DOE/NASA CONTRACTOR REPORT

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DESIGN DATA BROCHURE
SIMS PROTOTYPE SYSTEM 3

Prepared by

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Under Contract NAS8-32036 with

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George C. Marshall Space Flight Center, Alabama 35812

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Solar Energy

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16. ABSTRACT

This document describes a closed hydronic solar system for space and hot water heating. Design, performance, and hardware specifications are presented sufficient for architectural engineers and contractors to procure, install, operate and maintain a similar solar application.

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DESIGN DATA BROCHURE

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1.0 INTRODUCTION

The solar system design presented is a space and hot water heater, assembled from currently marketed components, for solar heating a single family dwelling of approximately 1200 square feet floor area. A prototype system has been designed, built and tested by IBM under contract NAS8-32036 to NASA Marshall Space Flight Center. This document provides design, performance, and hardware specifications sufficient for architectural engineers and contractors to procure, install, operate and maintain a similar solar application. Using the procedures and guidelines of Section 3, component substitutions can be made to meet the requirements for other single family or small commercial buildings.

2.0 SYSTEM DESCRIPTION

SIMS Prototype System 3 is a closed volume, passive drain down, solar system, for space and domestic water heating. Individually or in any combination (1) solar energy may be collected, (2) the house heated and/or (3) domestic water heated by energizing one of the three water pumps. The major hardware components are: (1) Sunworks flat plate collectors to capture the solar radiation, (2) an Adamson 1,000 gallon hot water storage tank, (3) a Ford Products 65 gallon tank for domestic hot water and (4) Grundfos pumps to transfer solar energy on command from the (5) Solar Control Corporation controllers. The components are configured into the collector, storage, energy transport and control subsystems which makeup the System 3 configuration. The following subsystem paragraphs describe the features of the respective subsystems. Component data provided by the respective vendors should be consulted for detailed hardware descriptions and ratings. A functional schematic of System 3 is shown in Figure 2-1. Enclosure 1 is the system description drawing.

2.1 COLLECTOR SUBSYSTEM

Technical data on the Sunworks liquid solar collector is presented in Appendix A. The basic collector module is a 7' x 3' rectangular unit housed in an aluminum frame and weighing 114 pounds. Each module has a single 3/16" thick tempered safety glass cover for the 18.7 Ft^2 selective surface absorber area. The liquid system has a flow pattern designed to provide uniform flow through all tubes and to drain without water entrapment. Inlet and outlet fluid connections are 1" dia. copper pipe.

The performance of the Sunworks collector in terms of collector efficiency is as described by Figure 2-2. The parameters are defined as follows:

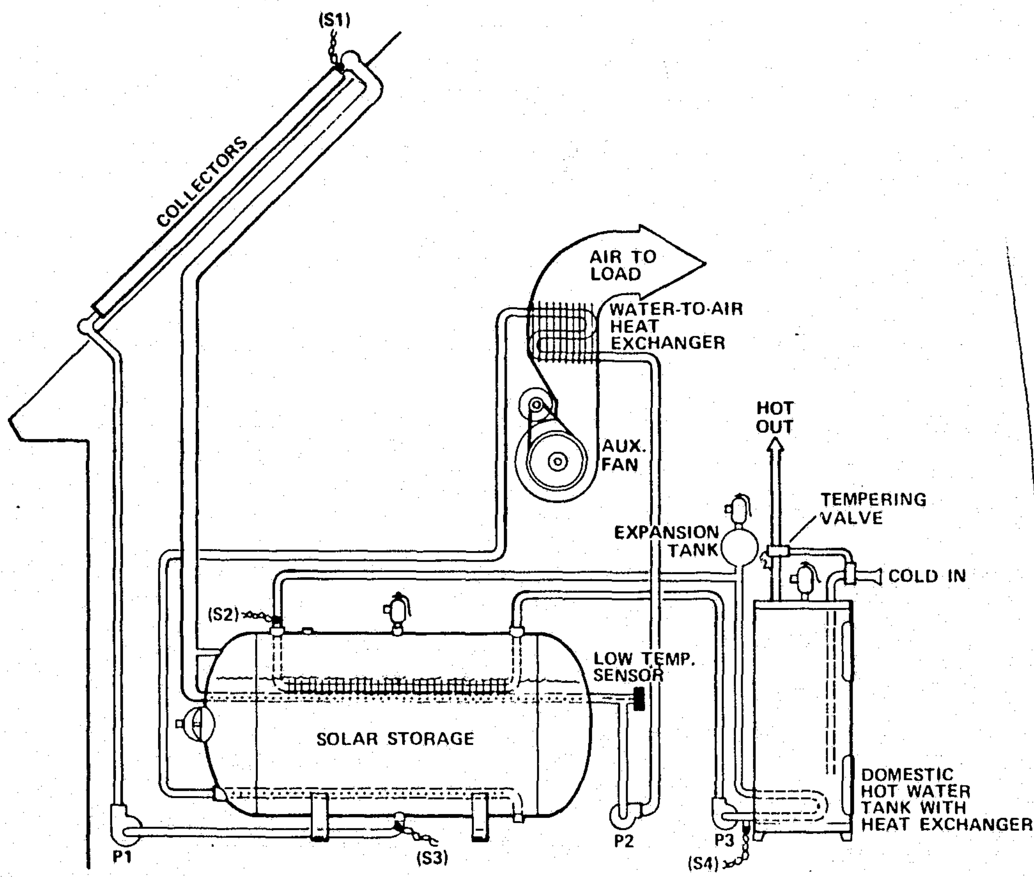

Figure 2-1 SYSTEM 3 DIAGRAM

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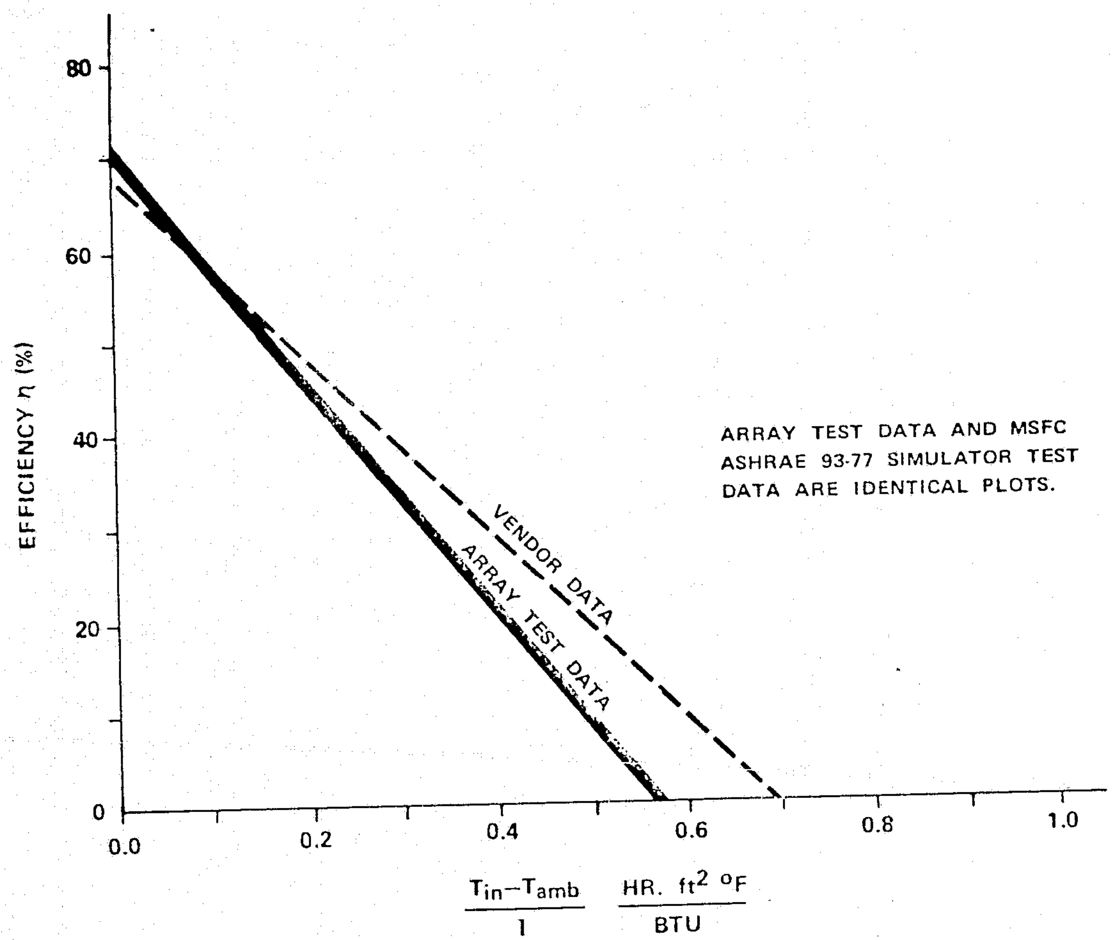


Figure 2-2 Collector Efficiency

η = Collector Efficiency

T_{in} = Inlet Fluid Temperature, ^{o}F

T_{amb} = Ambient Air Temperature, ^{o}F

I = Insolation, Btu/Hr./Ft^2

Section 3.2 describes how to size the array for specific applications. Collector mounting and installation guidelines are addressed in Section 5.1.

2.2 STORAGE SUBSYSTEM

The storage subsystem consists of an Adamson ASME 1000 gallon hot water storage tank and two internal distribution manifolds. The hot (top) and cold (bottom) distribution manifolds are designed to enhance stratification within storage. (The finned tube heat exchanger which provides heat to DHW is installed near the hot manifold.) In operation, the tank will contain approximately 900 gallons of solar heated water with the remaining volume functioning as an expansion tank and air separator. To reduce corrosion problems, the system is air tight; therefore, the internal pressure will vary with storage temperature. Pressure relief is provided at 30 psig.

2.3 ENERGY TRANSPORT SUBSYSTEM

The energy transport subsystem has three functional missions, with each function associated with one of the three circulating pumps.

2.3.1 Collector Heat Removal

Pump P1 transfers heat energy from the collectors to solar storage. A Grundfos Model UP 26-64F pumps lift water from the bottom of solar storage, through the collector array (where it is heated) and over the brink of the free fall return line. Solar heated water entering the free fall return line "drops" into storage. Section 3.2.2 provides guidelines for selecting and evaluating alternative pump configurations.

2.3.2 Space Heating

Pump P2 removes heat energy from solar storage and adds it to air being circulated from the heated space. A single Grundfos Model UP 26-64F pump is capable of providing 7 gpm design flow through the coils of an liquid-to-air heat exchanger against 14 Ft H_2O head. The Heat exchanger has been sized to supply 30,000 BTU/Hr from solar storage water at 120^{o}. Section 3 provides guidelines for selecting alternative heat delivery hardware and for evaluating the system performance as a function of operating conditions.

2.3.3 Domestic Water Heating

The DHW pump begins to transfer heat energy from solar storage to domestic hot water storage anytime the solar storage temperature is $20^{o}F$ greater than the temperature at the bottom of the DHW tank. The transfer circuit consists of a water filled loop connecting a finned tube heat exchanger in solar storage to a similar heat exchanger in DHW storage. The dual exchanger configuration provides double wall isolation between solar water and potable water. Energy transfer continues until the control differential is reduced to $4^{o}F$.

2.4 CONTROL SUBSYSTEM

The solar control subsystem provides for the independent, non-exclusive operation of each of the three liquid pumps to accomplish a desired heat transfer function. Two differential thermostats, a low temperature sensor and a standard two stage room thermostat provide the controller input signals.

The collector differential thermostat will start pump P1 when probe S1 is $20^{\circ}F$ hotter than probe S3. When the temperature of probe S3 becomes $4^{\circ}F \pm 2^{\circ}F$ colder than S1, pump P1 will turn off. This decision logic is shown in Figure 2-3.

The DHW differential thermostat will start pump P3 when probe S2 is $20^{\circ}F$ hotter than probe S4. When the temperature of probe S4 becomes $4^{\circ}F \pm 2^{\circ}F$ colder than probe S2, pump P3 will turn off. This decision logic is shown in Figure 2-4.

Freeze Protect: The differential thermostat is factory equipped with a freeze protect feature that will close the N-O contacts when probe #1 (typically collector probe) shows a temperature of $40^{\circ}F \pm 5^{\circ}F$. Since System 3 is designed to use passive drain down of the collectors for freeze protection, this feature must be disabled per vendor instructions from the collector control unit.

Boil Protect: The differential thermostat is factory equipped with a boil protect feature that will turn the controller off when a temperature of $180^{\circ}F$ is reached at the collector. This feature must be disabled per vendor instructions for the unit used to control collector operation.

Figures 2-3, 2-4 and 2-5 show the decision logic for the Collect and Store, Heat Domestic Water and Space Heat control modes. A wiring diagram for the control subsystem is shown in Figure 2-6.

