CHAPTER 7

ACCEPTABLE INSTALLATION PRACTICE

7.0 INTRODUCTION

This chapter deals for the most part with the special difficulties encountered when solar pool heating systems are installed on existing structures. The incorporation of collector mounting hardware in new construction requires cooperation between the affected trades (plumbing, roofing, carpentry, electrical) but presents few other difficulties

Because unglazed, low-temperature collectors most often are used for swimming pool heating in Florida, procedures for mounting unglazed plastic flat-plate collectors, flexible solar mats and pipe arrays will be discussed first.

When installing these collectors, follow the same safety rules which are in common use in the building industry.

7.1 FLAT-PLATE COLLECTORS

The optimum collector slope for spring and fall operation is equal to the latitude of the site. The best slope for winter is the latitude plus 15° and the collectors should face south if possible If roof space which faces within 45° of south is available, the collectors can be mounted directly on the roof. Remember that only a small penalty is paid for modest deviations from optimum slope or orientation Supports can be constructed to mount collectors at the ideal orientation, but, except in new construction, the additional cost is generally prohibitive Occasionally it nay be necessary to increase the collector area to compensate for less than optimum slopes or orientations

Collectors should be securely fastened to withstand maximum expected wind loads. Building code requirements for maximum wind velocities vary within the state of Florida from 80 to 130 miles per hour Wind loads at roof level may exceed 75 pounds per square foot Check the local building regulations for wind load provisions in your area.

Numerous mounting techniques are used to mount the large arrays of collectors required for pool heating Test data is not available for most mounting techniques, but one of the largest collector manufacturers did run wind tunnel tests on its recommended installation procedure and the mounted collectors withstood winds in excess of 100 mph

7.1.1 Procedures

To begin the installation, lay out the collectors on the available roof area avoiding as much as possible that portion shaded by trees, parts of the building, or other obstructions. If large numbers of collectors are involved, they may have to be divided into several banks with collectors in each bank plumbed in parallel. Plumbing arrangements from ban to bank are discussed in a following section

Once the placement is established, the collectors should be connected Short flexible couplings made of EPDM or butyl rubber often are used. They usually are slipped over the ends of the headers and are clamped firmly with stainless steel clamps. Once fastened together the collectors are cumbersome to move about; be sure they're in their final positions before the connections are made

Collectors often are mounted directly on asphalt shingle and tar and gravel roofs. An insulating support structure is sometimes used to protect the panels from abrasive roofing materials and to prolong their

The substrate can be spaced up from the roofing surface to provide ventilation for the underlying roofing membrane beneath. This

retard the development of fungus or mildew. Common 2½-inch, corrugated, four-ounce fiberglass panels are among the materials used for supporting flat, plastic solar collectors, but they should be insulated to prevent heat loss from the back of the collectors

Opinions of experienced roofers differ about the use of the substrate. Some recommend at least a 1½-inch air gap to provide for air circulation; others feel that a substrate may not be at all beneficial Numerous systems have been installed without substrates, but long-term durability data is not yet available. (Few problems with this kind of installation hav as yet been brought to the attention of the Florida Solar Energy Center staff.)

Collectors should be laid on the roof or substrate and strapped down at the header on both ends. At least two -- preferably three --cross straps should span the panel to further secure it. Figure 7.1 shows one possible arrangement

One end of the panel can be fastened to the roof with a short strap or clamp around the header. The other end should be fastened

an elastic material or spring to allow for expansion as the collector temperatures change--a 10-foot plastic collector may expand and contract as much as an inch in length. Straps should be installed across the panel body; one at either end, within a foot of the headers, and one across the middle are recommended. The straps should be made of material such as nylon or plastic-coated metal that will not scratch or abrade the collector, since they will rub across its surface The bands

