DR. 678

SOLAR/1090-79/50

MASTER

# Solar Project Description

# ALBUQUERQUE WESTERN-II MULTI-DWELLING BUILDING Albuquerque, New Mexico November 23, 1979

## U.S. Department of Energy

### National Solar Heating and Cooling Demonstration Program

### National Solar Data Program

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## NOTICE

Solar/1090-79/50
Distribution Category UC-59

# SOLAR PROJECT DESCRIPTION
# FOR
# ALBUQUERQUE WESTERN - II
# MULTI-DWELLING BUILDING - ALBUQUERQUE, NEW MEXICO



Department of Housing and Urban Development

Under Contract Number

H-2372

David Moore
Solar Heating and Cooling Demonstration Program Manager

By

The Boeing Company
David Beers, Program Manager

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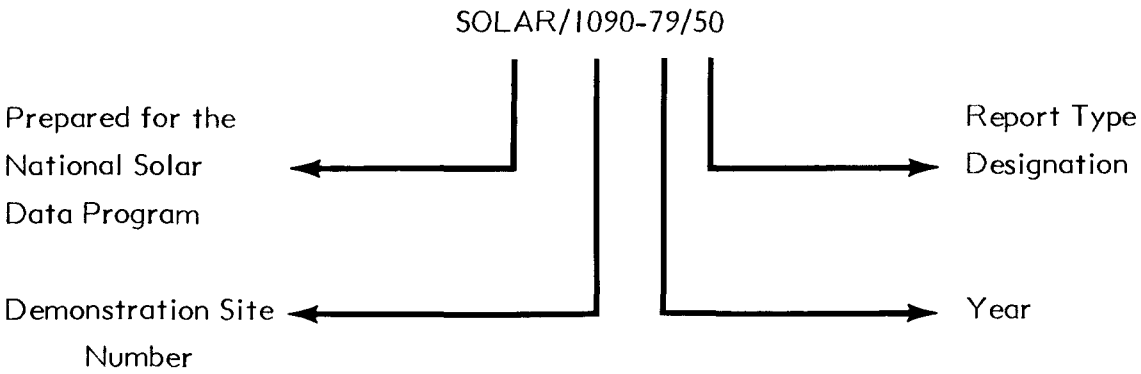
## NATIONAL SOLAR DATA PROGRAM REPORTS

Reports prepared for the National Solar Data Program are numbered under a specific format. For example, this report for Albuquerque Western - II, a Multi-dwelling project site, is designated as SOLAR/1090-79/50. The elements of this designation are explained in the following illustration:




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

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

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

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

# I. FOREWORD

The National Program for Solar Heating and Cooling is being conducted by the Department of Energy (DOE) as mandated by the Solar Heating and Cooling Demonstration Act of 1974. The Department of Housing & Urban Development is responsible to DOE for the Solar Residential Demonstration Program. 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:

- o Solar Project Description.
- o Operational Experience.
- o System Performance Evaluation.
- o Monthly Performance Reports.

Information contained herein for this Solar Project Description report has been extracted from data collected during site visits and from reference documents such as the project proposal, designer specifications, grantee submittals, manufacturer literature, photographs, specific "as-built" data and other project documentation available. The remaining reports in this series will utilize the Solar Project Description for supporting reference.

## II. EXECUTIVE SUMMARY

The following are the major solar energy descriptors:

- o Collector Type - Liquid
- o Freeze Protection - Yes, drain-down
- o Application - Hot water space heating
- o Storage - Water, 57,000 gallon tank
- o New or Retrofit - New
- o Performance Evaluation Instrumentation - Yes
- o Site-Specific Features - Gas-fired boiler auxiliary heating, tracking mount drive controls

The Albuquerque Western - II site is a four-story, 110-unit apartment building in Albuquerque, New Mexico. The solar energy system consists of a controlled system to preheat hot water used in space heating.

The solar energy system is designed to provide approximately 54 percent of the conditioned space heating load. The system has an array of tracking collectors with a gross area of 6429 square feet. The array faces south at an angle of 35 degrees to the horizontal. Water is used as the medium for delivering solar energy from the collector array to storage. Solar energy is stored underground in a 57,000-gallon concrete storage tank. During the space heating season, the heated water from storage is continuously circulated through the builidng to satisfy the space heating needs for each apartment. Auxiliary heating is provided by three inline gas-fired boilers. The system has three modes of operation.

The dwelling has been fully instrumented for performance evaluation since May 1978 and the data is integrated into the National Solar Data Network.

Original cost estimates for provisioning and installation of the solar system are given in section VI of this report. However, the final solar system cost and the cost of its instrumentation are not included in this report.

## III. SITE AND BUILDING DESCRIPTION

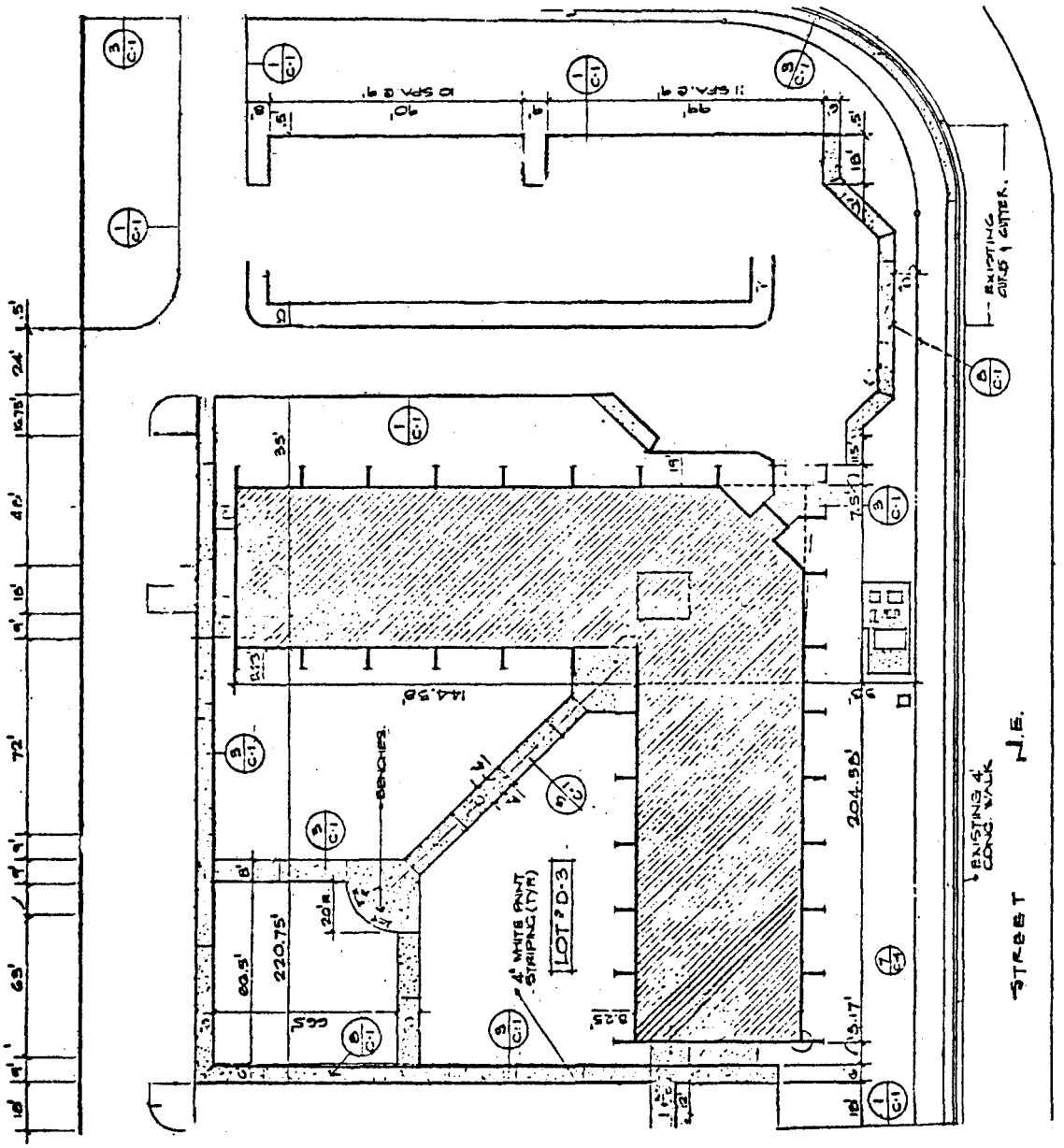



Figure III-1. Site Plan

Site Description (See Figure III-1)

