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DESIGN DATA BROCHURE SIMS PROTOTYPE SYSTEM 2

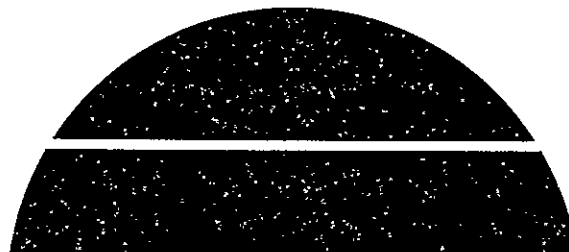
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for the Department of Energy



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Solar Energy

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16. ABSTRACT This document provides information on the design and performance of the IBM SIMS Prototype System 2, solar domestic hot water system, for single family residences. The document provides sufficient data to permit procurement, installation, operation, and maintenance by qualified architectural engineers or contractors.					
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DESIGN DATA BROCHURE

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1.0 INTRODUCTION

A solar energy system for supplying domestic hot water to single family residences has been designed by IBM under contract NAS8-32036 to the National Aeronautics and Space Administration's Marshall Space Flight Center. The prototype system illustrated pictorially in Figure 1-1, is an integration of currently marketed subsystems and has been built and demonstrated as part of the government's National Program for the Solar Heating and Cooling of Buildings. This document provides data generally describing the design and performance of the system with information sufficient to permit procurement, installation, operation, and maintenance by qualified architectural engineers or contractors.

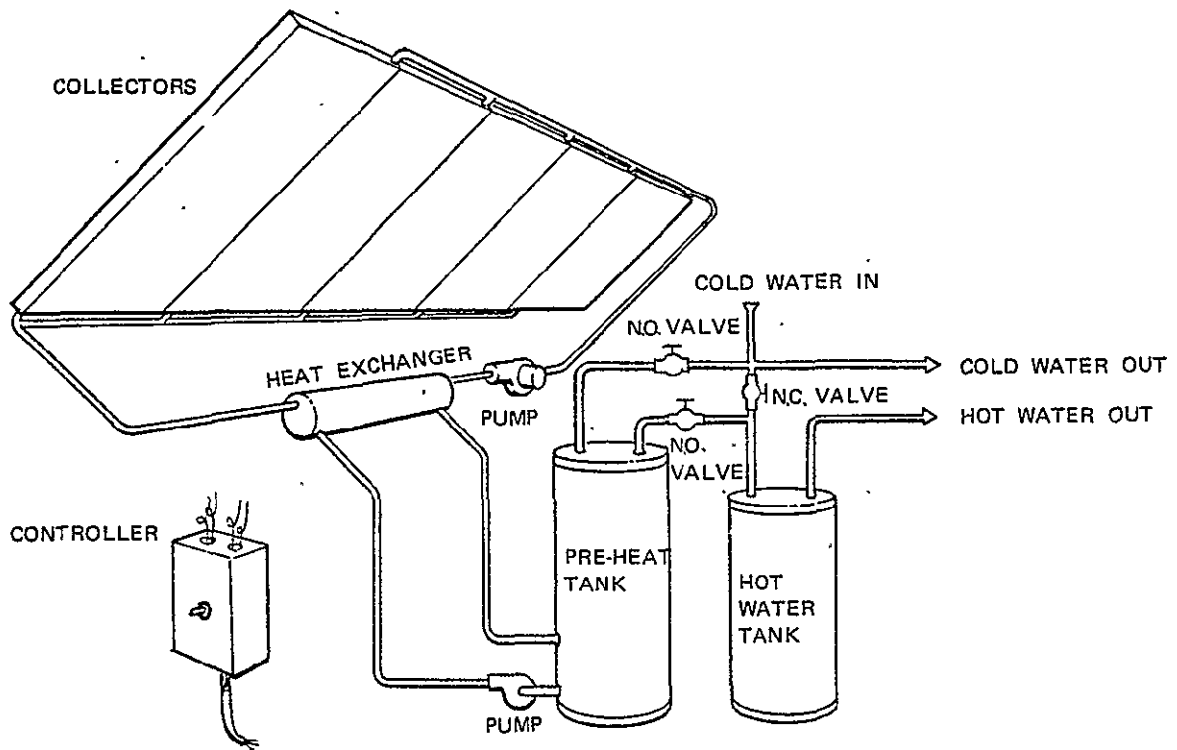


Figure 1-1. System Illustration

2.0 SYSTEM FUNCTIONAL DESCRIPTION AND OPERATION

SIMS Prototype System 2 is a liquid, closed loop, non-draining solar energy system for supplying domestic hot water to single family residences. As shown schematically in Figure 2-1, it consists of solar collectors, storage tank, pumps, heat exchanger and associated plumbing and controls. A silicone fluid circulated through the collector absorbs energy which is transferred by way of a heat exchanger to potable water stored in a preheat tank. The preheat tank, which is used to store solar energy, services a standard domestic hot water (dhw) heater tank which maintains the supply water at a preset temperature level, typically 140°F. City water replenishes that flowing from the preheat tank as water is drawn at the service outlets.

Thus solar energy is used to preheat water for the standard domestic hot water system, which is presumed to exist or be supplied separately and is not part of the solar energy system. The standard dhw system serves as the auxiliary energy source and can supply all hot water needs in the event of extended inclement weather. It is the primary functional interface with the solar energy system.

General features or characteristics of the system design are:

- Single family residence application
- Continental U.S. location
- Liquid flat plate collectors
- Silicone heat transfer fluid (non-toxic)
- Fail-safe double wall heat exchanger
- Automatic operation

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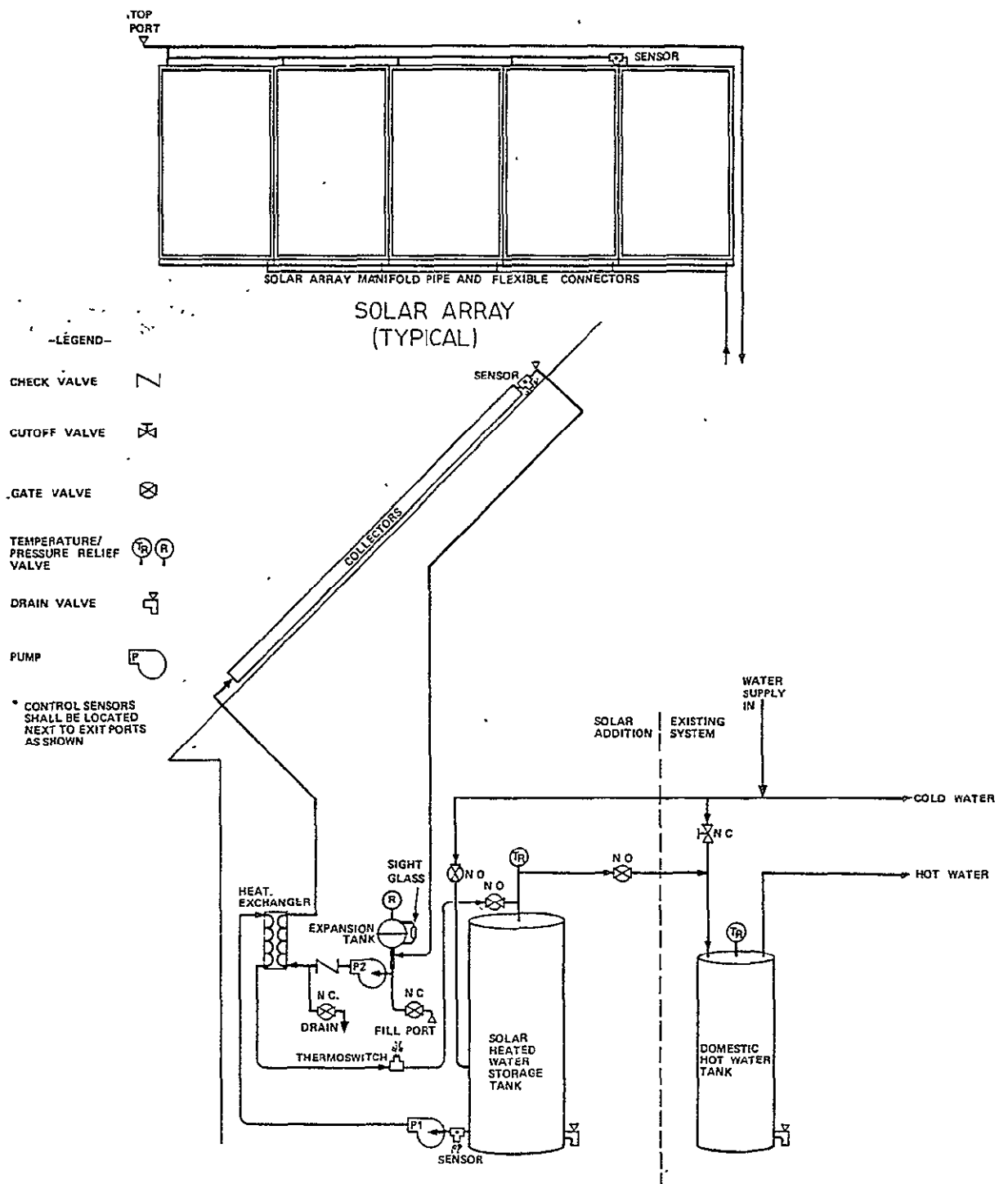


Figure 2-1. System 2 Functional Schematic

- Conventional auxiliary energy dhw system
- Over-temperature protection
- Freeze protected

The baseline system accommodates nominal domestic hot water requirements of 50 to 120 gallons per day at 140°F. This range is sufficient to cover the predominance of American households. The system can be scaled up or down, however, for a wide range of hot water requirements for single family, multi-family, or light commercial application without significant change to the design concept.

The detailed System 2 design is defined by IBM Drawing 7933631-D, SYSTEM 2 (LOF) DESIGN DESCRIPTION; and Drawing 7933449, SYSTEM PERFORMANCE SPECIFICATION FOR SIMS PROTOTYPE SYSTEM NO. 2.

The elements of the system are arranged into subsystems which are described in Section 3. System performance and sizing is addressed in Section 4.0, with an example case for a specific site/application. Installation considerations are identified and discussed in some detail in Section 5.0. Operation, maintenance, and repair information is provided in Section 6.0. Vendor data brochures for the major system components are included in Appendix A.

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3.0 SUBSYSTEM DESCRIPTION

The major subsystems comprising the solar hot water system are:

- Collector
- Storage
- Energy Transport
- Control.

A summary of the general characteristics of the subsystems is presented in Table 3-1, with a more detailed description in subsequent paragraphs.

Table 3-1. Subsystem Characteristic Summary

Subsystem	Description	Manufacturer/Model*
Collector	84" x 36" x 5.5" flatplate type, liquid, double glazed, non-selective, copper absorber and tubes	Libbey-Owens-Ford/1112 Sun Panel
Storage	80-120 gallon preheat tank	Ford Products Co.
Energy Transport	(1) Circulating pumps	Grundfos/UP25-42SF and UP26-64
	(2) Heat Exchanger	Solar Shop/HE1
	(3) Expansion Tank, 3 gal.	Ace/X8-0
	(4) Silicone Heat Transfer Fluid	Dow Corning/Q2-1132
	(5) Piping, Fittings, Valves	--
Control	(1) Differential Thermostat	Rho Sigma/106
	(2) Thermoswitch	Elmwood/3100
* or approved equivalent		

3.1 COLLECTOR SUBSYSTEM

The Libbey-Owens-Ford (LOF) Company Sun Panel Model 1112 liquid solar collector is shown pictorially in Figure 3-1. The basic collector module is a 7' x 3' rectangular unit housed in an aluminum frame and weighing 150 pounds. The absorber plate is an embossed copper sheet 0.021 inches in thickness with 3/8" diameter copper fluid tubing soldered to the back side. The absorber coating is non-selective flat black paint. Three inches of treated fiber glass insulation under the absorber plate, and side insulation is used to reduce heat loss. The module has two 1/8" thick tempered safety glass covers.

Typically, five (5) collectors are arrayed together with appropriate piping to form the collector subsystem. Section 4.0 describes how to size the array for specific applications. Collector mounting and installation guidelines are addressed in Section 5.0.

The liquid system has a parallel flow pattern designed to provide uniform flow through all tubes. The absorber plate tubes are 3/8" O.D. copper. The internal supply and return manifolds at the upper and lower end of the module are 5/8" O.D. copper. Inlet and outlet fluid connections are 1/2" male NPTF.

