2
- Solar conditioned space - 40,000 ft^2
- Height - One story
- Roof slope - Flat

Structure

- Walls
  - Frame - Concrete block, load bearing wall with integral split face exterior finish
  - Insulation - None
  - Interior finish - Painted block
  - Windows - Single glazed, metal frame
    - Area - 4 percent of surface area
  - Doors - Solid core wood
- Roof
  - Structural frame - Long span trusses, 4 ft on center, made of wood cords and steel struts with a plywood deck roof
  - Exterior finish - Mineral finish built-up roofing
  - Insulation - 6½ in. fiberglass batt (R-20) laid over hung ceiling
  - Interior finish - Acoustical tile, suspended ceiling
- Floor material - Concrete slab with carpet

Mechanical System

- Heating
  - Solar - Individual air handling units
  - Backup - Gas fired boiler
  - Distribution - Duct distribution
- Cooling
  - Solar - Two existing Arkla absorption chillers
  - Backup - Hot water boiler to chillers
  - Distribution - Duct distribution
- Special features - Solar is used for terminal reheating with air conditioning.
- Domestic hot water - Not part of solar system

IV. SOLAR SYSTEM DESCRIPTION

A. General Overview

The Irvine School solar energy demonstration project is represented in figure IV-A-1. The major components of the solar energy system include 4,932 ft^2 of evacuated tubular collectors, two 100-ton absorption chillers, a heat rejection system, and a 3,420,000 Btu/hr gas-fired boiler.

Subsequent sections describe the collectors, energy-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 a legend of symbols.

B. Collector Subsystem (see figure IV-B-1)

General Description

The collector array consists of 18 banks, 10 modules per bank for a total of 180 modules. Each module contains 24 tubes, 12 up and 12 down, in a series flow arrangement. Therefore, the array consists of 4,320 tubes.

The tubular glass collectors incorporate a high vacuum and a selective coating on the absorber tube. The cover and glass tubes are hermetically joined. The absorber tube is supported at the other end in a spring clip. The feeder tube provides reverse flow for the heat transfer medium. High temperature silicone rubber gaskets are used to seal the tubes in the manifold.

For freeze protection, water is circulated through the array when the ambient temperature reaches a set minimum. For overheat protection, a heat rejector is used on the roof of the building.

Collectors (see figure IV-B-2)

- Type - Evacuated glass tube
- Manufacturer - Owens-Illinois
- Number - 4,320 tubes