- Latitude - 35°
- Longitude - 106°
- Elevation - 5339 feet
- Annual degree days
  - Heating - 4294
  - Data location - Albuquerque, New Mexico
  - Data reference - Local Climatological Data Annual Summaries, Department of Commerce, National Oceanographic and Atmospheric Administration
- Average horizontal insolation
  - January - 1853 Btu/ft$^2$ day
  - July - 2250 Btu/ft$^2$ day
- Shading
  - Heating season -
  - Cooling season -

Building Description

- Occupancy
  - Multi-dwelling - 110 families
- Total area - Approximately 6429 ft$^2$
- Solar conditioned area - Approximately 5236ft$^2$
- Height -
- Roof slope at collector - 35°
- Special features - Three boilers in parallel for auxiliary heat and a tracking control system

Mechanical System

- Heating
  - Solar - 507 collectors
  - Auxiliary - Three gas-fired boilers
  - Distribution - Heated water circulation

## IV. SOLAR SYSTEM DESCRIPTION

### A. General Overview

This residential solar demonstration project (Albuquerque West - II Grant H-2767) located at Albuquerque, New Mexico is a liquid active system utilized for heating. Auxiliary units are provided for heating.

Subsequent sections describe the collector, storage, energy-to-load, and auxiliary subsystems. Specific details of the operating modes and controls are described in the final section. Figure IV-A-1 is a system schematic diagram.