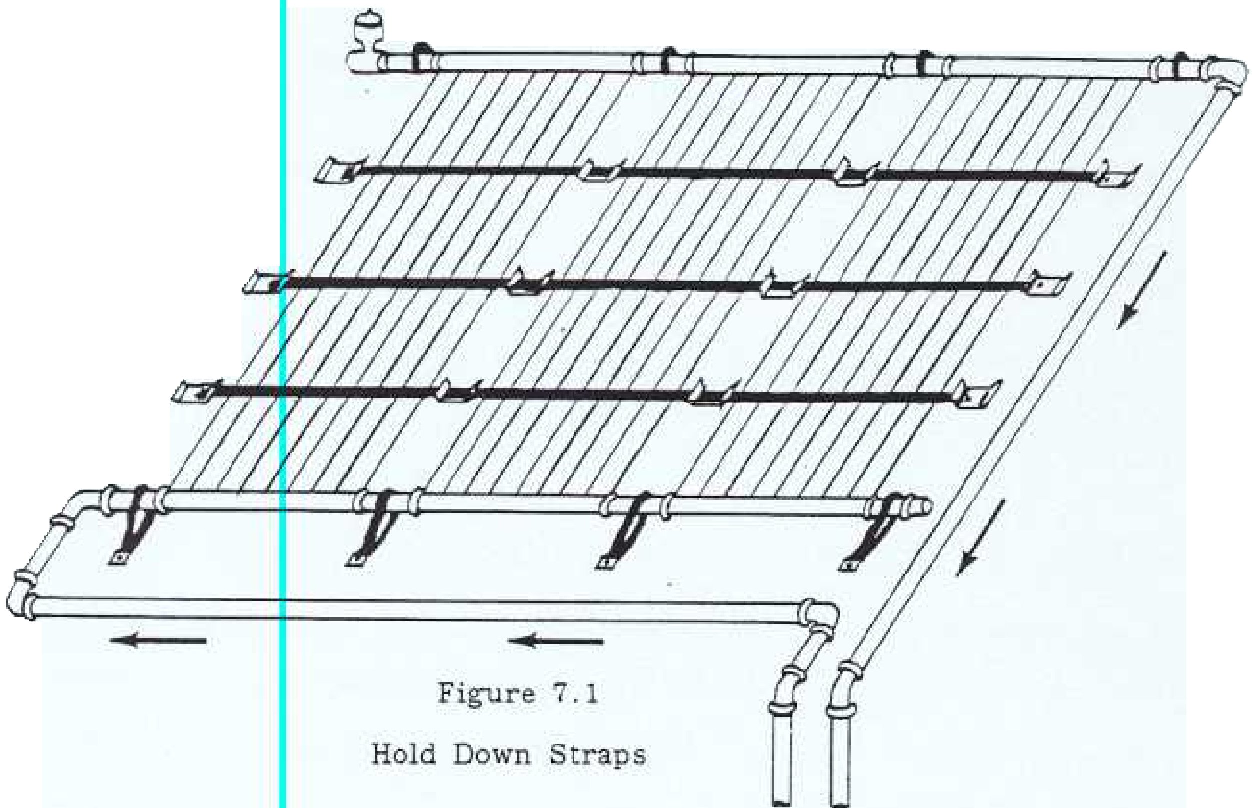


Figure 7.1

Hold Down Straps

should be snugged to clips fastened approximately an inch from the edge of the collector.

Figure 7.2 shows a typical mounting clip, which may be made of rigid plastic or metal. On asphalt shingle roofs, the clips may be fastened directly on top of the shingles--1/4-inch lag bolts long enough to penetrate the roof sheathing generally are recommended. In keeping with good construction practice, the lag screws should be screwed into roof rafters (rather than just roof sheathing) to keep the collectors secure. Because this mounting procedure is so tedious, many installers follow the simpler practice of driving lag bolts directly into the sheathing. The first full-scale hurricane will test this practice. Under either condition, a pilot hole should be drilled for the lag screw and after the drill chips are cleared away a sealant should be injected with a cartridge gun into the hole. An excess of sealant should be used to form a seal between the mounting cl