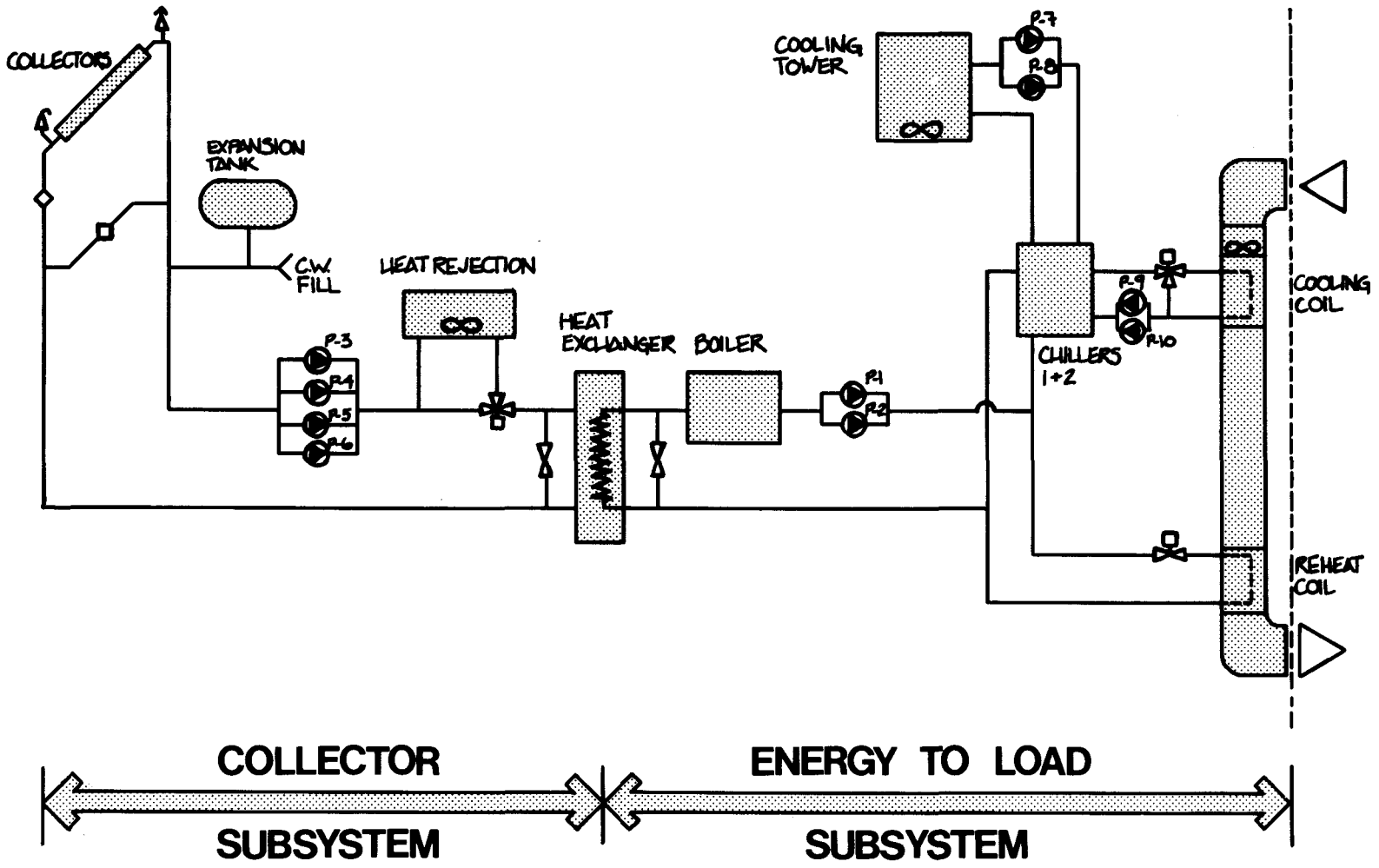


Figure IV-A-1. Overall Solar Energy System Schematic

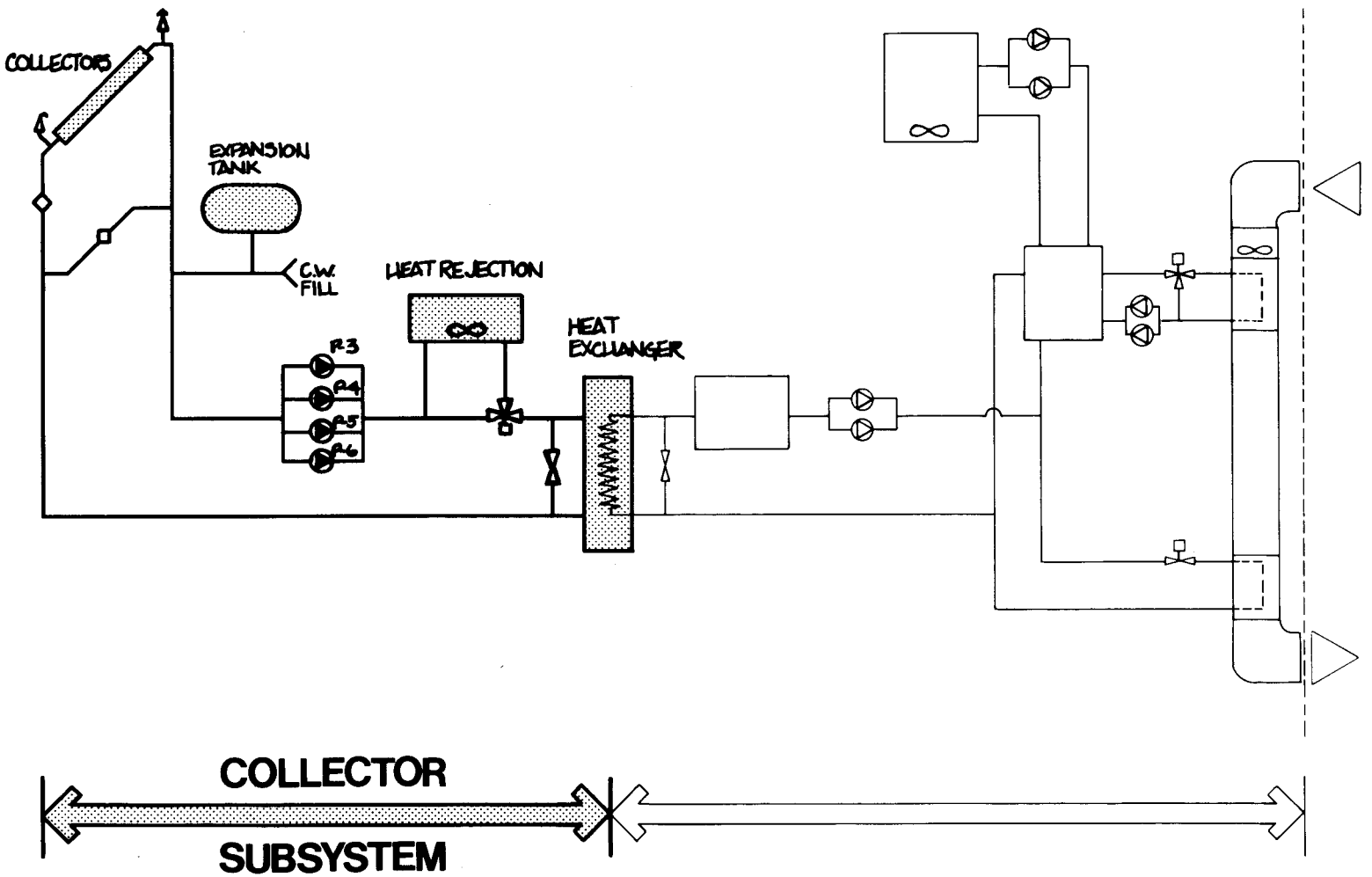


Figure IV-B-1. Collector Subsystem

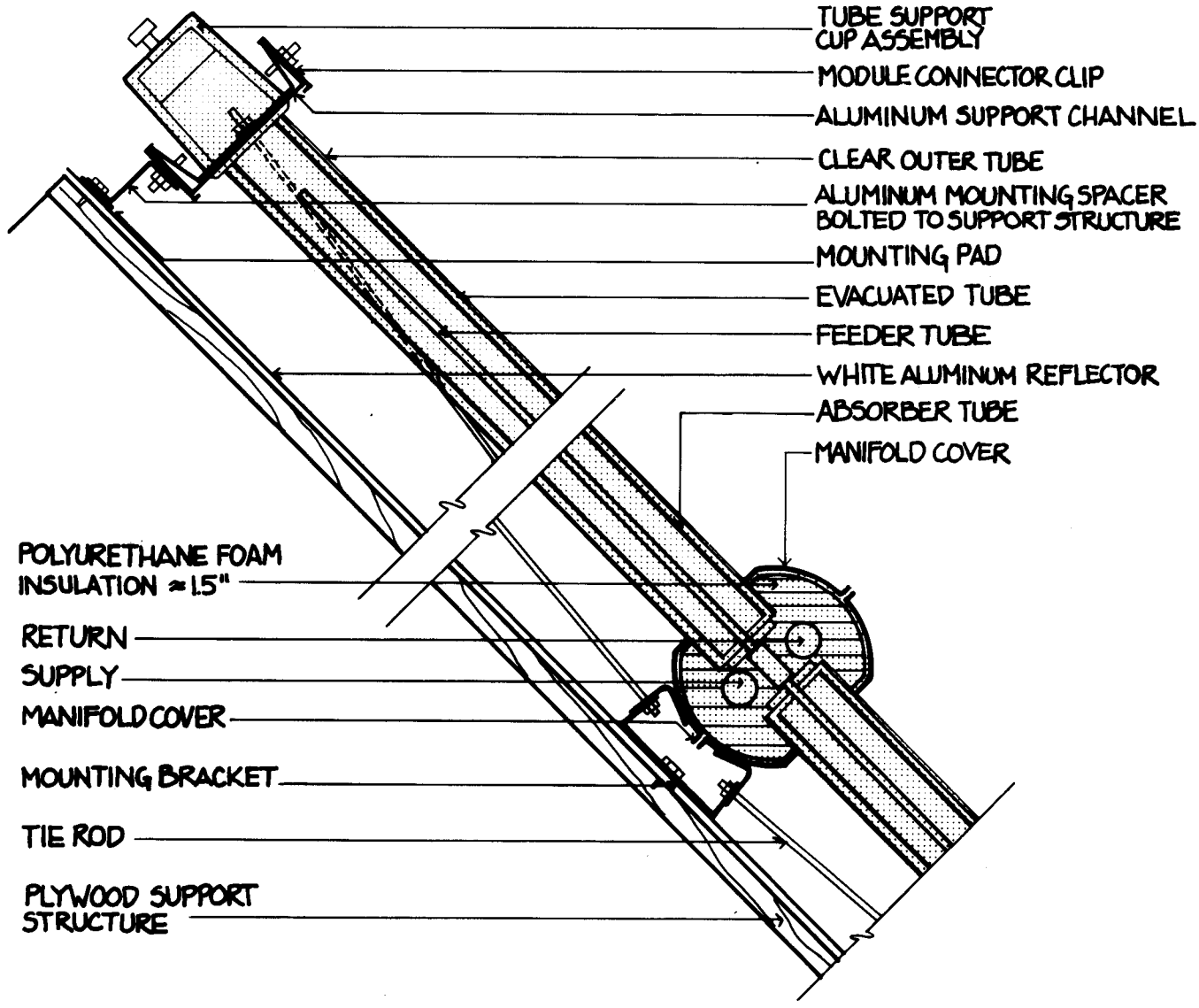


Figure IV-B-2. Solar Collector Detail

- Collector orientation - Due south
- Tilt angle - 25^{o} to the horizontal
- Array configuration - 18 banks, 10 modules per bank, 24 tubes per module (see figures IV-B-3 and IV-B-4)
- Gross array area - 5,760 ft^2
- Effective array area - 4,932 ft^2
- Module (24 tubes)
    - Assembly model number - SEC-100.5.A24
    - Installed gross area - 32 ft^2
    - Installed effective area - 27.4 ft^2
- Tube
    - Area - 2 in. diameter x 44 in. long
    - Filled weight - 6.7 lb/ft^2
    - Empty weight - 3.7 lb/ft^2
- Cover tube
    - Number - One
    - Material - Low iron, KG-33 Borosilicate glass
    - Thickness - 0.08 in.
    - Transmittance - 92 percent
- Absorber tube
    - Material - Low iron, KG-33 Borosilicate glass
    - Coating - Semi-conductor type selective coating
    - Absorptance - .86
    - Emittance - .05
- Fluid passage
    - Description - Fluid passage is through a glass feeder tube located inside the absorber tube; they do not touch. Fluid passes through