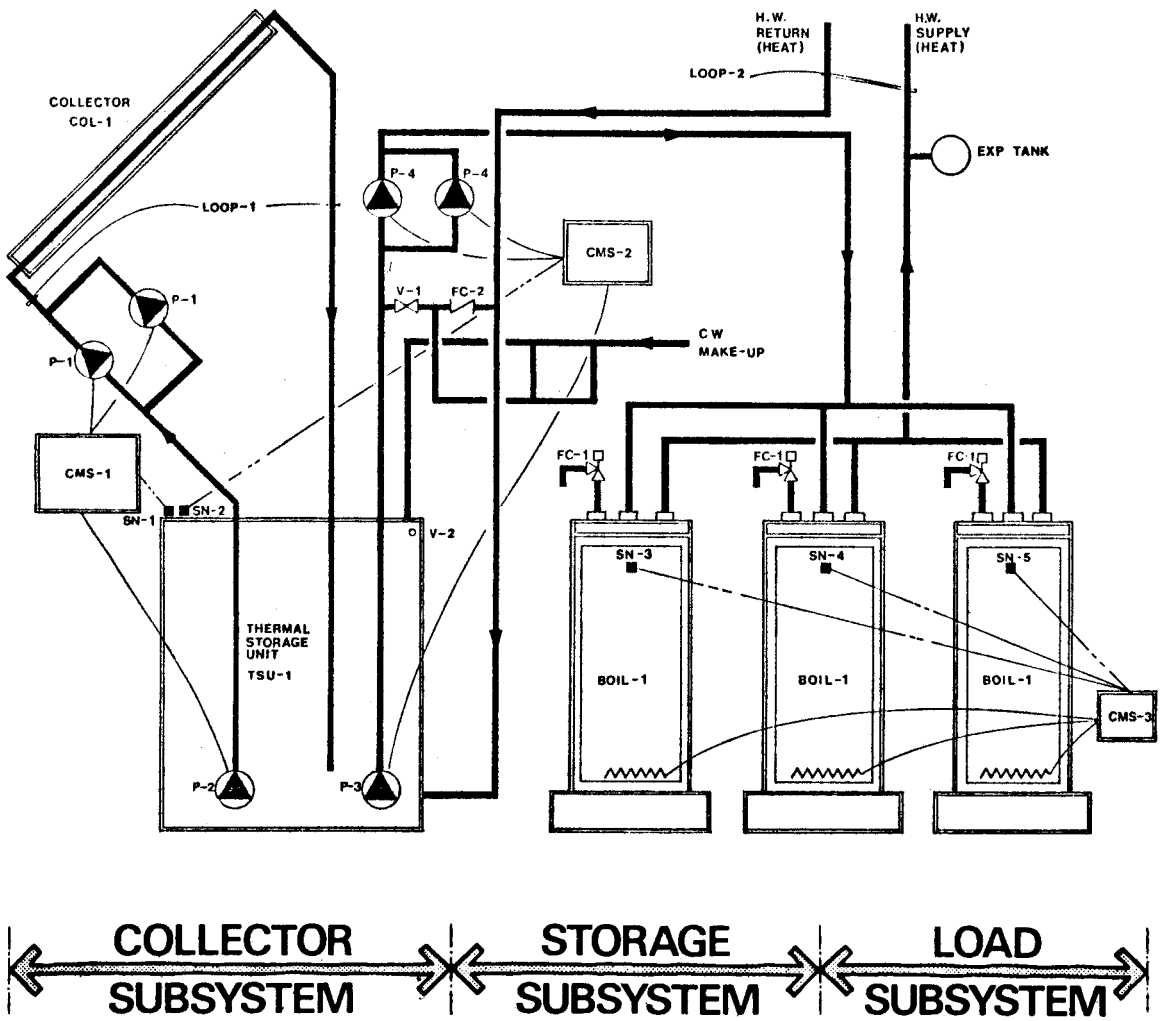



Figure IV-A-1. General Overview

B. Collector Subsystem (See Figure IV-B-1)

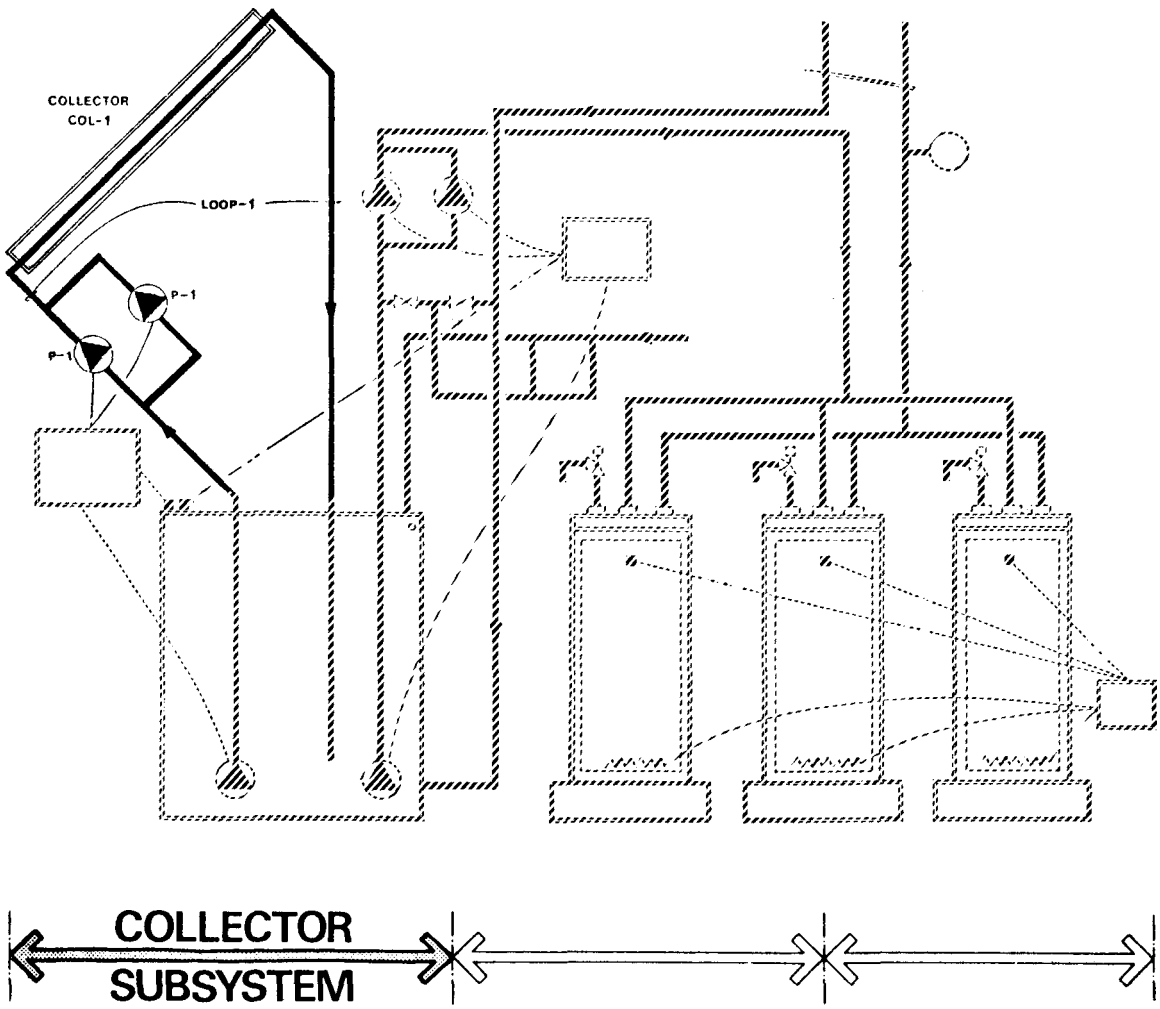



Figure IV-B-1. Collector Subsystem

Collector array system consists of 507 double glazed selective surface, parabolic tracking plate collector panels. Freezing protection is provided by drain off of collectors when inactive.

Collector (COL-1) (See Figure IV-B-2)

- Manufacturer - Albuquerque W Solar Industries
- Model name/number - Solcan
- Type - Liquid concentrating, reflector on tracking mount with fixed absorber
- Location - Roof
- Orientation -
- Tilt angle - $35^{o}$ from horizontal
- Number of collector panels - 507
- Array configuration -

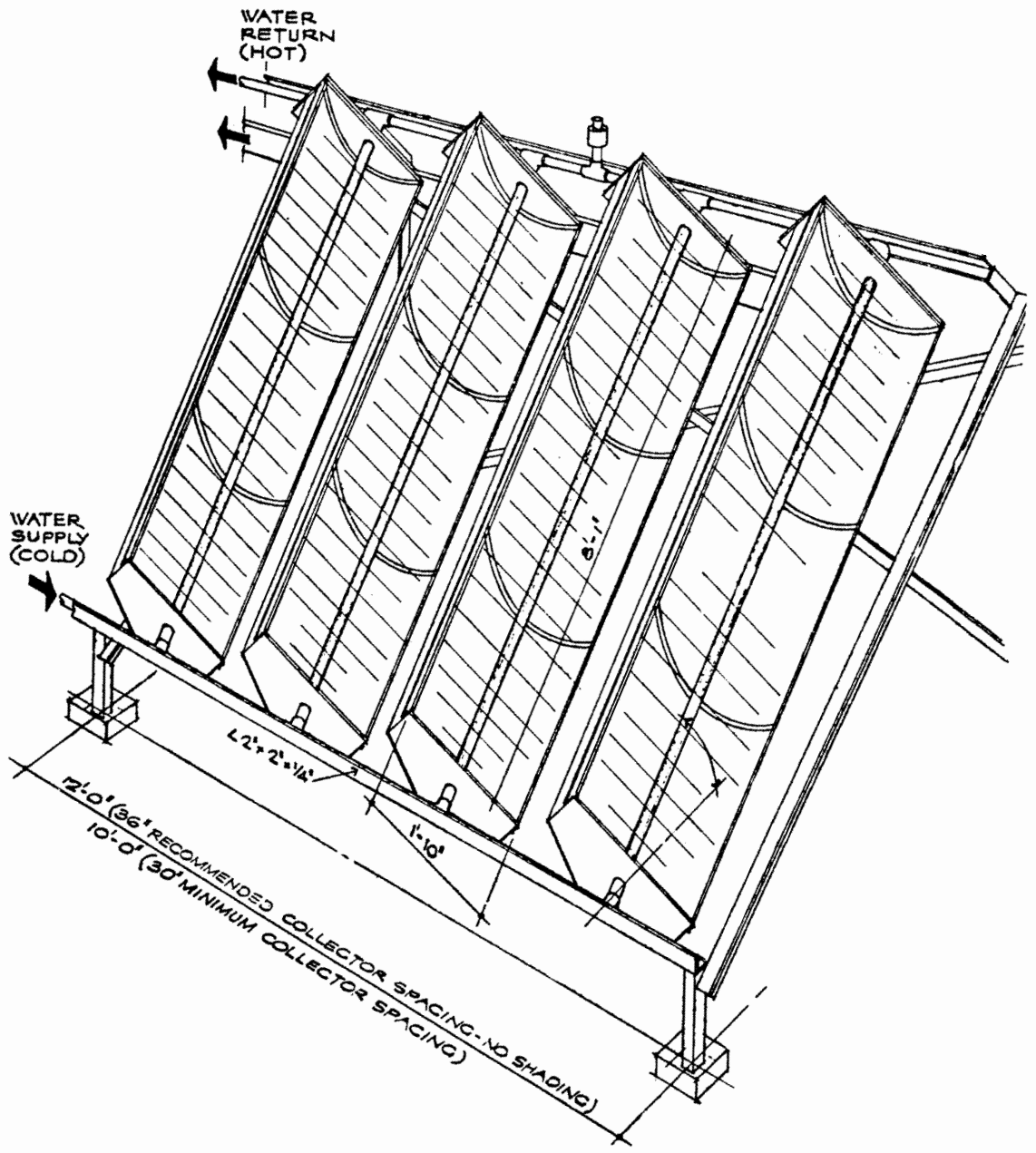



Figure IV-B-2. Solar Collector

- Collector
  - Total gross area of array - 6429 $ft^2$
  - Net aperture area - 5236 $ft^2$
  - Weight per panel, empty - 65 lb
  - Weight per panel, full - 66 lb
  - Panel length - 106 inches
  - Panel width - 22 inches
  - Standoff height - 12 inches
- Glazing (cover plate)
  - Number of cover plates - 1
- Cover plate No. 1
  - Manufacturer - Unknown
  - Material - Copper, type M
  - Thickness - 0.004 inch
  - Coating - None
  - Optical properties

| | (solar region) | (infrared region) |
|---|---|---|
| - Transmittance | 91% | Unknown |
| - Reflectance | 91% | Unknown |
| - Emittance - | 91% | Unknown |

  - Edge or surface treatment, other than coating - None
- Absorber
  - Manufacturer - Albuquerque W Solar Industries
  - Material - Copper, type M
- Coating
  - Material - Welbom Solar Black
  - Application method - Painted

| | (solar region) | (infrared region) |
|---|---|---|
| o Absorptance - | Solar 93% | Unknown |
| o Reflectance - | Solar 7% | Unknown |
| o Emittance - | Solar 93% | Unknown |

