



## **INSTALLATION OPERATION MAINTENANCE MANUAL**

# Direct-DPV-System Manual

Techno-Solis, Inc  
301 20th Street South  
St. Petersburg, FL 33712

Phone: (727) 823-6766  
Toll Free: (888) 99-SOLAR  
Fax: (727) 823-6768  
Email: [info@techno-solis.com](mailto:info@techno-solis.com)  
Web: [www.techno-Solis.com](http://www.techno-Solis.com)

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## INTRODUCTION

We at TSI would like to extend our congratulations on your purchase of a TSI DHW System. Years of research and development backed by critical engineering have brought you the finest solar products you can buy. Please take time to read this booklet thoroughly. Each step is outlined completely and clarified by diagrams where necessary. All questions which arise

from this material should be answered before you attempt installation of the system. With a little thought and careful planning, your TSI System can be installed quickly and easily by yourself or by a qualified plumber with a minimum of disruption to your business or home. "Conservation for today... Energy for tomorrow."

## BASIC TOOLS AND MATERIALS

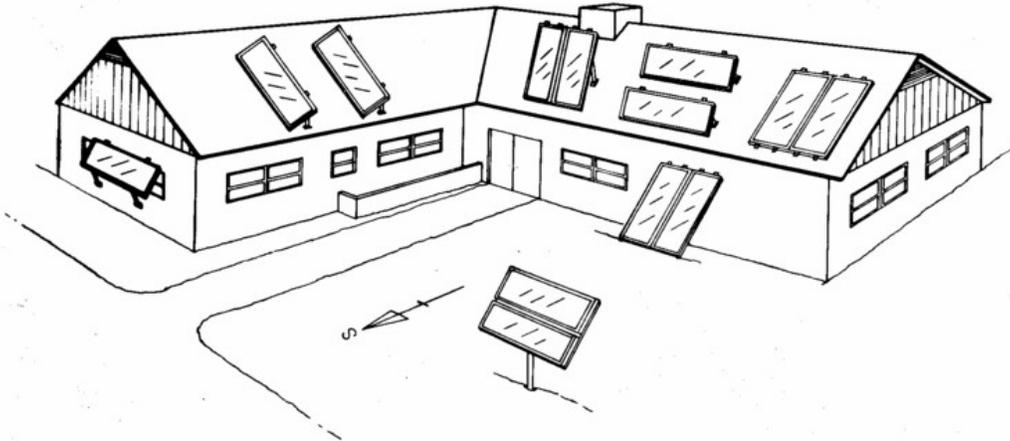
Electric Drill  
 Drill Index (w/ 1/2" and 3/4" Wood Bits)  
 Hack Saw  
 Tubing Cutter  
 Tin Snips  
 16' Tape Measure  
 24" Level  
 Flashlight  
 Extension Cord  
 Slip Joint Pliers  
 Needle Nose Pliers  
 Pipe Wrenches, 10" & 14"  
 Open End Wrenches, 9/16 & 7/16  
 Screw Driver 6" Flat Blade  
 Screw Driver 6" Philips  
 Wire Stripper or Knife  
 Wire Cutters

Adjustable Wrenches 8" & 10  
 Torch and Striker  
 100 PSI Pressure Gage  
 Putty Knife  
 High Temperature Pipe Joint Compound  
 Wire Nuts or Connectors  
 Miscellaneous Copper Pipe & Fittings (3/4")  
 Solder Flux  
 Emory Paper  
 Silicon Caulk and Roof Tar  
 1/2" I.D. Copper Tubing & Installation  
 Angle Iron  
 Threaded Rod, Nuts, & Washers  
 Stainless Screw Clamps  
 Thermal Adhesive  
 Aluminum Flashing Sheet

## 1. COLLECTOR LOCATION

Proper location and orientation of the solar collectors is important for maximum system efficiency. The collectors should be unshaded for the middle six hours of the day in each month of the year and should be located as close to the storage tank as possible to minimize heat loss in the piping runs. The best orientation is achieved

when the collectors are facing due south and tilted at an angle from the horizontal of latitude + 10°. Figure 1 below shows many alternatives for collector mounting. When roof mounting, placing the collectors as close as possible to the peak of the roof will make installation easier due to increased attic access.

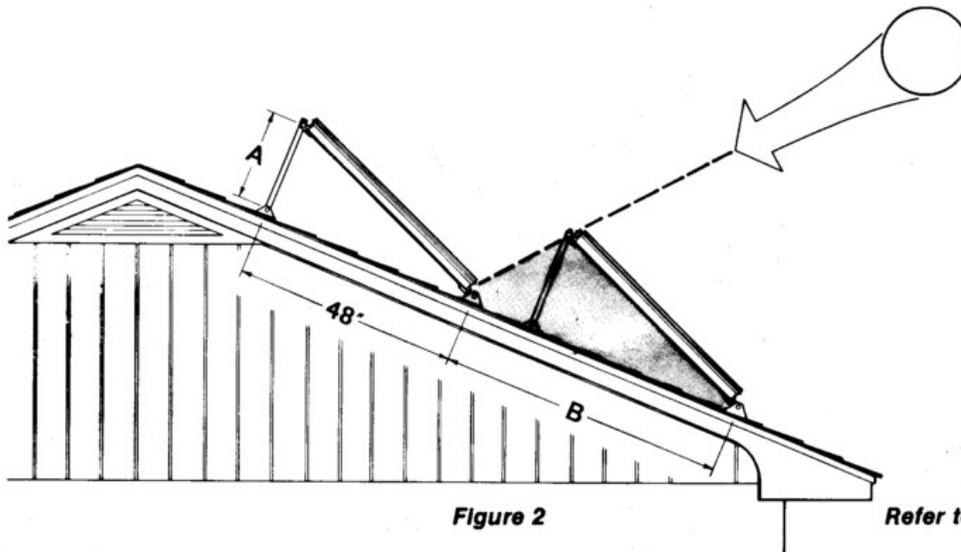


**Figure 1**

## 2. COLLECTOR ORIENTATION

Proper tilt angle for solar collectors is latitude plus 10° (see latitude map). This favors the winter sun because ambient temperatures are lower during the winter and collector efficiency suffers. This 10° additional tilt equalizes year round performance. Spacing can be determined from Table 1.