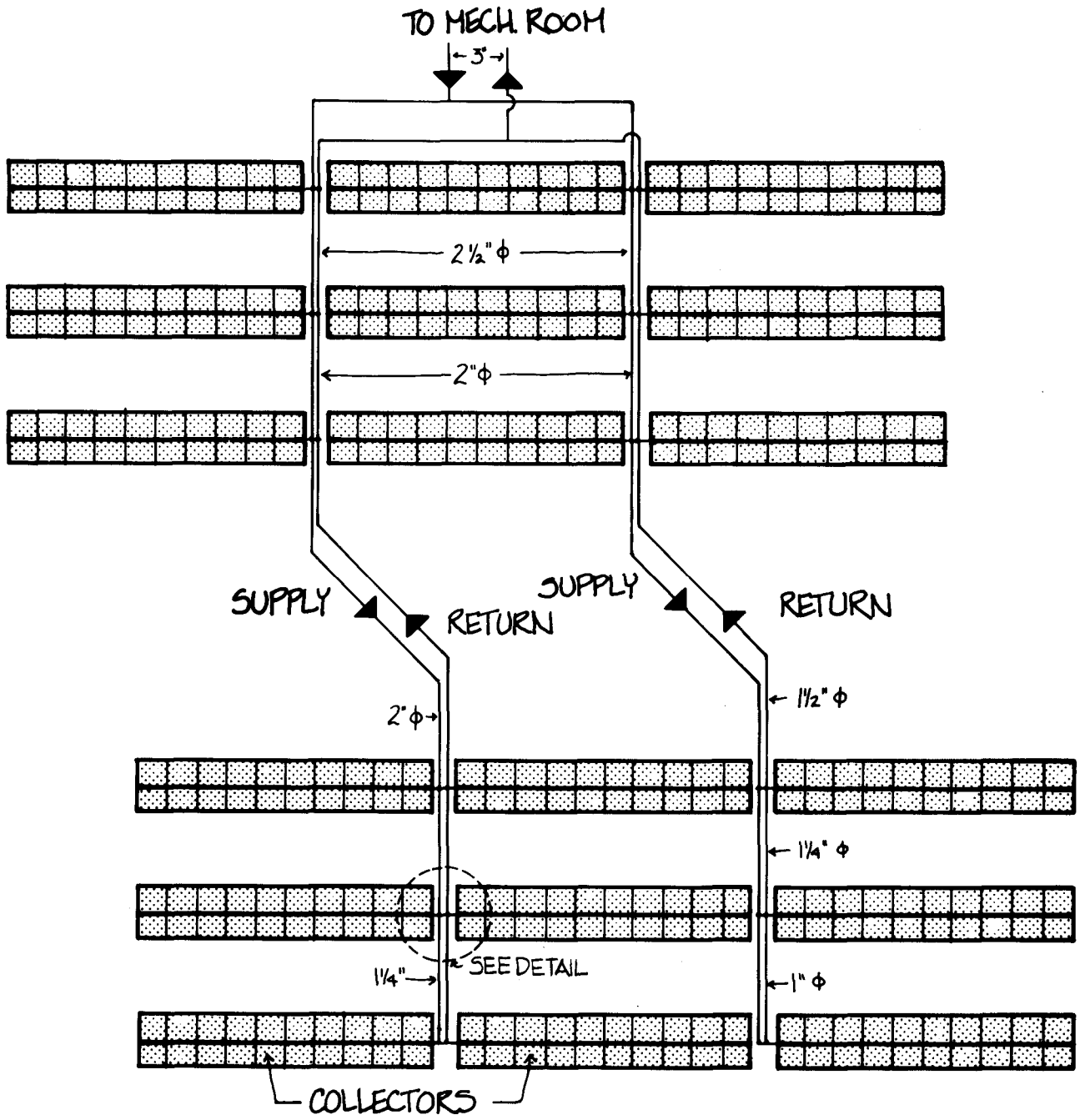


Figure IV-B-3. Solar Collector Array

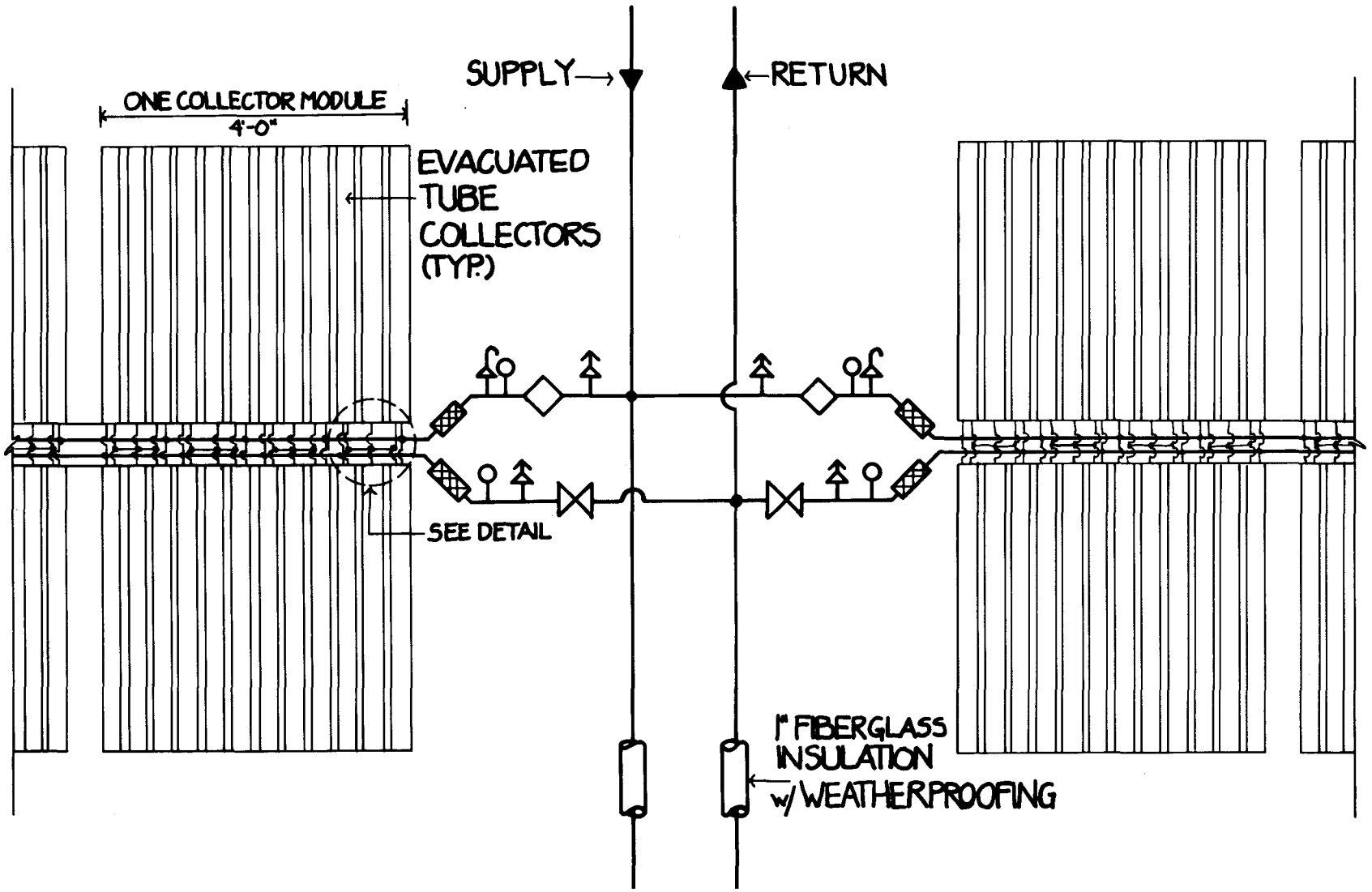


Figure IV-B-4. Collector Array Detail

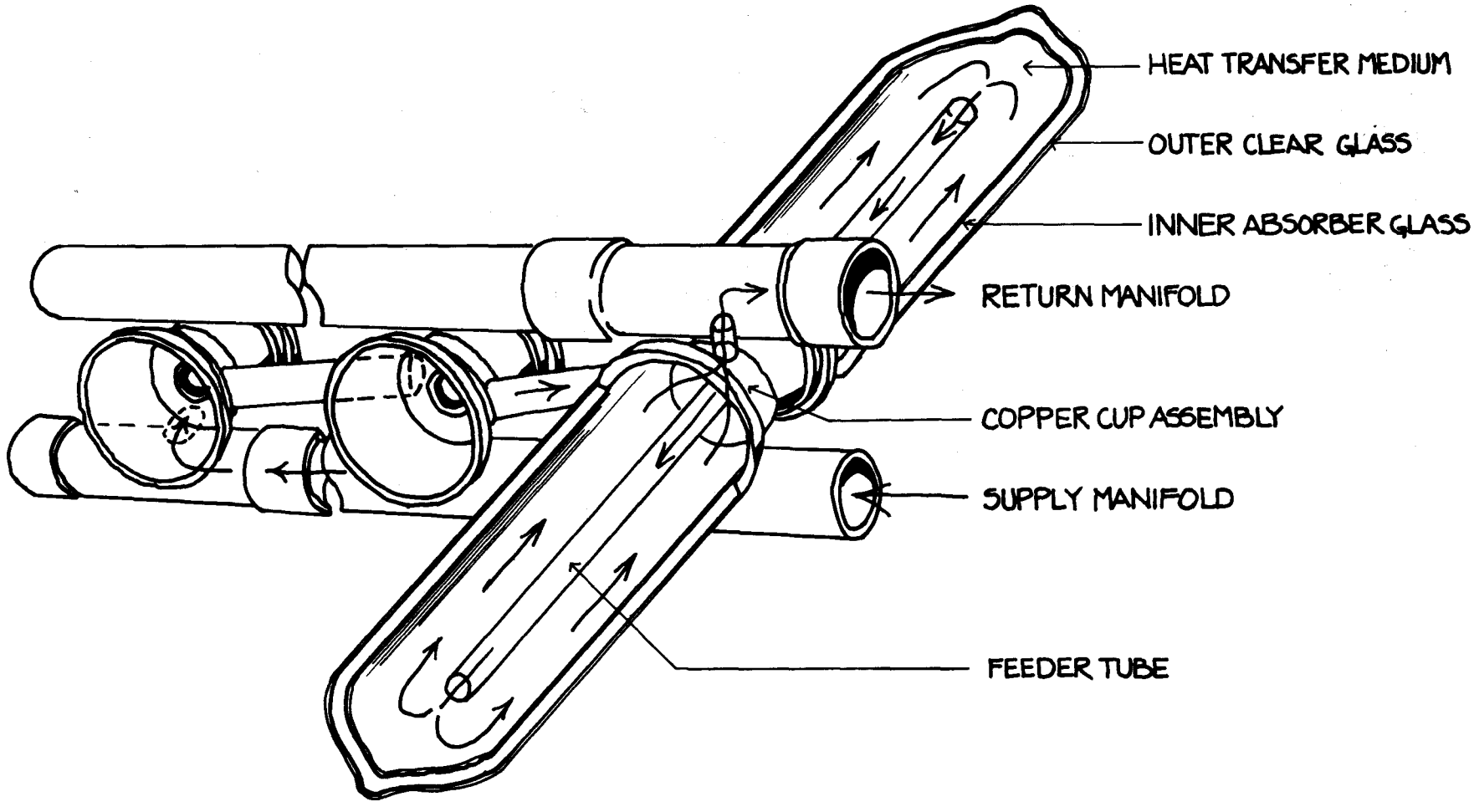


Figure IV-B-5. Collector Internal Manifold and Fluid Flow Detail

the feeder tube and then doubles back between the feeder tube and the absorber tube to the manifold (see figure IV-B-5).

- o Manifold location - Manifold is an integral part of collector (see figure IV-B-5).
- o Insulation - Insulation is provided by a vacuum between absorber tube and the outer glass tube.

Collector Piping (above roof)

- Branch piping (see figure IV-B-4)
  - o Piping configuration - Reverse return (each module)
  - o Material - Black steel
  - o Size - Ranges from 1 in. to 3 in. in diameter
  - o Approximate total length - 600 ft
  - o Insulation - 1 in. fiberglass
  - o Waterproofing - Aluminum jacket
  - o Piping support - Two piping support systems are used: (1) redwood blocking, applied over roofing cement, nailed to roof deck. Pipe is strapped to blocking (see figure IV-B-6); (2) steel angle bracket nailed to roof deck with roofing cement applied. Pipe is strapped to angles (see figure IV-B-7).
  - o Piping roof penetration - Piping does not penetrate roof; rather, it runs down along exterior wall on the outside of building.
- Vents
  - o Manual
    - Location - Between collector manifold and main branch line, one on both supply and return lines
  - o Pressure relief
    - Location - Between the collector manifold and the supply pipe, set at 30 psi