The performance of the LOF collector in terms of collector efficiency is as described by Figure 3-2. The parameters are defined as follows:

η = Collector Efficiency

T_{in} = Inlet Fluid Temperature, $^{\circ}F$

T_{out} = Outlet Fluid Temperature, $^{\circ}F$

T_{amb} = Ambient Air Temperature, $^{\circ}F$

I = Insolation, Btu/Hr./Ft²

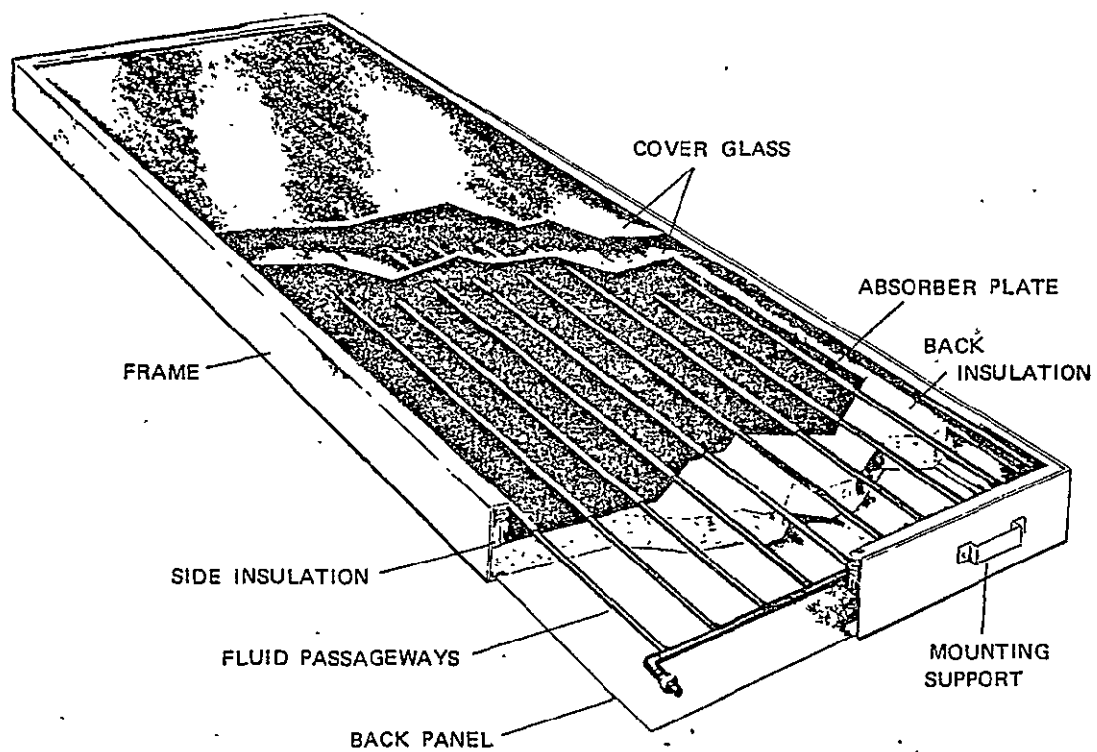
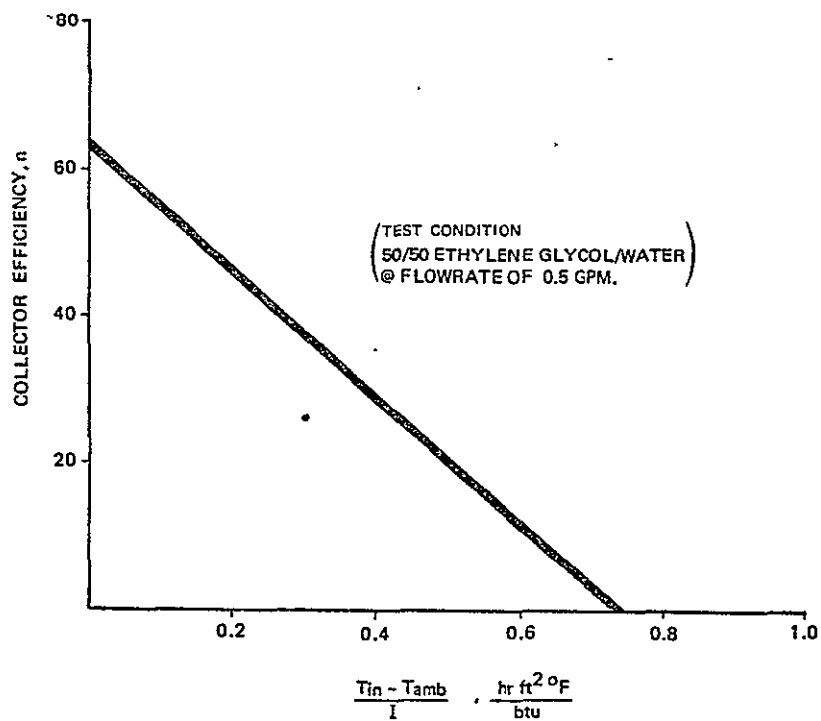


Figure 3-1. Libbey-Owens-Ford Model 1112 Sun Panel Collector



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Figure 3-2. LOF Collector Efficiency

3.2 STORAGE SUBSYSTEM

The baseline energy storage unit consists of a 120 gallon preheat tank, 28 inches in diameter and 68 inches in height. The unit, Ford Products Model AB 120S, is stone-lined and of standard domestic hot water tank construction. The tank is insulated with 2 inches of fiber glass. All fittings are 3/4 inch NPT. The integral thermostat will be utilized to provide over-temperature protection.

Smaller standard sized units of 80 or 100 gallon capacity may be used if site or application sizing requirements (discussed in Section 4.0) dictate.

3.3 ENERGY TRANSPORT SUBSYSTEM

The energy transport subsystem is comprised of circulating pumps, a liquid-to-liquid heat exchanger, expansion tank, silicone heat transfer fluid and associated plumbing (piping, fittings and valves).

- Two pumps are utilized in the System 2 design. In the collector loop the fluid is circulated by a Grundfos Model UP26-64 pump, 1/12 horsepower capacity, 110 volts AC. The water loop uses a Grundfos Model UP25-42SF unit of stainless steel construction with 1/20 horsepower, capacity, 110 volts AC. Both units have internal bearings lubricated by the pumped fluid. Fluid line connection at the pumps are by 1 inch female pipe thread fittings. Ball type isolation valves are included at inlet and outlet ports as an integral part of the pumps.
- The heat exchanger between the collector and water loops is all copper and of "fail-safe" double wall construction to preclude leakage of the silicone fluid into the potable water. Overall dimensions are 3 inches diameter by 31 inches long, with 1 inch diameter inlet and outlet connections for the silicone loop and 1/2 inch inlet and outlet connections for the water loop. The heat exchanger is manufactured by Solar Shop, "TRANSOLATOR" Model HE1.
- To compensate for thermal expansion and contraction of the collector fluid, a 3-gallon A.S.M.E. expansion tank is included in the primary loop. The tank is galvanized steel with 3/4 and 1/2 inch pipe thread fittings. Manufacturer is ACE, Model X 8-0.
- The heat transfer fluid used in the collector loop is a dimethyl silicone, Dow-Corning Q2-1132. Characteristics are:
 - Non-toxic
 - Inert, stable
 - Low freezing point ($<-120^{\circ}\text{F}$)
 - High boiling point ($>400^{\circ}\text{F}$)
 - Dielectric
 - Acceptable heat transfer and fluid flow properties.

The silicone fluid has a higher propensity for leakage than such liquids as water or ethylene glycol, requiring more stringent design control of fittings and joints.

Piping is standard Type L copper tubing, one inch diameter in the collector loop and 3/4 inch in the water loop. Flexible couplings, Hydro-Flex Model 904, are used to connect the collectors to the supply and return headers. All valves are of type common to the building construction trades. Sweat joints (soldered) are preferred for the piping system, to minimize the potential for fluid leakage, although threaded fittings are acceptable when necessary. Compression or flare fittings are avoided. Installation considerations for the piping system and the system in general is discussed in Section 5.0

3.4 CONTROL SUBSYSTEM

The control subsystem provides for the following control mode/functions.

- A. Normal (Automatic) Collection - This mode provides control for the collection of solar energy when collectable in sufficient quantity to add to the energy state of the preheat tank. This is accomplished with a Rho-Sigma Model 106 differential thermostat, including fluid SP type temperature sensors at the collector outlet and the (lower) preheat tank exit. Circulator Pumps P1 and P2 (See Figure 2-1) are simultaneously turned on when the collector temperature exceeds the tank temperature by 20 F degrees. Pump P2 circulates silicone fluid to transfer absorbed solar energy from the collectors to the primary side of the heat exchanger. Pump P1 circulates preheat tank water through the secondary side of the heat exchanger where it is heated and returned to the tank. Both The pumps are shut off when the differential temperature drops below 3 F degrees.

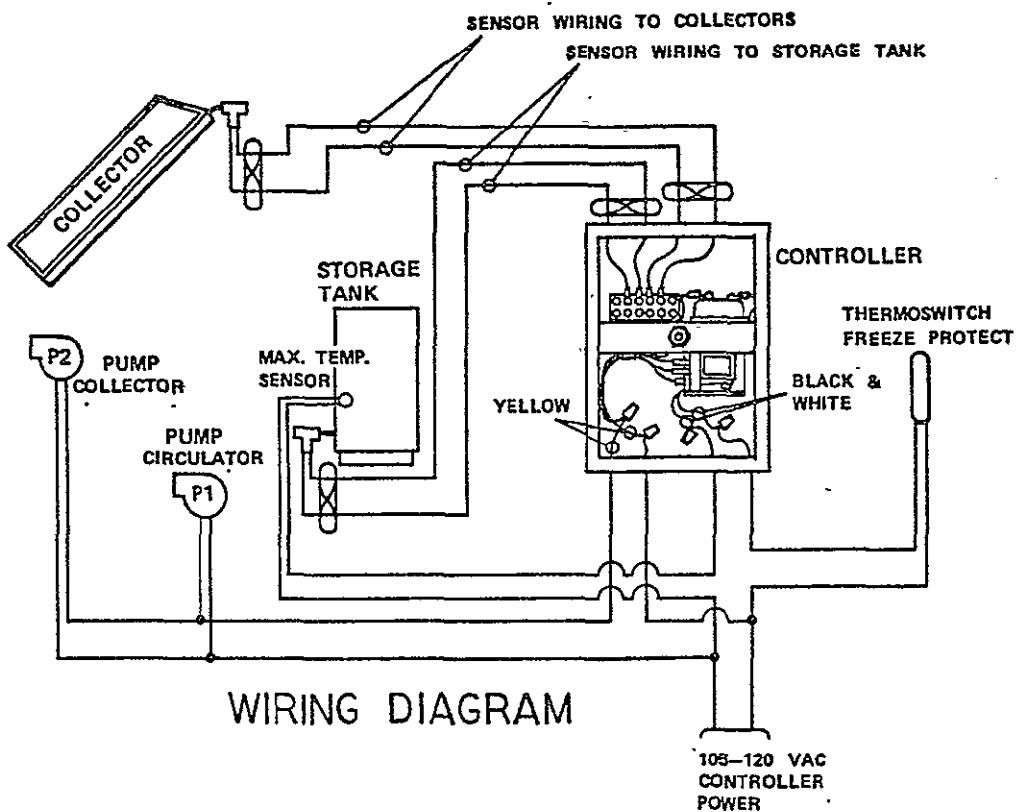
As domestic hot water is used, city water at line pressure is supplied to the bottom of the preheat tank. Solar heated water from the top of the preheat tank flows into the conventional domestic hot water heater. The latter operates in the conventional fashion, adding auxiliary energy as required to maintain the temperature in the dhw tank at the set point.

- B. Over-Temperature Protection - The control subsystem removes power from the controller and hence the coolant pumps when the temperature in the preheat tank exceeds a safe or desirable preset temperature level. This is generally the control temperature of the conventional dhw tank, typically 140°F. The adjustable, normally closed thermostat provided with the preheat tank will provide the sensing and switching for this function.

- C. Manual Operation - To support solar system activation, checkout and maintenance operations, a mode of control is provided in which the pumps are powered up continuously regardless of the temperature difference between collector and preheat tank. Note that the solar preheat tank can gain or lose heat depending on the relative collector and tank temperatures. This mode is provided also by the Rho-Sigma differential thermostat via the ON switch.

- D. Low Temperature Protection - The control subsystem includes a provision to insure against freezing of the water in the preheat tank under all possible normal operating modes. Such a condition can be envisioned only if the controller is inadvertently left in the Manual Operation ON mode under severe cold weather conditions or if the control system fails. A thermoswitch (Elmwood Co., Model 3100) is mounted to the water pipe between the heat exchanger outlet and the preheat tank. The snap action switch is set to open at 40°F on decreasing temperature, removing power from the controller and thus shutting down the pumps.

The Control Subsystem wiring diagram is shown in Figure 3-3. Further details of Control Subsystem operation are presented in Section 6.0, Operation, Maintenance and Repair.