When collectors are mounted one behind the other, they are spaced apart so that in the morning and afternoon on December 21, when the sun is at its lowest altitude, the collectors will not shade each other and cause efficiency loss.



**Figure 2**

**Refer to Table 1**

LATITUDE		25° N		30° N		35° N		40° N		45° N		50° N	
COLLECTOR TILT		35°		40°		45°		50°		55°		60°	
		A	B	A	B	A	B	A	B	A	B	A	B
ROOF PITCH	FLAT	29	96	33	113	37	145	41	145	44	145	48	145
	5° 1/12	25	83	29	93	33	113	37	132	41	133	44	141
	9° 2/12	22	74	26	82	30	77	34	110	38	115	41	118
	14° 3/12	17	66	22	72	26	82	30	92	34	95	38	98
	18° 4/12	14	61	18	66	22	74	26	81	30	85	34	87
	23° 5/12	10	58	14	60	18	66	22	72	26	74	30	77
	27° 6/12	7	58	11	58	15	61	19	66	23	68	27	70
	30° 7/12	4	58	8	58	13	58	17	58	21	58	25	58
	34° 8/12	0	58	5	58	9	58	13	58	17	58	22	58
	37° 9/12	-2	58	3	58	7	58	11	58	15	58	19	58
	40° 10/12	-4	58	0	58	4	58	8	58	13	58	17	58
	43° 11/12	-7	58	-3	58	-2	58	6	58	10	58	14	58
	45° 12/12	-8	58	-4	58	0	58	4	58	8	58	13	58
	VERTICAL	-44		-41		-37		-33		-29		-25	

Table 1. All Lengths in inches

### 3. COLLECTOR DIMENSIONS

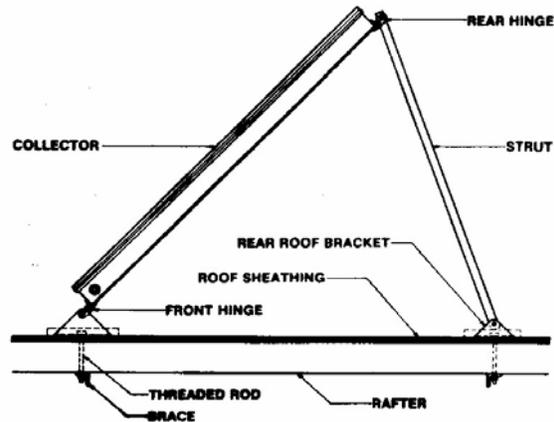
Collector	TS-21	TS-24	TS-26	TS-28	TS-32	TS-40
Gross Area (ft <sup>2</sup> )	20.87	23.81	25.35	27.97	31.91	39.79
Dimensions (in)	85¼ x 35¼	97¼ x 35¼	77¼ x 47¼	85¼ x 47¼	97¼ x 47¼	121¼ x 47¼
Transparent Area (ft <sup>2</sup> )	19.22	21.99	23.65	26.16	29.93	37.47
Weight (lb)	74	84	90	99	113	153
Tested: TUV (DIN 4757, RAPPERSWILL, ONORM M7714, FSEC, SRCC, Metropolitan Dade County, Miami Test Lab						

Table 2. Collector Dimensions for TSI DHW series

#### 4. MOUNTING HARDWARE

Provided in the TSI package is specially designed mounting hardware to speed collector installation. This hardware consists of four LOCK-TIGHT hinge sets, four roof brackets, two rear struts, and bolts (Figures 3, 4, and 5).

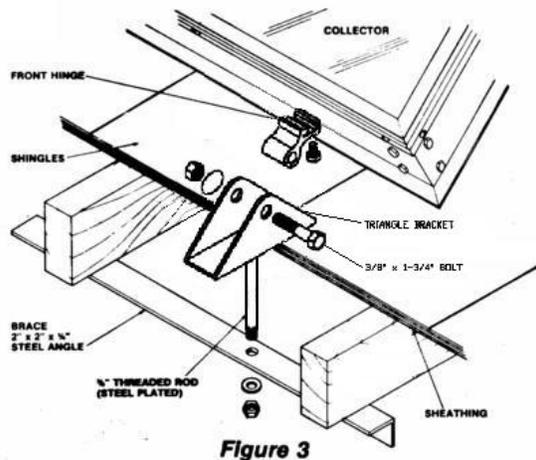
- (a) After locating the mounting points from Table 1, the mounting bracket holes should be drilled.
- (b) A heavy coating of sealant should be applied to the bottom of the flashing plate, which should fit flat against the roof. It is necessary for the plate to slide under the above shingles to insure proper drainage of water.
- (c) The bottom of the roof bracket and the area around the threaded rod should also be thoroughly coated with tar sealant. When the bracket is set in place, alignment with the collector hinges is necessary before final tightening of the nuts. This should be completed before the sealant has time to set.
- (d) The threaded rod is fastened through a 2' x 6" wood or 2" x 2" x 1/4" steel angle bracket under the roof as shown.
- (e) The rear struts should be cut and drilled to conform to Table 1. All bolts should be



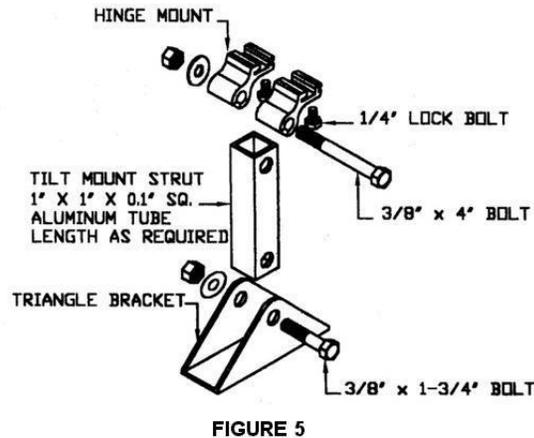
**Figure 4**

tightened securely. A stainless steel washer should be placed where the threaded rod passes through the aluminum bracket.

It is very important that the penetrations through the roof be well sealed. It should be carefully checked that all bolts are coated with tar and that no leaks are possible.