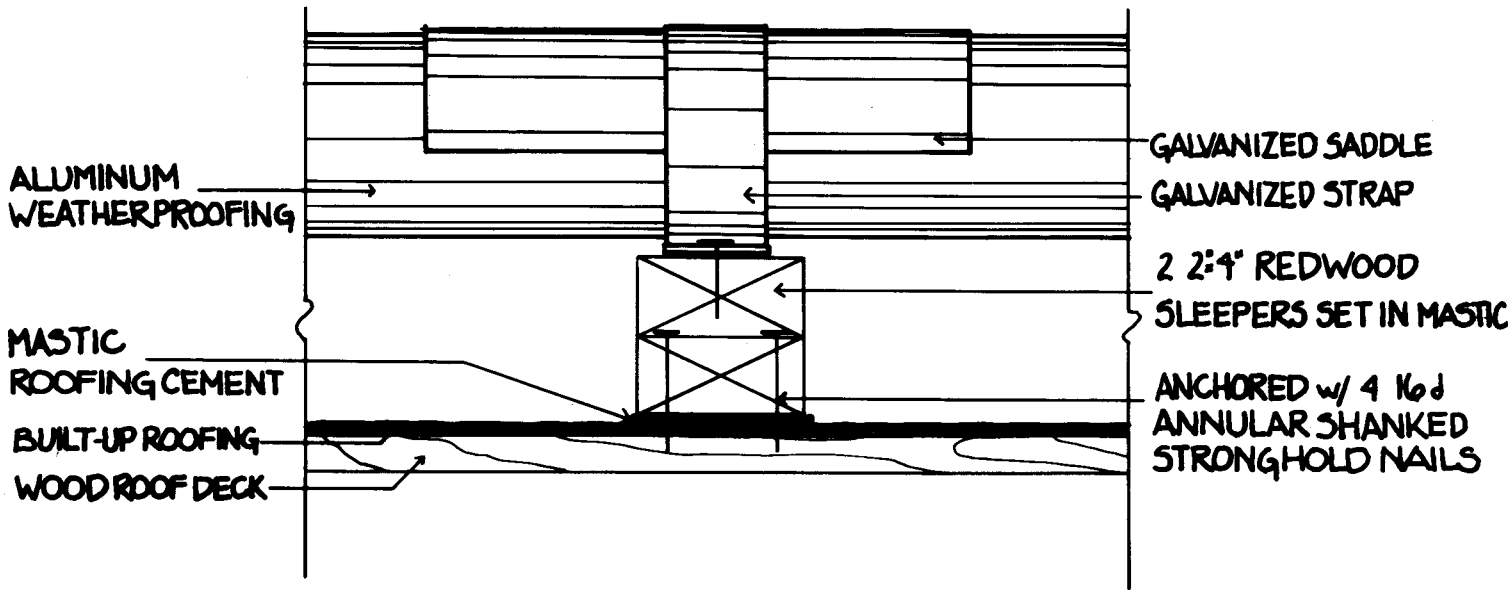


Figure IV-B-6. Pipe Support Detail--Type I

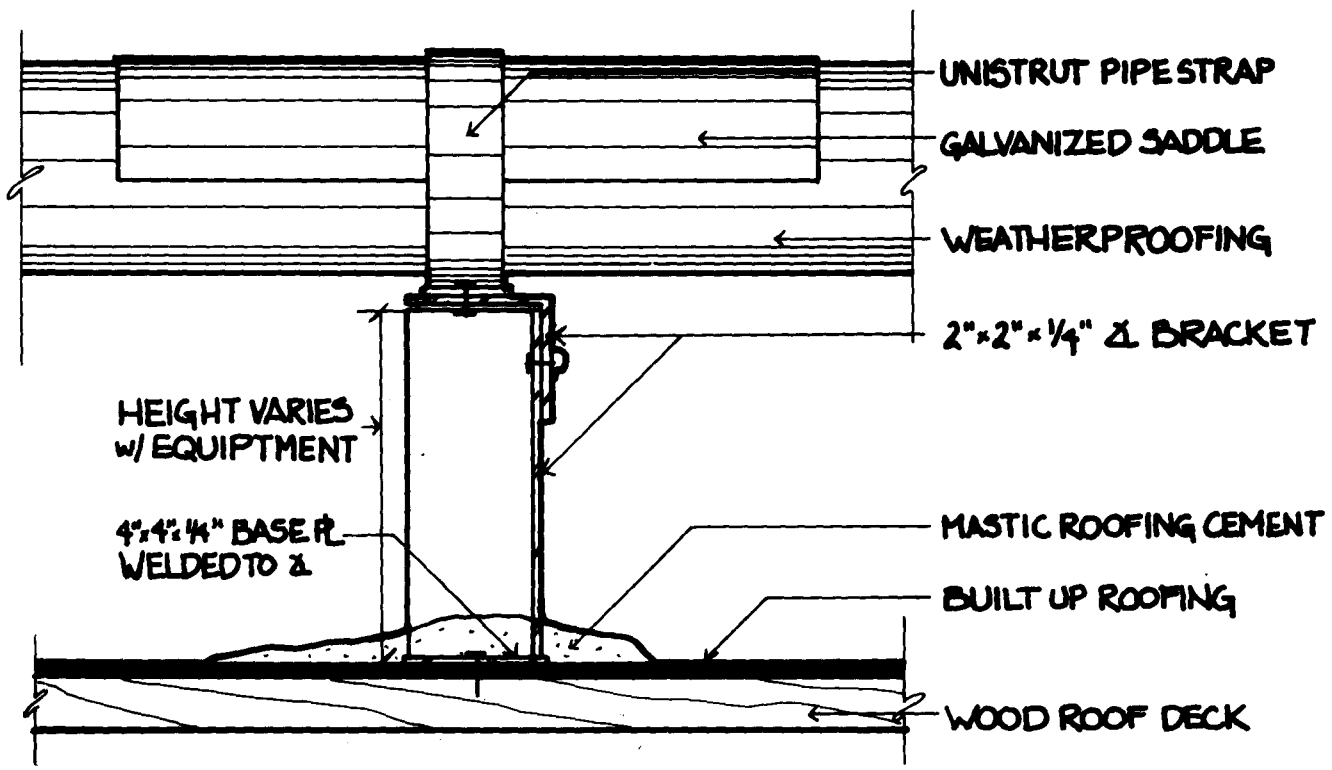


Figure IV-B-7. Pipe Support Detail--Type 2

- Valves
  - o Balance
    - Type - Combination flow control and shutoff
    - Location - Between main supply branch line and collector bank manifold inlet
  - o Shutoff
    - Type - Gate
    - Location - Between main return branch line and collector bank manifold outlet

Collector Piping (within module) (see figure IV-B-5)

- Description - Evacuated tubes are connected to copper cup assemblies which are connected to the copper manifold by copper tube; high temperature silicone rubber O-ring and grommets are used for seals (see figure IV-B-5).
- Size - 5/16 in. between manifold and cup assembly
- Manifold size - 1 in. diameter
- Insulation - The copper cup assembly and the internal manifold are encased in a molded urethane foam which serves as an insulating support structure; average thickness is 1½ in.
- Waterproofing - A waterproof PVC plastic jacket

Collector/Reflector Support (see figures IV-B-8 and IV-B-9)

- General Description - A treated wood structure is nailed to sleepers bolted through the roof to blocking that is nailed to the roof truss. The support structure is made up of 2 x 4's and larger members fastened together by nails and nailed metal straps. Plywood sheathing is nailed to the frame and forms a 25^{o} slope to which the collector modules are mounted. A white aluminum sheet is pressure bonded over the plywood to serve as a diffuse reflector for the evacuated tube collectors. Wind bracing is placed along the vertical back face of the structure. The collector module is bolted to the plywood sheathing using mounting spacers to lift it a few inches off the surface (see figure IV-B-10). The wood structure and sleepers are pressure treated and are unpainted. A typical collector structure is approximately 40 ft long x 7 ft wide x 4 ft 9 in. high. There are 18 total collector support structures.
- Structural framing material - Treated wood