WIRING TABLE			
CIRCUIT/COMPONENT	POWER AMPS	RATING VOLTS	NOTES
COLLECTOR SENSOR			18 ga. TWISTED PAIR
STORAGE SENSOR			18 ga. TWISTED PAIR
COLLECTOR PUMP	1.65	120 ac	YELLOW CONTROLLER WIRES
CIRCULATOR PUMP	0.85	120 ac	YELLOW CONTROLLER WIRES
CONTROLLER	0.05	120 ac	BLACK AND WHITE CONTROLLER POWER WIRES. CONNECT TO 120 VAC THROUGH THERMOSTAT AND MAX. TEMP SENSOR N.C. CONTACTS AS SHOWN.

Figure 3-3. Control Subsystem Wiring Diagram

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4.0 SYSTEM PERFORMANCE AND SIZING

The primary system parameters which determine the overall performance of the System 2 design for any given site/application are the collector unit performance,* collector area and, to a much lesser extent, the preheat storage tank size. The sizes selected for a given application of this design are influenced primarily by the local insolation, the cost of auxiliary fuel, and the hot water load (consumption rate). System 2 was designed for nominal values of these conditions applicable to the most statistically significant portions of the continental United States. It thus represents a design with wide-spread application potential with only slight adjustments necessary in system size. The "nominal" conditions as used herein are defined as:

- Insolation, mean daily total, 1200-1700 Btu/Ft²
- Auxiliary Fuel Cost (Elec.) 0.02-0.04 \$/KWH
- Hot water consumption 50-120 gallons/day

A. Collector

Evaluation has shown that the optimum collector area for this system design is one collector panel (19.7 Ft²) for each 15 gallons per day of hot water consumption. This approximate relationship holds for the range of nominal conditions and results in a solar contribution of from 45 to 65% of the annual dhw load. (For applications where the hot water consumption rate is unknown, a typical single family residence with an automatic washer is some-

* The collector unit performance is fixed since System 2 specifies the LOF collector. Subsequent discussion of system sizes is therefore applicable specifically only to the use of this collector.

times assumed to consume an average of 75 gallons/day, thereby requiring five (5) solar panels.) For locations with higher auxiliary fuel cost, an additional collector panel is cost-justified. Similarly for a site with exceptionally high solar insolation one less panel is recommended.

B. Storage

The optimum preheat tank size is approximately 24 gallons per collector panel. This is based on producing the highest performance return per initial (tank) cost and assumes the use of a preheat tank of a size common to standard domestic hot water tank manufacturer. Sizes in this category in the general range of interest are typically 80, 100 and 120 gallons. The tank size selected should be based on the above criteria, considering these incremental tank sizes and any physical restrictions or limitations that might be imposed by the site.

C. Performance For An Example Site

The initial site for the System 2 baseline design is a single family residence located in Bangor, Maine. Pertinent system/site parameters including collector area and tank sizes are compiled in Table 4-1.

Table 4-1. Example Case Site and System Parameters

Parameter	Value
<ul style="list-style-type: none"> • <u>Site Conditions</u> <ul style="list-style-type: none"> Location Application Hot Water Consumption Delivery Temperature Supply Water Temperature Insolation Auxiliary Fuel Cost • <u>System Design</u> <ul style="list-style-type: none"> Number of Collectors Collector Area Tilt Angle Azimuth Angle Storage Size 	<ul style="list-style-type: none"> Bangor, Maine DHW, Single Family Residence 75 gallons per day* 140°F 55°F, mean 1300 Btu/Ft², mean daily ** 0.0268 \$/KWH 5 98.5 Ft.² 45° 0° (due south) 120 Gallons
<p>*Recommended design value for typical residence with automatic washer per NBS 76-1059 "Intermediate Minimum Property Standards for Solar Heating and Domestic Hot Water Systems".</p> <p>** On horizontal plane</p>	

For the above conditions the System 2 design will supply annually approximately 10.89×10^6 Btu to the total hot water load of 19.44×10^6 Btu. This is a percent solar contribution of 56%.

5.0 INSTALLATION

The intent of this section is to provide the architect or engineer with general guidelines which may be utilized in development of detailed installation plans and specifications. In the event of conflict between this data and local codes or standards, the code or standard shall take precedence.

5.1 GENERAL

The solar energy system can be installed as part of new construction or integrated into existing facilities. With few exceptions, the system consists of hardware available through local sources and common to the building construction trades.

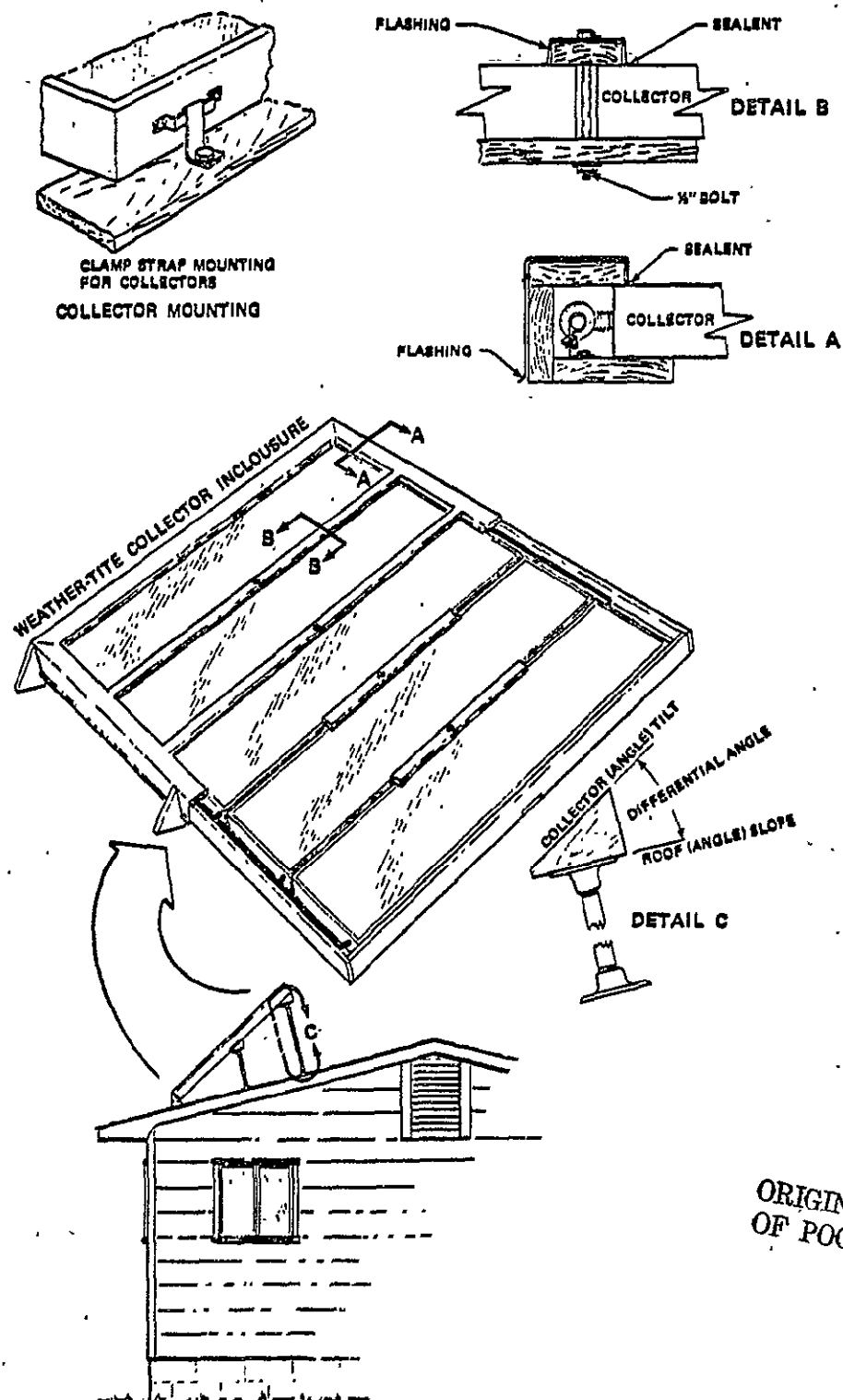
5.2 INSTALLATION CONSIDERATIONS

A. COLLECTORS

The collectors are ganged via a supply and return header to form either a roof or ground mounted array. For a maximum efficiency, the collector array should be mounted facing due south, although a variance of $\pm 20^\circ$ will not greatly affect system performance. The array must also be tilted from the horizontal at an angle approximating the local latitude. A variance in tilt angle about this optimum of $\pm 10^\circ$ will not significantly affect long-term system performance. As shading will significantly decrease 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 (Figure 5-2). 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.



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Figure 5-1. Typical Collector Array Installation Using Weather-Tight Enclosure

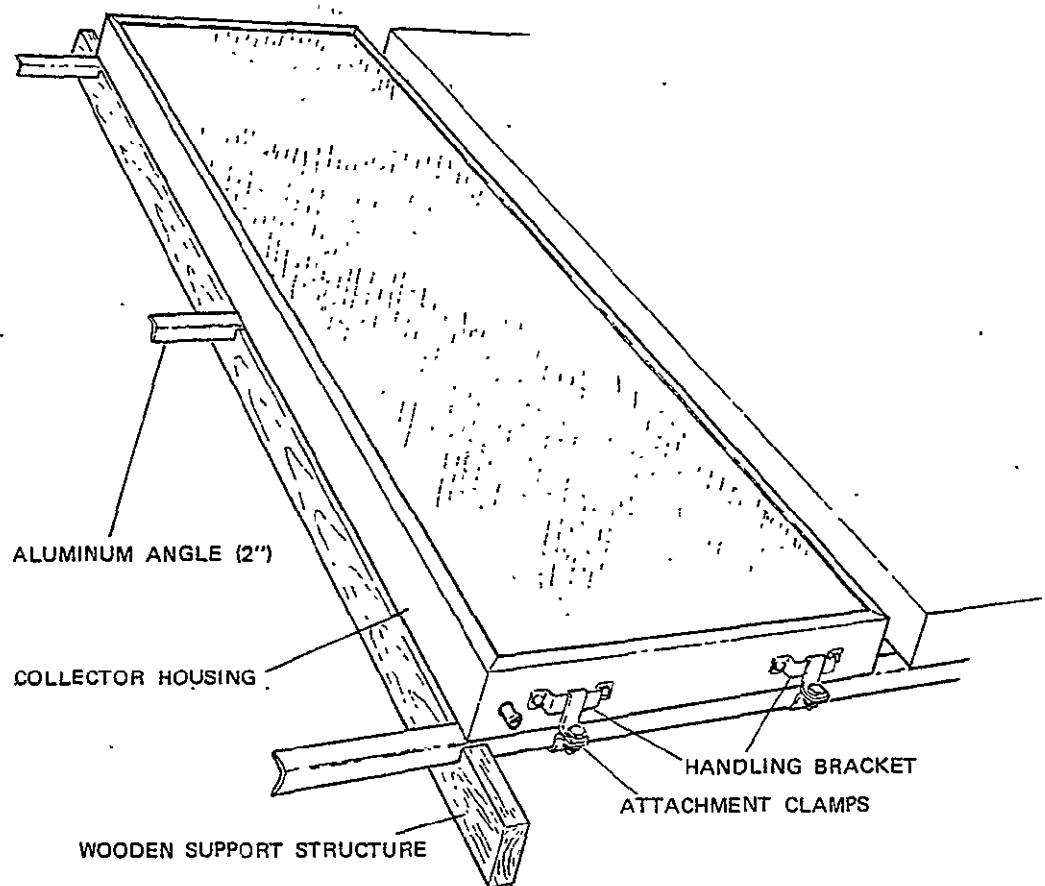


Figure 5-2. Alternate Collector Framing Method

If preferred by the owner, or necessary by the orientation of the building, the collector array may be ground mounted on an "A" frame structure properly constructed.

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.

All ground-mounted arrays must be designed to protect the collectors from snow drifts, water and other site conditions which could impact the collector performance.

B. 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 flame 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.

Insulation on fittings shall be applied in such a manner as to allow for removal of these fittings without disturbing the adjacent insulation.

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

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C. PIPING, FITTINGS AND PUMPS

Type "L" copper tubing (1" for the collector silicone fluid loop and 3/4" for the water preheat tank loop) shall be installed with minimum bends and a maximum length of 50 feet for each loop. High temperature solder (95% tin, 5% silver) shall be used on all sweat fittings in the collector (silicone fluid) loop. Sweat fittings in the water loop should be soldered with 50% tin and 50% lead. A mild solder flux should be used prior to the soldering operation. To minimize potential for leakage of the silicone fluid, the use of compression and/or flare fittings should be avoided, and threaded fittings minimized.

Teflon tape and teflon pipe dope must be used on all threaded connections. To eliminate potential leaks due to thermal expansion, flexible couplings, as manufactured by Hydro-Flex, or equal, shall be used to connect the collectors to the supply and return headers.

Fittings shall be installed which will provide for the filling and draining of collector (silicone loop). The circulating pump shall be capable of being replaced without the need for draining the entire loop. Fittings shall be installed in the preheat tank (water) loop which will allow for segregation of the solar energy system from the conventional domestic hot water tank without interruption in the supply of hot water to the residence.