- o Heat transfer fluid passages
  - o Location - In absorber
  - o Pattern - Parallel
  - o Materials - Copper, type M
  - o Wall thickness - 0.042 inch
  - o Maximum operating conditions
  - o Protective coating inside fluid passage - None
- o Frame
  - o Manufacturer - Albuquerque W Solar Industries
  - o Product Name/Number - Solcan
  - o Material - Steel, 25 galvanized
  - o Protective coating - Galvanized
  - o Number of structure attach points per module to building - Two
  - o Desiccant - None
  - o Freeze protection - Drain down
  - o Overheating protection - Concentrator off tracking device
- o Reflector
  - o Material - Plastic, Mylar
  - o Physical dimensions
    - Length - 101 inches
    - Width - 22 inches
  - o Concentration factor - 10.0%

- Collector performance
  - Method of evaluation - ASHRAE
  - Point Number 1 2 3 4
  - n = Collector thermal efficiency (%) - Information Not Available
  - $t_i$ = collector inlet temperature ($^oF$) - Information Not Available
  - $t_a$ = ambient air temperature ($^oF$) - Information Not Available
  - $I_t$ = insolation intensity Btu/hr $ft^2$ - Information Not Available
  - ASHRAE $(t_i-t_a)/I_t$ - Information Not Available
  - Test flow rate - Information Not Available
  - Test collector area
    - Gross - Information Not Available
    - Net - Information Not Available
  - Fluid specific heat - Information Not Availabale
  - Test fluid medium - Information Not Available

Liquid Circulation Loop No. 1 (COL-1 to TSU-1)

- Design maximum operating temperature - $165^o$ F
- Design liquid flow - 225 gpm
- Heat transfer medium - Water (100%)
  - Specific heat - 1.00 Btu/lb/$^o$ F
  - Density - 63 lb/$ft^3$
  - Boiling point - $212^o$ F
  - Freezing point - $32^o$ F
  - Maximum recommended use temperature - $165^o$ F
  - Toxicity - Potable
  - pH factor -
  - Chemical feeder to maintain pH factor - No
  - Inhibitor - None

- Piping
  - Rigid - Copper, M type
  - Piping insulation - Mineral Fiber - Glass Fiber
  - Location - Above grade
  - Filters - None
- Circulator pump (P-1)
  - Manufacturer - Armstrong
  - Model Name/Number - 1 1/2 base mounted
  - Type - Centrifugal
  - Maximum operating conditions
    - Temperature - 200° F
  - Motor size - 0.75 hp
  - Maximum motor speed - 1750 rpm
  - Drive - Direct
  - Circulating volume - Low head mode - 75 gpm
  - Operating head (dynamic) - Low head mode - 100 ft head
  - Motor operation - 0.75 bhp
- Distribution Valve (V-1)
  - Function - ON-OFF
  - Operation - Manual
  - Type - Gate
  - Material exposed to heat transfer fluid - Bronze

Control Mode Selector (CMS-1)

- Modes controlled - Collector-to-Storage
- Sensors (SN-1) and (SN-2)
  - Manufacturer - Unknown
  - Type - Temperature, thermistor

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

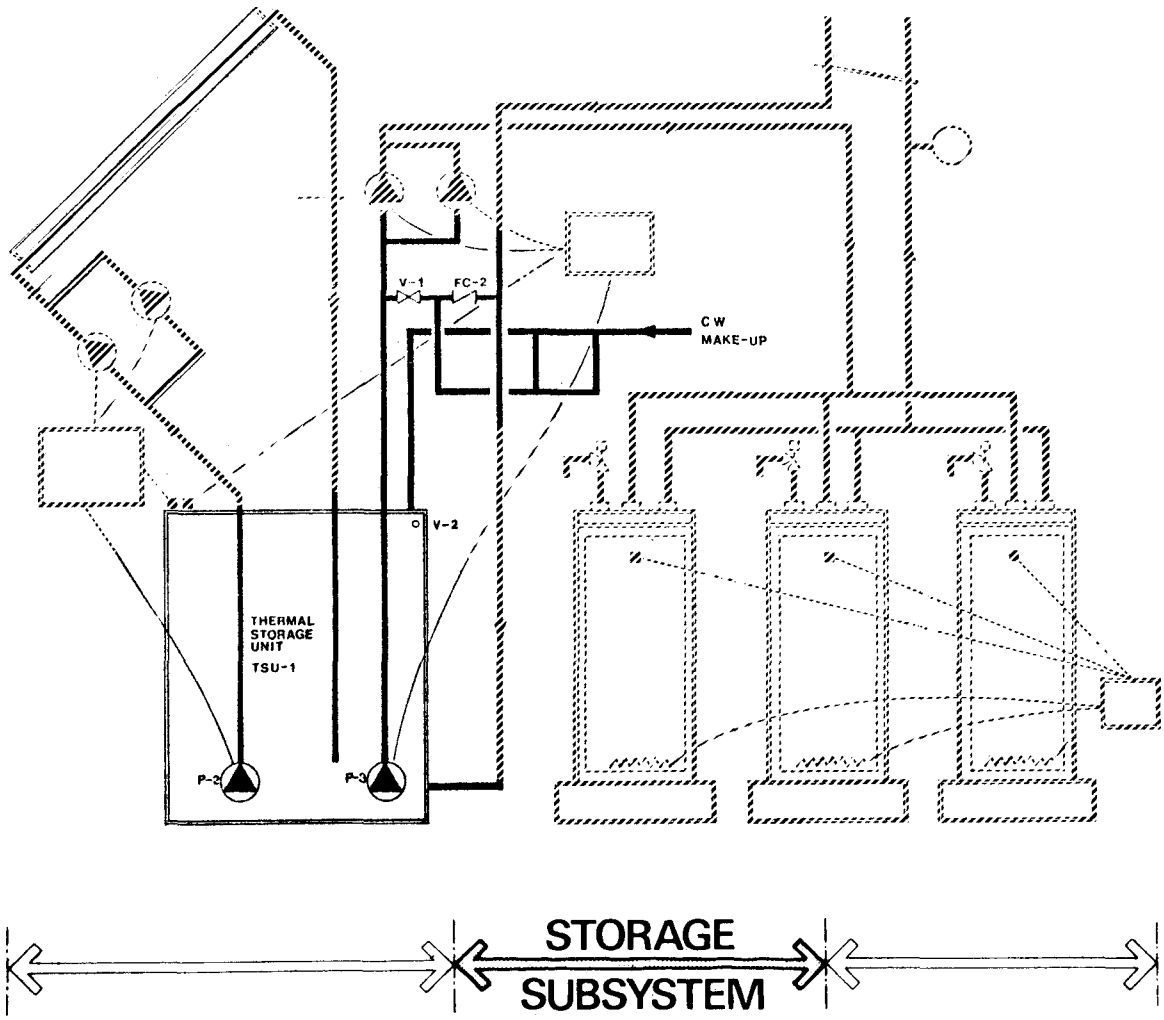



Figure IV-C-1. Storage Subsystem

Solar energy storage is provided by a 57,000 gallon underground storage tank. This tank is made of concrete with a Hypolon liner interior.