**Figure 3**



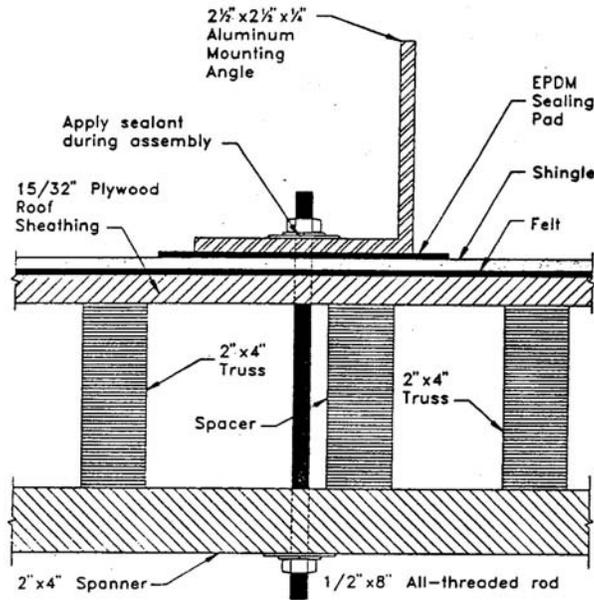
**FIGURE 5**

There are three acceptable ways to secure the collector mounting brackets to the roof.

1. Spanner Mounting
2. Lag Bolt Mounting
3. J-Bolt Mounting

In spanner mounting after the brackets are positioned on the chalk line, a 3/8" hole is drilled between the rafters. Aluminum flashing is positioned over the hole where the top of the flashing is extended up under the shingle above the 3/8" hole and extends down over it. Caulk is applied between the flashing and the roof. The bracket is then positioned over

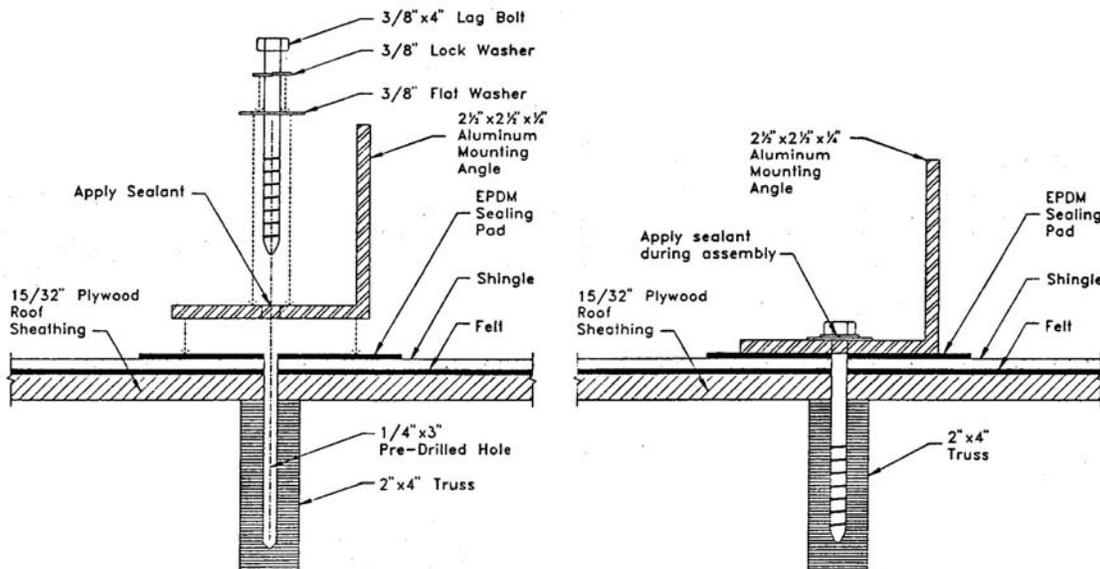
the 3/8" hole using sealant between the bracket and the flashing. A piece of 3/8" all-thread is then inserted through the hole. A washer and nut secures the all-thread to the bracket (be sure the seal underneath the washer and on top of the nut). The all-thread rod should extend about 4" below the roof rafters. Drill a 3/8" hole in a 2 x 4 and insert the all-thread rod through it. The 2 x 4 should span 2 rafters. With a washer and double bolt secure the all-thread to the 2 x 4. Tighten down until the bracket is tightly secured to the roof. Be careful not to over-tighten and bell out the roof underneath the bracket. (See Figure 6)



**Figure 6. Spanner Mounting**

In lag bolt mounting you must locate the center of the rafters along the top and bottom chalk lines. One method is to have one man on the roof and another in the attic. Using a hammer the man on the roof can tap the roof and determine where it is denser sounding. The roof man can drill a pilot hole while the attic man helps with distance corrections.

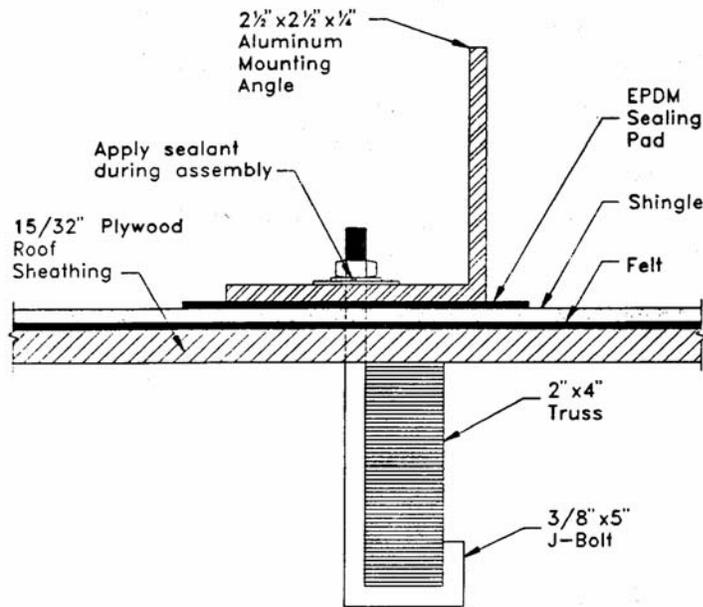
Then the attic man can call off the distance to the next rafter while the roof man drills corresponding pilot holes. Flashing the brackets is done as previously described. Secure the brackets to the roof using a 1/4" x 3" stainless lag screw, a flat washer, and a lock washer (Figure 7).