Pipe hangers and supports shall be installed in accordance with local code requirements. Insulating couplings or a dielectric flanged union shall be used between connections of dissimilar metals.

D. HEAT EXCHANGER

To ensure satisfaction of code requirements and prevent possible contamination of the domestic hot water supply, a double wall heat exchanger must be utilized. This exchanger should be installed in a well insulated or heated area not subject to freezing temperatures.

E. TANKS

The solar storage or preheat tank must have connections to facilitate the supply and return lines to the water side of the heat exchanger. In cases where only one connection is available, it will be necessary to modify the tank drain fitting to provide for a connection to the solar water loop while retaining the capability for draining the storage tank. The preheat tank should be installed in a well insulated or heated area not subject to freezing temperatures.

F. 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 120 VAC 60 Hz disconnect switch. 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 run in solid conduit.

5.3 MISCELLANEOUS

A. MAINTENANCE AND REPAIR

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

B. 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.

C. INSTALLATION INSTRUCTIONS

Documentation shall be developed which will describe the inter-connecting requirements of the components installed and their interface with the building and site. This documentation, including the "as-built" drawings may be used together with the Operating, Maintenance, and Repair instructions.

6.0 OPERATION, MAINTENANCE AND REPAIR

6.1 GENERAL

Prior to acceptance of the system installation from the installation contractor, the following tests will be performed:

- Pneumatic test of the collector subsystem (silicone fluid) to 75 PSI, which pressure is in excess of twice the normal operating pressure.
- Hydrostatic test of the solar heated water storage subsystem in accordance with local code.
- Testing of operating controls to insure program sequence of operation.
- On-site and computer checkout of data acquisition sensor installation to insure proper installation and operation.
- Operational test of solar energy system to insure proper installation and sequence of operation in accordance with the design requirements.

Upon satisfactory completion of acceptance tests, the system should function with minimum maintenance.

6.2 SYSTEM OPERATION

A. Shutdown

Should it be necessary to shut down the solar energy system, all that is required is to move the switch on the Rho Sigma controller to the "OFF" position. For added safety reasons, it is recommended that the Power Disconnect switches to the circulating pumps and the controller be placed in the "OFF" position.

B. Startup

The solar energy system can be operated in either automatic or manual modes. Prior to operating in either mode, a check should be made to insure that all valves are in the proper position (open or closed), and that the Power Disconnect switches to the circulating pumps (P1 & P2) are in the "ON" position. The Power Disconnect switch to the "Controller" should also be in the "ON" position. After completing the above check, the system can be placed in the Automatic Operation mode by moving the switch on the Rho Sigma Controller unit to the "AUTO" position. The solar energy system can also be operated in the manual mode by placing the switch on the Rho Sigma Controller unit to the "ON" position. However, as this will result in continuous operation of the circulating pumps (P1 and P2), this mode of operation is not recommended except for maintenance and checkout of the system.

This system has also been equipped with a freeze protection (thermoswitch) device which will shut the system down if the temperature of the water in the water side of the heat exchanger drops below 40 F. This shut down is accomplished by removing power to the "Controller" which drops power to the circulating pumps P1 and P2. As the temperature of the water rises above 45 F, the system is automatically placed back in operation.

6.3 PREVENTATIVE MAINTENANCE

Although the system is designed for maximum reliability, it is recommended that periodic inspections be made (once per month) of the installation to insure continued safe operation of the system. Fittings and pipe insulation should be inspected for traces of silicone oil and/or water stains. Once per quarter the system should be switched to manual operation to check the operation of the pumps and continued flexibility of the controller unit. Other than replacement of the packing on valves and the circulating pump, the system should be maintenance free.

6.4 REPAIR

- o All repair work should be accomplished by qualified personnel.
- o Prior to the start of any repair the system must be shut down in accordance with the SHUT DOWN procedure outlined in SYSTEM OPERATION section of the brochure.

A. Collector Subsystem (Silicone Fluid Loop)

In the event of a leak or replacement of defective element in the silicone fluid loop it will be necessary to drain the fluid from the subsystem (except for the collector pump which is equipped with isolation valves) by opening the top port on the high point of the loop and the drain valve located on the low side of the loop. The silicone fluid should be recovered by draining into clean five-gallon containers as the fluid will be reused upon completion of repair. CAUTION: Drain only when system is cool.

Upon completion of repair, it is necessary to pneumatically test the subsystem loop (at 75 psi) to insure continued safe operation of the system.

The collector loop can then be recharged by pumping the silicone fluid into the system through the fill port connection with the top port on the top of the system open. The collector circulating pump should be run briefly after filling to remove any trapped air; then add additional fluid, if necessary, and close the fill and top ports tightly.

B. Solar Heated Water Storage Subsystem (Water Loop)

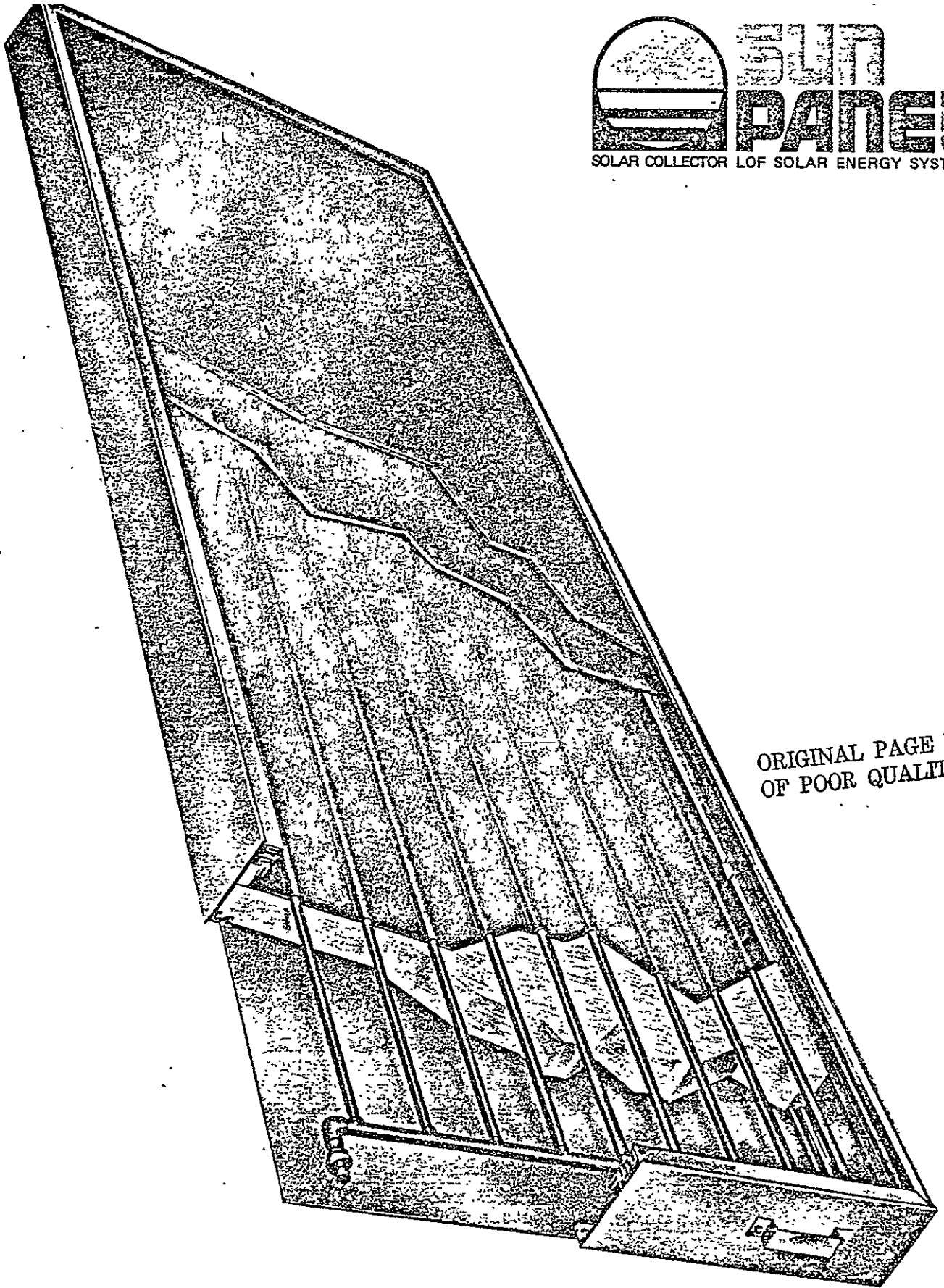
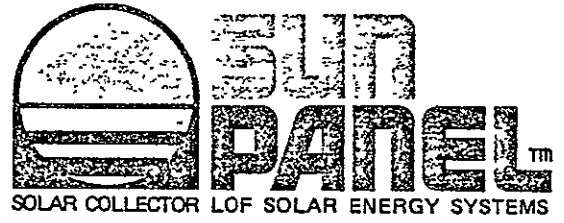
To repair a leak or faulty component of the water storage subsystem, the following procedure should be followed:

- (1) Shut system down in accordance with procedure outlined in the System Operation Section.
- (2) Close water supply valve to water storage tank and the valve between the water preheat tank and the domestic hot water tank.
- (3) Open cold water supply valve to domestic hot water tank to provide for continued operation of the conventional domestic hot water supply system.
- (4) Drain the solar heated water storage loop by opening the drain valve on the bottom of the water preheat tank.
- (5) Replacement of the circulating pump can be accomplished without draining the loop; simply close the isolation valves located in the flange on each side of the pump, disconnect the pump and replace with a new unit.
- (6) Upon completion of repair the subsystem can be recharged by closing the drain valve, opening the water supply valve to the preheat storage tank and the domestic hot water tank, and closing the supply valve to the domestic hot water tank. To purge the subsystem of air, it will be necessary to open a hot water tap within the residence.

APPENDIX A

MAJOR COMPONENT VENDOR DATA BROCHURES

NOT REPRODUCIBLE

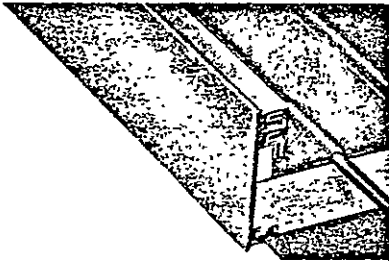


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Features

High-Performance Materials Throughout

Internal temperatures up to 400°F. can occur with no-flow conditions on a sunny day. All materials used in a solar collector must have high performance characteristics to withstand these extreme temperatures. Ordinary materials at high temperatures may break down and emit gases, which will gradually coat the inside of the glass cover plates, reducing their transmittance and the operating efficiency of the collector. The SunPanel collector materials have been chosen or treated to prevent offgasing, even at internal temperatures up to 400°F.

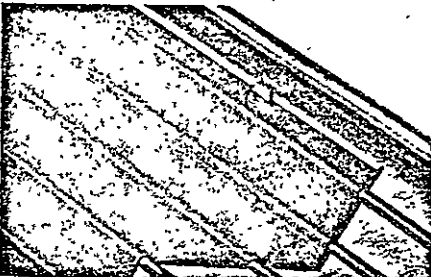


Aluminum Housing

Heavily ribbed extruded frame construction gives the SunPanel solar collector sufficient strength to be used as part of the actual roof. Top and bottom panels are sealed against the elements, yet can be removed if necessary. Insulated support of absorber plate and cover plates minimizes heat loss through the frame. Aluminum frame and bottom cover protect against rust staining.

All-Copper Absorber Plate

For long term reliability and good performance, copper is without equal. Its heat transfer characteristic is twice that of aluminum, and eight-times that of steel. With excellent corrosion resistance, copper tubing has been used in domestic and commercial plumbing systems for decades.



Fluid Tubing Integral With Absorber Plate

An all-copper liquid system is soldered to the embossed copper absorber plate for maximum heat transfer. A parallel tube pattern provides uniform flow through each panel, and the panels can be connected in either series or parallel arrangements. Inlet and outlet connections are in the same plane as the absorber plate, to prevent vapor blocks and fluid entrapment. The SunPanel collector is designed for an average flow of 0.5 gallons per minute, with pressures up to 100 psi. Pressure drop at this flow is less than 0.5 psi, with a 50% glycol-water solution at 140°F.



Insulation

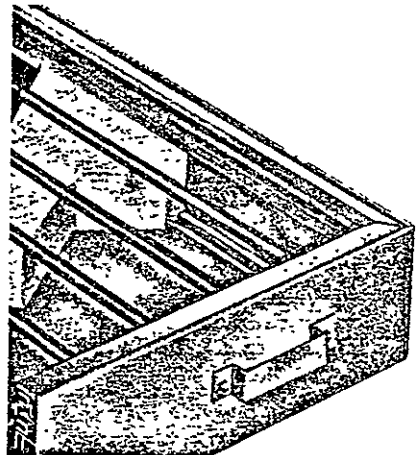
Three inches of treated fiber glass insulation under the absorber plate, and a special side insulation keep the heat where it belongs, both for minimum loss from the system, and protection of building interior when the SunPanel solar collector functions as a roof component. Fiber glass insulation meets all fire codes.