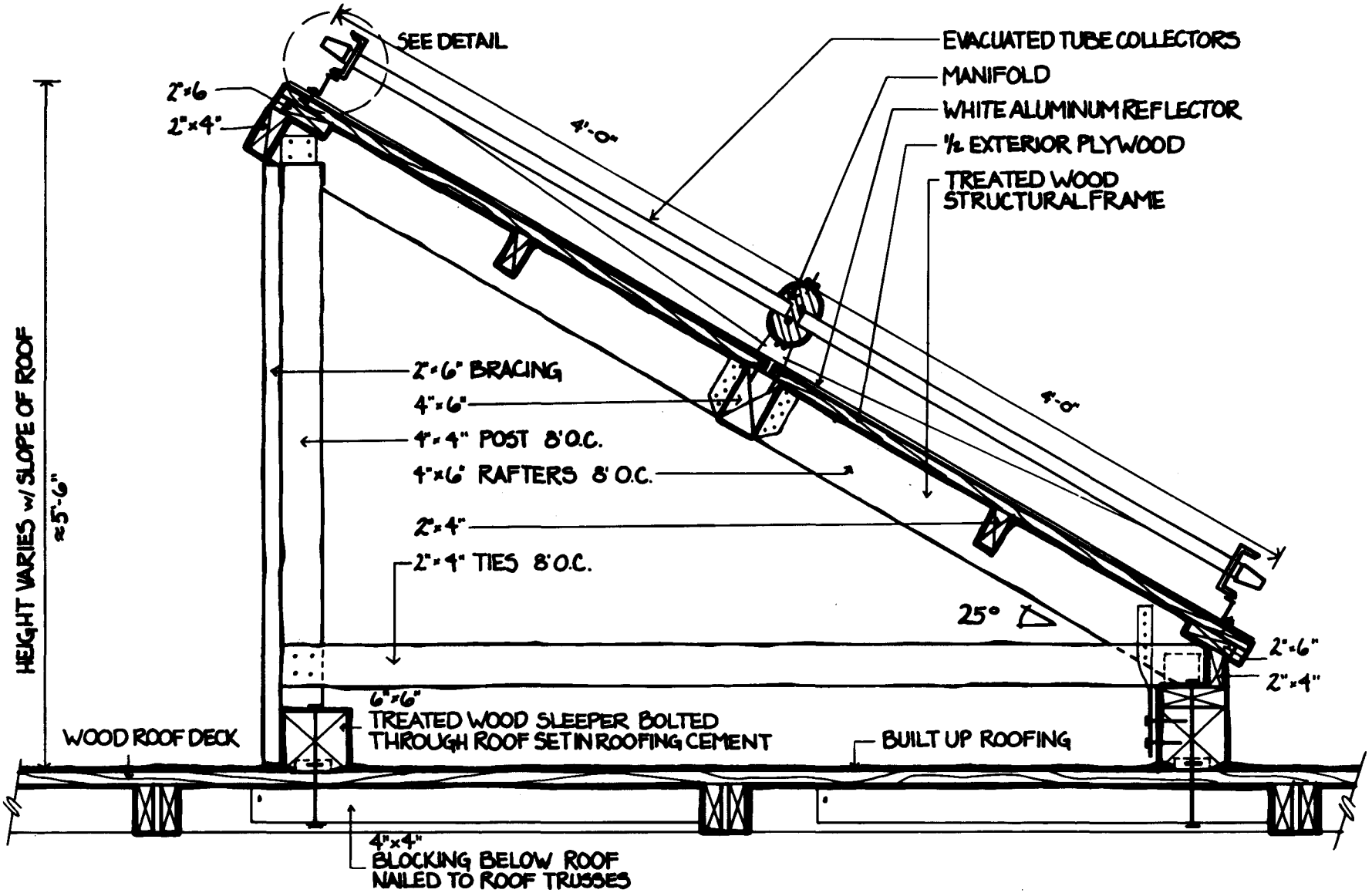


Figure IV-B-8. Subsection View of Collector Support Structure

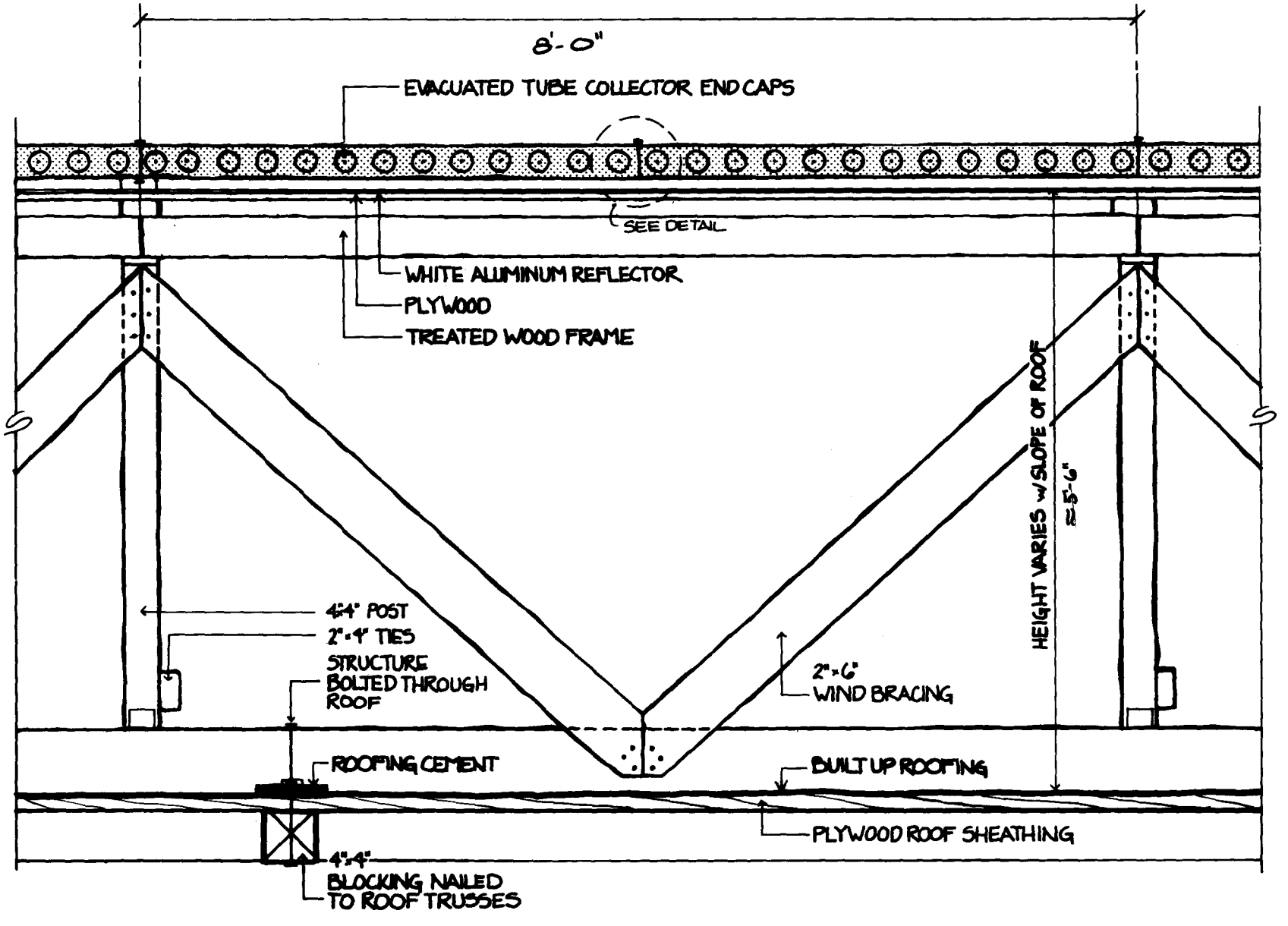


Figure IV-B-9. Back Elevation of Collector Support

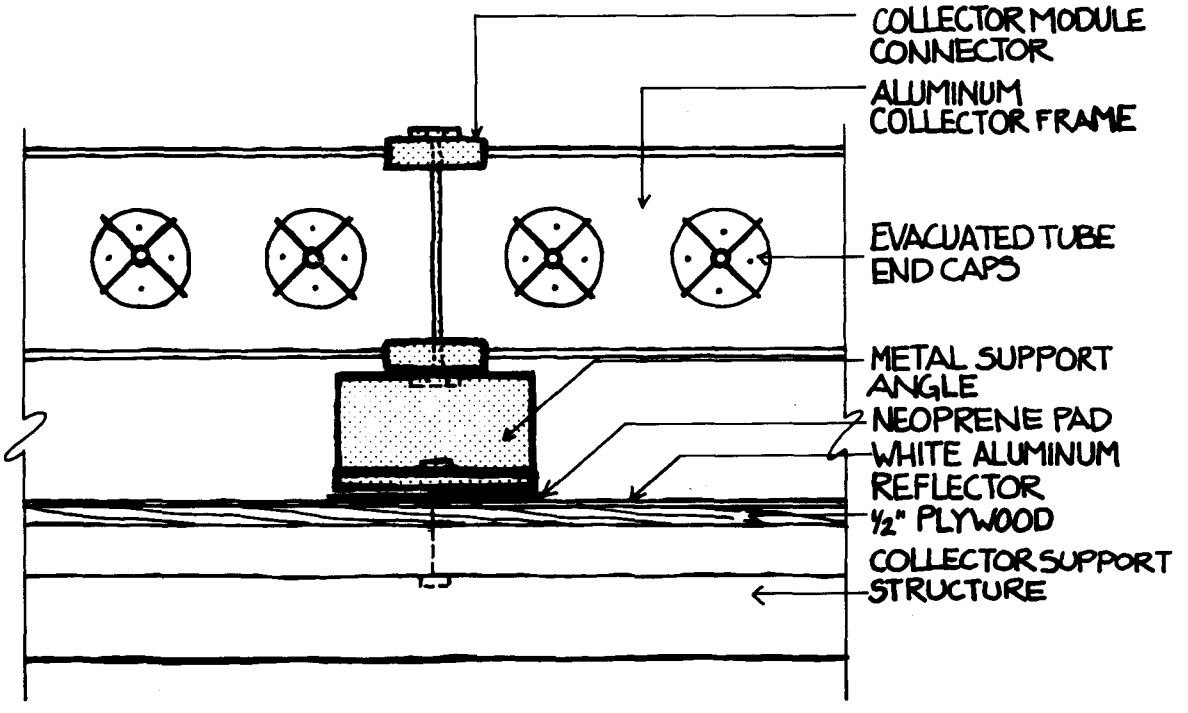


Figure IV-B-10. Collector Mounting Detail

- Framing finish - None
- Fasteners - Steel straps and nails
- Collector attachment - Bolts

Reflectors

- General - A white aluminum sheet placed behind the collector tubes
- Size - 0.019 in. thick
- Installation - Pressure bonded to the plywood sheathing of the collector structure

Piping (below roof)

- Material - Schedule 40 black steel
- Size - 3 in. diameter
- Insulation - 1 in. urethane with aluminum jacket
- Valving
    - Balance and shutoff
        - Type - Butterfly
        - Size - 3 in.
    - Triple duty valve
        - Type - Shutoff, check and flow meter
        - Size - 1.5 in.
        - Manufacturer - Bell and Gossett

Heat Transfer Medium

- Type - Water

Mechanical Equipment

- Heat exchanger
    - Location - Mechanical room
    - Manufacturer/Model no. - Young Radiator Company/R-1305-5R-1P

- Material - Steel shell, cast iron bonnets, and brass tubes
- Type - Sheel and tube
- Rated capacity
  - Flow rate shell - 140 GPM
  - Flow rate tube - 550 GPM
  - Rating - 850,000 Btu/hr
  - Shell inlet temperature - 217.5° F
  - Shell outlet temperature - 205° F
  - Tube inlet temperature - 201.8° F
  - Tube outlet temperature - 205° F

- Heat rejector
  - Location - Roof
  - Manufacturer - Young Radiator Company
  - Model number - HC11D2
  - Type - Air cooled
- Expansion tank
  - Material - Steel
  - Capacity - 300 gal

Visual Monitoring Equipment

- Pressure gauges - Manufactured by Trerice
- Display board
  - Location - Center core of school building
  - Description - A 60 in. x 36 in. panel with a color coded piping diagram, indicator lights to show system operations, and a thermometer indicator to show temperatures.