**Figure 7. Lag Bolt Mounting**

J-bolt mounting is done very similar to lag screw mounting except instead of drilling into the center of a rafter, a hole must be drilled directly beside a rafter. The size of the hole must be slightly larger than the bolt diameter. This is more easily accomplished if the attic man would drill a pilot hole through the roof along side the chosen rafter.

Fit the bolt through the mounting brackets and insert the bolt (J side first) through the hole in the roof. Work the J underneath the rafter before tightening the nut. Use double nuts or lock-washers to securely fasten the mounting bracket to the J-bolt (Figure 8).



**Figure 8. J-Bolt Mounting**

## 5. MOUNTING HARDWARE SPACING

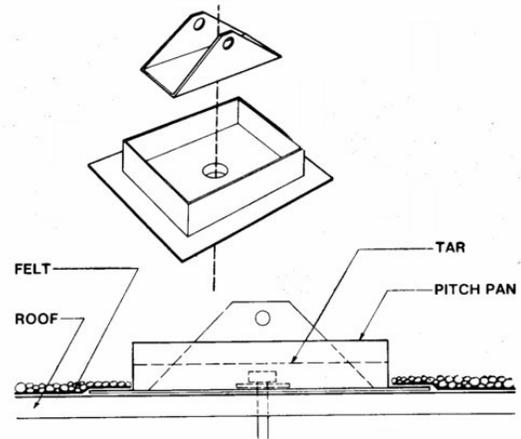
Model	Size (ft)	Outside Box Dim. (in.)	Center Line to Center Line (in.)		
			TS-MH	TS-FM	TS-RM
TS-21	3 x 7	35.1875 x 85.1875	88.4375	88.9375	88.9375
TS-24	3 x 8	35.1875 x 97.1875	100.4375	100.9375	98.9375
TS-26	4 x 6.5	47.1875 x 77.1875	80.4375	80.9375	78.9375
TS-28	4 x 7	47.1875 x 85.1875	88.4375	88.9375	86.9375
TS-32	4 x 8	47.1875 x 97.1875	100.4375	100.9375	98.9375
TS-40	4 x 10	47.1875 x 121.1875	124.4375	124.9375	122.9375

**Table 3. Distance between centerlines of top and bottom mounts for all TSI DHW series**

## 6. PITCH PAN

The pitch pan is necessary any time standing water is encountered (Figure 9). The purpose is to provide an adequate seal around any penetration in the roof.

- (a) The pitch pan is placed in the proper position and flat on the roof.
- (b) Its flange is sealed with roofing felt and hot tar.
- (c) The holes are sealed on the inside with roofing tar to a sufficient level to insure a permanent seal.



**Figure 9**

## 7. ARRAY MOUNTING

When adequate southern exposure is available on a roof of proper slope, the collectors may be mounted directly on the roof with no struts (Figure 10). This type of "array" mounting is economical, attractive, and can be installed on a roof of typical framing construction.

- (a) The location of the collectors is established and angle brackets are fastened to the roof in the same manner as the standard brackets in Figure 3.
- (b) Continuous  $2\frac{1}{2} \times 2\frac{1}{2} \times \frac{1}{4}$  aluminum angles are mounted to these brackets along the roof the full length of the collector run.

- (c) The collectors are bolted to these angles through the MH-RM mounting flange with  $\frac{3}{8}$ " bolts (one bolt per  $8\text{ ft}^2$  of collector). Twelve-foot long collectors should have a center angle support in addition to the two used with other models.

- (d) Flashing can be run at the top and bottom edges of the array to cover piping and provide a very attractive installation.

For only a few collectors in a row, consider the MH-FM hardware. (6 brackets per panel).

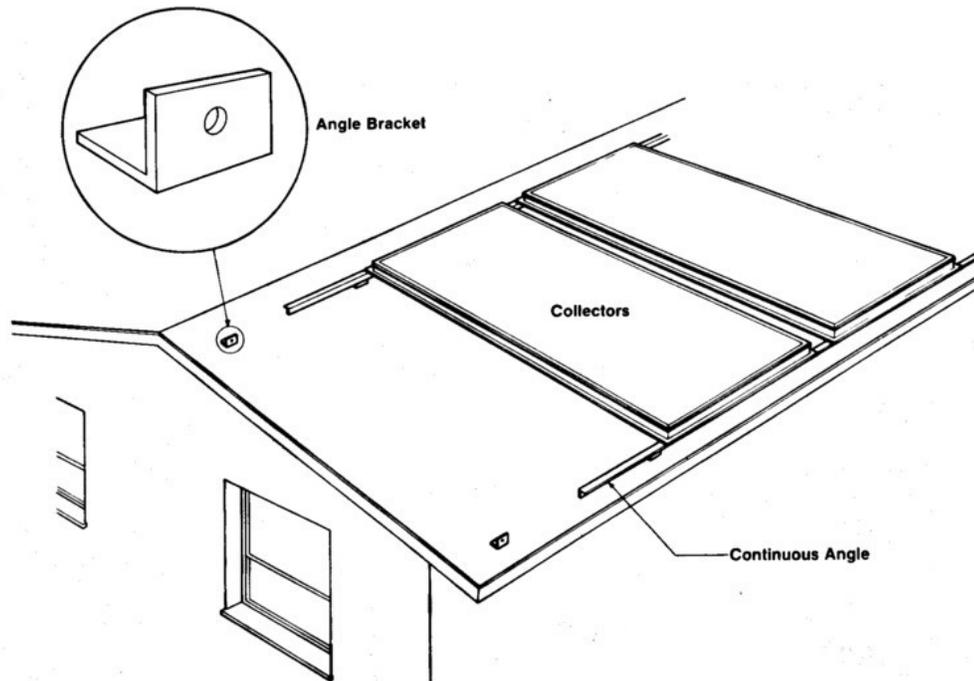


Figure 10

## 8. COLLECTOR PIPING

The piping of the system should be considered before a final decision is made on how the collectors are mounted. Piping should be made of copper tube of the type meeting local codes, insulated with Armaflex or similar, and painted or wrapped with aluminum tape where exposed to ultraviolet radiation.