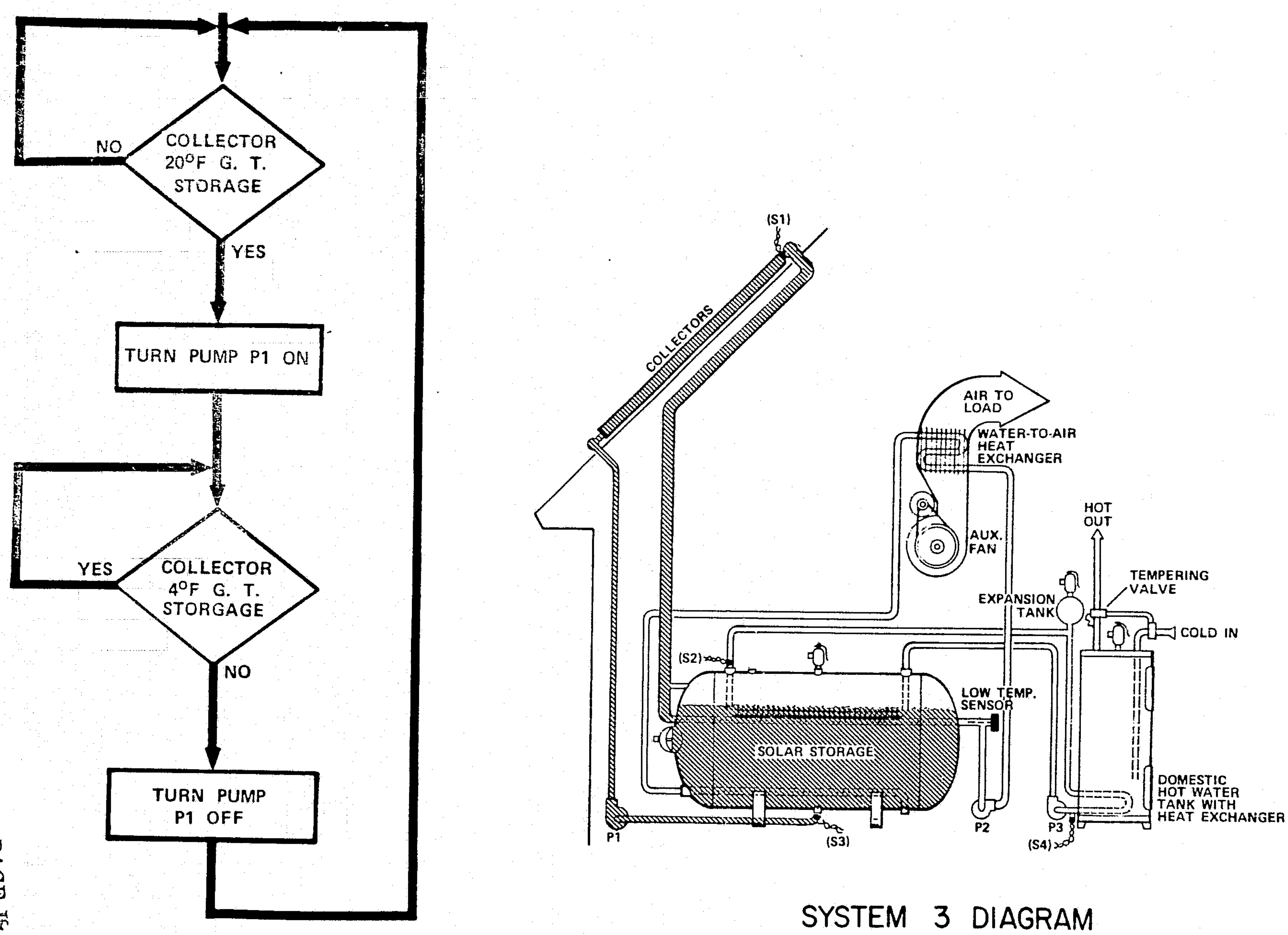
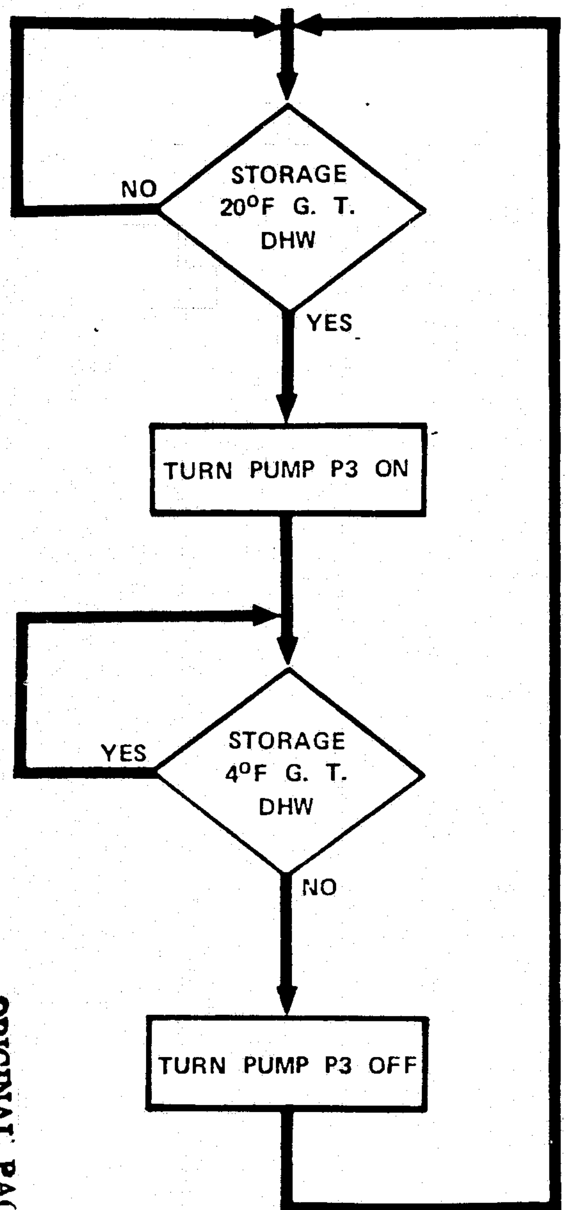
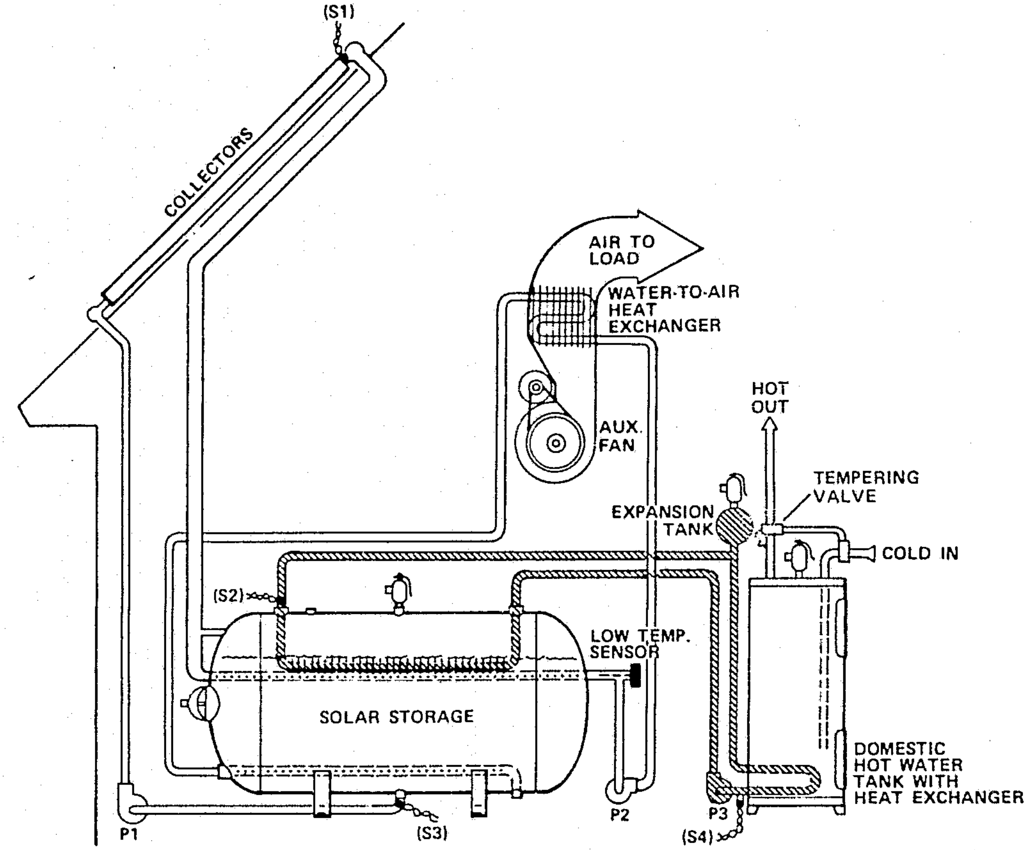


Figure 2-3 Collect and Store





SYSTEM 3 DIAGRAM

Figure 2-4 Heat Domestic Hot Water

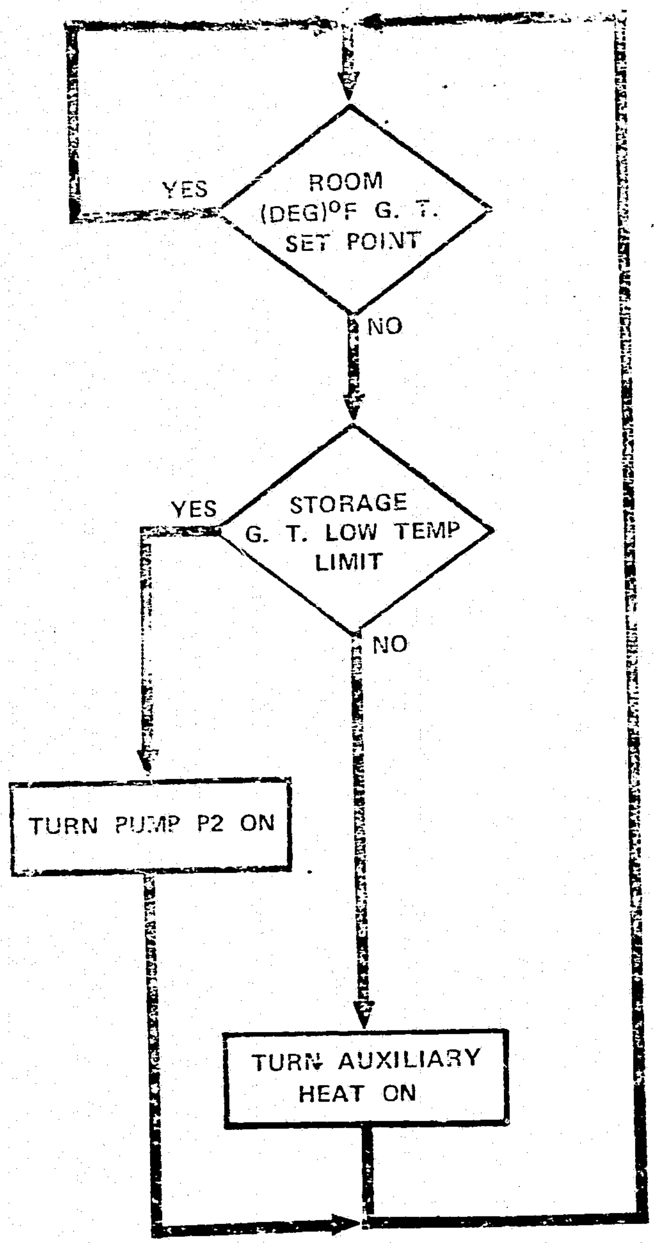
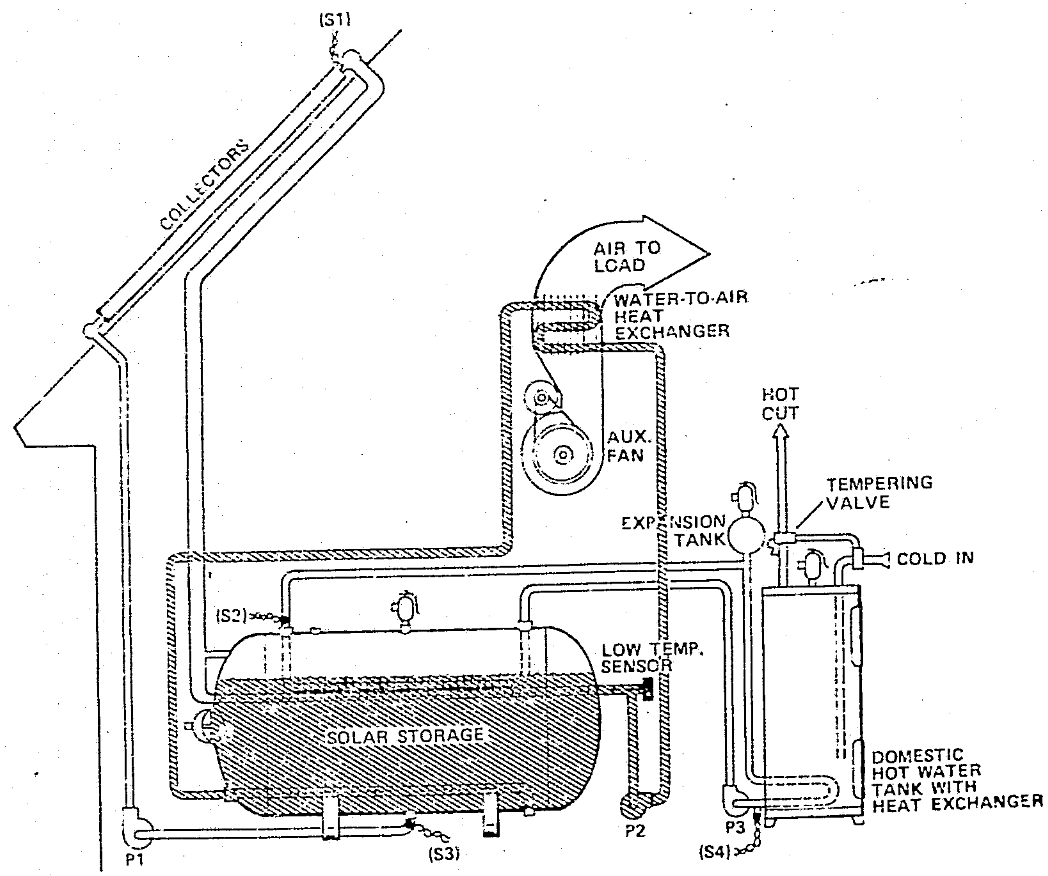