Thermal Storage Unit (TSU-1)

- Container - 57,000 gallon concrete tank
  - Total storage volume - 2673 $ft^3$
    - Length - Not available
    - Diameter - Not available
- Storage medium
  - Maximum rated operating conditions - 165° F
    - Heating - 165° F
  - Storage medium - Water (100%)
  - Specific heat - 100 Btu/lb/° F
  - Density - 63 $lb/ft^3$
  - Viscosity over working temperature range - 40
  - Boiling point - 212° F
  - Freezing point - 32° F
  - Recommended medium temperature - 160° F
  - Toxicity - Potable
  - pH Factor -
  - Inhibitor - No
- Heat transport to and from medium
  - Collector side - No heat exchanger
  - Demand side - No heat exchanger
  - Medium flows through loop - 2
- Container construction
  - Type - Concrete
  - Location - Below grade
  - Auxiliary heaters - No

- Thermal resistance - R-12
- Exterior finish -
- Filters - No

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

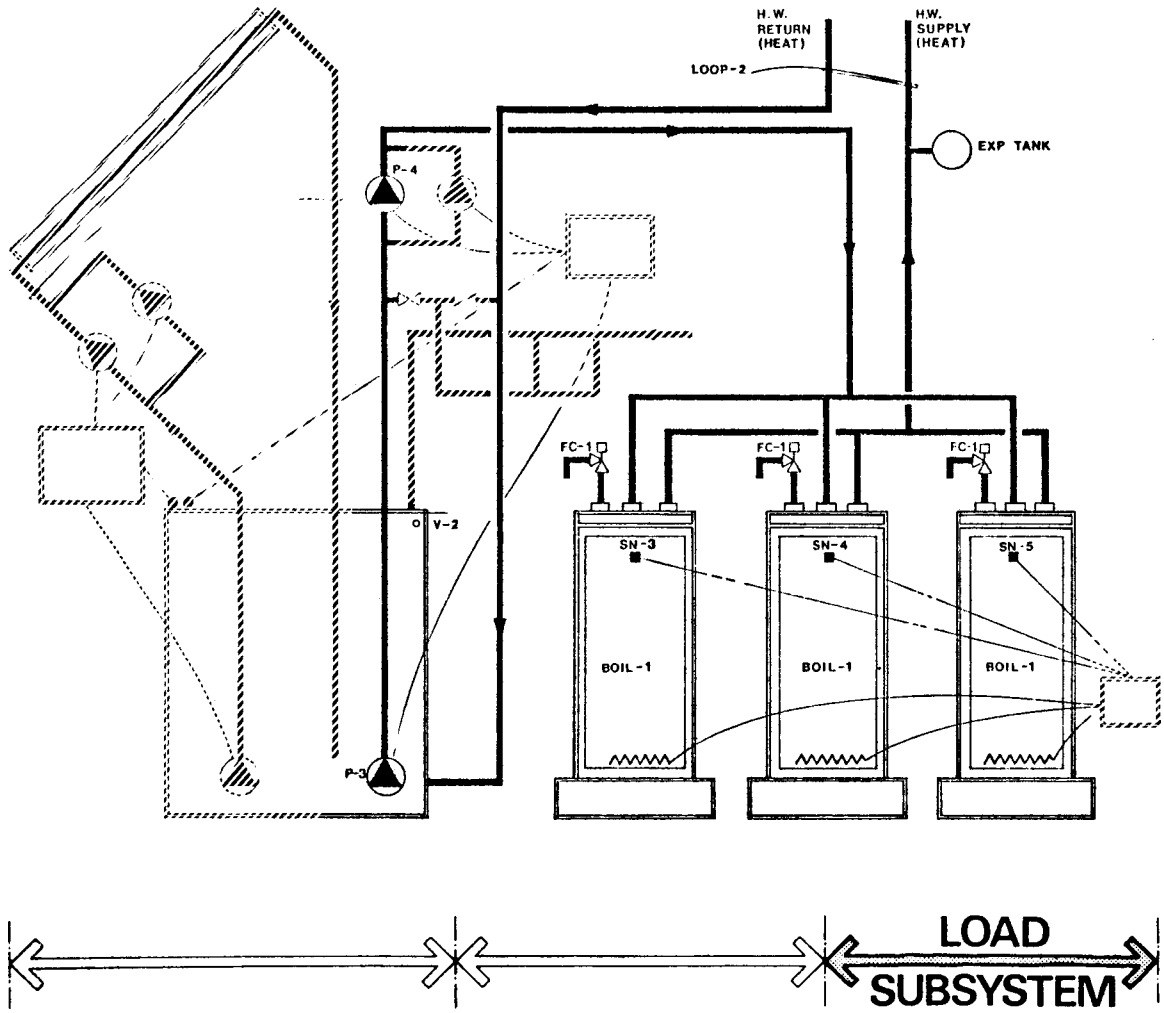



Figure IV-D-1. Energy-to-Load Subsystem

Solar energy stored in the 57,000 gallon storage tank is used to meet the space heating demands by circulation of hot water. Auxiliary space heating, supplementing this source, is provided by three natural gas-fired boilers. When solar energy is not available, the gas boilers are activated to supply the necessary energy for space heating. Circulation pump (P-3) is on most of the time unless storage is bypassed during maintenance or emergencies.

Liquid Circulation Loop No. 2 (TSU-1 to BOIL-1)

- Design operating temperature - 165° F
- Heating design liquid flow - 250 gpm
- Heat transfer medium
  - Medium - Water (100%)
  - Specific heat - 1.00 Btu/lb/° F
  - Density - 63 lb/ft$^3$
  - Boiling point - 212° F
  - Freezing point - 32° F
  - Maximum recommended use temperature - 165° F
  - Toxicity - Potable
  - pH factor - 7
  - Chemical feeder - No
  - Inhibitor - No
  - Loop description - Recirculate hot water
  - Piping - Rigid
    - Rigid - Copper
    - Insulation - Mineral/glass fiber
    - Location - Above and below grade
    - Exterior finish - Cement clothcoated fabric
    - Finish and insulation - Joint type-tape and mastic
- Circulator pump (P-2, P-3 and P-4)TSU-1-to-BOIL-1
  - Manufacturer - Armstrong
  - Model Name/Number - 3/4 F
  - Type - Centrifugal

- Maximum operating conditions
  - Dynamic pressure - 100 ft heat @ 75 gpm
  - Temperature - 200° F
- Material exposed to heat transfer fluid - Bronze
- Motor size - 0.75 hp
- Maximum motor speed - 1750 rpm
- Drive - Direct
- Speed - Single
- Circulating volume - Low head mode - 100 ft @ 75 gpm
- Motor operation - 0.75 bhp

- Distribution Valve (V-2)
  - Function - ON-OFF
  - Operation - Automatic
  - Type - Float valve
  - Materials exposed to heat transfer fluid - Bronze

Control Mode Selector (CMS-2)

- Modes controlled
  - Collector to storage - ON -
  - Storage to space - ON -
  - Sensor
    - Type - Temperature, thermistor
- Control Mode Selector (CMS-3)
  - Manufacturer - Unknown
  - Product Name/Number -
  - Function - Auxiliary-to-space

- Sensors (SN-3) and (SN-4)
    - Type - Thermostat
- Fail Safe Control (FC-1)
    - Manufacturer - Unknown
    - Product Name/Number - Unknown
    - Type - Temperature and pressure relief