Tempered Glass Cover Plates

Tempered glass is impervious to the ultraviolet rays of the sun, and retains its strength even when exposed to the high temperatures generated inside the collector. Two layers of glass, with an air space between them, give superior thermal insulation, retaining heat in cool ambient situations.

Integral Mounting Supports

Permanently attached mounting supports simplify handling of SunPanel during shipping and installation, then function as brackets for attaching the collector to its framing.



Fluid Connections

Inlet and outlet connections are $\frac{1}{2}$ " male NPTF. Optional flexible connections, with custom-designed Aeroquip hoses, made of Teflon with stainless steel braided covers, are available.

Vented for Moisture Relief

Desiccants are not required with the SunPanel collector design. Pressure equalization passages eliminate condensation, even during idle periods. Any moisture that might collect will be dissipated rapidly during collector operation.

Flat Plate Design

Research shows a flat plate collector provides high overall heat collection with direct and diffuse light, and it need not be critically oriented in relation to the sun. Motor drives and rotation mechanisms are not required for high performance.

Collector Installation



13.25/Li

Mounting

SunPanel collector is 36" x 84" in size, and requires a nominal 5" wide space at the top and bottom, for mounting, pipe fittings and pipe insulation. Allow 1/8" - 1/4" clearance between side-by-side panels for thermal expansion. In designing layout, provide for collector servicing, including removal and replacement of individual collectors if required. Cover glass may be replaced without removing entire panel.

Position panels with vent opening at bottom. For adequate draining, collectors must be tilted at least 5 degrees from horizontal, with the short side level.

SunPanel is designed to be supported from the four mounting brackets, permitting a variety of mounting arrangements without disturbing the watertight integrity of the collector housing. However, direct contact of the collector housing with dissimilar metals must be avoided to prevent galvanic corrosion.

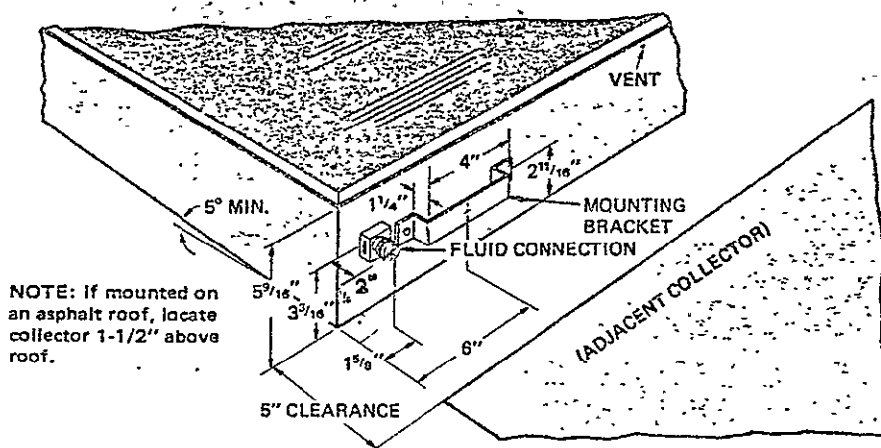
If the panel is mounted on an asphalt roof, support it a minimum of 1-1/2" above the surface to allow water runoff. The collector can become an integral part of the roof. The collector must be supported by the roof framing. An asphalt roof surface is not intended for structural support due to asphalt's softening characteristics during warm weather.

For other types of roofing consult specific roofing manufacturers.

Piping

SunPanel collectors can be connected in series or parallel arrangements. Follow good piping practice, with connections to be as short and direct as possible, and also allow for pipe expansion and contraction. Include balancing valves in multiple panel circuits to permit equalization of flow through each collector. Provide air vents at high points in the piping system, and include an expansion tank in any closed loop system. Insulate all piping to minimize heat loss and to improve system performance.

Select pumps, valves and heat exchangers to be compatible with heat transfer fluid or antifreeze to be used in system. Isolate dissimilar metals in system to prevent galvanic action.



NOTE: If mounted on an asphalt roof, locate collector 1-1/2" above roof.

Handling

Store SunPanel collectors in a dry, protected place prior to installation, and handle with care. The cover plates are fully tempered glass which is resistant to some impact loads. However, they can be broken by mishandling.

If a cover glass is broken, replacements are available for immediate shipping. To replace the glass, cut the caulking beads around the edge of the frame. Release the glass retaining member from the frame with a thin screwdriver. The lower glass is held in place with a spacer, which can be lifted out. Be sure the glass support gasket is smooth, clean and flat before replacing retainers. Recaulk around the glass with LOF recommended glazing material, along the raised edge of the frame, and along the diagonal seams at the corners.

Protect the collectors during construction activity in the area. Sparks from welding operations can damage the glass and the aluminum housing. Run-off from alkaline materials or oxidizing steel, if allowed to remain on the collector surfaces, can cause stains. It may be necessary to clean the panels frequently during construction and for a period after completion. Dirt, dust and deposits will reduce collector performance.

Usually during normal operation the collector panels are self-cleaning through rain and wind. In especially dusty locations, however, they may require periodic inspection and cleaning to retain high performance.

Caution: Before handling or cleaning collectors that have been exposed to sunlight, make sure they are not too hot to touch. Glass and metal surfaces

above 150 degrees F. will burn unprotected skin.

Support Structure

Support structure for ground or roof installation must be properly anchored. Ground collector supports must extend below the frost line. All supports must be designed to structurally support the collectors and resist design snow and wind loads.

The structural design of the support structure should be sufficient to prevent deflection, racking or twisting of the individual collectors for dead and live loads. Local building codes must be consulted to determine the design snow and wind loads. If the collectors are to be installed on or near large buildings or other geographical features which may have unusual shapes and affect the normal wind velocity, additional design factors may be required.

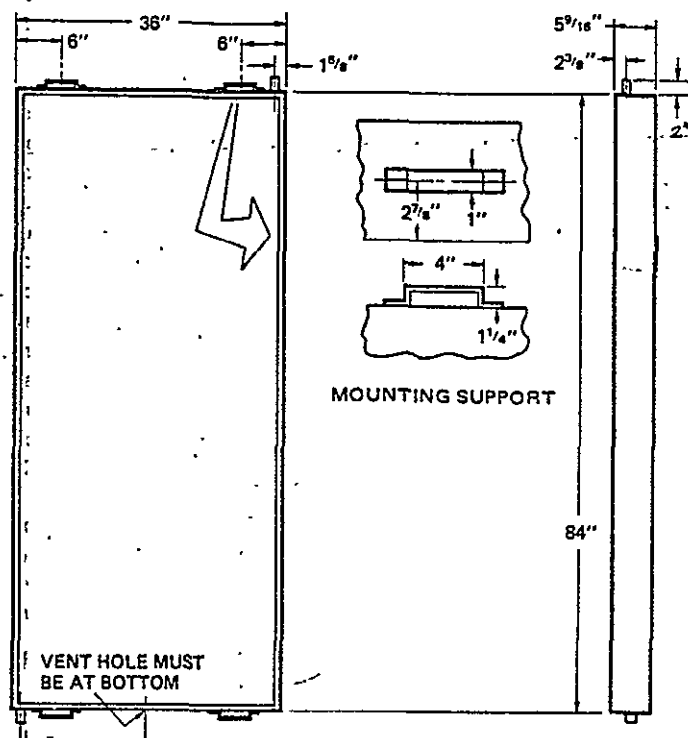
Any support system used should be designed to last the life of the collectors, and should be constructed or treated so it will not rust or cause staining of adjacent materials. The system should also be materially compatible with the collector housing.

The mounting and tie-down system for support racks can be accomplished by the four (4) mounting brackets which are also used as handles during installation. (See illustration.)

Support hardware is available for pitched roofs, to allow mounting the collectors at the roof pitch or various angles.

Further detailed installation information is available in our Solar Collector Installation brochure, SF 3-76

Dimensions



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Specifications

Cover glass (2) (fully tempered)	- 1/8" TUF-FLEX® tempered safety glass
Exposed absorber plate area	- 19.47 sq. ft.
Absorber plate	- all copper
Heat transfer fluid-system	- all copper
Frame and back panel	- aluminum
Back insulation	- 3" treated fiber glass
Recommended fluid flow rate	- 0.5 gpm
Pressure drop at recom. flow (glycol/water)	- 0.5 psi
Design pressure	- 100 psi
Test pressure	- 200 psi
Burst pressure (calculated)	- 450 psi
No-flow protection required	- none
Maximum internal temperature (no-flow)	- 450° F
Performance test specification	- NBSIR 74-635
Environmental conditions	- -40° F. to +120° F.
Maximum wind or snow load	- 30#/SF
Fluid connections	- 1/2" male NPT
Installation orientation	- short side horizontal
Min. tilt angle to allow complete draining of panel	- 5° (from horizontal)
Maximum tilt	- 90°
Mounting	- 4-point, on brackets
Panel weight (filled)	- 150 lbs.
Installed load	- 7.5#/SF
Shipping weight	- 160 lbs.

Warranty

We warrant that our SunPanel™ solar collector panel will meet our published specifications and will be free of defects in the material and workmanship for a period of one year from the date of manufacture. This warranty shall not apply to solar collectors which have not been handled, installed, or used in accordance with our published instructions, or to the replacement parts or panels beyond the warranty period applicable to the original solar panels. Our liability under this warranty shall be limited to replacement of the material, FOB, the shipping point nearest the installation, or at our option to refund the purchase price, and we shall not be liable for cost of removal or installation of or any consequential damages or other damages in connection with such collector panel.

We make no warranty of merchantability, no warranty that SunPanel is fit for any particular purpose or use and no other warranty is expressed or implied.

Applications

The SunPanel solar collector is designed to generate heat energy from sunlight, in systems operating at temperatures over 200° F. The actual amount of heat which can be produced depends upon geographic location, season and climatic conditions, sun angle and panel orientation, and system variables such as the specific heat value of the heat transfer fluid, fluid inlet temperature and rate of flow through the collector.

The applications described below represent typical systems using SunPanel collectors. Specific applications should be designed with the help of a professional heating engineer, using data and recommendations from the following pages.

Pump Control

LOF will mount a specified temperature sensor to the absorber plate with 12 inch leads through the housing as an optional accessory.

Hot Water Application

A very simple system in which the hot water supply for the household is heated through a heat exchanger from the solar collectors on the roof. Operation of the pump is controlled by a thermostat, stopping circulation of heat transfer fluid when the water in the tank reaches the desired temperature, or when the temperature of the collectors drops below that of the stored water. A back-up heating element can be installed in the storage tank if necessary.

If freezing temperatures occur, an antifreeze solution is recommended for the heat transfer fluid circulating through the collectors. Local codes should be consulted concerning the type of heat exchanger to be used with antifreeze solutions.

Combination Heating and Hot Water Application

This system contains an additional heat exchanger, a storage tank with a closed liquid circuit to a coil in the plenum of the furnace, and a separate hot water heater.

Stone or glass lined steel tank with fiberglass insulation

Water temperature adjustable from 120° to 180°

Easy to install—factory wired and piped—requires no chimney connection

Corrosion proof bronze circulator

Sparkling enamel jacket—easy to keep clean

SPECIFICATIONS

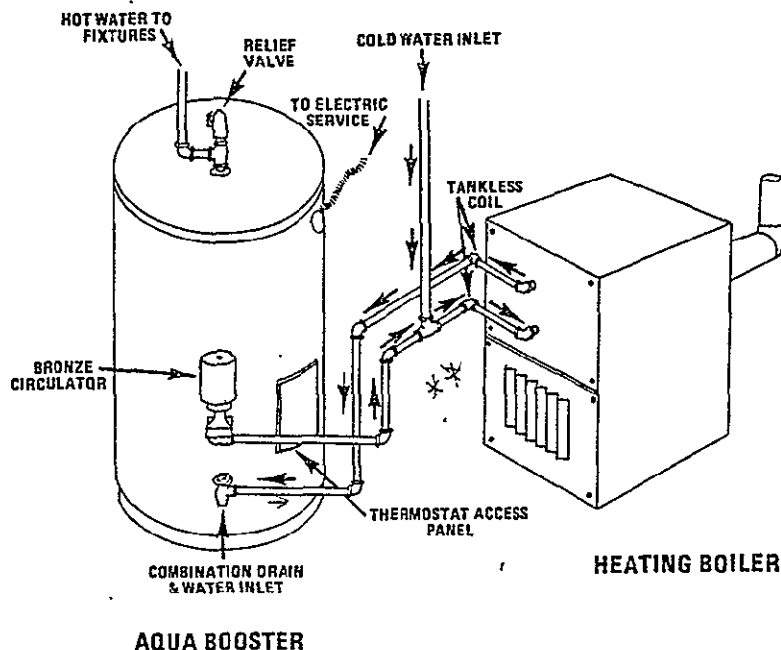
STONE LINED MODELS 10 YEAR STRAIGHT GUARANTEE (Do Not Require Anode)

Model	AB40S	AB65S	AB80S	AB120S
Capacity Gallons	40	65	80	120
Height	53½"	55½"	69½"	68"
Overall Diameter	20"	24"	24"	28"
Floor to Drain	6½"	7½"	7½"	7½"
Circ. Disch. to Floor	12½"	13½"	13½"	13½"
Max. Width	27"	31"	31"	35"
Water Connections	¾"	¾"	¾"	¾"
Weight, Lbs.	230	340	400	510

GLASS LINED MODELS 5 YEAR STRAIGHT GUARANTEE

Model	AB30GM	AB40GM
Capacity Gallons	30	40
Height	50"	60"
Overall Diameter	16"	16"
Floor to Drain	6"	6"
Circ. Disch. to Floor	12"	12"
Max. Width	23"	23"
Water Connections	¾"	¾"
Weight, Lbs.	100	115

IMPORTANT: INSTALL WITH RELIEF VALVE



The Ford Aqua Booster is a reserve storage tank that uses the present boiler and burner to supply abundant hot water. It hooks up to the tankless coil of a boiler and stores 30 to 120 gallons (depending on tank size) of constant temperature hot water.