C. Storage - None

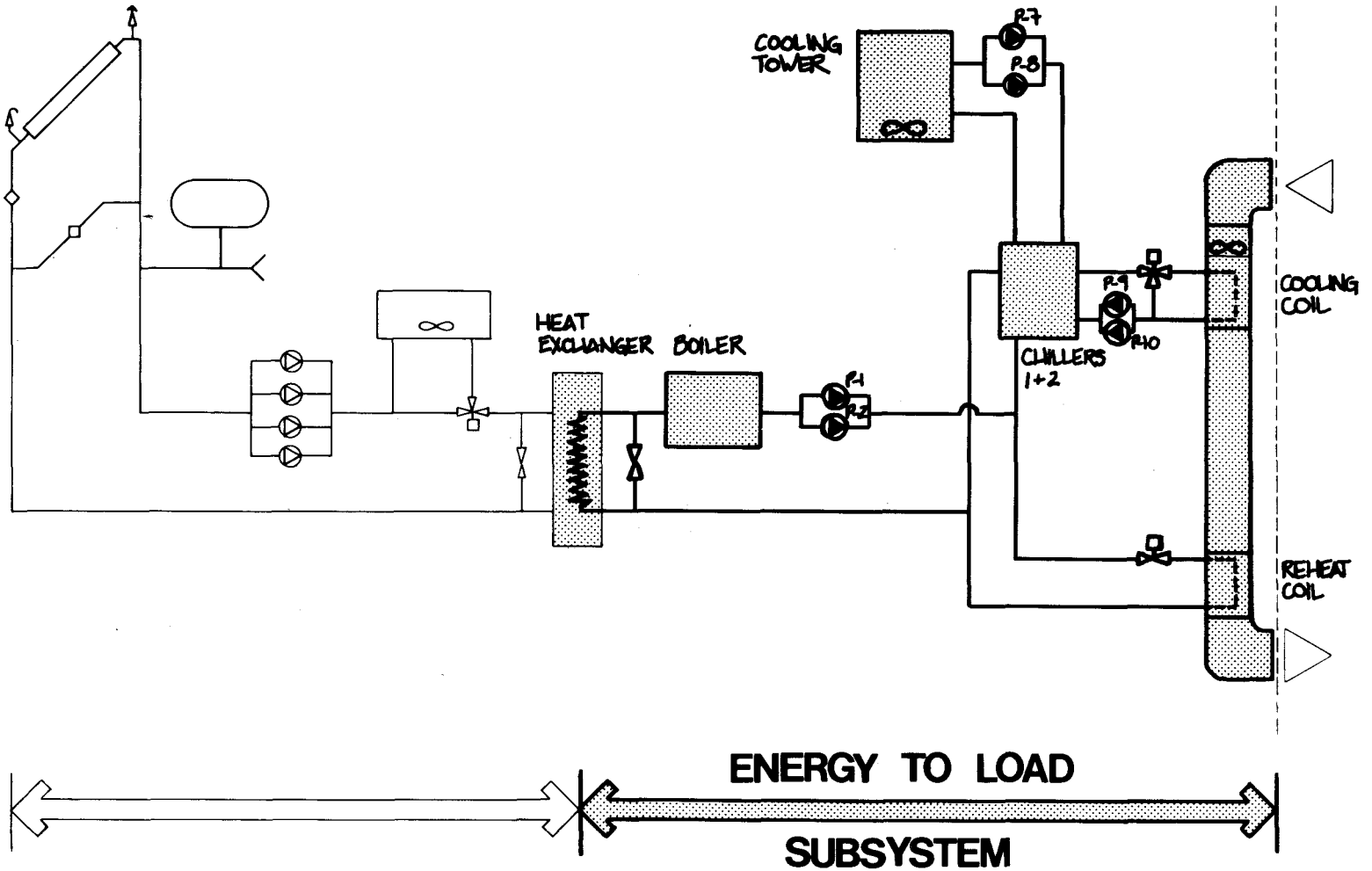


Figure IV-D-1. Energy-to-Load Subsystem

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

General Description

Space heating is provided by circulating hot water from the heat exchanger, through the auxiliary boiler, to the duct mounted reheat coils (one coil for each of the seven roof top air handling units). Space temperature is maintained by varying the flow of hot water to the coil through the use of a two-way automatic temperature control valve. The fan in the roof top air handling unit circulates air across the coil and supplies and returns air to and from the space through ductwork in the school's ceiling space.

Space cooling is provided by circulating hot water from the heat exchanger through the auxiliary boiler to the two Arkla absorption chillers. Chilled water from the chillers is circulated to the cooling coils in the seven roof top air handling units. A cooling tower is used to cool condenser water for the chillers. Space temperature is maintained by varying the flow of chilled water to the coil through the use of a three-way control valve. The fan in the air handling unit circulates air across the coil and supplies and returns air to and from the space through ducts mounted in the school's ceiling. See table IV-D-1 for the pump schedule.

Space Heating

- Piping - Black steel
  - Insulation - 1 in. urethane with aluminum jacket
- Valves
  - Type - Electric, three-way
  - Manufacturer - Barber Coleman
- Air handling unit
  - Manufacturer - Lanco Manufacturing Company
  - Type - Horizontal draw through
  - Location - Roof

- Boiler
  - Type - Gas fired furnace
  - Manufacturer/Model No. - Thermo-Pak/4275 T
  - Input - 4,275,000 Btu/hr
  - Output - 3,420,000 Btu/hr

Space Cooling

- Piping - Same as heating
- Valves - Same as heating
- Air handling units - Same as heating
- Chillers (typical of 2)
  - Type - Absorption
  - Manufacturer - Arkla
  - Model No. - WE 1200-WV
  - Capacity - 100 tons
  - Input - 1,682,000 Btu/hr
- Cooling tower
  - Type - Counterflow
  - Manufacturer - Baltimore Aircoil
  - Model No. - VNT-200AS
  - Capacity - 200 tons

E. Control Subsystem

General Description

The solar energy system can operate in five basic modes: (1) collector protection; (2) solar energy collection; (3) collector-to-space heating/cooling; (4) solar heat rejection; and (5) collector backup protection. System operations are controlled by several temperature sensors.

Table IV-D-1. Pump Schedule

PUMP NO.	NAME	FLOW RATE GPM	HEAD FT. H_2O	POWER HP	RPM	REMARKS
1	Load Loop Hot Water Pump	550	75	20	1750	
2	Load Loop Hot Water Pump	550	75	20	1750	Spare
3	Collector Main Pump	140	110	10	3500	
4	Collector Main Pump	140	110	10	3500	Spare
5	Collector Auxiliary Pump	20	8	1/6	1750	
6	Collector Auxiliary Pump	20	8	1/6	1750	Spare
7	Condenser Pump	700	75	25	1760	
8	Condenser Pump	700	75	25	1760	Spare
9	Chilled Water Pump	200		7.5	1740	
10	Chilled Water Pump	200		7.5	1740	Spare

1. Collector Protection Mode

General Description - This mode occurs when the lower flow capacity (20 GPM) auxiliary collector pump (P5) is turned on by a clock timer. This is before collection begins and is required to establish flow past the collector outlet sensor prior to initiation of solar energy collection (mode 2). This mode is re-entered daily at the completion of mode 2 operation and is subsequently terminated by the clock timer. To provide freeze protection, this mode is also entered when the ambient temperature is less than 38° F. The clock controller is overridden when this control temperature is reached.

2. Solar Energy Collection Mode

General Description - This mode occurs when the main collector pump (P3) is on. Mode entry requires a differential temperature of 15° F between the collector outlet and the load side inlet to the heat exchanger. When the differential temperature again drops below 15° F (adjustable), mode 1 is re-entered.

3. Collector-to-Space Heating/Cooling Mode

General Description - In this mode, heating and cooling loads may be active at the same time. This mode is enabled at all times and receives energy from the solar energy system when available. If solar energy is not available or is insufficient to satisfy the full demand, the auxiliary boiler is activated to supply the remaining demand. This mode is normally disabled at night by clock timers controlling the boiler and the boiler loop pump.

4. Solar Heat Rejector Mode

General Description - This mode occurs when excess solar energy is diverted from the collector loop and rejected to the environment through a liquid-to-air heat exchanger on the roof. This mode is entered if the temperature at the collector loop outlet from the heat exchanger exceeds a variable set point (approximately 215° F). Upon exceeding this set point temperature, a three-way valve is switched to initiate collector loop flow through the heat rejector, and the heat rejector fan is turned on to increase the air flow across its coils. When the heat exchanger

outlet temperature drops below another variable set point (approximately 200° F), the three-way valve is reversed, the heat rejector fan is turned off, and this mode is terminated. This mode is employed when the collected solar energy exceeds the immediate demand from the load subsystems.

5. Collector Backup Protection Mode

General Description - This mode is entered when the collector outlet temperature exceeds a set point (approximately 220° F). Control design assumes the collector pumps or the heat rejector are not operating properly if this temperature is exceeded. In this mode, normally open solenoid valves allow city supply water to enter the collectors and drain out at the collector outlet. This mode also protects against collector thermal shock damage if power outage occurs.

An additional operational consideration is the main pump switchover and alarm operation. The alternate highflow pump (P4) will immediately be turned on if the other pump (P3) has been energized but no flow detected. The alarm will sound if both main pumps fail to operate: either if the small pumps (P5, P6) fail or collector flush (mode 5) is initiated during nonpower outage periods.

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 performance factors that 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 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, and
- 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