Care should be taken in the spacing of collectors as attachment of piping is easiest with properly aligned collectors. The collectors and piping to the storage tank should be slightly sloped downward (3" in 8 feet) to allow draining in case of freezing conditions. Soldered connections should be made with 95/5 solder.

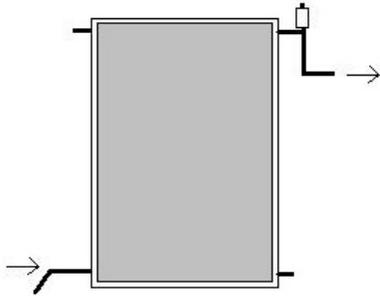


Figure 11

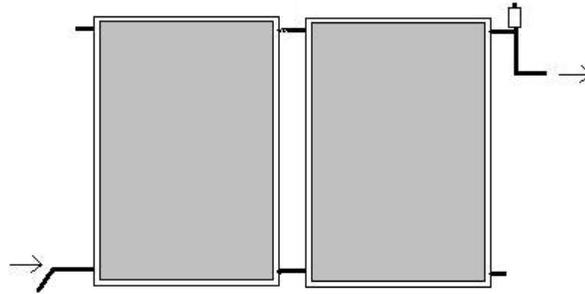


Figure 12

## 9. COLLECTOR PIPING DETAIL

The outlets of the collector are 1" copper pipe nipples (Figure 13). They should be piped as shown with provisions for an automatic air vent. This will prevent air lock and subsequent loss of system efficiency. The copper union makes attachment of piping to collector easy. Teflon tape or high temperature, high quality pipe sealant should be used when making threaded connections. The collector inlets should be piped similarly but without the automatic air vent.

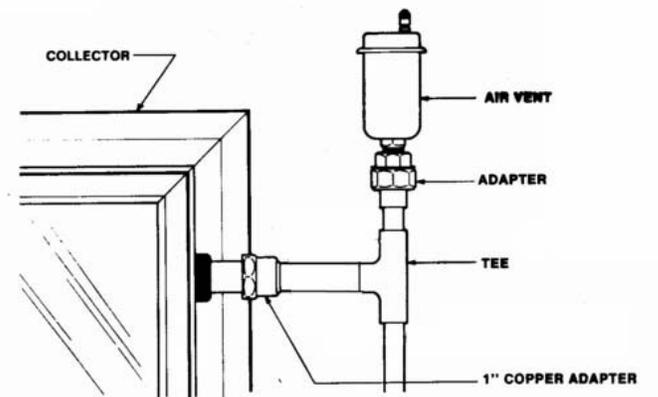


Figure 13

## 10. SENSOR MOUNTING AT COLLECTOR

The controller heat sensor is mounted to the nipple outlet of the collector (Figure 14). A stainless steel screw clamp should be used. The entire nipple should be wrapped thoroughly with insulating tape so that the sensor is isolated from the outside air. For open loop systems in freezing climates, two freeze sensors should be mounted, one at the outlet with the heat sensor, and one at the inlet as indicated. These sensors should be connected in parallel with the heat sensor. When connected to the controller, they will activate the pump when freezing conditions exist.

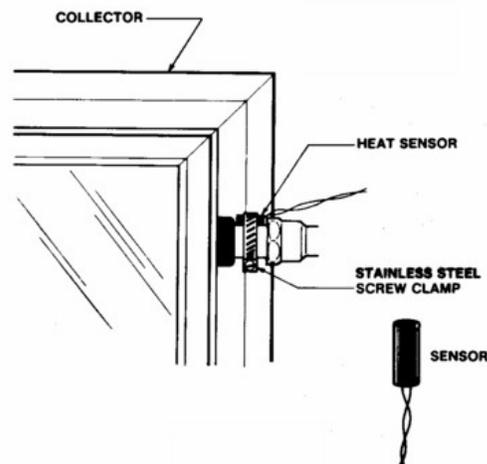


Figure 14

## 11. PIPING THROUGH THE ROOF

Piping through the roof should be weatherproofed as shown in Figure 15.

- (a) A hole is drilled in the roof large enough for the copper tube to pass through.
- (b) A standard lead flashing cover is placed around the hole with its base cemented to the roof and its upper edge slid under the adjoining shingle.
- (c) Polybutylne Adhesive is then placed on the top and bottom of the flashing and around the copper tube providing a weatherproof seal.

Sensor wiring should be placed through this penetration also. Care should be taken that the sensor wire is insulated from the hot pipe.

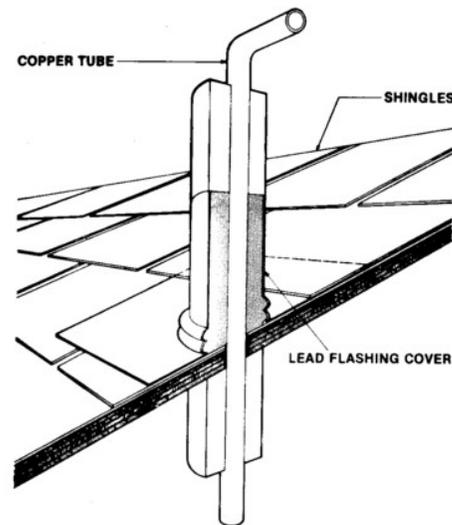


Figure 15

## 12. STORAGE TANK PLACEMENT

To minimize expense and heat loss, the tank should be placed near the collectors and central to points of greatest water demand. It should be located in as warm a spot as possible. It should be located with adequate ventilation, with a minimum of 6-8 inches of clearance and with ready access to controls and serviceable parts.

Provision should be made to prevent water damage in case of leakage. A catch pan with a minimum of  $\frac{3}{4}$ " drain line at least 2" in height may be installed and pitched for proper drainage. Electrical service of 240V should be available for the element and 110V for the pump and controller.

### 13. SENSOR MOUNTING AT STORAGE TANK

Heat sensor mounting at the storage tank is done at the lower element cover or at the cover labeled as "thermostat" (Figure 16).