E. Auxiliary Subsystems (See Figure IV-E-1)

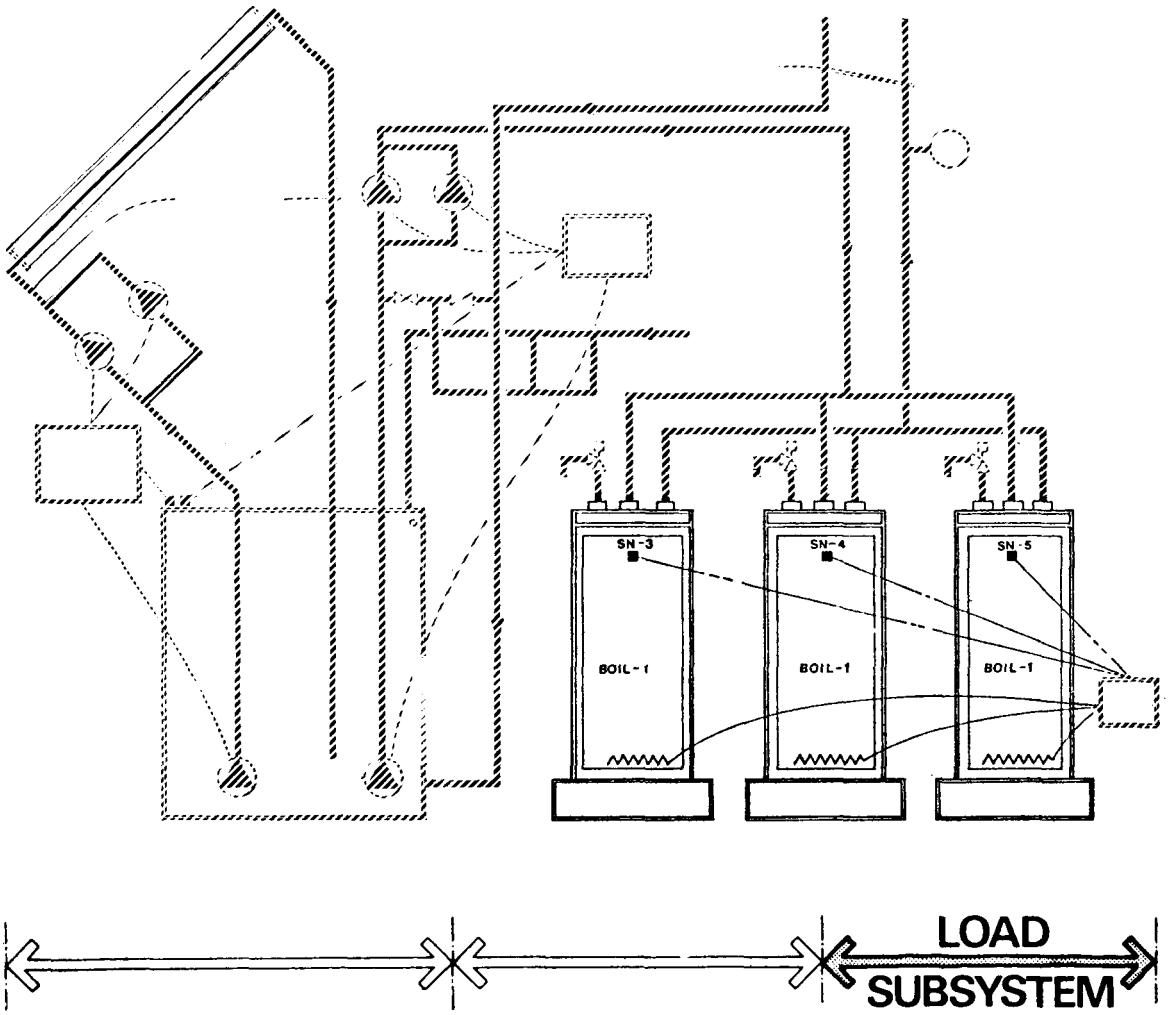



Figure IV-E-1. Auxiliary-to-Load Subsystem

The auxiliary space heating activates when the natural gas-fired boiler system is required to "top out" the continuously circulating hot water for the space heating.

- Auxiliary Load Boiler (BOIL-1)
  - Manufacturer - Raypack
  - Model Name/Number - 945 T (3 each)
  - Energy source - Natural gas
  - Energy input - 945,000 Btu/hr
  - Energy output - 756,000 Btu/hr
  - Burner ignition method -

F. Modes of Operation (See Figure IV-F-1)

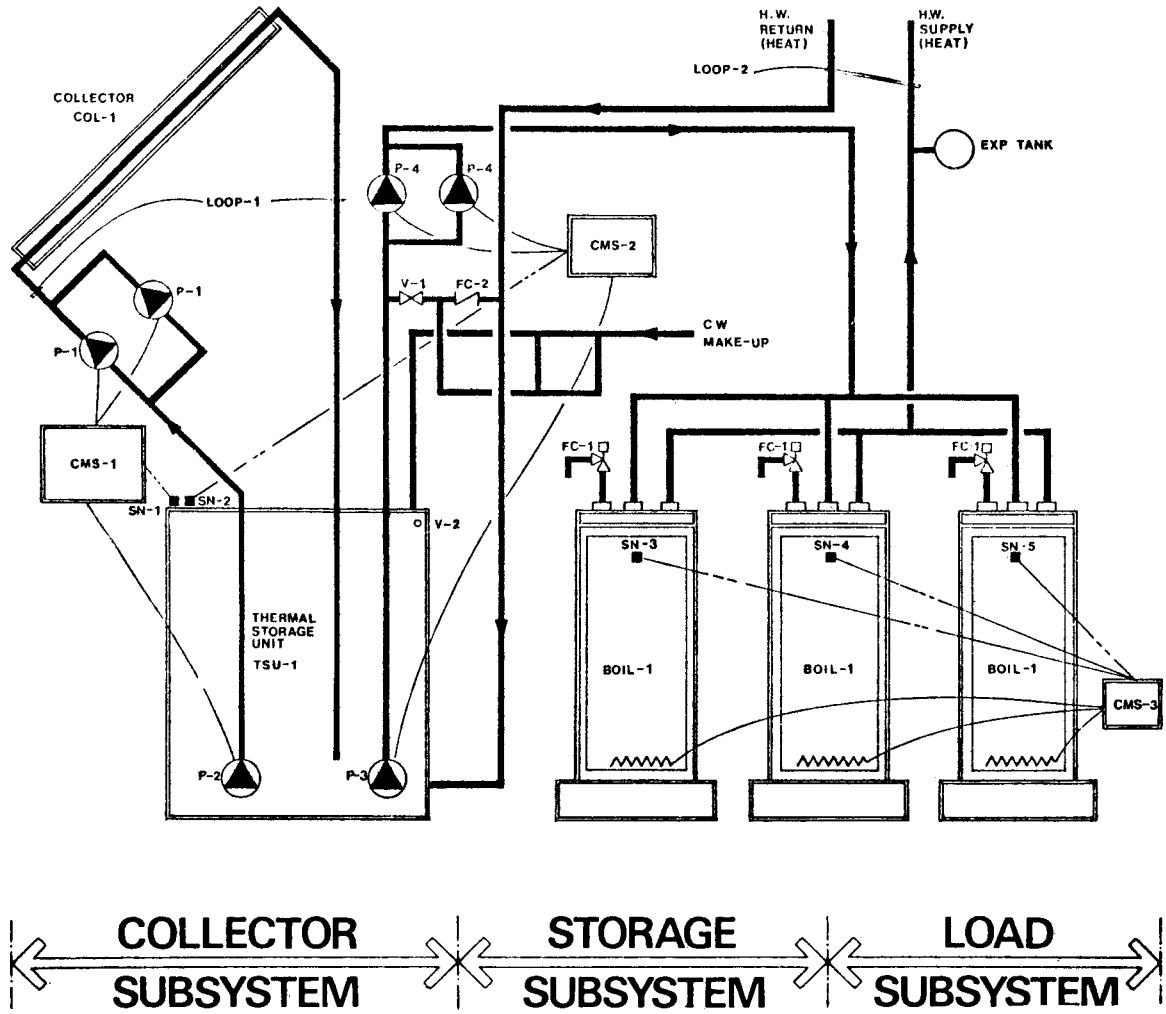



Figure IV-F-1. Controls Diagram

The Albuquerque West - II's solar system is shown on Figure IV-F-1. The system consists of the following three subsystems: a) Collector subsystem, b) storage subsystem, c) load (space heating ) subsystem and d) auxiliary loads subsystem. The auxiliary subsystem is a natural gas-fired boiler which utilizes the storage water.

Operation of the solar system and the auxiliary subsystems may involve one or more of the three modes of operations described below.

Mode 1 - Collector-to-Storage:

This mode activates when the collector-to-storage pump goes on. This occurs when adequate insolation is available, based on a minimum insolation intensity.

Mode 2 Space Heating-from-Storage:

This mode activates when the storage-to-space-heating circulation pump is on. This pump runs most of the time unless storage is bypassed during maintenance or emergencies.

Mode 3 - Auxiliary-Space Heating:

This mode activates when the natural gas-fired boiler system (3 boilers in parallel operation) is required to "top-out" the continuously circulating hot water in the space heating system to obtain a manually selected DHW load. This occurs when the solar energy system can no longer meet the preset temperature.