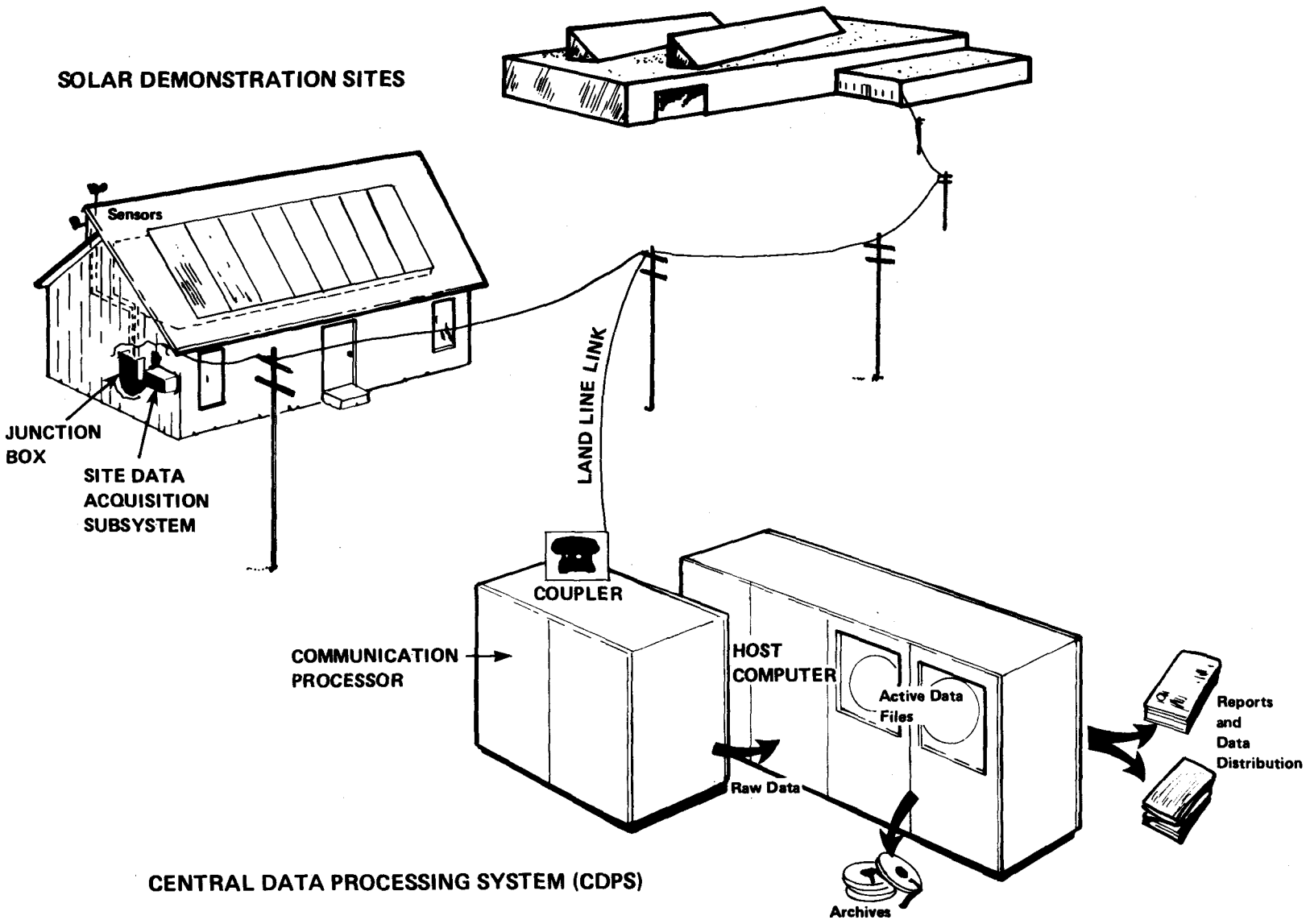


Figure V-A-1. The National Solar Data Network

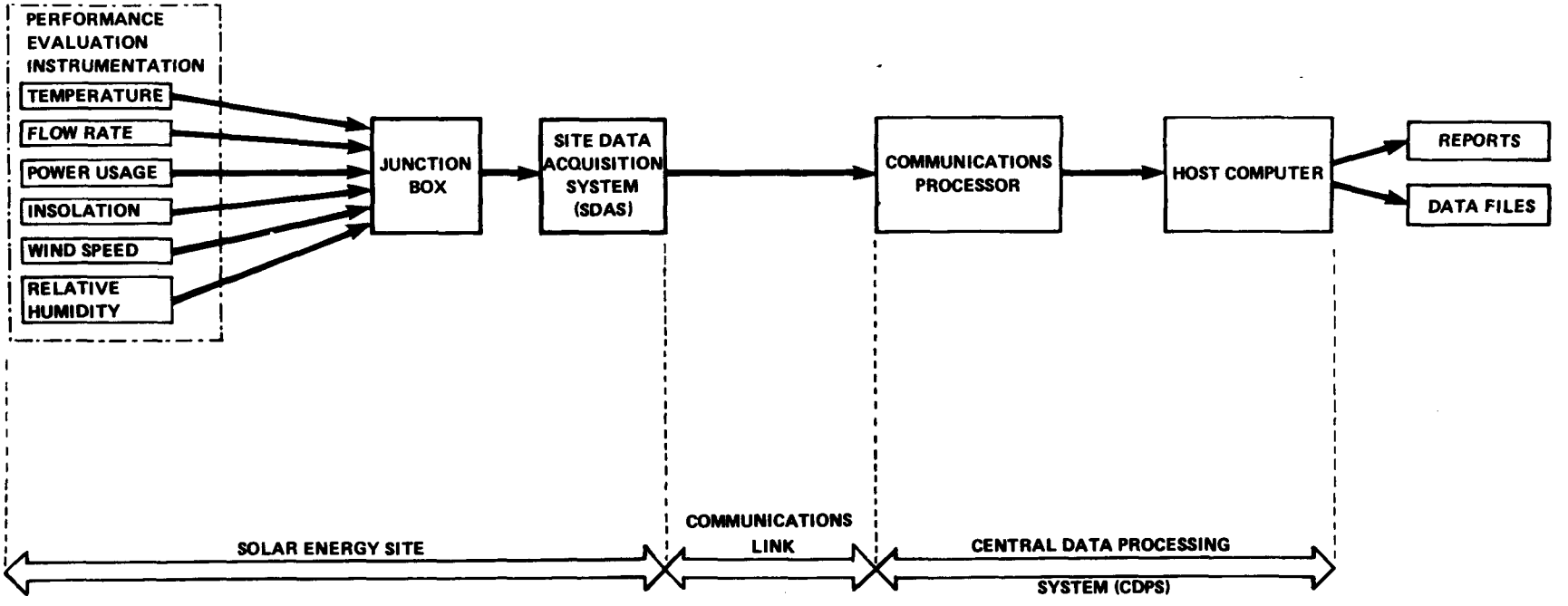


Figure V-A-2. Data Flow Path for the National Solar Data Network

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 and V-B-2.

Table V-B-1. Temperature Instrumentation for Irvine School

SENSOR	NAME	RANGE (F)		MFGR.	THERMOWELL PART NO.	PROBE PART NO.
		Min.	Max.			
T001	Outside Ambient Air Dry Bulb Temperature	-20	120	Minco	IS4	S53-P85
T100	Collector Array Inlet Temperature	30	450	Minco	F203U15	S57-P40
T102	Heat Rejector Inlet Temperature	30	450	Minco	F203U15	S57-P40
T103	Collector Loop/Heat Exchanger Inlet Temperature	30	450	Minco	F203U15	S57-P40
T150	Collector Array Outlet Temperature	30	450	Minco	F203U15	S53-P40
T152	Heat Rejector Outlet Temperature	30	450	Minco	F203U15	S53-P40
T153	Collector Loop/Heat Exchanger Outlet Temperature	30	450	Minco	F203U15	S53-P40
T400	Heating Coils Inlet Temperature	30	230	Minco	F203U10	S57-P40
T401	Load Loop/Heat Exchanger Inlet Temperature	30	230	Minco	F203U15	S57-P40
T450	Heating Coil Outlet Temperature	30	230	Minco	F203U10	S53-P40
T451	Load Loop/Heat Exchanger Outlet Temperature	30	230	Minco	F203U15	S53-P40
T500	Auxiliary Boiler Inlet Temperature	30	230	Minco	F203U15	S57-P40
T501	Chiller Generator Inlet Temperature	30	230	Minco	F203U15	S57-P40
T502	Chiller Chilled Water Supply Inlet Temperature	30	160	Minco	F203U15	S57-P40
T503	Chiller Condenser Water Inlet Temperature	30	160	Minco	F203U15	S57-P40
T550	Auxiliary Boiler Outlet Temperature	30	230	Minco	F203U15	S53-P40
T551	Chiller Generator Outlet Temperature	30	230	Minco	F203U15	S53-P40
T552	Chiller Chilled Water Supply Temperature	30	160	Minco	F203U15	S53-P40
T553	Chiller Condenser Water Outlet Temperature	30	160	Minco	F203U15	S53-P40
T600	Inside Temperature	-20	120	Minco		S53-P85

Table V-B-2. Flow Rate Instrumentation for Irvine School

SENSOR	NAME	RANGE (GPM/CFM)			MFGR.	MODEL NO.
		Min.	Design	Max.		
W100	Collector Array By-Pass Flow Rate	0	70	80	Ramapo	MKV-2-W01
W102	Heat Rejector Flow Rate	0	140	160	Ramapo	MKV-2-W01
W103	Collector Array Flow Rate	0	140	160	Ramapo	MKV-2-W01
W400	Heating Coils Flow Rate	0	72	83	Ramapo	MKV-2.5-W01
W500	Total Heating/Cooling Loop Flow Rate	0	552	635	Ramapo	MKV-5-W01
W501	Chiller Generator Flow Rate	0	480	550	Ramapo	MKV-5-W01
W502	Chiller Chilled Water Flow Rate	0	200	230	Ramapo	MKV-4-W01
W503	Chiller Condenser Flow Rate	0	700	800	Ramapo	MKV-6-W01
F500	Auxiliary Boiler Gas Flow Rate (CFM)	0	71	82	American Meter	AL5000

Table V-B-3. Power Instrumentation for Irvine School

SENSOR	NAME	PHASE	MFGR.	FULL SCALE INPUT		MODEL NO.
				Volts	Power (kW)	
EP101	Collector Main and Spare Pump Power	3	Ohio Semitronics	480	11.70	PC5-54
EP500	Auxiliary Boiler Power	1	Ohio Semitronics	115	0.25	PC5-1
EP501	Chiller Operating Power (1)	1	Ohio Semitronics	115	0.40	PC5-10
EP502	Chilled Water Pump Power	3	Ohio Semitronics	480	7.80	PC5-24
EP504	Chiller Operating Power (2)	1	Ohio Semitronics	115	0.40	PC5-10
EP505	Cooling Tower Fan Power (1)	3	Ohio Semitronics	480	21.00	PC5-54
EP507	Load Loop Hot Water Pump Power	3	Ohio Semitronics	480	21.00	PC5-54
EP508	Cooling Tower Fan Power (2)	3	Ohio Semitronics	480	21.00	PC5-54

Table V-B-4. Miscellaneous Instrumentation for Irvine School

SENSOR	NAME	MODEL NO.	MFGR.
I001	Collector Plane Total Insolation	PSP	Eppley
I002	Collector Plan Diffuse Insolation	PSP with Shadow Band	Eppley
D901	Atmospheric Corrosion Monitor	ART II	Weather Measure
RH901	Humidity Sensor	TH 2013-2	Weather Measure