Figure 2-5 Space Heat



SYSTEM 3 DIAGRAM

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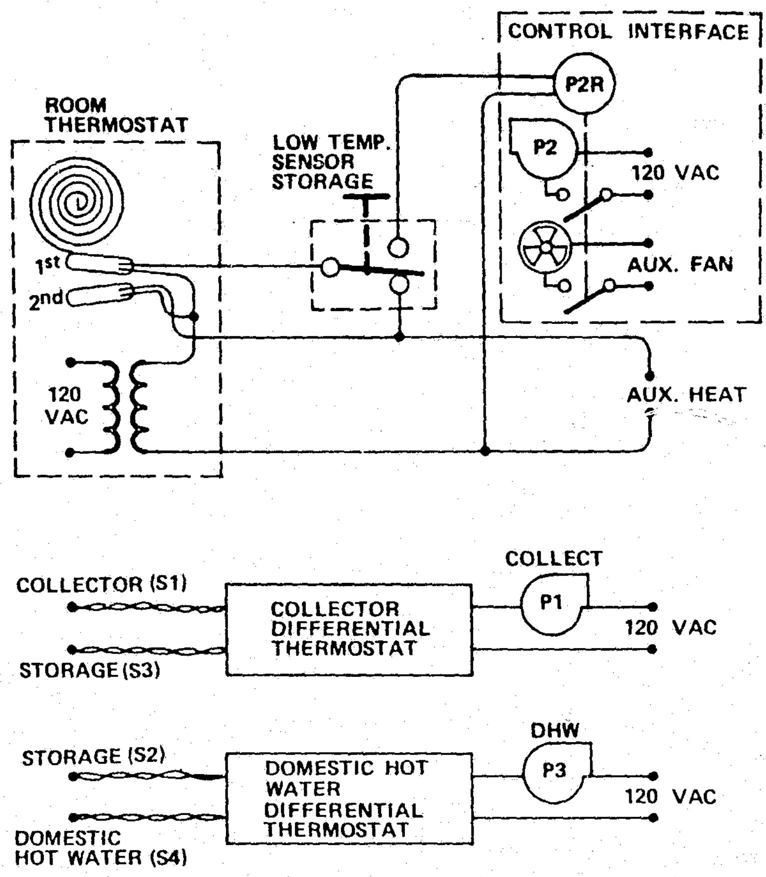

CONTROL DIAGRAM

Figure 2-6 Control Wiring

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3.0 PERFORMANCE

System performance is determined by two general classes of forcing parameters: (1) load characteristics, and (2) design sizing.

3.1 LOAD CHARACTERISTICS

Given a solar system design, the performance (percent solar contribution) is a function of the load characteristics. If the actual building load is not known, a value may be assumed based on normal construction experience. For instance a well insulated one-story building with storm windows and doors, 6 inches of insulation in the ceiling and 3.5 inches in the wall will have a building load (U) of approximately 11 Btu per day per ^{o}F per 1 square foot of house (floor) area. The same house design without storm windows and doors and only 3.5 inches of insulation in the ceiling will have approximately 14 Btu per day per ^{o}F per 1 square foot of house (floor) area. A building load coefficient (Btu/Hr-^{o}F) may be calculated by:

$$\text{Building Load Coef} = \frac{U \times \text{Floor Area } (Ft^2)}{24}$$

This coefficient is required for collector sizing or performance calculations in Section 3.2.

3.2 SIZING

The sizing parameters, which determine the overall performance of the System 3 design for any given site/application, are the collector area, pump selection, heat exchanger UA product, and storage tank size. Site dependent selections are influenced primarily by the local insolation, the cost of auxiliary fuel, and the heating demand load. Some applications may find it desirable or necessary to make component substitutions or adjust size selection to meet unique requirements. The following sections present data to evaluate the impact of the more common sizing alternatives.

3.2.1 COLLECTOR ARRAY SIZING

Sizing of the collector array can be approached from at least three techniques. The least satisfactory generally applies to retrofit applications in which the array is selected to fit the amount of roof area available. The second approach establishes a desired solar contribution for the system and sizes the array accordingly. The third approach is to determine the most cost effective array size for a particular economic scenario.

The solar contribution for various "roof area available" array sizes may be found from the family of curves in Figure 3-1.

Given a desired solar contribution, Figure 3-1 may also be used to determine the required collector array size. Most design goals will be within the 40 to 70 percent solar contribution range.

Fuel cost is the primary economic driver for array sizing. Although Figure 3-2 shows a direct relation between fuel cost and array size, the actual economic model used to prepare the data included capital expenditure, interest rate, inflation rate, taxes and amortization of solar hardware.

3.2.2 PUMP SELECTION

System 3 is designed as a closed volume system. If the closed design is not maintained, stainless steel or bronze body pumps must be specified.

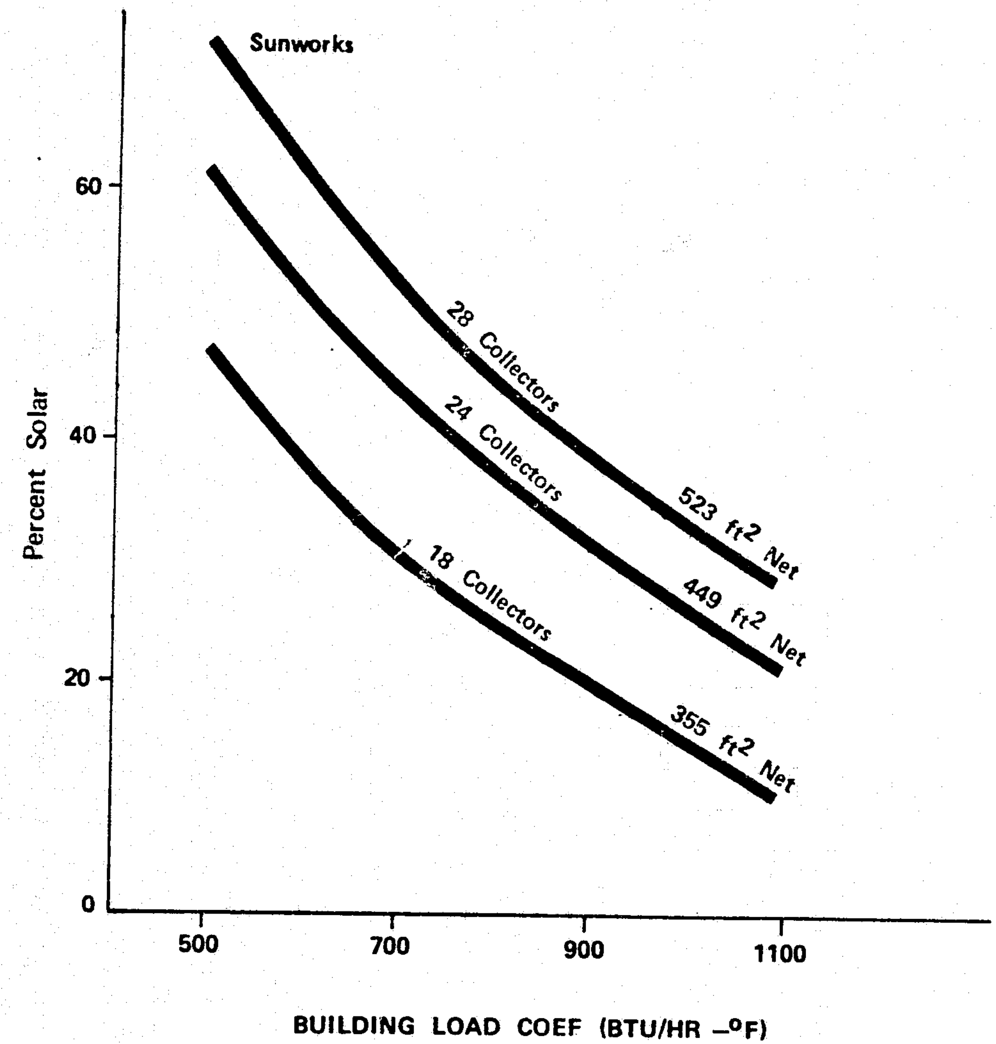

Figure 3-1 Solar Contribution

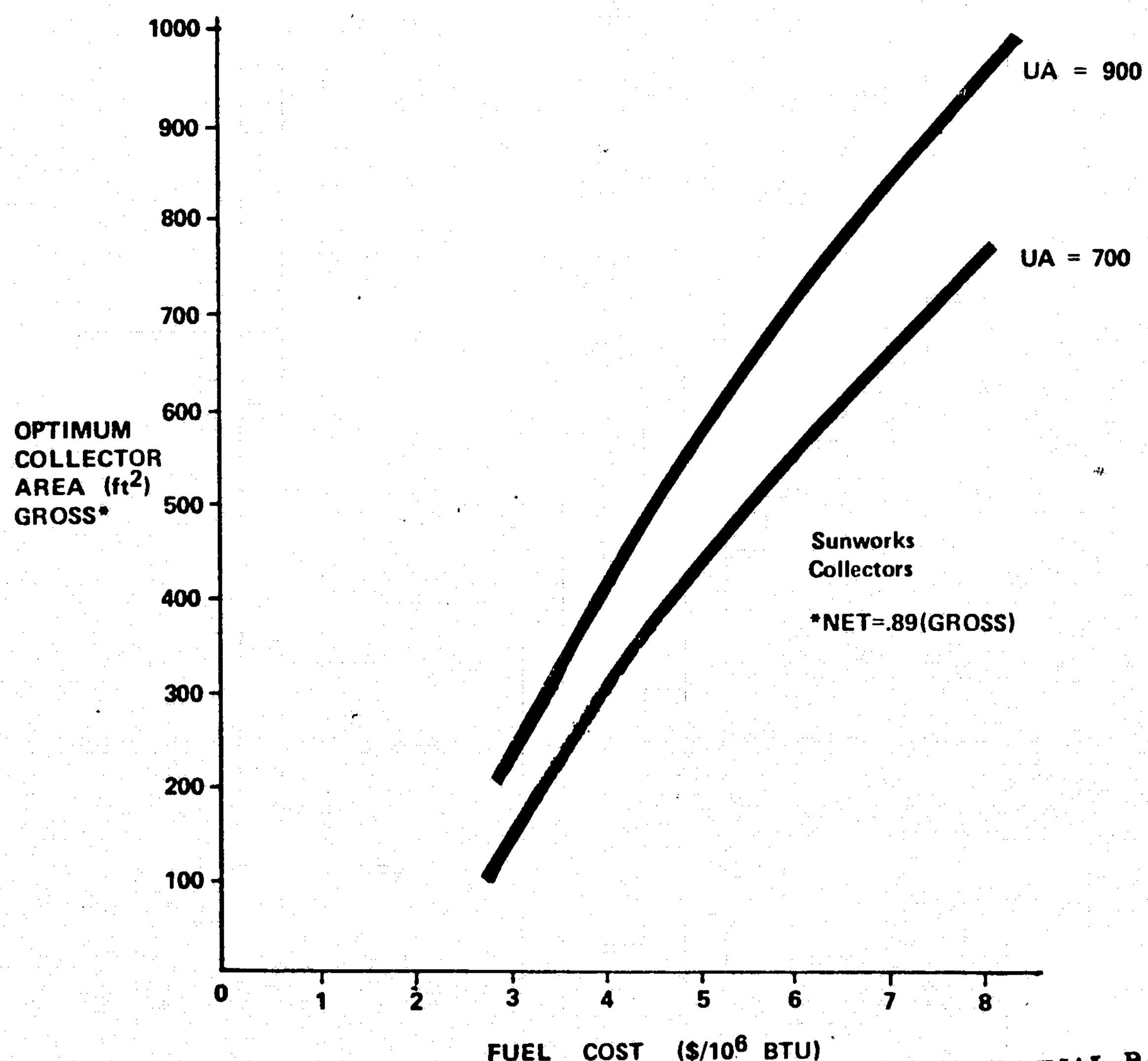

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Figure 3-2 Economic Sizing

The collector pump should be sized to deliver 1.5 gph of water per square foot of collector area against the installed pressure head. The pressure head is the sum of the hydrostatic head (difference in elevation between the storage tank water surface and the entry to "free fall" return line) and the flow friction head.

Two (or more) centrifugal pumps may be connected in series to double the pressure head capability for a given flow rate. This procedure was used for the baseline design. The heat delivery pump should be sized to deliver 7 gpm against the installed flow friction head. The pump should also be capable of initial charging of the heat exchanger circuit. Refer to Appendix A for Grundfos pump performance data.

The DHW Pump should be sized to delivery 2 gpm through the installed system.

3.2.3 HEAT EXCHANGER

3.2.3.1 Storage Heat Exchanger

The sizing of the liquid-to-liquid heat exchanger, which transfers energy from storage to the DHW subsystem, is not critical due to the low cost of operating the DHW circulator pump. A nominal sizing between 1000-2000 Btu/Hr-^{o}F has been selected.

3.2.3.2 Delivery Heat Exchanger

This liquid to air heat exchanger is sized to deliver approximately 30,000 Btu/Hr at the design conditions. To determine alternative sizing:

$$HX = Load \times (65 - SBP)$$

where:

HX = Heat Exchanger Rating at Design Conditions, BTU/Hr

Load = Bldg Load Coef in Btu/Hr$^{\circ}$F

SBP = Solar Balance Point Desired in $^{\circ}$F

Heat exchanger cost/size constraints will dictate a SBP 10-25°F above the ASHRAE Design Winter Temperature for most applications.