- The cover should be removed and fiberglass insulation pushed aside so that the wall of the tank is accessible
- Clean the sensor mounting area and apply a thermal adhesive such as "Liquid Aluminum."
- The sensor should then be pressed into this and held in place with a strip of tape.
- The fiberglass insulation should then be placed in its original position and the cover replaced with care not to damage the sensor leads.

When the adhesive hardens a good thermal bond is achieved. (NOTE: Some tanks come with a 1/4" threaded stud and nut located at the bottom of the tank to mount the sensor.)

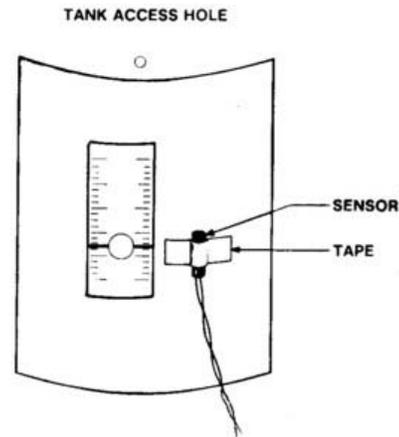


Figure 16

### 14. OPEN LOOP FLUID HANDLING SYSTEM

A TSI open loop solar water heater operates by circulating water from the storage tank to the solar collectors when the collectors are at a higher temperature than the tank. This function is controlled by a differential temperature controller

with heat sensors. When the collectors are warmer than the water inside the tank, the controller switches on the pump. (Figure 17)

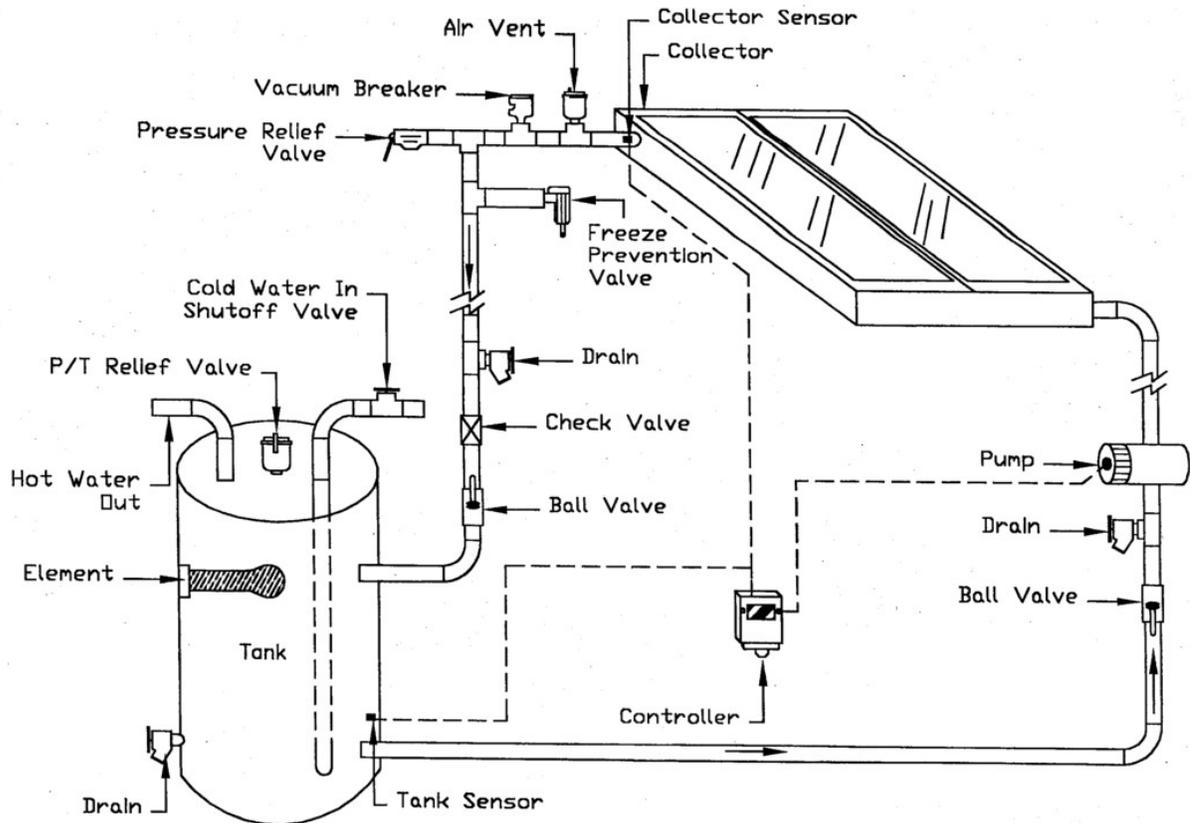


Figure 17

A recirculation feature of the controller provides freeze protection. When the frost sensors at the collector indicate freezing temperatures, the pump is switched on and warm water is circulated through the collectors until warmed. The pump is then automatically switched off. This cycle repeats periodically until freezing conditions no longer exist. When a hard freeze is imminent or a power failure occurs, the system should be drained by closing the two gate valves that isolate the collector loop and opening the two valves that allow the collectors to drain.

Automatic air vents in the top of the system prevent

air locks. Care should be taken that no air can be trapped in piping to and from the collectors. Water returns to the tank from the collectors via a drop tuber that extends halfway down the interior of the tank. This allows the returning water to stratify properly.

A check valve in the return line from the collectors prevents thermosyphon losses during the night. Temperature and pressure relief valves protect the system from damage.

A backup electric element is provided in the top of the tank to supply hot water during inclement weather. Power required is 240 volts.

## 15. OPEN LOOP DIFFERENTIAL TEMPERATURE CONTROLLER

NOTE: When instructions are provided in the controller package, follow those and disregard the following.

The open loop differential temperature controller controls the pump to gain maximum system efficiency. When one of the two heat sensors provided with the unit rises nominally  $10^{\circ}\text{F}$  above the other sensor, a power control relay is energized. Then, when the first sensor drops to within  $5^{\circ}\text{F}$  of the second sensor, the control relay remains energized holding its power contacts closed; however, when the temperature difference sensed is  $5^{\circ}\text{F}$  or less, the relay contacts open. (The  $5^{\circ}\text{F}$  value is designated as the "turn-off differential.") The first sensor is called the COLLECTOR SENSOR, since when properly installed monitors the temperature of

the water in the solar collector. The second sensor is called the STORAGE SENSOR. The frost sensors activate the relay when freezing conditions exist. Mount the controller in any position or location that is convenient and sheltered from the elements. Aesthetics and economy of running power leads should dictate the location, since there is no restriction on the length of leads to the sensors. Connections to the circuit terminal strip inside the controller enclosure should be made according to Figure 15. ALL CONNECTIONS SHOULD BE MADE WITH ACCORDANCE WITH LOCAL ELECTRICAL CODES.