I001 Total Insolation
I002 Diffuse Insolation
T001 Outside Air
T600 Room Air

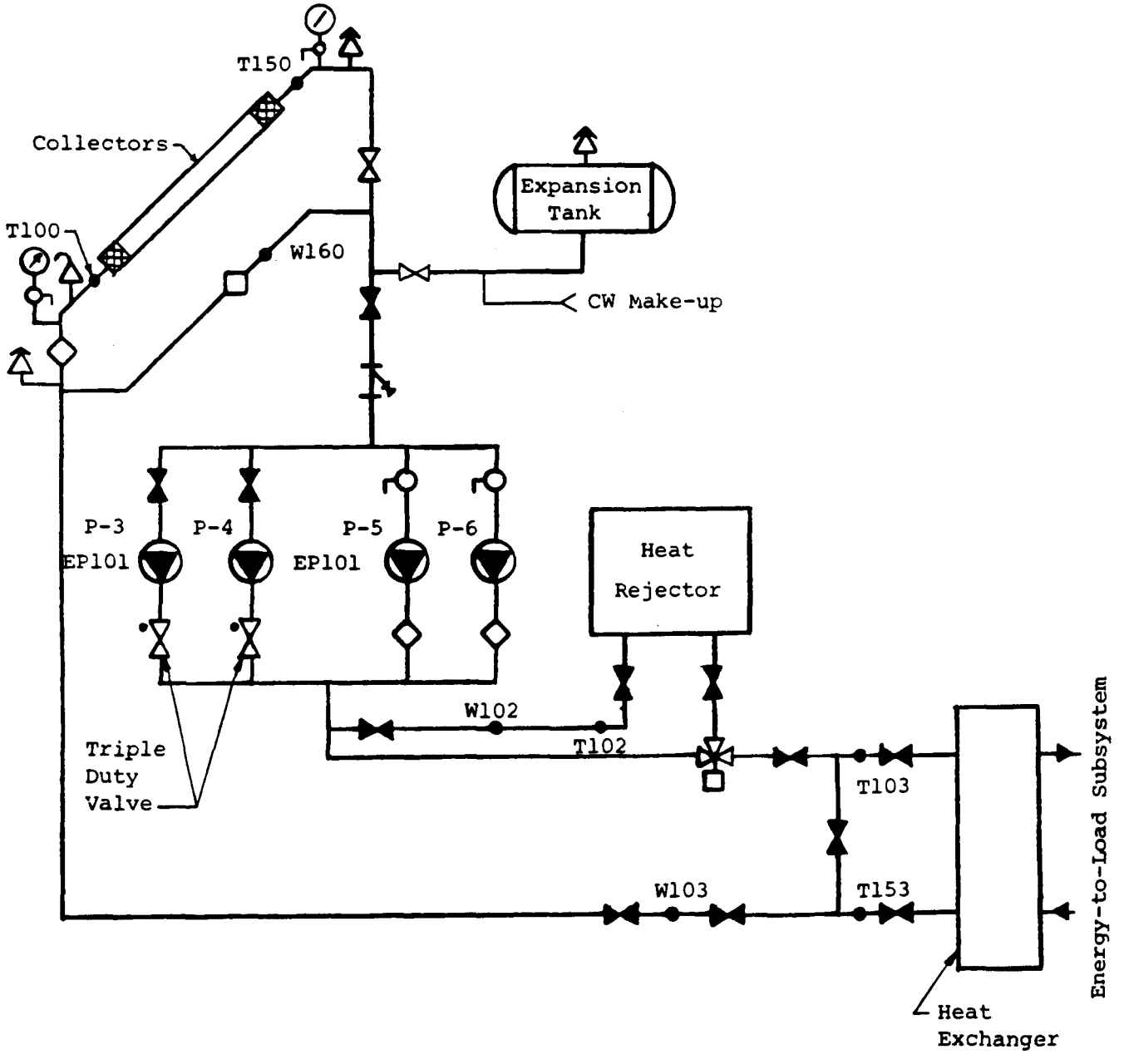


Figure V-B-1. Performance Instrumentation Schematic--Collector Loop

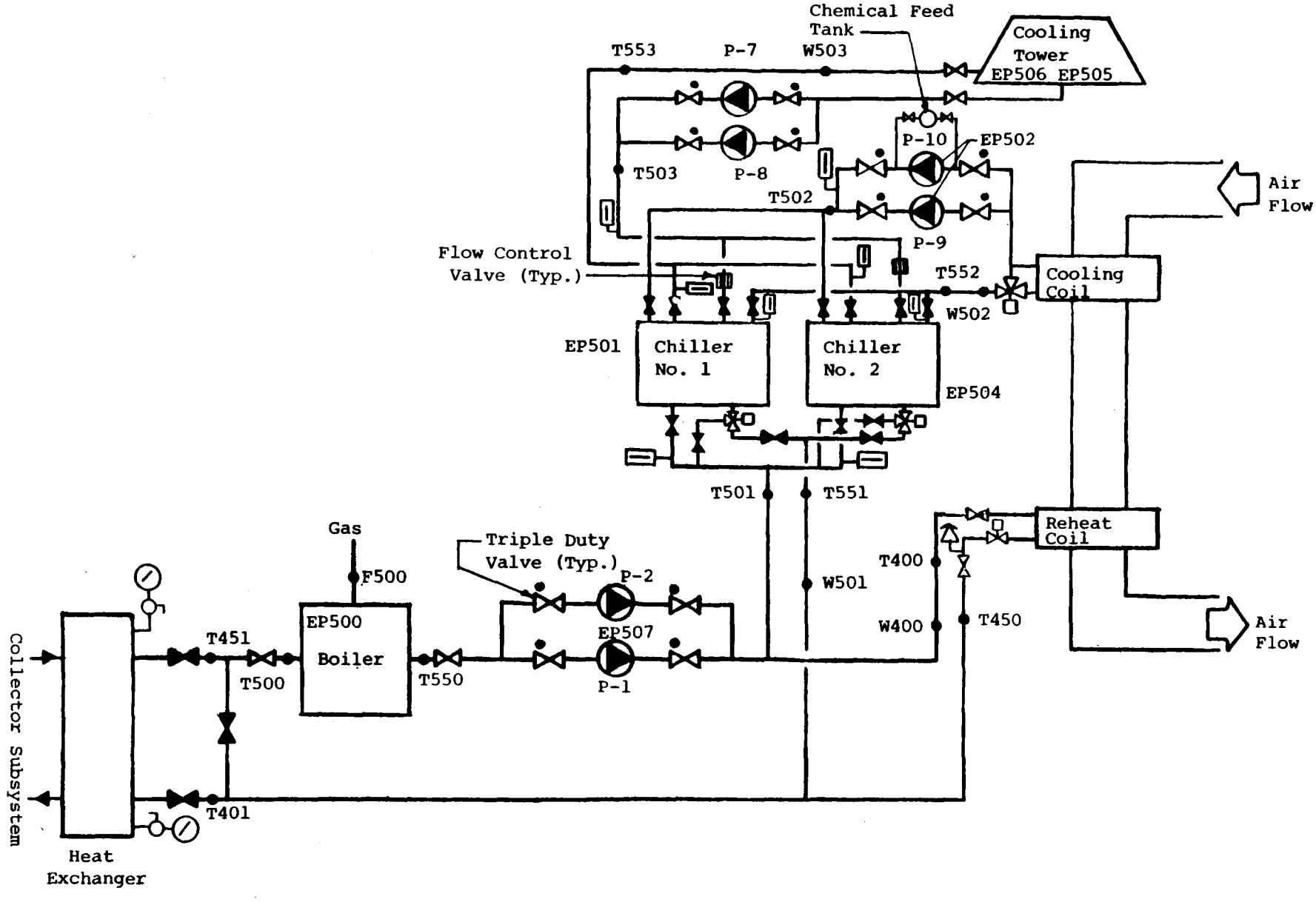


Figure V-B-2. Performance Instrumentation Schematic--Load Loop

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° 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.

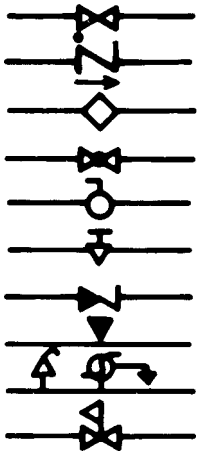
TON OF REFRIGERATION - A unit of refrigeration equivalent to 12,000 Btu/hr.

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.

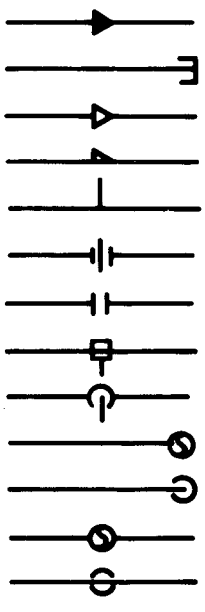
ZONE - Portions of a conditioned space which use a common control because of their similar heating and cooling requirements.

VALVES



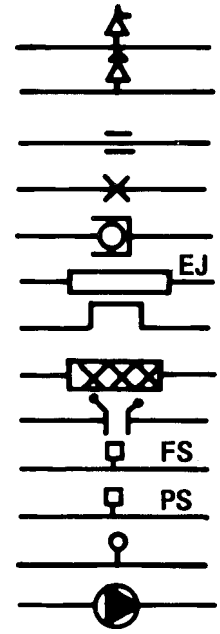
GATE VALVE
CHECK VALVE
BALANCING VALVE
GLOBE VALVE
BALL VALVE
PLUG VALVE
BACKFLOW PREVENTER
VACUUM BREAKER
RELIEF OR SAFETY
PRESSURE REDUCING
ANGLE GATE VALVE
ANGLE GLOBE VALVE
CONTROL VALVE, 2 WAY
CONTROL VALVE, 3 WAY
BUTTERFLY VALVE
4 WAY VALVE

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

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