Using the above HX value and the design solar storage temperature enter Figure 3-3 to size alternative heat exchanger.

3.3 SIZING AND PERFORMANCE EXAMPLE

Given:

Single Family Residence - No storm windows or doors
- 1200 Ft^2 floor area

Conventional Fuel Cost - \$4.5 per 10^6 Btu

3.3.1 DETERMINE BUILDING LOAD COEFFICIENT

Using guidelines from Section 3.1, assume U = 14. Therefore:

$$\text{Building Load Coef (UA)} = \frac{14 \times 1200 \text{ Ft}^2}{24}$$

$$UA = 700 \text{ Btu/Hr} - {}^{\circ}F$$

3.3.2 DETERMINE COLLECTOR ARRAY SIZE

Using the guidelines from Section 3.2.1, enter Figure 3-2 at fuel cost \$4.5/10^6 Btu. Read optimum collector area near 400 Ft^2.

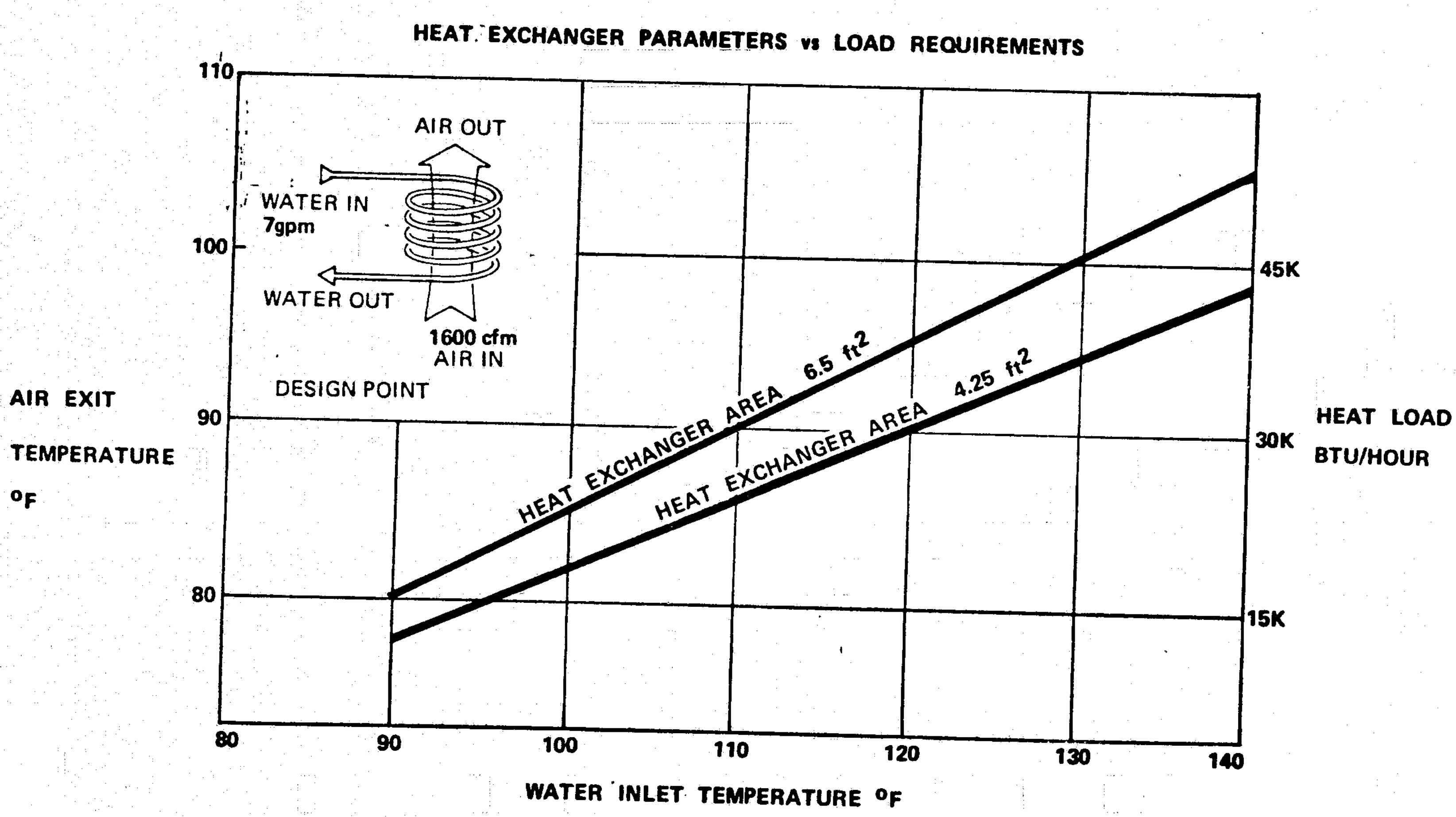


Figure 3-3 Heat Exchanger Sizing

Enter Figure 3-1 at Building Load Coef = 700 Btu/Hr-^{o}F and 355 Ft^2 (net) Collectors (18 units). Read 34×10^6 Btu/Year Solar

Then

$$\text{Percent Solar} = \frac{\text{Btu/Year Solar}}{\text{UA X Heating Degree Days/Year}}$$

4.0 OPERATION AND MAINTENANCE

4.1 OPERATING THEORY

System operation will be described by reference to an ideal solar day. As morning solar insolation increases, solar collector stagnation (no flow) temperature will increase. When the collector sensor temperature exceeds the storage temperature by 20°F, the collector pump P1 will start.

Air will be purged from the collectors as water from storage fills the collector volume and begins to flow into the "free fall" return. The collector temperature decreases as heat is removed by the flow. The solar control will maintain collector flow only so long as 4°F minimum temperature difference betwen the collector exit and storage is maintained.

The "free fall" return is sized for head loss below 1/4 ft H_2O per 100 ft. of pipe to avoid any possibility of back pressure build-up leading to vent air vapor lock. The relatively large sizing assures passage of vent air "going up" against a "down" water flow.

The space heat subsystem is activated by a room thermostat first stage heat request if the storage water temperature is above the minimum set point (72-80°F). (If the minimum storage temperature test fails, the heat request is routed to the auxiliary heat equipment.)

System pump P2 supplies storage water to a fin coil heat exchanger sized to deliver 30,000 Btu/hr with a 120°F water supply temperature. Room thermostat second stage heat requests always turn on the auxiliary heat. Solar heat and auxiliary heat may operate concurrently.

The heating of domestic water is not restricted to collector operating periods. Heat will be transferred from storage to the DHW tank anytime storage temperature satisfies the 20°F/4°F differential thermostat parameters. When main storage temperature is below the DHW temperature set point, the electric heater in the top of the tank makes up to the required difference.

4.2 OPERATING SEQUENCE

4.2.1 INITIAL OPERATION

When 115 vac power is supplied to the control units they become operational. Acceptance of the solar system from the installation contractor should include the following procedures:

- o The entire storage, collector and heat delivery circuits should be pneumatically tested at 50 psig for a sufficient length of time to permit examination of all pipe joints for leakage. The domestic hot water transfer circuit should not leak when tested in accordance with local or national codes.

- o Testing of operating controls to insure program sequence of operation.

- o Operational test of solar energy system to insure proper installation and sequence of operation in accordance with the design requirements.

To checkout system operation sequentially, depress and hold down the button on each of the Differential Controllers. This places the respective functions in manual ON position. Verify that the respective pumps operate.

Release the control button. Control will return to normal operation.

Adjust low temperature sensor point to 90-100°F or as desired for minimum solar delivery temperature.

4.3 MAINTENANCE

Although the system is designed for maximum reliability, a quarterly inspection is desirable as an indicator of continued safe operation. All piping should be inspected for indication of water leakage and each of the automatic operating modes verified. While leakage is easily recognized by water spotting of the insulation, the detection of operating modes is more difficult. Due to the quiet operation of the liquid pumps, an automotive type stethoscope is desirable to detect pump operating periods. Using the stethoscope, check to verify each pump operation by testing at various times throughout the operating cycle.

The primary preventative maintenance procedure is to insure that the hermetically sealed hydronic hardware does not develop a leak. The maintenance of a closed (air tight) system is essential for corrosion control.

Sodium silicate is used as the chemical corrosion inhibitor in the water. Initial formulation of water and sodium silicate should be 25 ppm (.21 lb. per 1,000 gal) of S_iO_2. After the system is fully coated with S_iO_2, a maintenance level of 8 to 10 ppm of S_iO_2 should be maintained.

REPAIR

- o <u>All repair work should be accomplished by qualified personnel.</u>
- o The skills required to repair the solar system hardware are within the normal craft capability of plumbing contractors.
- o If repairs require full drainage of main storage, the 8-10 ppm S_iO_2 maintenance level should be added. If chemical analysis of concentration not available do not add additional S_iO_2 except following storage drainage.
- o All leaks must be expedientially repaired.

5.0 INSTALLATION

5.1 COLLECTORS

For maximum efficiency, the collector array should be mounted facing the south, although a variance of $\pm 20^0$ will not greatly affect system performance. The array must be tilted from the horizontal at an angle approximating the local latitude plus 15 degrees. A variance in tilt angle about this optimum of $\pm 10^0$ will not significantly affect long-term system performance. The array must be installed in an area free of shadows from trees or adjacent structures. Although not required, the construction of a weather-tight enclosure for the collector array (similar to that noted in Figure 5-1) will provide protection to the supply and return piping, structural support for the collectors and be aesthetically acceptable to home owner. This enclosure can be attached directly to the roof sheathing for those installations where the slope is compatible with the necessary tilt angle. In such installations, care should be taken to install proper flashing around the framing and to provide proper clearance around and between the collectors (minimum of 5" on perimeter and 1/4" to 1/2" between collectors).

This method of framing can also be utilized for locations where the roof slope is less than the required tilt angle by the addition of standoff's which will elevate the array to the proper angle.

Alternate methods of framing may also be utilized. In all cases, care should be exercised to insure proper pipe insulation, protection around roof penetrations, and to select materials in accordance with good construction practice.

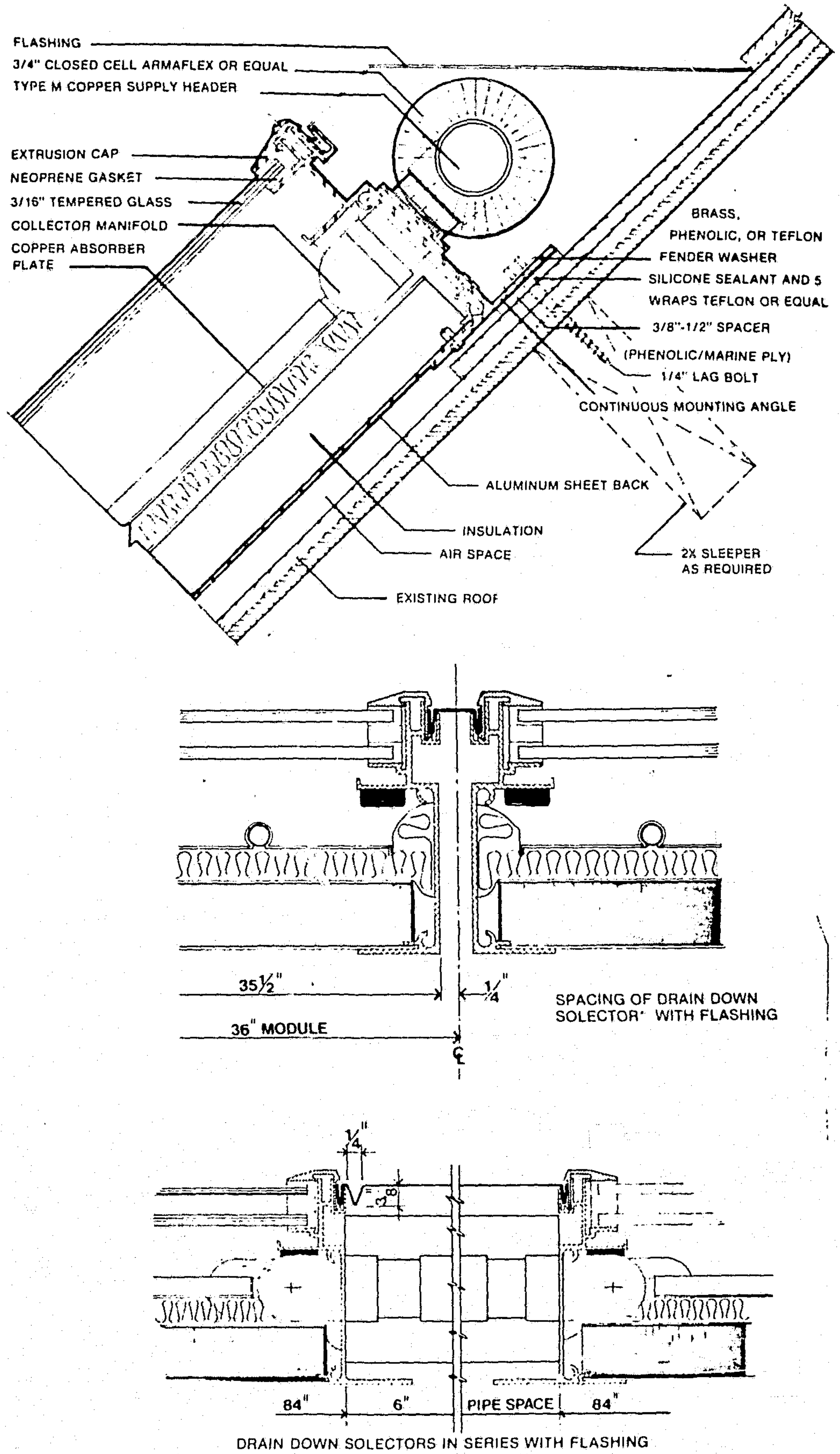


Figure 5-1 Collector Installation

The collector array may also be mounted on an exposed framing. However, in this type installation, it is recommended that the remaining elements of the system be located within the facility.