### OPERATING VOLTAGE

105 to 125 vac, 60 Hertz

### CONTROL RELAY CONTACT RATING

One third HP inductive load.

### TURN-ON DIFFERENTIAL

$10^{\circ}\text{F}$  ( $+1^{\circ}\text{F}$ ) for Storage Sensor at  $135^{\circ}\text{F}$

### TURN-OFF DIFFERENTIAL

$5^{\circ}\text{F}$  ( $+1^{\circ}\text{F}$ ) for Storage Sensor at  $135^{\circ}\text{F}$

### SENSOR MATCHING ACCURACY

$1^{\circ}\text{F}$  or less at  $135^{\circ}\text{F}$

### MAXIMUM SENSOR TEMPERATURE

$300^{\circ}\text{F}$

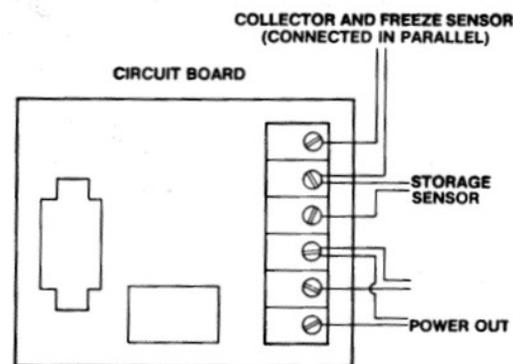


Figure 18

## 16. OPEN LOOP START-UP

After visual inspection of the complete system, it is ready for filling and pressure testing. All drain valves should be closed, all other valves opened. The air vent caps should be loosened two turns to allow air to escape the system. The cold water inlet valve should then be opened slowly and system checked for leaks as it fills. When the system is completely full, indicated by water escaping from the air vent when the valve is depressed it should be pressure checked with normal pressure for 30 minutes. Final inspection should then be made and power to the controller turned on. If the sun is shining and the storage tank is cool, the pump should come on and water should flow through the

collector. The first water through the collectors will be very hot but should stabilize in about 15 minutes. The return lines from the collectors should be hotter than the inlet lines and the collector glass should be slightly warmer than ambient temperature.

Testing of the frost sensor can be made at night when the pump is not normally working. A piece of ice set on the sensor should be sufficient to turn the pump on. The pump should turn off as soon as the sensor has a few seconds to warm back up when the ice is removed. Caution should be exercised when working on the roof at night.

## 17. OPEN LOOP MAINTENANCE

Maintenance of an open loop system is straightforward. The tank should be partially drained every 6 months to allow minerals to be removed preventing scale build up (this is recommended for all water heaters). The wye strainer should be cleaned at least once a year or more often if harsh water conditions exist. The

power should be switched off, the piping drained, and the screen removed and cleaned.

The collector glass should be kept clean for best system performance. Rainwater will usually suffice but a garden hose can be used during dry weather. The air vent caps should be loosened two turns for proper operation and best system performance.

## 18. DIRECT PV SYSTEM

The single photovoltaic module, attached to the top of the solar collector (Figure 19) operates a brushless 12 VAC or 24 VAC pump at a speed relative to the amount of available sun. When clouds pass over, the pumping operation slows to allow the water to remain in the collector longer for continued heating. When the sun goes down in the evening the pumping action will stop.

The solar system is installed as per the open loop installation manual. The photovoltaic module will replace the differential control and sensors. Be sure

to mount the panels on the same plane as the solar collector.

When wiring the photovoltaic module to the circulating pump use 16 gage stranded double exterior PVC jacketed wire for lengths up to 85 feet for 10 and 25 watt modules. Use 14 gage for over 85 feet for a module over 1.4 amps. When wiring the module to the pump remember that the black wire is always ground and the red wire is the hot wire. Do not reverse the polarity.