# 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 residential demonstration sites which were selected for thermal performance evaluation. The data flow in the Network includes monthly and seasonal system performance reports describing the thermal performance of the solar energy system and subsystems.

The performance evaluation instrumentation at each selected demonstration site is part of a comprehensive data collection system that allows for valid analyses of the solar system performance. Collected data are both applicable and practical in calculating thermal performance factors that describe the behavior of the solar 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:

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

Site data are recorded sutomatically 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.

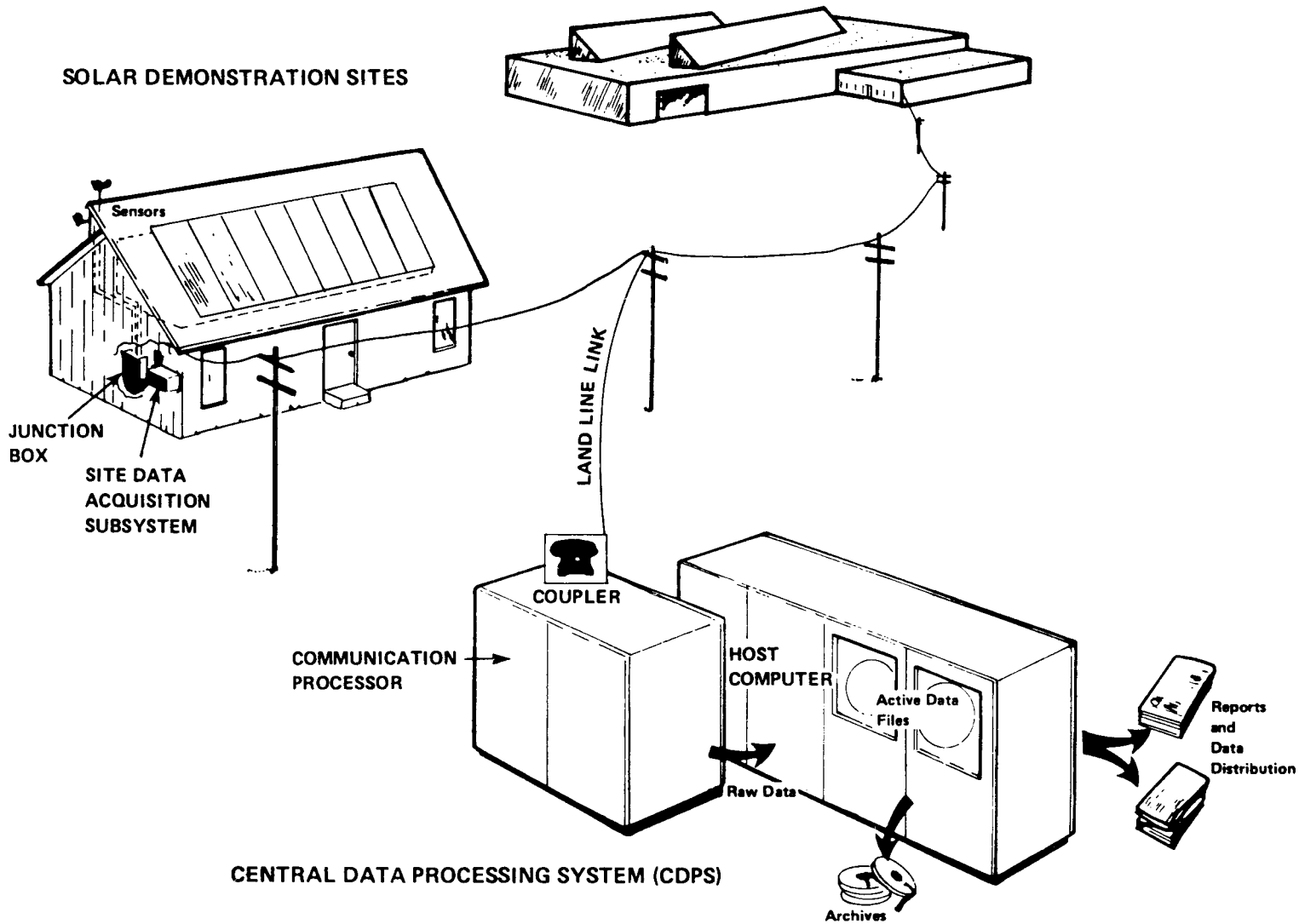



Figure V-A-1. The National Solar Data Network

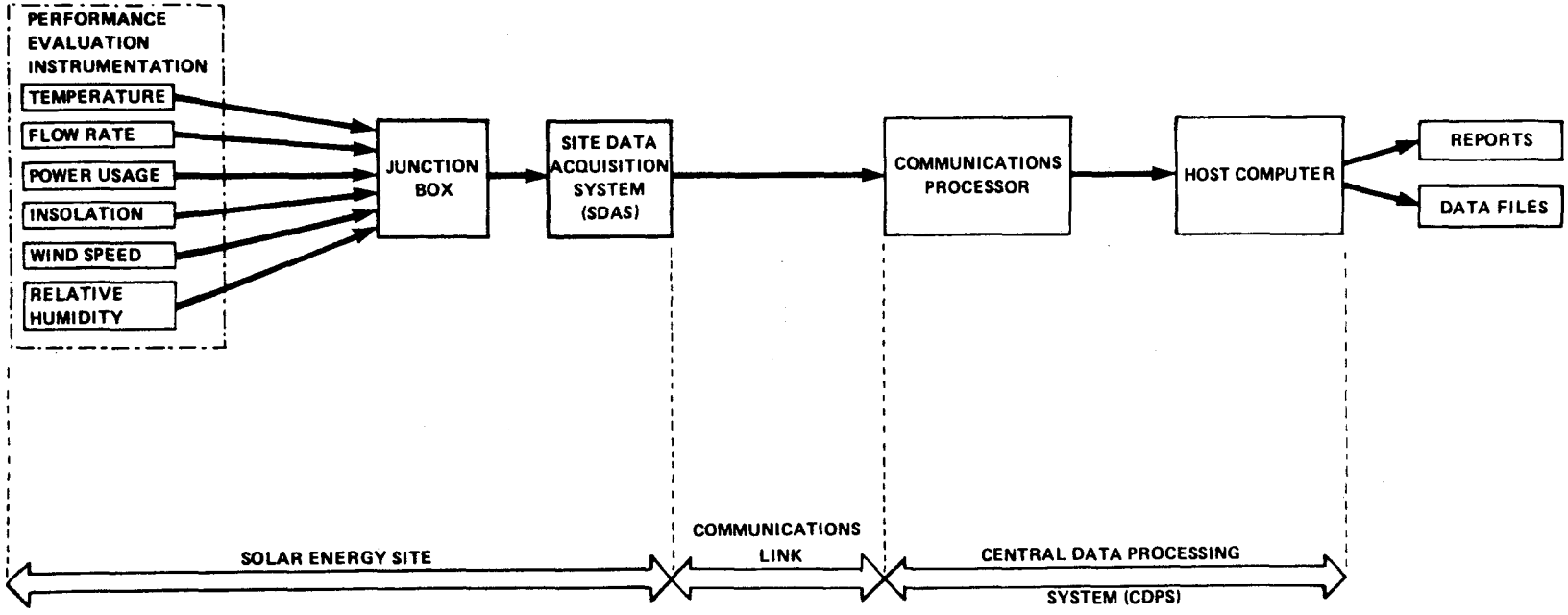



Figure V-A-2. Data Flow Path for the National Solar Data Network

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

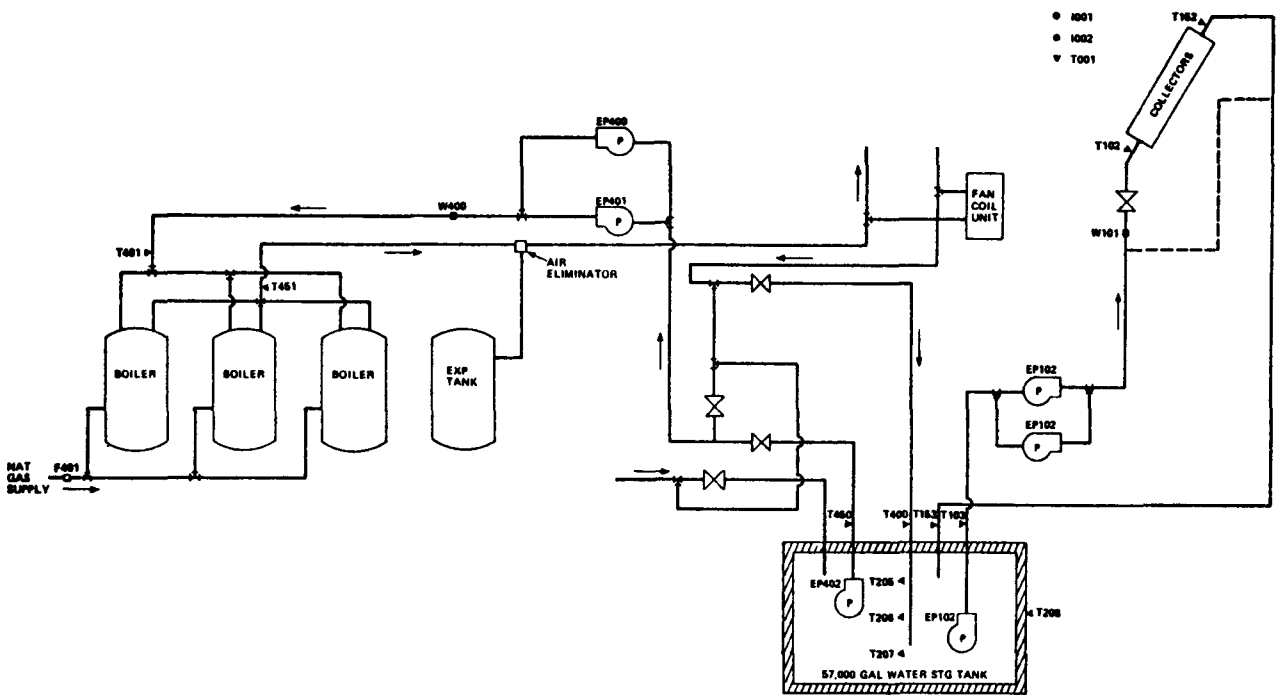



Figure V-B-1. Sensor and Control Diagram

| SENSOR | DESCRIPTION OF MEASUREMENT | MODEL NO. |
|---|---|---|
| T102 | Temperature, collector inlet | S57P-60 |
| T152 | Temperature, collector outlet | S53P-60 |
| W101 | Flow, main collector line | MKV-4, 30-300 gpm |
| T103 | Temperature, storage tank outlet | S57P-60 |
| T153 | Temperature, storage tank outlet | S53P-60 |
| EP102 | Power, main solar pumps (2) plus primer | PC5-53 w/CT"W" |
| EP402 | Power, primer pump for HW heating | PC5-5 |
| T205 | Temperature, storage tank, top | S53P-720 |
| T206 | Temperature, storage tank, middle | S53P-1120 |
| T400 | Temperature, storage tank inlet | S57P-60 |
| T450 | Temperature, storage tank outlet | S53P-60 |
| T401 | Temperature, HW boiler inlet | S57P-60 |
| T451 | Temperature, HW boiler outlet | S53P-60 |
| W400 | Flow, hot water heat system | MKV-4, 3-300 gpm |
| EP400 | Power, Hot water pump 1 | PC5-23 |
| EP401 | Power, hot water pump 2 | PC5-23 |
| F401 | Flow, gas to HW heater boilers | A.M. AL-5000 |
| T208 | Temperature, storage tank, external | S53P-60 |

## VI. COST DATA

### A. General

The following cost data depicts only solar energy portion of the construction costs. Costs of instrumentation is not included since it is not part of the construction effort.

### B. Construction Grant Funds

| Solar Subsystem | Applicants Request | Construction Grant |
|---|---|---|
| Collectors | | |
| Energy Storage | | |
| Distribution and Controls | | |
| Installation | | |
| Other | | |
| Total | | |

### C. Construction Period:

# VII. 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.
ANTI-FREEZE FREEZE PROTECTION SYSTEM - A freeze protection system that uses additives or solutions to the heat transfer medium, which 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 reversal of flow in a distribution system.
BACKFLOW PREVENTOR - 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 $59^{\circ}$ F to $60^{\circ}$ 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 absorbes solar radiation and transfers the absorbed thermal energy to a heat transfer fluid.