5.2 INSULATION

All piping, fittings tanks, pumps and heat exchanger shall be insulated with appropriate material. The insulating material, binders, jackets, etc., shall be UL listed and labeled. All above material, binders, jackets, etc., shall also have a frame spread rating of 25 or less and smoke development rating and fuel contribution rating of 50 or less when tested in accordance with ASTM E84.

All piping and pumps shall be insulated with a minimum "R" value of 5. Tanks and heat exchanger shall be insulated with a minimum "R" value of 11.

No wheat paste, mold breeding, or mold sustaining organic insulating materials shall be used.

5.3 PIPING

Install the one inch collector copper supply line, with minimum turns, fittings and length, pitched toward storage for complete gravity drain down. Install the two inch copper pipe collector "free fall" return line with minimum turns, fittings and length; pitched $0\text{-}45^{o}$ from vertical. Other flows sized for 4 fps max. and 4 ft. loss per 100 ft. High temperature solder such as 95% tin, 5% silver or equivalent should be used for sweat fittings in the collector loop. For lower temperature loops, 50% tin/50% lead solder should be used. A mild flux such as Nokorode (paste flux) should be used throughout. Where threaded fittings are required, Teflon tape or Teflon pipe dope must be used.

5.4 SYSTEM CONTROL

Control of the solar energy system is accomplished through the installation of a commercially available controller unit. The unit should be mounted in the same area as the water storage tank. The unit receives electrical service from a separate, clearly labeled 120 VAC 60 Hz disconnect switch located for easy access. This service provides for operation of the circulating pumps and control devices. Sensor wiring shall be 18 gauge twisted pair connected to the pigtails of the installed sensors using conventional wire nuts. All control wiring shall be protected from damage.

5.5 MISCELLANEOUS

5.5.1 MAINTENANCE AND REPAIR

Components of the solar energy system should be located for easy access for maintenance and repair.

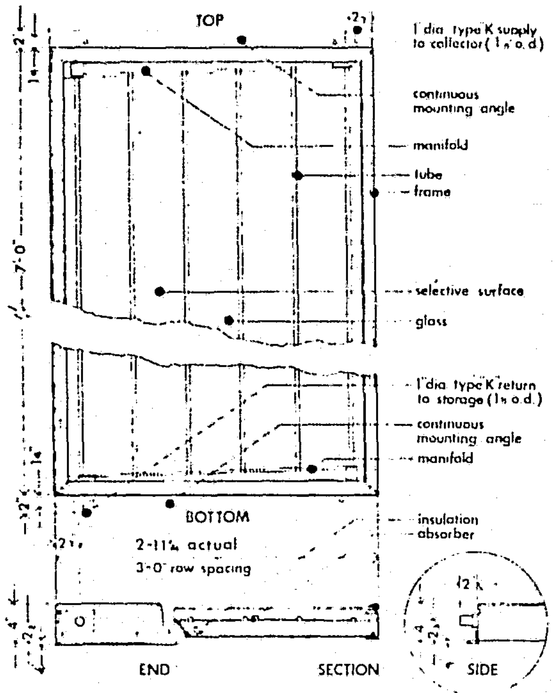
5.5.2 IDENTIFICATION

Main shutoff valves and power disconnect switches shall be located in such a manner as to be easily accessible and conspicuously identifiable in the event of an emergency.

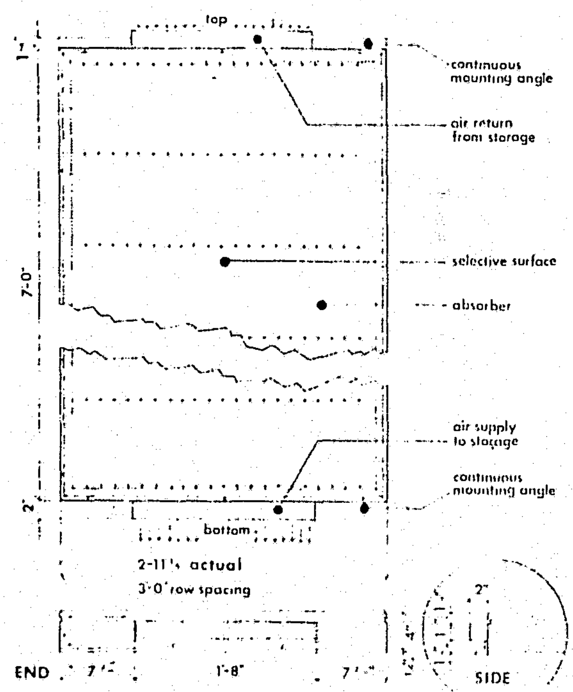
5.5.3 INSTALLATION DOCUMENTATION

Vendor supplied documentation which describe the interconnecting requirements of the components installed and their interface with the building and site, and the "as-built" drawings should be considered part of the Operating, Maintenance and Repair instructions.

APPENDIX



SUNWORKS LIQUID COLLECTOR



SUNWORKS AIR COLLECTOR

TECHNICAL DATA ON *SOLECTOR** SOLAR ENERGY COLLECTORS (LIQUID-TYPE AND AIR-TYPE)**

Cover: single glass, 3/16 in. tempered, edges swiped, 92% solar transmittance
Absorber container: sides, aluminum extrusion; rear, aluminum sheet 0.05 in. thickness
Air space between cover and absorber: approximately 1 in.
Gasketing material: neoprene "U" gasket
Weatherproofing: this module can be placed out in the weather without need for further weatherproofing
Finish on aluminum sides of container: standard mill finish. Anodized clear or black finish available at extra cost
Dimensions of surface-mounted module:
—outside dimensions overall: 36 in. wide x 84 in. long x 4 in. thick (add 1-3/8 in. each end for continuous mounting bracket)
—effective absorber area = 18.68 ft^2
—ratio of usable absorber area to total surface covered: 0.902
—glass area: 18.96 ft^2
Method of anchoring: continuous mounting bracket is fastened to each end of frame for anchoring; four predrilled holes are provided for anchor bolt or screw connections; additional holes may be drilled by installer if required
Solector solar energy collectors can be mounted end-to-end for series flow or side-by-side for parallel flow. It is recommended that no more than three collectors be connected in series. The *Solector* solar energy collector modules for both liquid and air are identical in size, 3 ft. wide and 4 in. thick and are available in two lengths, 5'4" long or 7'0" long.

DATA ON LIQUID *SOLECTOR* SOLAR ENERGY COLLECTORS

Absorber:
—copper sheet: 0.010 in. thick (7 oz.)
—selective black: minimum absorptivity .90; maximum emissivity .12; manufactured by Enthone Inc., durable to 400°F.
—copper tubes: ¼ in. ID (0.375 in. OD) M-type
—tube spacing: 6 in. on center
—tube pattern: grid
—manifolds: 1 in. ID (1.125 in. OD) M-type copper
—tube connections to manifold: silver solder
—bond between tube and sheet: soft solder
—connection to external piping: 1 in. ID (1.125 in. OD) K-type copper, extending 2 in. beyond collector ends; supply, top right; return, bottom left (when viewed from the top)
—manifold/tubes pressure-tested to 15 atm: 125 psig working pressure
Insulation behind absorber: 2½ in. thick fiberglass, 1.5 lb/ft^3 density, R = 10.4
Weight per module: 113.9 pounds, filled; 111 pounds, empty. (NOTE: the liquid in the collector is equal to: 0.36 gallons or 46.4 ounces or 2.90 pounds or 0.05 ft^3 or 80.5 in^3.)
Recommended flow rate through collector: 1 gph/ft^2 of collector (F_R = 0.95) (flow resistance at this rate is negligible)
Collector coolant: coolant can be inhibited alcohol-water mixtures such as standard automobile anti-freeze made by Union Carbide or duPont. In areas where regular tap water is used as a coolant, it is important that the pH be controlled between 6 and 8. These collectors can be used with other coolants but the user must contact the manufacturer for approval of specific liquids. (See guarantee statement available from Sunworks.)

DATA ON AIR *SOLECTOR* SOLAR ENERGY COLLECTORS

Absorber:
—copper sheet: 0.016 in. thick (12 oz.)
—selective black: minimum absorptivity .90; maximum emissivity .12; applied by Enthone, Inc., durable to 400°F.
—air chamber: 7/8 in. high, mechanical bond to absorber
—connection to external duct: 1½ in. x 20 in. duct stub extending 2 in. beyond end of collector envelope
—distribution pattern: parallel top to bottom, behind absorber
Insulation behind absorber: 1 in. thick fiberglass plus 1 in. urethane: R = 10
Weight per module: 111 lb.
Recommended flow rate through collector: 3 cfm/ft^2 of collector (flow resistance at this rate is negligible)
NOTE: Manufacturer reserves right to change specifications and dimensions without notice

*Trademark of Enthone, Inc. **Patents Pending

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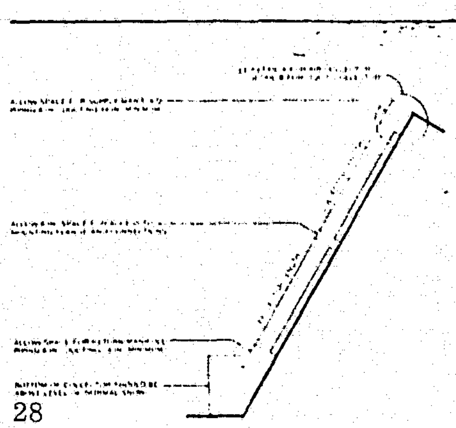
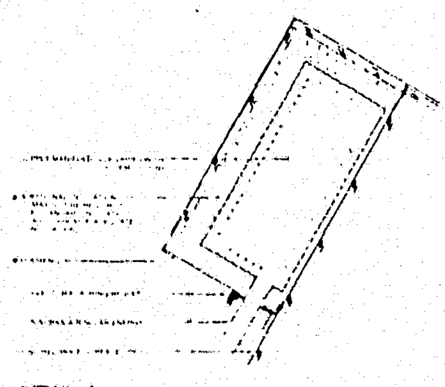
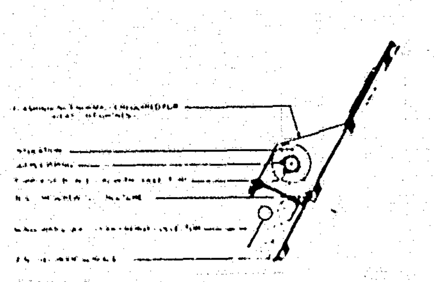


TYPICAL ROOF LOCATION COLLECTORS IN SERIES



DETAIL A

TYPICAL SUPPLY DUCT FOR AIR COLLECTOR



DETAIL B

TYPICAL SUPPLY PIPING FOR LIQUID COLLECTOR

Hot Water Storage Tanks . . .
Description, Operation, Selection Of Equipment

An Adamson Hot Water Storage Tank used in conjunction with a boiler or other independent water-heating unit, provides an alternate system for heating and storing domestic hot water. A properly sized tank will provide storage capacity sufficient to meet peak and normal system demands.

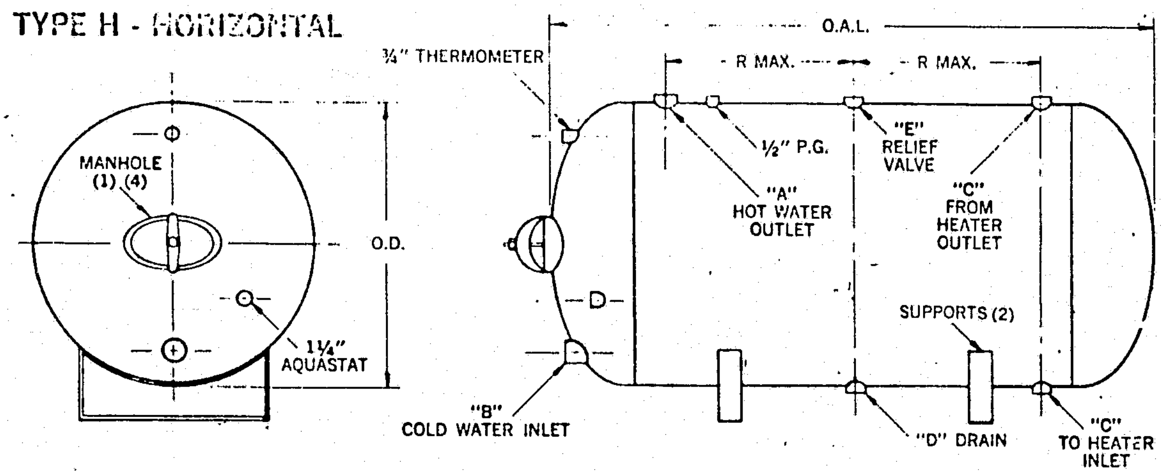
OPERATION

Incoming cold water enters the lower part of the storage tank. Either by gravity flow or forced flow, the cold water leaves the storage tank and passes through the water heating unit. The heated water is returned to the upper part of the storage tank where it is held in reserve until required by the system. As required, water is supplied to the system from the hot water outlet in the upper part of the tank.