The Aqua Booster solves one of your toughest customer complaints: not enough hot water from an undersized boiler coil.

Commercial accounts and other high-volume hot water users are also prospects.

LIBERAL WARRANTY

A new storage tank; including the casing, but less the circulating pump, will be furnished if tank leakage occurs within five years on glass-lined models and within ten years on stone-lined models. Unit must be installed with a relief valve. All other parts are covered under one year warranty. Labor, freight or delivery charges are not included.

FORD
products
corporation


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

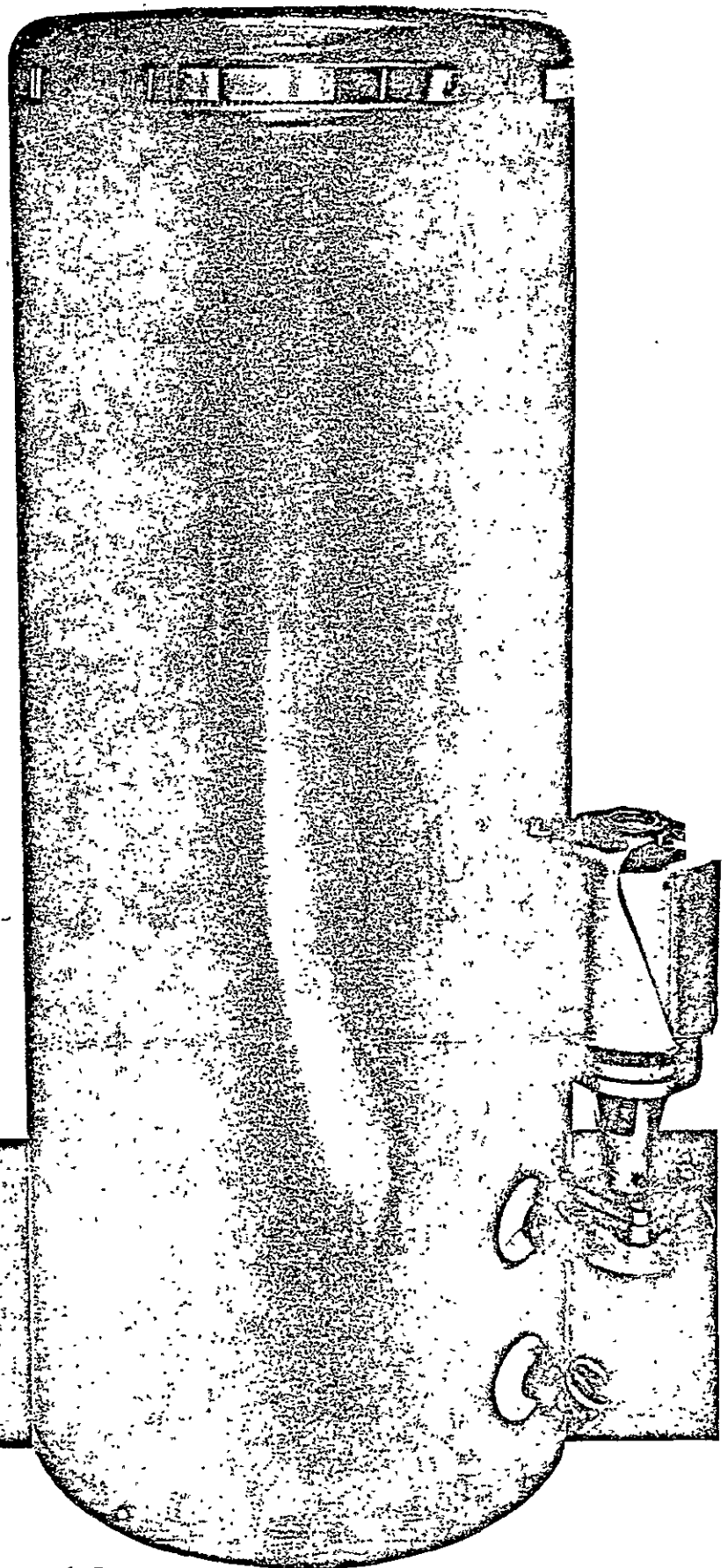
PRODUCT EXCELLENCE AQUA BOOSTERS AQUA COILS FURNACES AND WATER HEATERS

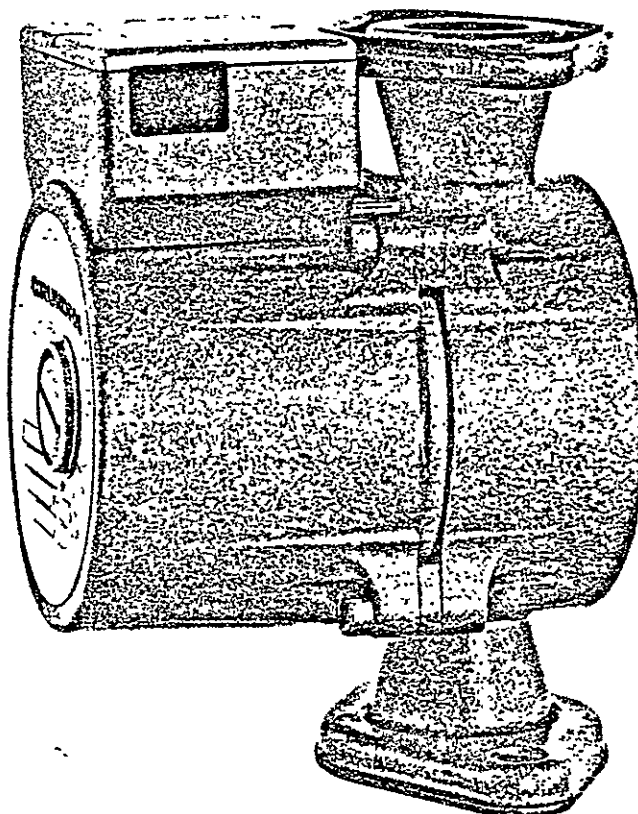
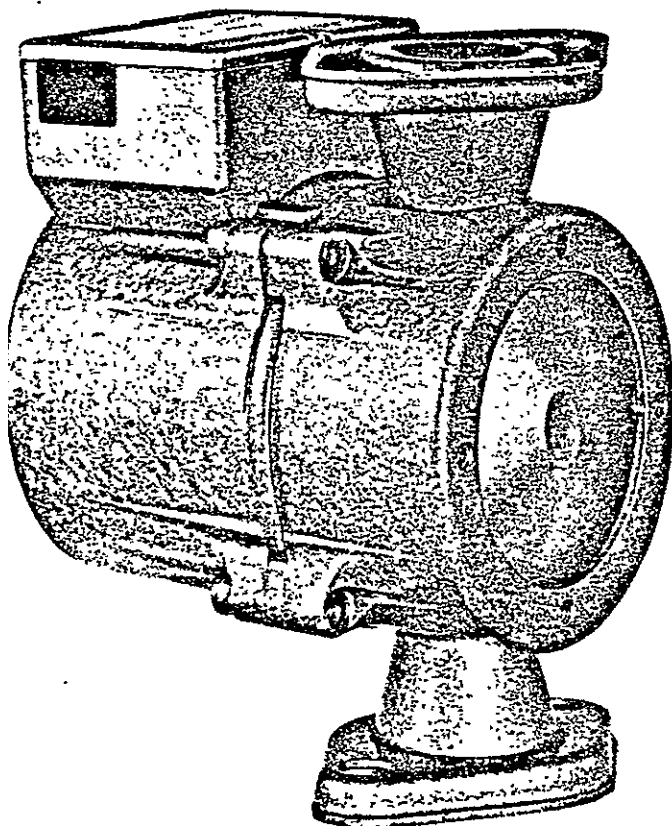
FORD AQUA BOOSTER

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An Economical
Reserve Hot
Water Storage
Tank from

 **FORD**
products
corporation





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.

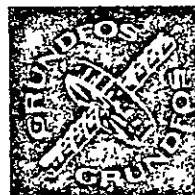
Ethylene/propylene rubber: O-rings, gasket.

Silicon rubber: Winding Protection.

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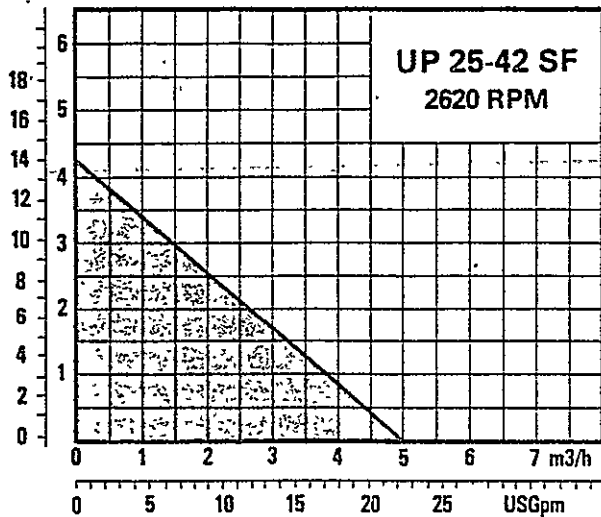
APPLICATIONS

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

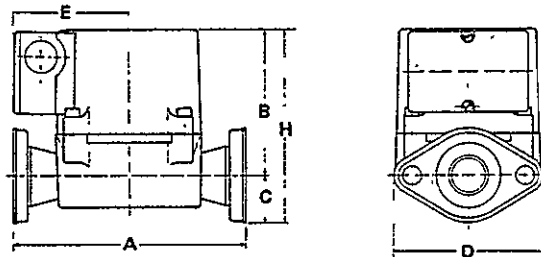
Feet head
Meter head



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

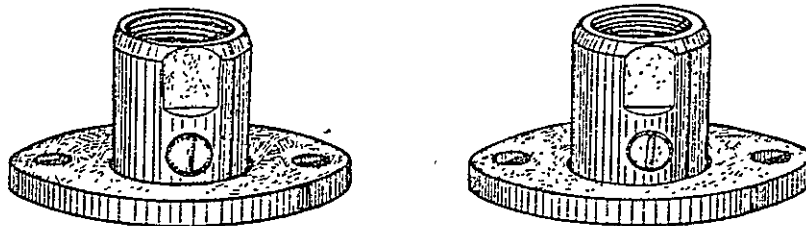


Type	A mm inches	B mm inches	C mm inches	D mm inches	E mm inches	H mm inches	Packing 1xwxh mm/"	Ship. vol. m3 Cbft.	Weight Kg Lbs.
UP 25-42 SF (w/flanges)	165 6 1/2	109.5 3 3/4	33.5 1 1/3	106 4 1/4	82 3 1/4	129 5 1/8	200 x 180 x 160 7 7/8 x 7 x 6 1/4	0.005 1/5	3 6 1/2

ISOLATION VALVES

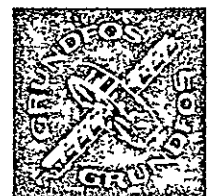
GRUNDFOS recommends the use of isolation valves with circulation pumps in all systems.