COMBINED COLLECTORS - An assembly that both collects 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 where the air is conditioned by heating or cooling.

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

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 other substances suspended in the air.

DRAIN-DOWN FREEZE PROTECTION SYSTEM - A freeze protection system that prevents potential water freeze-up within the collector and exterior piping by automatically draining and replacing the water with a non-freezing medium such as air, nitrogen, etc.

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

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 oriented 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.

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.

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

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 in a medium due to temperature differentials, commonly noticed in storage tanks filled with water.

THERMOSTAT - A temperature sensing device which controls the heating and cooling systems for space conditioning or the hot water heater.

TILT ANGLE FROM HORIZONTAL - Angle between the horizontal plane and the plane of collector.

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

TRACKING COLLECTOR - A set of solar energy tracking collectors that automatically move in order to constantly aim towards the sun.

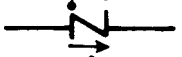
VAPOR BARRIER - A material which is used to reduce the transmission of water vapor.

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

B. Legend For Solar System Schematics

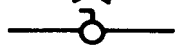
## VALVES

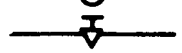

GATE VALVE


CHECK VALVE


BALANCING VALVE


GLOBE VALVE


BALL VALVE


PLUG VALVE


BACKFLOW PREVENTER


VACUUM BREAKER

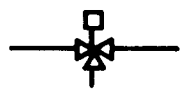

RELIEF OR SAFETY


PRESSURE REDUCING

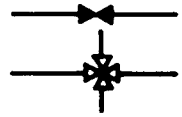

ANGLE GATE VALVE


ANGLE GLOVE VALVE


CONTROL VALVE, 2 WAY

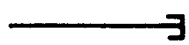

CONTROL VALVE, 3 WAY


BUTTERFLY VALVE


4 WAY VALVE

## FITTINGS


DIRECTION OF FLOW

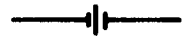

CAP

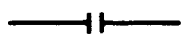

REDUCER, CONCENTRIC


REDUCER, ECCENTRIC


TEE


UNION

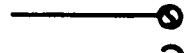

FLANGED CONNECTION


CONNECTION, BOTTOM


CONNECTION, TOP


ELBOW, TURNED UP

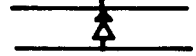

ELBOW, TURNED DOWN

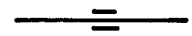

TEE, OUTLET UP


TEE, OUTLET DOWN

## PIPING SPECIALITIES


AUTOMATIC AIR VENT


MANUAL AIR VENT


ALIGNMENT GUIDE


ANCHOR


BALL JOINT

EXPANSION JOINT


EXPANSION LOOP


FLEXIBLE CONNECTION


FLOWMETER FITTING

FLOW SWITCH

PRESSURE SWITCH


PRESSURE GAUGE


PUMP


PIPE SLOPE


STRAINER


STRAINER, W/BLOW OFF


TRAP



CONTROL SENSOR


INSTRUMENTATION SENSOR


THERMOMETER


THERMOMETER WELL ONLY



COLD WATER SUPPLY


BLOWER

AS — AIR SEPARATOR

EXP TK — EXPANSION TANK

WS — WATER SOFTENER

HED — HOSE END DRAIN