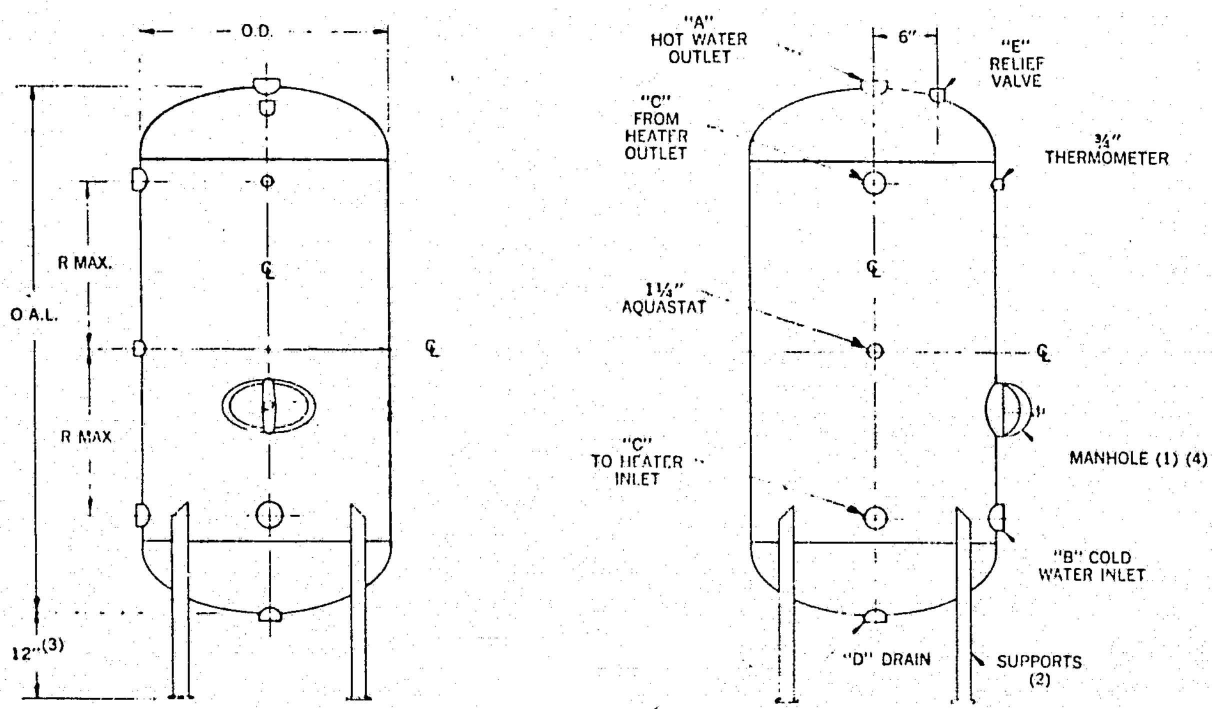
SELECTION

The charts on page 10 give normal GPH requirements of 140 F water for plumbing fixtures in various types of installations. By totaling the GPH requirement and applying storage capacity factors as illustrated, the required storage capacity can be determined. Selection of the proper size hot water storage tank can be determined from the chart on page 16.

TYPE H - HORIZONTAL



TYPE V - VERTICAL



Water Storage Heater And Tanks

TYPE H — HORIZONTAL
TYPE V — VERTICAL

Tank No.	DIMENSIONS OD Dia. In.	L OAL Ft.	CAPACITY (gallons) Actual	Nominal	OPENING SIZES A & B	C & D	E	R-Max
D 48	24	4	84	94	1½	1	1	10
D 60	24	5	107	118	1½	1	1	16
D 72	24	6	130	141	1½	1	1	22
D 84	24	7	153	165	1½	1	1	28
D 96	24	8	176	188	1½	1	1	34
D120	24	10	222	235	1½	1	1	46
E 48	30	4	127	147	1½	1	1	8
E 60	30	5	163	184	1½	1	1	14
E 72	30	6	199	220	1½	1	1	20
E 84	30	7	235	257	1½	1	1	26
E 96	30	8	270	294	1½	1	1	32
E108	30	9	306	330	1½	1	1	38
E120	30	10	342	367	1½	1	1	44
F 60	36	5	232	264	2	1½	1	13
F 72	36	6	284	317	2	1½	1	19
F 84	36	7	335	373	2	1½	1	25
F 96	36	8	387	423	2	1½	1	31
F108	36	9	439	476	2	1½	1	37
F120	36	10	490	529	2	1½	1	43
F144	36	12	594	635	2	1½	1	55
F168	36	14	697	740	2	1½	1	67
G 72	42	6	379	432	2½	1½	1½	17
G 84	42	7	450	504	2½	1½	1½	23
G 96	42	8	520	576	2½	1½	1½	29
G108	42	9	591	648	2½	1½	1½	35
G120	42	10	661	720	2½	1½	1½	41
G144	42	12	802	864	2½	1½	1½	53
G168	42	14	943	1008	2½	1½	1½	65
G192	42	16	1084	1152	2½	1½	1½	77
H 72	48	6	490	564	2½	2	1½	16
H 96	48	8	675	752	2½	2	1½	28
H120	48	10	860	940	2½	2	1½	40
H144	48	12	1045	1128	2½	2	1½	52
H168	48	14	1230	1316	2½	2	1½	64
H192	48	16	1415	1504	2½	2	1½	76
H216	48	18	1600	1692	2½	2	1½	88
J 96	54	8	844	952	2½	2	1½	26
J120	54	10	1077	1190	2½	2	1½	38
J144	54	12	1311	1428	2½	2	1½	50
J168	54	14	1546	1666	2½	2	1½	62
J192	54	16	1780	1904	2½	2	1½	74
J216	54	18	2014	2142	2½	2	1½	86
J240	54	20	2248	2380	2½	2	1½	98
K 96	60	8	1030	1175	3	2½	1½	25
K120	60	10	1320	1469	3	2½	1½	37
K144	60	12	1609	1763	3	2½	1½	49
K168	60	14	1899	2056	3	2½	1½	61
K192	60	16	2188	2350	3	2½	1½	73
K216	60	18	2478	2644	3	2½	1½	85
K240	60	20	2768	2938	3	2½	1½	97
K288	60	24	3347	3525	3	2½	1½	119
K360	60	30	4215	4408	3	2½	1½	157

Tank No.	DIMENSIONS OD Dia. In.	L OAL Ft.	CAPACITY (gallons) Actual	Nominal	OPENING SIZES A & B	C & D	E	R-Max.
L 96	66	8	1281	1408	3	2½	1½	23
L120	66	10	1632	1760	3	2½	1½	35
L144	66	12	1983	2112	3	2½	1½	47
L168	66	14	2334	2465	3	2½	1½	59
L192	66	16	2685	2817	3	2½	1½	71
L216	66	18	3036	3169	3	2½	1½	83
L240	66	20	3387	3521	3	2½	1½	95
L288	66	24	4089	4225	3	2½	1½	119
L360	66	30	5141	5281	3	2½	1½	155
M120	72	10	1864	2115	3	2½	1½	34
M144	72	12	2281	2538	3	2½	1½	46
M168	72	14	2699	2961	3	2½	1½	58
M192	72	16	3116	3384	3	2½	1½	70
M216	72	18	3533	3807	3	2½	1½	82
M240	72	20	3950	4230	3	2½	1½	94
M288	72	24	4734	5076	3	2½	1½	118
M360	72	30	6036	6351	3	2½	1½	154
P120	84	10	2490	2879	4	2½	1½	31
P144	84	12	3058	3455	4	2½	1½	43
P168	84	14	3626	4030	4	2½	1½	55
P192	84	16	4195	4606	4	2½	1½	67
P216	84	18	4763	5182	4	2½	1½	79
P240	84	20	5331	5758	4	2½	1½	91
P264	84	22	5899	6334	4	2½	1½	103
P288	84	24	6467	6909	4	2½	1½	114
P312	84	26	7035	7486	4	2½	1½	126
P336	84	28	7603	8061	4	2½	1½	138
P360	84	30	8171	8637	4	2½	1½	151
S120	96	10	3193	3760	4	2½	1½	28
S144	96	12	3935	4512	4	2½	1½	40
S168	96	14	4677	5264	4	2½	1½	52
S196	96	16	5419	6016	4	2½	1½	64
S216	96	18	6162	6768	4	2½	1½	76
S240	96	20	6904	7520	4	2½	1½	88
S264	96	22	7646	8272	4	2½	1½	100
S288	96	24	8388	9024	4	2½	1½	112
S312	96	26	9131	9776	4	2½	1½	124
S336	96	28	9873	10528	4	2½	1½	136
S360	96	30	10615	11280	4	2½	1½	148
S384	96	32	11357	12032	4	2½	1½	160
S408	96	34	12100	12784	4	2½	1½	172

All Dimensions in Inches Unless Otherwise Indicated.

A.S.M.E. requirements state that if the opening is greater than 3" and the working pressure is greater than 125 PSI, the opening must be a flanged nozzle.

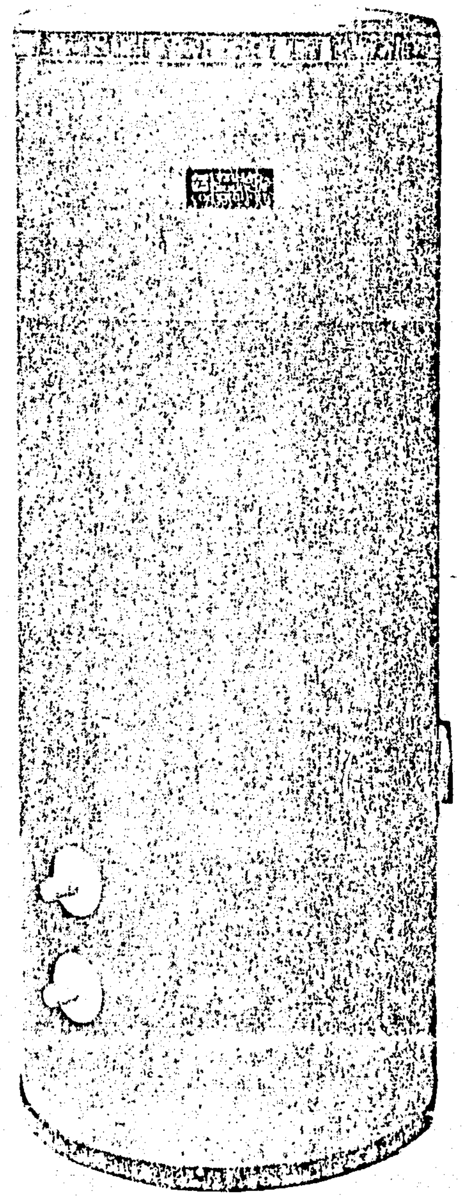
(1) 11" x 15" manhole is required on A.S.M.E. tanks 42" diameter and larger.

(2) Support details are shown on pages 31 and 32.

(3) Clearance can be changed as required.

(4) On all lined tanks 30" and under, manhole must be in center of the head.

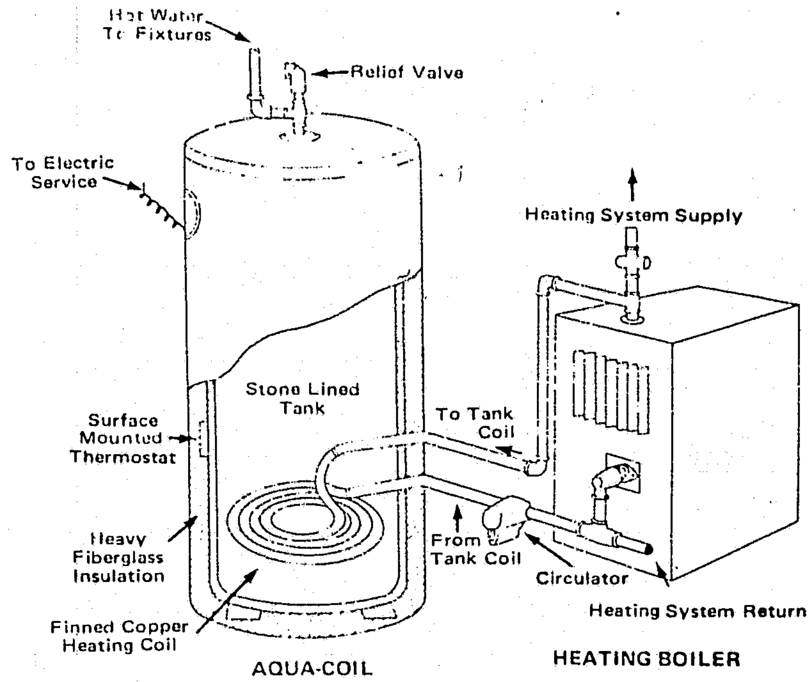
FORD AQUA-COIL



Uses Boiler Water With A Coil In The Tank To Supply Abundant Quantities Of Hot Water

FORD
products
corporation

- No liming of coil
- Can use a cast-iron circulator
- Provides an abundance of hot water from modern mini-boilers
- Long life stone-lined tank
- Adjustable water temperature
- Easy to install
- Eliminates pressure drop in domestic hot water system



An internal coil in the tank uses boiler water heat. This insures maximum efficiency without an extra burner unit.

SPECIFICATIONS

STONE-LINED MODELS 5 YEAR LIMITED WARRANTY (Do Not Require Anode)		
Model	TC40	TC65
Capacity Gallons	40	65
Height	53½"	55¼"
Overall Diameter	20"	24"
Floor to Drain	6½"	7½"
Circ. Disch. to Floor	12¾"	13¾"
Max. Width	27"	31"
Water Connections	¾"	¾"
Weight, Lbs.	230	340
*Recovery Capacity	45	90

*Gal/Hr. Raised 100° F

Recovery capacity is based on a boiler setting of 200°F and entering water temperature of 40°F.