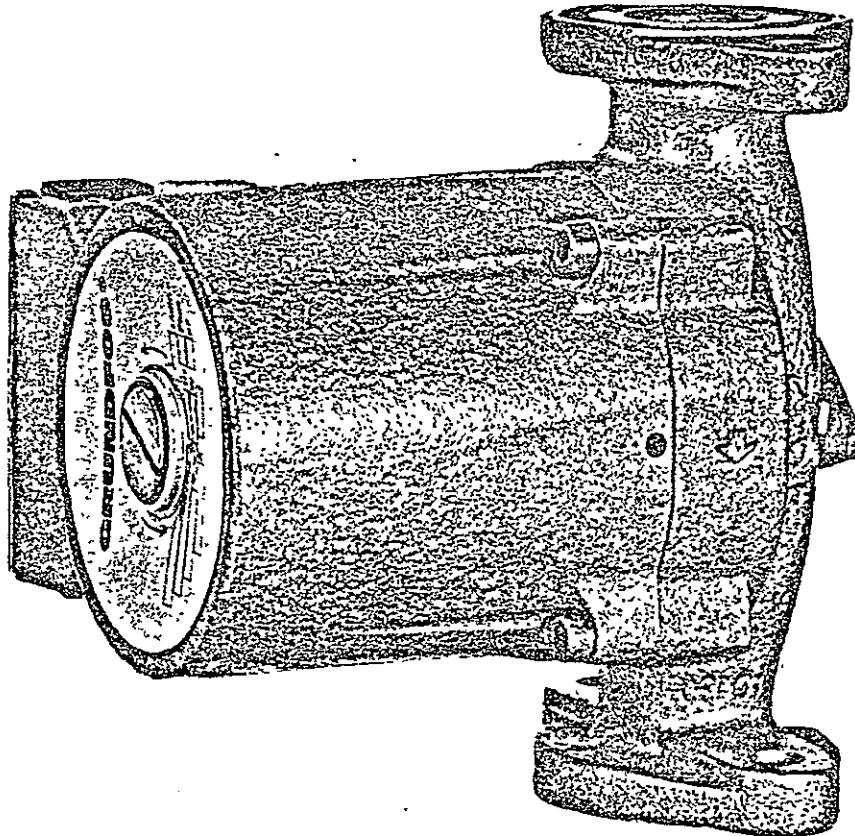
Flange Isolation Valve



ORDER NUMBERS

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





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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.

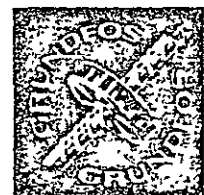
The pump's "diamond-hard" aluminum oxide bearing construction, combined with the high starting torque of the motor, ensures re-start after shutdown.

MATERIALS

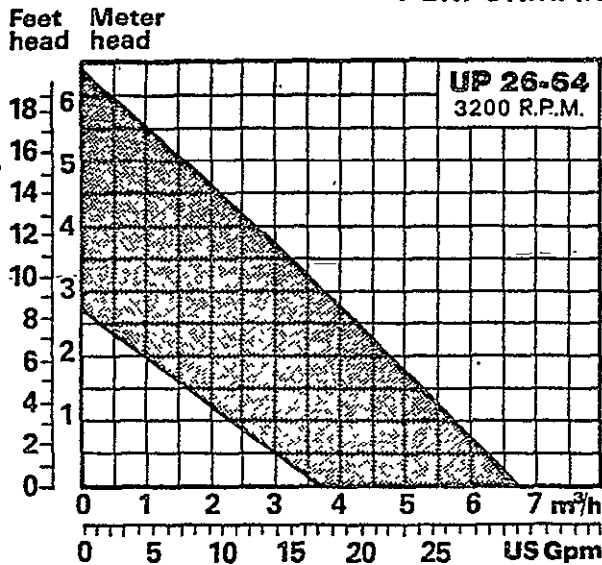
Stainless steel:	Rotor can, shaft, rotor cladding, bearing plate, impeller, variable flow adjustment plate, thrust bearing cover.
Aluminum oxide:	Top bearing, shaft ends, bottom bearing.
Carbon/aluminum oxide:	Thrust bearing.
Cast iron	Pump housing.
Ethylene/propylene rubber:	O-rings, gasket.
Silicon rubber:	Winding Protection.

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

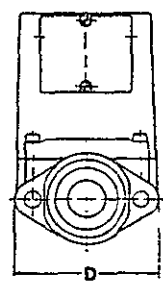
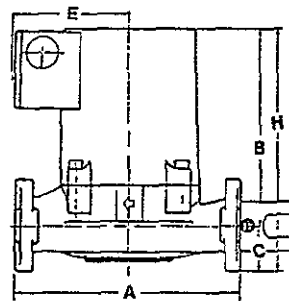
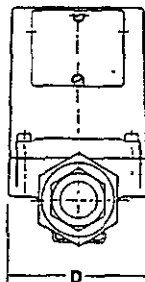
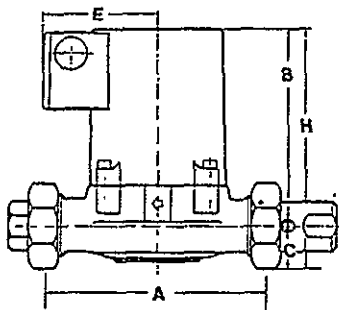
The UP 26-64 is operated by an energy-conserving 1/12th HP (1.65amp) motor, which has built-in overload protection. However, because of its advanced design, the pump produces heads from 8 to 20 feet or flows from 16 to 30 GPM. The pump's small size and high efficiency make it suitable for many varied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

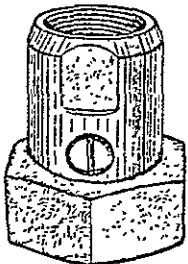
UP 26-64 F



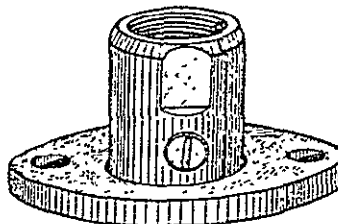
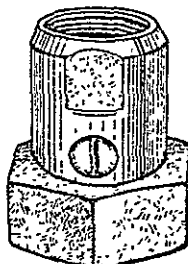
Type	A mm inches	B mm inches	C mm inches	D mm inches	E mm inches	H mm inches	Packing 1xwxh mm/"	Ship. vol. M ³ Cbf.	Weight kg Lbs.
UP 26-64U with unions	180 7 1/16	236 9 1/4	32 1 1/4	102 4 1/8	80 3 3/16	165 6 1/2	195 x 200 x 200 7 3/4 x 7 7/8 x 7 7/8	0.008 1/4	5.5 12 1/8
UP 26-64F with flanges	165 6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

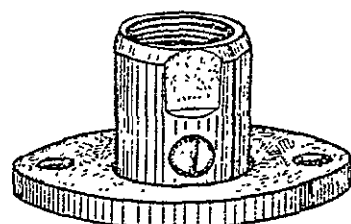
GRUNDFOS recommends the use of isolation valves with circulation pumps in all systems.



Union Isolation Valve



Flange Isolation Valve



ORDER NUMBERS

Type	Order No.	Unions		Flanges		Flange Valves Union Valves	
		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





SILICONE HEAT TRANSFER LIQUIDS FOR SOLAR INDUSTRY APPLICATIONS

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DOW CORNING® Q2-1132 SILICONE HEAT TRANSFER LIQUID

Description

Dow Corning® Q2-1132 Silicone Heat Transfer Liquid is a water clear liquid having a viscosity of 20 centistokes (77°F). It is fluid from -50°F to 600°F, exhibits heat stability, oxidation resistance, very low vapor pressure and a high flash point. It is essentially noncorrosive to common engineering metals and is virtually nontoxic. This fluid has a high dielectric strength and, as such, will not promote galvanic corrosion.

Use

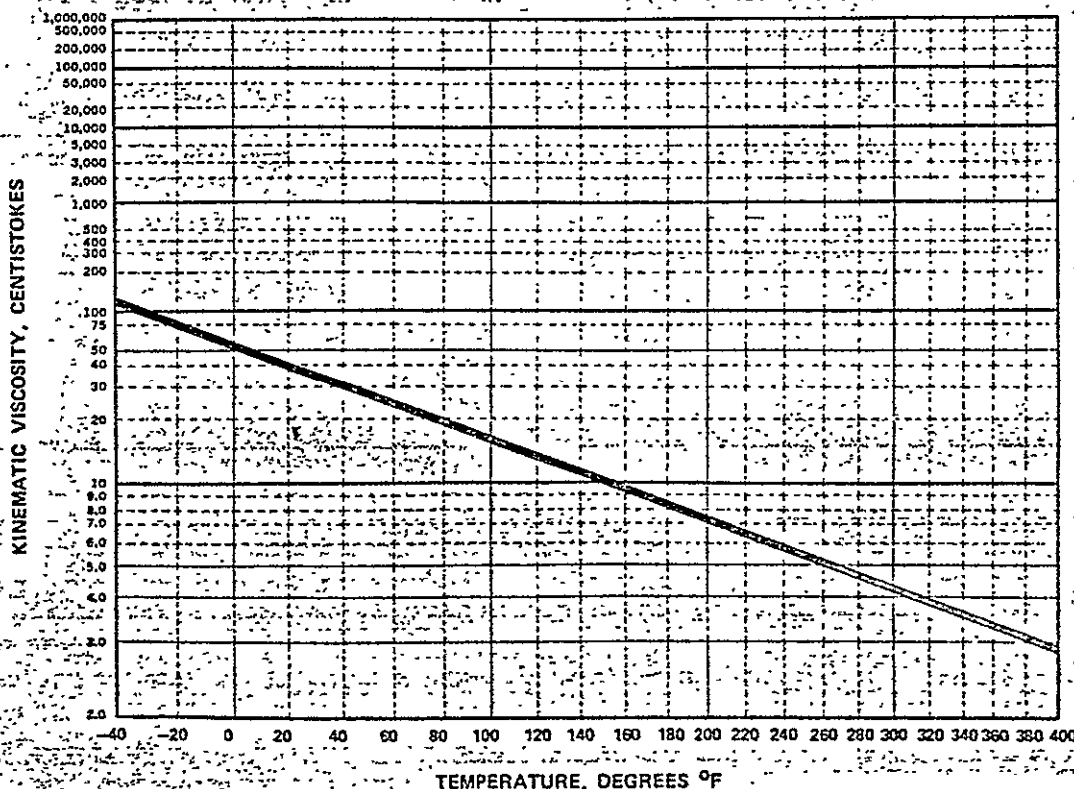
Dow Corning® Q2-1132 Silicone Heat Transfer Liquid is intended for use in the collection loop of liquid solar systems to take energy from the solar collector panels and carry it to the thermal load or thermal storage. It is intended for operation in the temperature range of -50°F to 400°F with intermittent exposure to 450°F in systems that are essentially closed.

Typical Properties

		CTM*
Flash point, open cup	450°F	0021
Fire point	500°F	0052
Viscosity, centistokes @	77°F	0004
	140°F	
	210°F	
Specific heat, BTU/lb°F @	104°F	0.37
	212°F	0.39
	392°F	0.42
Thermal conductivity BTU/hr/ft² °F/ft @	0°F	0.086
	100°F	0.083
	200°F	0.080
Density @	77°F	0.946
	140°F	0.918
	180°F	0.898
	220°F	0.880
	300°F	0.842
Pour point	-121°F	0133
Coefficient of Expansion, cc/cc°C		0.00107
Vapor pressure, 400°F, mm.Hg.	5.0	0803

*Corporate Test Methods.

VISCOSITY TEMPERATURE CHART*
FOR DOW CORNING Q-2-1132 SILICONE HEAT TRANSFER FLUID



*Data collected using Dow Corning CTM 004

Solar System Design Considerations

Physical Properties

The relatively flat temperature-viscosity slope for Dow Corning® Q2-1132 Silicone Heat Transfer Liquid allows for the fluid to be pumped at -50°F and it generates essentially no vapor pressure at 400°F. This obviates the need for freeze protection through system draining procedures. The low vapor pressure allows for a simple closed loop design with no provisions for stagnation conditions. When the system load and storage capacity have been satisfied, the solar panels simply sit with the fluid in them. Compared to solar systems using other fluid this can eliminate an expensive network of high temperature sensors, control valves, and "excess-heat" exhaust systems.

Fluid Stability

The thermal stability of Dow Corning® Q2-1132 Silicone Heat Transfer Liquid was studied in closed systems at 600°F and 650°F. Based on these studies and extrapolating back, the data indicates the thermal degradation in closed systems to be negligible at 400°F.

The oxidative stability of Dow Corning® Q2-1132 Silicone Heat Transfer Liquid was studied at 392°F by aging the fluid in combination with various metals including magnesium, copper, tin, aluminum and brass. After 1000 hours in essentially open systems the fluid exhibited excellent viscosity stability.

Table 1 Dow Corning® Q2-1132 Silicone Heat Transfer Liquid. Aged 1000 hr/392°F With Various Materials in Fluid.

Material	Viscosity Cs. @ 73°F	Specific Gravity	% Wt. Loss, Fluid
Control	20.0	0.962	(Not Aged)
Aluminum	23.4	0.966	5.30
Copper	22.0	0.952	4.37
Tin	28.4	0.957	1.85
Brass*	40.0	0.962	7.87
Magnesium *	40.5	0.964	0.43

* The viscosity drift after 1000 hours under these conditions is likely due to the high activity of magnesium and the zinc in the brass.