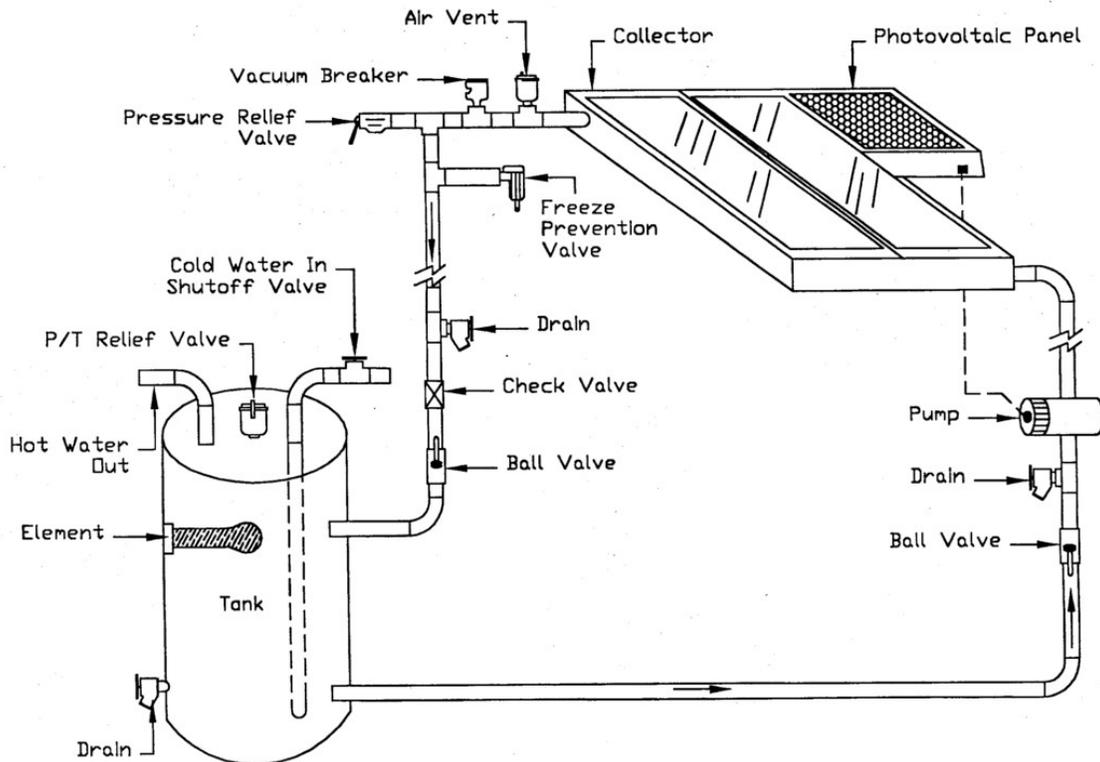


Figure 19

## 19. OPERATIONAL CHECKLIST

Before the system is turned on, the piping and electrical systems should be evaluated to see if they match the supplied drawings. If you are satisfied that the system is installed correctly, it should be filled and powered according to the preceding instructions. When the system is in the operational mode, care should be taken to check all piping for leaks and to make sure sufficient insulation has been used to provide maximum system efficiency. All modes of operation should be checked by the installer to assure proper functioning under all conditions.

### TROUBLE SHOOTING GUIDE

Problems with systems usually fall under two categories: system leaks or lack of sufficient solar heated water.

#### LEAKS

If leaks exist the system should be shut down for repairs. Make sure the electrical circuit to the controller is off. Close off the cold water inlet or in case of a leak in the closed loop system, isolate as much of the system as possible and then drain and repair the affected area.

There is a possibility that what appears to be leaks may be condensation on the pipes. Also water escaping for the T & P valve may be an indication of proper function as they are designed to vent off excess temperature and pressure.

#### INSUFFICIENT HOT WATER

If insufficient hot water is available a system malfunction may not be indicated. A low amount of solar radiation or heavy water demand can be the cause.

If no excessive demands are put on the system and ample solar radiation is available, the system should operate properly. The pump should run each sunny day until a full supply of hot water is stored. If the pump does not run, there is a problem on the electrical end of the system. Either the pump,

controller, or sensors are malfunctioning. The controller can be bypassed by running a power cable directly to the pump and checking its function separate from the control system. Make sure that the problem is not a blown fuse or a tripped breaker. If the pump runs normally when powered externally, the control circuit is the problem area. Eagle Sun controllers use thermistor sensors to determine modes of operation. A controller tester is available from TSI for checking differential function. Check sensor wiring. If no faulty wiring can be discovered, replace sensors.

If the pump is running all the time, even when the collectors are cool, then the storage sensor or collector sensor may be open. It is also possible that the sensor wire itself is at fault. To check this, test the continuity with an ohm meter. Be sure to disconnect the sensor when performing this test. Test the wire with both ends open, then retest often twisting the 2 sensor wires together at one end. The system can be set on a timer or switched on manually until the controller is properly functioning.

#### CONDENSATION ON COLLECTORS

If condensation occurs inside the collectors, ¼" vent holes should be drilled in the lower side of the collector. Three holes should be drilled, one at each end of the bottom of the collector and one in the center. These holes should be drilled 1" from the base of the collector

This should clear up any condensation within three days.

#### OTHER PROBLEMS

A noisy pump is an indication of worn bearings obstruction or loss of prime. As a rule of thumb about 8 to 12 degrees should be expected as a normal gain across a collector in bright sun at proper flow rate.

## SYSTEM PARTS LIST

Solar Collectors  
 Set of Mounting Hardware for each collector  
 Hot Water Storage Tank  
 Circulator Pump  
 Pump Flanges  
 Differential Temperature Controller  
 Controller Sensors  
 Fluid circulation components (valves and fittings)  
 Installation Manual

## COLLECTOR YARD MOUNT

When no sunny roof area is available or for “show” systems, the collectors can be mounted on the ground as shown in Figure 17. The piping and control wiring to the tank should be insulated and buried. It is important that the length of these piping runs be minimized.

## Notes:

1. Front edge of collector should be 18” above ground
2. Use washers on all bolted wood connections
3. All pieces must be measured and cut to orient collector at latitude + 10° – consult trigonometric reference.
4. Piping to collector may be buried.

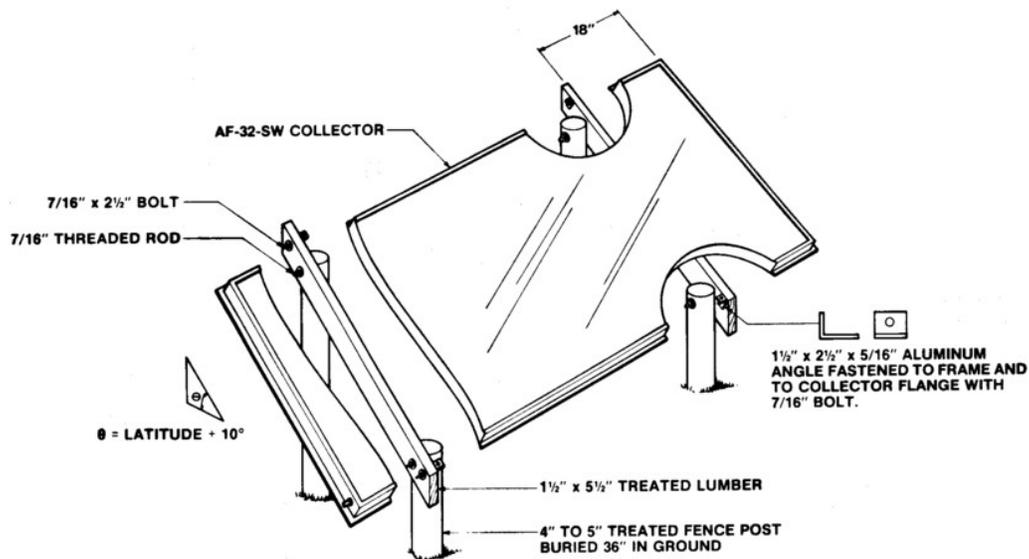


Figure 17