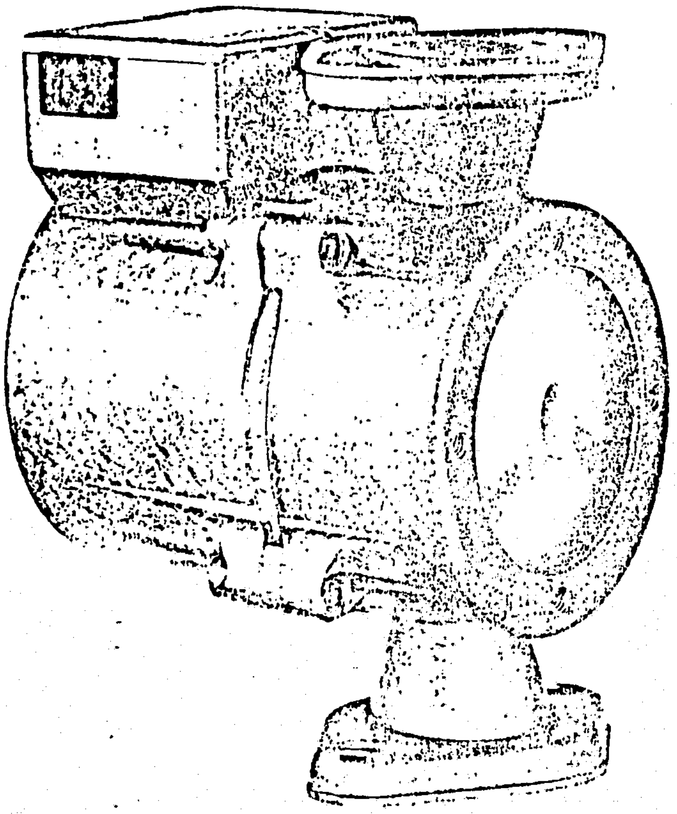
Aqua-Coil includes an insulated jacket, stone-lined storage tank with copper heating coil, thermostat, circulator and drain cock. Connecting piping is not included. Where boiler water temperature is not maintained, relay must be installed for domestic hot water. With a multi-zone heating system, a zone control valve may be used in place of a circulator.

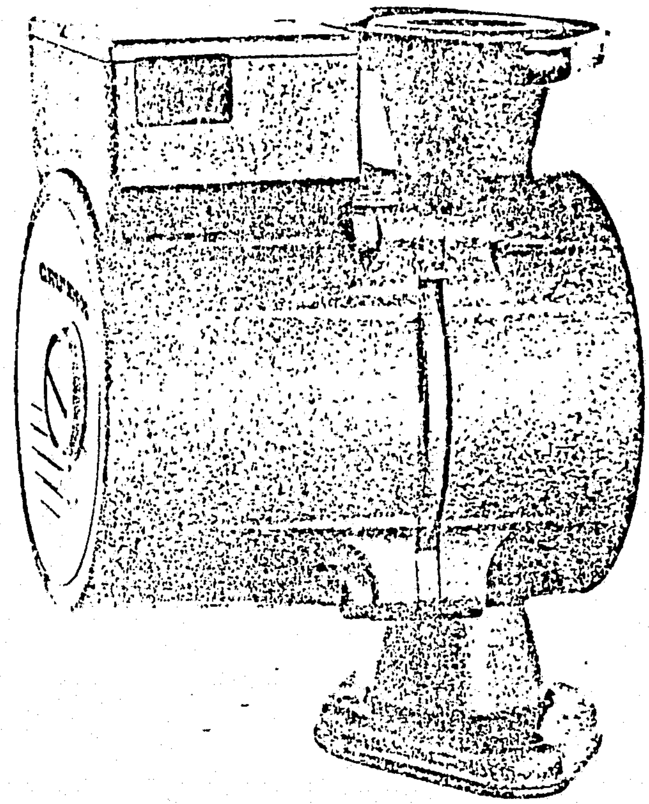
Warranty certificate available on request.

FORD products corporation

Ford Products Road, Valley Cottage, New York 10989 / Phone: (914) 358-8282

GRUNDFOS | STAINLESS STEEL CIRCULATOR PUMPS | UP 25-42SF





INFORMATION: Stainless steel circulator pump—UP 25-42 SF

The UP 25-42 SF is a revolutionary circulator pump. The water passing through the pump touches nothing but high quality fabricated stainless steel. The volute section, for example, is constructed of type 316 stainless. As with all Grundfos circulators, the UP 25-42 SF is engineered to be interchangeable with the pumps of all other major manufacturers.

CONSTRUCTION

The UP 25-42 SF is a water lubricated pump. However, in order to protect the rotor and bearings from damaging impurities which may be present in the circulating water, they are separated from the stator and the pump chamber by a liquid filled rotor can. The motor shaft extends out from the rotor can, into the pump chamber through the aluminum oxide bearing, which also functions as a seal. During initial operation, the pump is automatically self-vented; however, due to the isostatic principle, there is no further recirculation of water into the closed rotor can.

The pump's "diamond-hard" aluminum oxide bearing construction, combined with the high starting torque of the motor, ensures re-start after shutdown.

MATERIALS

Stainless steel: .... Pump chamber, rotor can, shaft, rotor cladding, bearing plate, impeller, thrust bearing cover.

Aluminum oxide: .... Top bearing, shaft ends, bottom bearing.

Carbon/aluminum oxide: .... Thrust bearing.
Aluminum: .... Motor housing, pump housing cover.
Ethylene/propylene rubber: .... O-rings, gasket.
Silicon rubber: .... Winding Protection.

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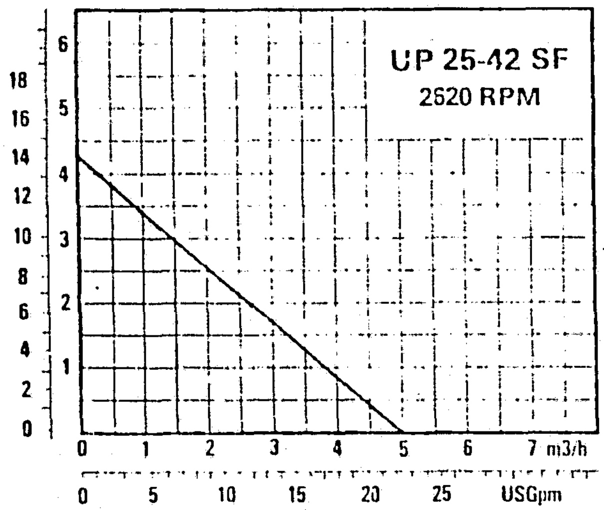
APPLICATIONS

The UP 25-42 SF is particularly suited for open and potable systems. The stainless steel construction protects the pump from the corrosion that has plagued cast iron and bronze-lined pumps in these types of applications. The pump is intended for circulation and booster applications in domestic water systems.

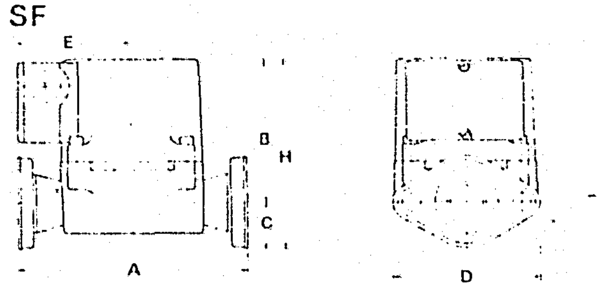
PERFORMANCE CURVE UP 25-42 SF



ELECTRICAL AND PERFORMANCE DATA

The UP 25-42 SF is operated by an energy-conserving 1/20th HP (0.85 amp) motor which has built-in overload protection. However, because of advanced engineering design, the pump produces up to 14 feet of head or a flow of up to 23GPM. The pump's small size and high efficiency make it suitable for many varied applications and greatly reduces installation problems.

DIMENSIONS UP 25-42 SF

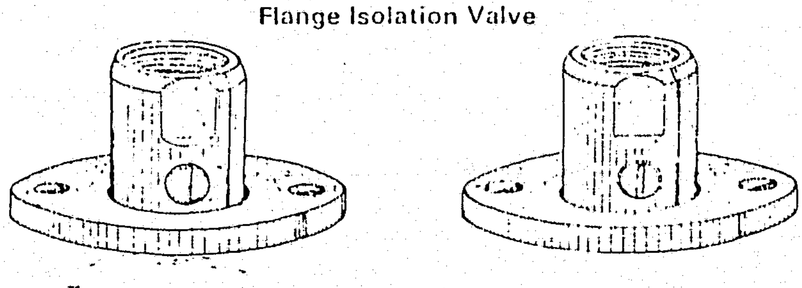


Type	A mm inches	B mm inches	C mm inches	D mm inches	E mm inches	H mm inches	Packing 1xwxh mm "	Ship. vol. m3 Cbft	Weight Kg Lbs.
UP 25-42 SF (w/flanges)	165 6 1/2	100.5 3 3/4	33.5 1 1/3	106 4 1/4	82 3 1/4	129 5 1/8	200 x 180 x 160 7 7/8 x 7 x 6 1/4	0.005 1/5	3 6 1/2

ISOLATION VALVES

GRUNDFOS recommends the use of isolation valves with circulation pumps in all systems.

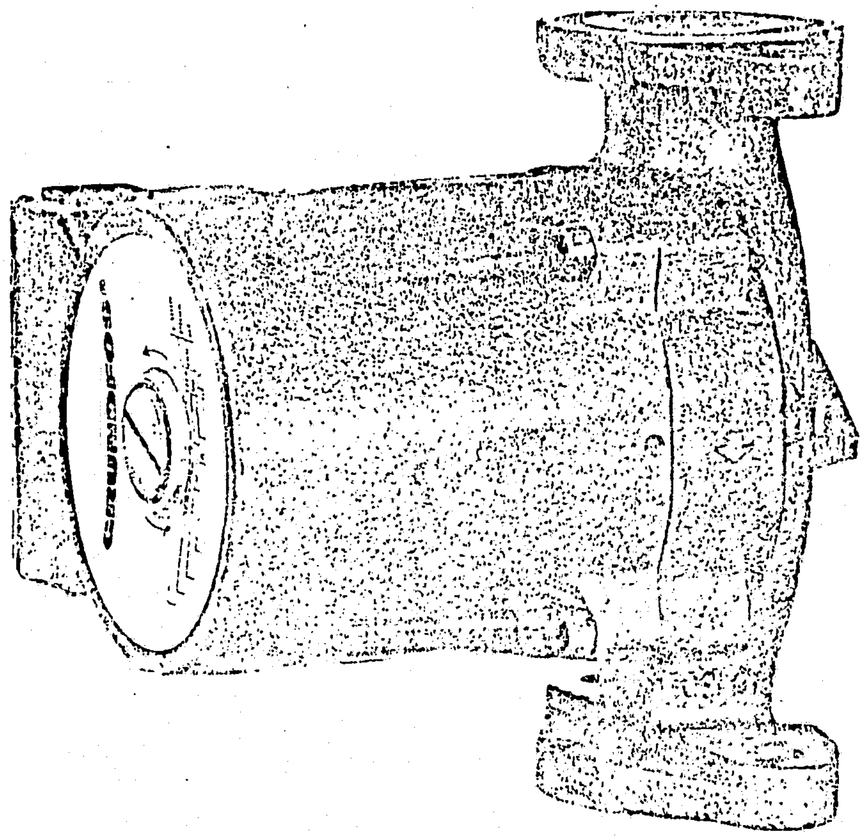
Flange Isolation Valve



ORDER NUMBERS

		Bronze Flanges		Flange Valves	
Type	Order No.	Dim.	Order No	Dim.	Order No
UP 25-42 SF with flanges	51.06 21 13	3/4" 1" 1 ¼"	51.96 51 51.96 52 51.96 53	1"	51.97 72

GRUNDFOS	VARIABLE HEAD CIRCULATOR PUMP	UP 26-64



INFORMATION Variable Head Circulator Pump — UP 26-64

The UP 26-64 is fitted with variable-head-control. This innovative mechanism, which controls both the head and the flow produced by the pump, allows the installer, by a simple hand adjustment, to precisely match the UP 26-64 to the demands of many varying systems.

CONSTRUCTION

The UP 26-64 is a water lubricated pump. However, in order to protect the rotor and bearings from damaging impurities which may be present in the circulating water, they are separated from the stator and the pump chamber by a liquid filled rotor can. The motor shaft extends out from the rotor can, into the pump chamber through the aluminum oxide bearing, which also functions as a seal. During initial operation, the pump is automatically self-vented; however, due to the isostatic principle, there is no further recirculation of water into the closed rotor can.

The pump's "diamond-hard" aluminum oxide bearing construction, combined with the high starting torque of the motor, ensures re-start after shutdown.

MATERIALS

Stainless steel: .... Rotor can, shaft, rotor cladding, bearing plate, impeller, variable flow adjustment plate, thrust bearing cover.

Aluminum oxide: .... Top bearing, shaft ends, bottom bearing.

Carbon/aluminum oxide: .... Thrust bearing.
Cast iron .... Pump housing.
Ethylene/propylene rubber: .... O-rings, gasket.
Silicon rubber: .... Winding Protection.