Flammability

The flash and fire points of Dow Corning® Q2-1132 Silicone Heat Transfer Liquid are 450°F and 500°F respectively and as such are above the maximum stagnation temperature of most nonconcentrating solar collectors.

Toxicity

Extensive testing has shown Dow Corning® Q2-1132 Silicone Heat Transfer Liquid to be among the least toxic chemicals available. Copies of several studies in this regard are available on request.

Corrosion Characteristics

Based on over 30 years in the manufacture of this basic silicone fluid with processing temperatures reaching 600°F, our experience indicates Dow Corning® Q2-1132 Silicone Heat Transfer Liquid is essentially noncorrosive to common engineering metals. Specific corrosion tests on this polydimethylsiloxane fluid as part of Dow Corning's brake fluid and electrical transformer fluid program further confirm the noncorrosive nature of Dow Corning® Q2-1132 Silicone Heat Transfer Liquid at temperatures as high as

392°F. Typical test results from the humidified fluid corrosion test as per SAE XJ 1705 are listed below.

Table 2 Humidified Fluid Corrosion Test

Metal	Max. Wt. Change mg/cm ²	Actual Wt. Change mg/cm ²
Tinned Iron	0.1	0.01 Bright
Aluminum	0.1	0.01 Bright
Steel	0.1	0.01 Bright
Cast Iron	0.1	0.01 Bright
Brass	0.2	0.02 Light Stain
Copper	0.2	0.02 Medium Stain

Residential Construction Materials

Preliminary testing on Dow Corning® Q2-1132 Silicone Heat Transfer Liquid was conducted to determine the effect of spills or system leaks on common materials of home construction such as roofing shingles, painted wood, asphalt floor tile and foam-backed carpet. No permanent damage was noted and normal cleaning methods are effective in clean-up.

Competitive Fluids

Any one or more of the following characteristics can be experienced with other heat transfer fluids.

Freezing	Sludge Formation
High pressure	Scale Buildup
Corrosion	Property Damage
Corrosion Inhibitor Depletion	Low Flash Point
Frequent Fluid Replacement	Periodic Maintenance
Fluid Breakdown to Tars and Acids	

Most of these shortcomings can be effectively designed for by employing more expensive metals, more sophisticated controls, pressure relief systems, and "excess-heat" exhaust hardware while requiring periodic fluid quality checks and more frequent fluid replacement.

When looking at total solar system costs, it is often the case that a simple on-off collection loop using Dow Corning® Q2-1132 Silicone Heat Transfer Liquid is the least expensive from both an initial cost and operation standpoint.

Low maintenance costs and long life further add to the cost effectiveness and reliability of a solar system utilizing Dow Corning® Q2-1132 Silicone Heat Transfer Liquid.

Field Testing

Solar systems that utilized a Dow Corning silicone heat transfer liquid have been installed and tested (ERDA contract W-7405-ENG. 36). These tests confirm the system effectiveness and stability of this fluid even under stagnation conditions.

A solar hot water system specifically designed for rapid recovery was installed in Vermont utilizing 240 ft² of solar panels with two series connected 80 gallon water tanks. This system uses Dow Corning® Q2-1132 Silicone Heat Transfer Liquid and has been in operation for over 12 months. As the residence was unoccupied for eight months of the first year, the total stagnation time is estimated at over 1000 hours. The panels are aluminum Rollbond® and no mechanical provisions are made for freezing or high temperature stagnation. To date the system is meeting all the performance expectations. Analysis of the fluid shows no degradation or breakdown.

*Rollbond is a Registered Trademark of Olin Corp.

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Over sixty residential solar hot water systems utilizing Q2-1132 silicone heat transfer fluid have been installed commercially to date. Several thousand solar hot water systems utilizing Dow Corning® Q2-1132 are expected to be installed by mid-1977. Performance data from this level of field usage can be made available to solar systems suppliers interested in supplying warrantable and cost effective residential solar systems.

Design Considerations

Dow Corning Q2-1132 Silicone Heat Transfer Liquid is designed to last for the life of your solar system. Therefore careful consideration must be given to system design, materials of construction and field installation in order to insure long lived, maintenance free operation.

Pumps

Canned hot water circulating pumps are recommended for pumping Dow Corning Q2-1132 Silicone Heat Transfer Liquid. Good field experience with Grundfos® variable head circulator pump model, UP 26-64, is available. Currently the model UP 26-64, a 1/12 H.P. size, is the largest canned pump available in the United States from Grundfos®, although models up to 3 H.P. are available in Europe. Grundfos® Pump Corporation plans to manufacture by April of 1977 additional models of 1/4, 1/2, 3/4, 1 1/2, 2 & 3 H.P. in the United States in the same canned configurations. Other manufacturer's canned pumps are expected to be suitable for Dow Corning Q2-1132 Silicone Heat Transfer Liquid pumping.

Good field experience with hot water circulating pumps using external motors is not yet available in silicone liquid solar loops. Dow Corning's Technical Service and Development Department is currently working with leading pump & packing manufacturers to test and specify the proper shaft seals and body gaskets for this application.

The sizing of the pump for the requirements of the job should be done with the help of the specific pump manufacturer. He will need to know head requirements, flow rates, and liquid properties. Dow Corning Q2-1132 has a lower specific heat than water and the flow rate must be increased by a factor of 2 to 2.5. This will increase the pumping head. The capacity of the pump will be lowered due to Q2-1132's higher viscosity.

Heat Exchangers and Tanks

Dow Corning Q2-1132 Silicone Heat Transfer Liquid can be used with copper, brass, bronze, aluminum, black iron, and galvanized tanks, tubing, and collectors. Dissimilar metals may be used in any combination within the system as Q2-1132 silicone heat transfer liquid is inert to these metals. When joining dissimilar metals, external corrosion can result under humid conditions and this should be taken into consideration.

The question is frequently asked as to whether double walled heat exchangers are needed between silicone liquids and potable water. Dow Corning feels that the systems manufacturer should make this decision and refers the

manufacturer to the publication "Toxicology of the Silicones", Publication Number 22-379.

Heat exchanger and tank sizings to meet the requirements of the job should be done with the help of the manufacturer.

Piping, Joints, Valves, Vents, and Ancillary Equipment

Common high quality plumbing and heating equipment appears to work satisfactorily with Dow Corning Q2-1132 Silicone Heat Transfer Liquid systems according to current field experience. All seals and gaskets should be chosen for high temperature operation. Viton and ethylene propylene rubbers are generally acceptable. Copper, black iron, aluminum and galvanized piping may be used. Plastic piping should be avoided. Viton and EPDM high temperature hose is generally satisfactory for flexible connections.

Mechanical Construction

Mechanical joints must be carefully made. Sweat copper joints are the most preferable as threaded joints are a potential source of leaks and should be kept to a minimum. All threaded joints should either be made with Teflon tape plus Teflon pipe dope or with Dow Corning Fluorosilicone Sealant. Standard silicone sealants cannot be used. Fluxes should be non-acidic, non-aggressive types. Gross contamination with dope and fluxes will color the fluid.

Quality mechanical construction is essential for leak prevention. After construction is completed, the system should be air pressure tested for 24 hours. The system must be clean and free of water. Upon filling, the system should be carefully purged of air.

Packaging

Dow Corning® Q2-1132 Silicone Heat Transfer Liquid is available in 55 gallon drums [440 lbs. (200 Kg.) net].

Shipping Limitations

None

Storage and Shelf Life

Dow Corning® Q2-1132 Silicone Heat Transfer Liquid has an unlimited useful life when stored at 77°F.

Warranty

This product is presently available on an introductory basis to solar original equipment manufacturers and future availability is dependent on industry acceptance.

The information and data contained herein are based on information we believe reliable. You should thoroughly test any application, and independently conclude satisfactory performance before commercialization. Suggestions of uses should not be taken as inducements to infringe any particular patent.

Specification writers, please contact Dow Corning Corporation, Midland, MI 48640, before writing specifications on this product.

For further information, contact Technical Service and Development, (517) 496-5823.

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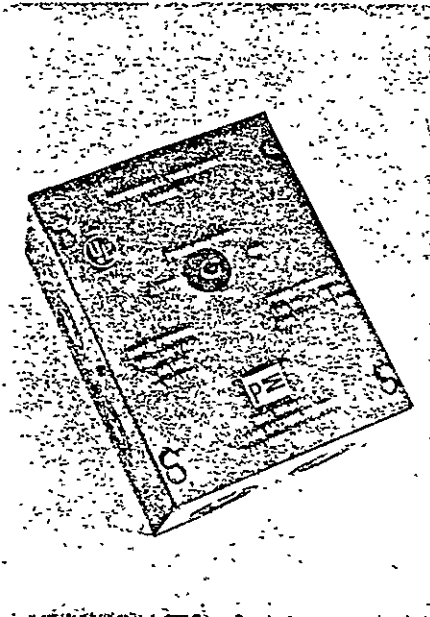
DOW CORNING CORPORATION, MIDLAND, MICHIGAN 48640

Atlanta Boston Brussels Chicago Cleveland Dallas Detroit Greensboro
Tokyo Toronto

DOW CORNING



RS 106



Differential Thermostat

Input: 120 VAC

Standard Output:

SPDT Relay rated at 10 amps.

1/3 hp at 120 VAC

1/2 hp at 240 VAC

Switch with manual ON-OFF-AUTO positions.

Relay contacts make when

$$\Delta T_{on} = T(\text{collector}) - T(\text{storage}) > 20^{\circ} \pm 3^{\circ}F$$

Relay contacts break when

$$\Delta T_{off} = T(\text{collector}) - T(\text{storage}) < 3^{\circ} \pm 1^{\circ}F$$

Housed in standard NEMA box to assure compatibility with standard electrical trade hardware.

Wiring connections made by standard electrical trade procedures.

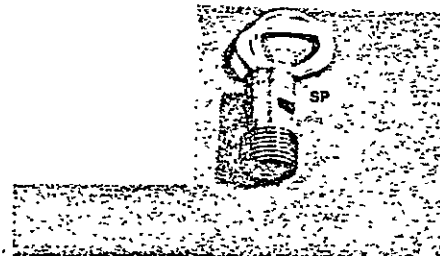
Optional outputs:

2PDT relay, 10 amp per contact.

3PDT relay, 10 amp per contact.

Factory adjustment of T on and T off can be made to customer specifications.

SENSORS



All Rho Sigma sensors are electrically identical and interchangeable and are designed to withstand stagnation temperatures of solar collectors. Two and only two sensors are required with each differential thermostat.

The SP Sensor is epoxied into a rugged brass housing with standard 1/2" pipe threads for easy installation into standard plumbing fixtures.

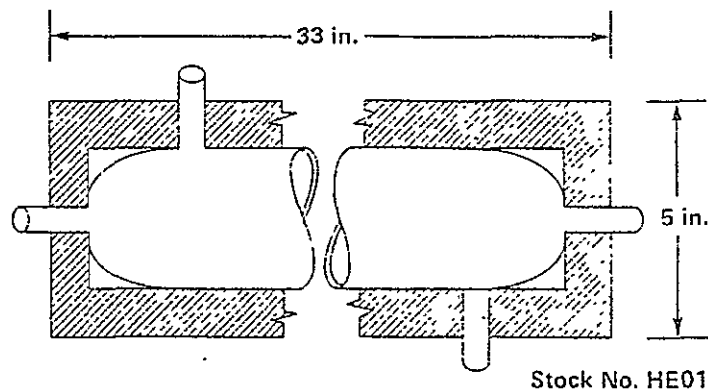
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SOLAR DOMESTIC WATER HEATER SYSTEMS

HEAT EXCHANGERS

SOLAR SHOP'S "TRANSOLATOR" MODEL HE1

- DESIGNED AND BUILT SPECIFICALLY FOR SOLAR WATER HEATING SYSTEMS
- ALL-COPPER CONSTRUCTION ENSURES CORROSION-FREE LONG LIFE AND EFFICIENT HEAT TRANSFER
- DOUBLE-WALL CONSTRUCTION PROTECTS DOMESTIC HOT WATER FROM CONTAMINATION
- LARGE SHELL SIDE HEAT TRANSFER AREA AND LOW PRESSURE DROP
- MEETS ALL U. S. PLUMBING CODES
- CONFORMS TO THE SOLAR HEATING SYSTEM INTERIM PERFORMANCE CRITERIA ESTABLISHED BY HUD AND ERDA REQUIRING DOUBLE-WALL CONSTRUCTION OF HEAT EXCHANGERS USED FOR DOMESTIC HOT WATER HEATING
- SIZED TO OPERATE EFFICIENTLY WITH UP TO 100 ft² OF SOLAR COLLECTORS
- DESIGNED FOR USE WITH VISCOUS HEAT-TRANSFER FLUIDS SUCH AS SILICONE OIL
- OPERATES EFFICIENTLY WITH WATER AND ANTIFREEZE SOLUTIONS
- ALL CONNECTIONS ARE 1/2-in. NOMINAL STANDARD COPPER TUBING (OTHER SIZES AVAILABLE UPON REQUEST)



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