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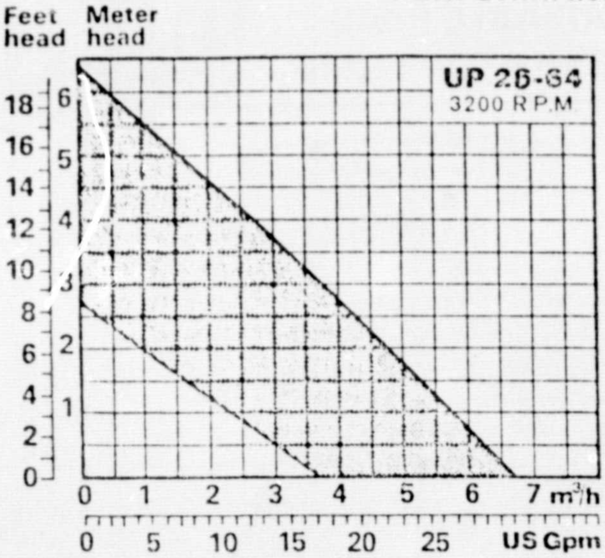
APPLICATIONS

The UP 26-64 should only be used in closed systems (i.e. solar, hydronic). The pump is intended only for the circulation of water. However, solutions such as ethylene glycol can be used without hindering pump performance. For open system applications ask for Grundfos' stainless steel volute circulator pumps.

PERFORMANCE CURVES UP 26-64



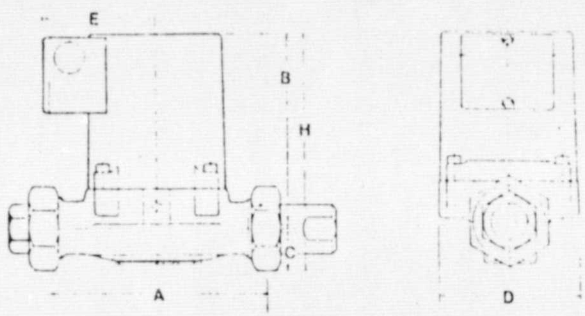
ELECTRICAL AND PERFORMANCE DATA

The UP 26-64 is operated by an energy-conserving 1/12th HP (1.65amp) motor, which has built-in overload protection. However, because of its advanced design, the pump produces heads from 8 to 20 feet or flows from 16 to 30 GPM. The pump's small size and high efficiency make it suitable for many varied applications and greatly reduces installation problems.

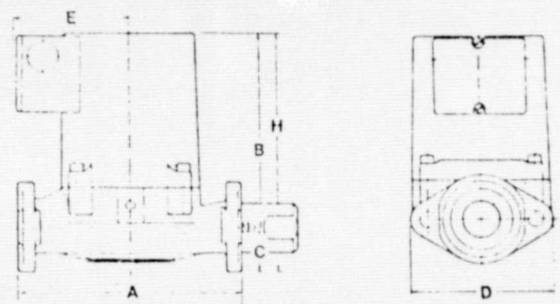
Contact Grundfos for information regarding the complete line of circulator pumps and twin pumps.

DIMENSIONS

UP 26-64 U



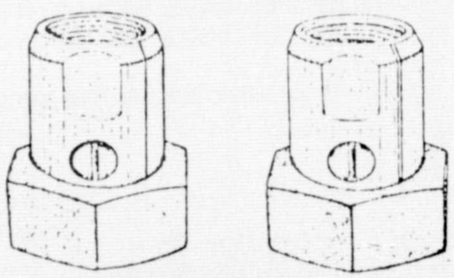
UP 26-64 F



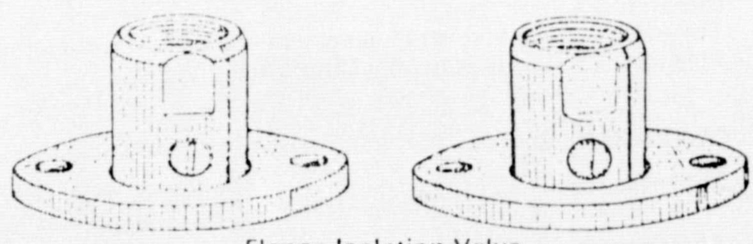
Type	A mm inches	B mm inches	C mm inches	D mm inches	E mm inches	H mm inches	Packing 1xwxh mm/"	Ship. vol. M³ Cbft.	Weight kg Lbs.
UP 26 64U with unions	180 7 1/16	236 9 1/4	32 1 1/4	102 4 1/8	80 3 3/16	165 6 1/2	195 x 200 x 200 7 3/4 x 7 7/8 x 7 7/8	0.008 1/4	5.5 12 1/8
UP 26 64F with flanges	165 6 1/2	128 5 1/16	33.5 1 3/8	106 4 1/4	82 3 1/4	161.5 6 3/8	195 x 200 x 200 7 3/4 x 7 7/8 x 7 7/8	0.008 1/4	5.5 12 1/8

ISOLATION VALVES

GRUNDFOS recommends the use of isolation valves with circulation pumps in all systems.



Union Isolation Valve



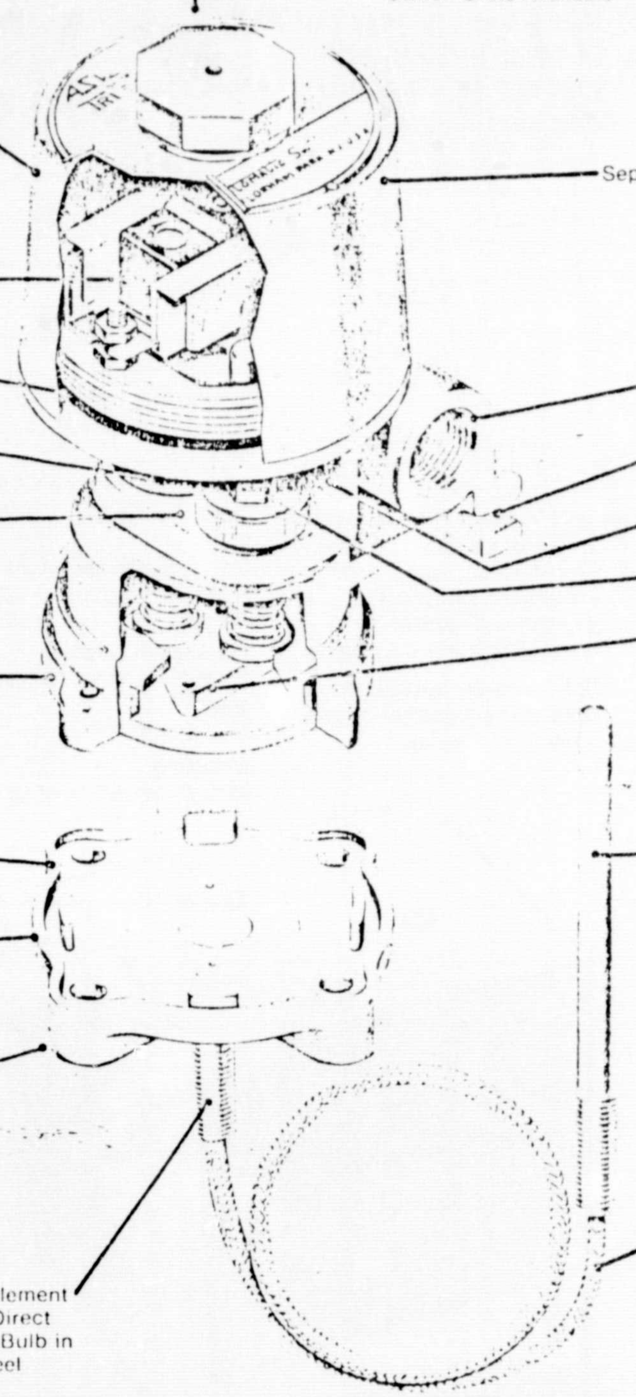
Flange Isolation Valve

ORDER NUMBERS

		Unions		Flanges		Flange Valves Union Valves	
Type	Order No.	Dim.	Order No.	Dim.	Order No.	Dim.	Order No.
UP 26-64F with flanges	52 22 30 13	3/4" 1"	51.95 21 51.95 22	3/4" 1"	51.96 01 51.96 02	1"	51.97 72
UP 26 64U with unions	52 25 20 13			1 1/4" 1 1/2"	51.96 03 51.96 04	1	51.98 72

ASCO's TRI-POINT TEMPERATURE SWITCH

incorporates the features most wanted!



*0.6% copper content or less.

Temperature Switches

FIXED DEADBAND TYPE

Adjustable Set Point
Non-Adjustable Reset Point

ASCO TRI-POINT

SERIES: SB10 • SB11 • SB12

GENERAL DESCRIPTION: This series of ASCO TRI-POINT Temperature Switches is the fixed deadband type. They consist of two separate sub units, a factory adjusted switch assembly unit and a temperature transducer unit. The temperature transducer utilizes a vapor fill to actuate the switch assembly unit in response to temperature changes. These temperature switches may be purchased as an assembled unit, or they may be purchased as two separate units for field assembly. *In all cases, when ordering, the third digit of the switch assembly unit must be identical to the third digit of the temperature transducer unit.*

Example: SB10A Assembled to **QA10A1**
└── Must Be Identical ──┘

OPERATION: The temperature transducer uses the vapor pressure principle in which the vapor pressure of the liquid in the sensing bulb is related to the temperature being sensed. This pressure is converted into a force and transmitted to the balance plate. One adjustable spring applies a counter force to the balance plate. Movement of the balance plate is transmitted to the snap action electrical switch by an operating rod. The actuation (set) point of the switch is adjustable over the full temperature range of the switch. The reactuation (reset) point is not adjustable. The temperature difference between the set and reset points is the deadband as listed below.

OPTIONAL FEATURES: Several options are available; for details and availability, consult pages 9, 10 and 11.

ELECTRICAL INFORMATION: Consult page 9 for electrical ratings and schematics for standard and optional snap action switches.

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SPECIFICATIONS

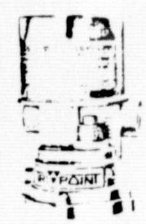
HOW TO SELECT AND ORDER

1. Determine the temperature range needed. Preferably the actuation point should be in the middle two-thirds of the span. Check that the maximum temperature rating is sufficient.
2. Read across and select one switch assembly unit with the proper enclosure.
3. Continue across the same line and select one transducer according to the construction desired.
4. **Field Assembly:** Order the switch assembly unit and the transducer unit by their respective catalog numbers if you desire to field assemble the temperature switch. The third digit in each catalog number must be identical.
5. **Factory Assembly:** Add the two catalog numbers together separated by a slash (/), if you desire a completely assembled temperature switch.

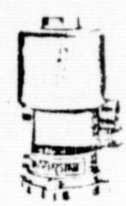
Example: For a temperature switch required to actuate at 50°F, select a 0-90°F switch. Such a temperature switch with a general purpose enclosure and copper capillary and bulb would be catalog number SB10A/QD11A1.

SWITCH ASSEMBLY UNITS

(Two 3/4" NPT Conduit Hubs Standard)



General Purpose Type

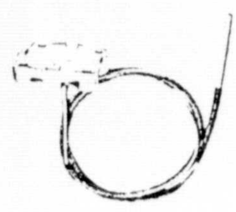


Explosion-Proof Type

TEMPERATURE TRANSDUCER UNITS

Direct Probe

Capillary and Bulb



Armored Copper Capillary or Plain Stainless Steel Capillary

	ADJUSTABLE OPERATING RANGE (In Degrees)	MAX. TEMP. (In Degrees)	DEADBAND AT MID RANGE* (In Degrees)	GENERAL PURPOSE ENCLOSURE	WATERTIGHT ENCLOSURE	EXPLOSION-PROOF ENCLOSURE	DIRECT PROBE: COPPER	DIRECT PROBE: 316 S.S.	6' CAPILLARY AND BULB: COPPER (Armored Capillary)	6' CAPILLARY AND BULB: 316 S.S. (Plain Capillary)
				CATALOG NO.	CATALOG NO.	CATALOG NO.	CATALOG NO.	CATALOG NO.	CATALOG NO.	CATALOG NO.
°F	−60 - 20	200	3	SB10A	SB11A	SB12A	QA10A1	QA10A4	QA11A1	QA11A4
°C	−51 - −7	93	1.7							
°F	−30 - 60	250	3	SB10A	SB11A	SB12A	QB10A1	QB10A4	QB11A1	QB11A4
°C	−34 - 16	121	1.7							
°F	0 - 90	300	4	SB10A	SB11A	SB12A	QD10A1	QD10A4	QD11A1	QD11A4
°C	−18 - 32	149	2.2							
°F	50 - 160	350	3	SB10A	SB11A	SB12A	QF10A1	QF10A4	QF11A1	QF11A4
°C	10 - 71	177	1.7							
°F	100 - 220	450	3	SB10A	SB11A	SB12A	QJ10A1	QJ10A4	QJ11A1	QJ11A4
°C	38 - 104	232	1.7							
°F	160 - 260	500	4	SB10A	SB11A	SB12A	QL10A1	QL10A4	QL11A1	QL11A4
°C	71 - 127	260	2.2							
°F	225 - 340	600	6	SB10A	SB11A	SB12A	QN10A1	QN10A4	QN11A1	QN11A4
°C	107 - 171	316	3.3							
°F	300 - 450	700	6	SB10A	SB11A	SB12A	QT10A1	QT10A4	QT11A1	QT11A4
°C	149 - 232	371	3.3							
°F	350 - 510	800	7	SB10A	SB11A	SB12A	QU10A1	QU10A4	QU11A1	QU11A4
°C	177 - 266	427	4							

*At Extreme Ends of Range, Values May Vary up to 50% of Listed Deadband.

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