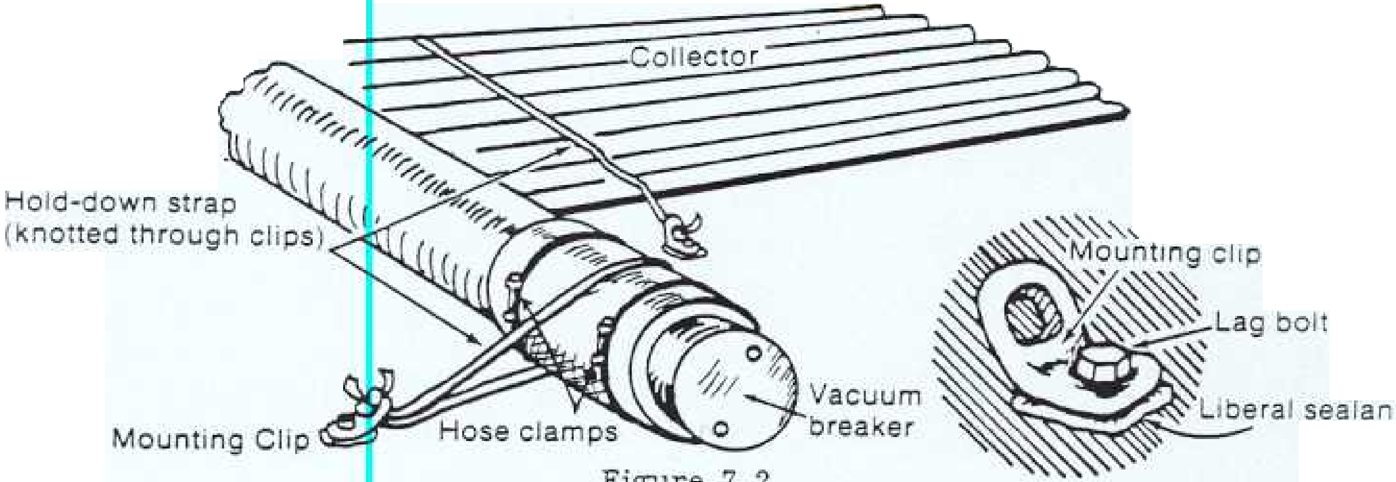


Figure 7.2

Collector Mounting Details

lag bolt is tightened. Polysulfide or silicone sealants adhere well to common building materials and appear to be very durable. Urethane sealants are also very durable but do not stick as well to some roofing surfaces.

Sealing 100 or more roof penetrations is a tedious procedure that must be done with the utmost care. Two installers may want to take turns to make the job go easier.

Sealing of mounting brackets on tar and gravel (builtup roofing) requires careful cleaning around the bracket. Scrape off the old gravel down to the tar, and clear off all dirt and residue. If the tar surface is very dirty or irregular, soften it with a solvent such as mineral spirits. After sealing the clip with polysulfide, pour roofing tar over the bracket base and cover with gravel. This last step is necessary to prevent ultraviolet damage to the tar and premature failure of the roof.

Mounting collectors on other roof types is more difficult. On cedar shake roofs, mounting screws should pass through the shakes and fasten securely to the plywood or purlins beneath. Don't be stingy -- use good quality sealant and enough of it to form a good, sealed penetration. Don't tighten the fasteners tight enough to split the shake.

Concrete tile roofs, especially common in the south part of Florida present special mounting difficulties. The safest solution is to construct a rack to support the collectors above the tile surface. The rack should be constructed of a durable material such as aluminum cedar or pressure-treated wood. It should be strong enough to withstand maximum anticipated wind loads. Insulated substrate and collectors may be fastened to the rack. The rack itself must be securely fastened to the roof trusses, not to the sheathing.

Figure 7.3 illustrates a typical mounting bracket arrangement. To install the bracket, a tile must be removed or broken, exposing the waterproof membrane on the sheathing below. This waterproof surface (commonly called slate), not the tiles, forms the moisture barrier and must be resealed where mounting bolts penetrate it.

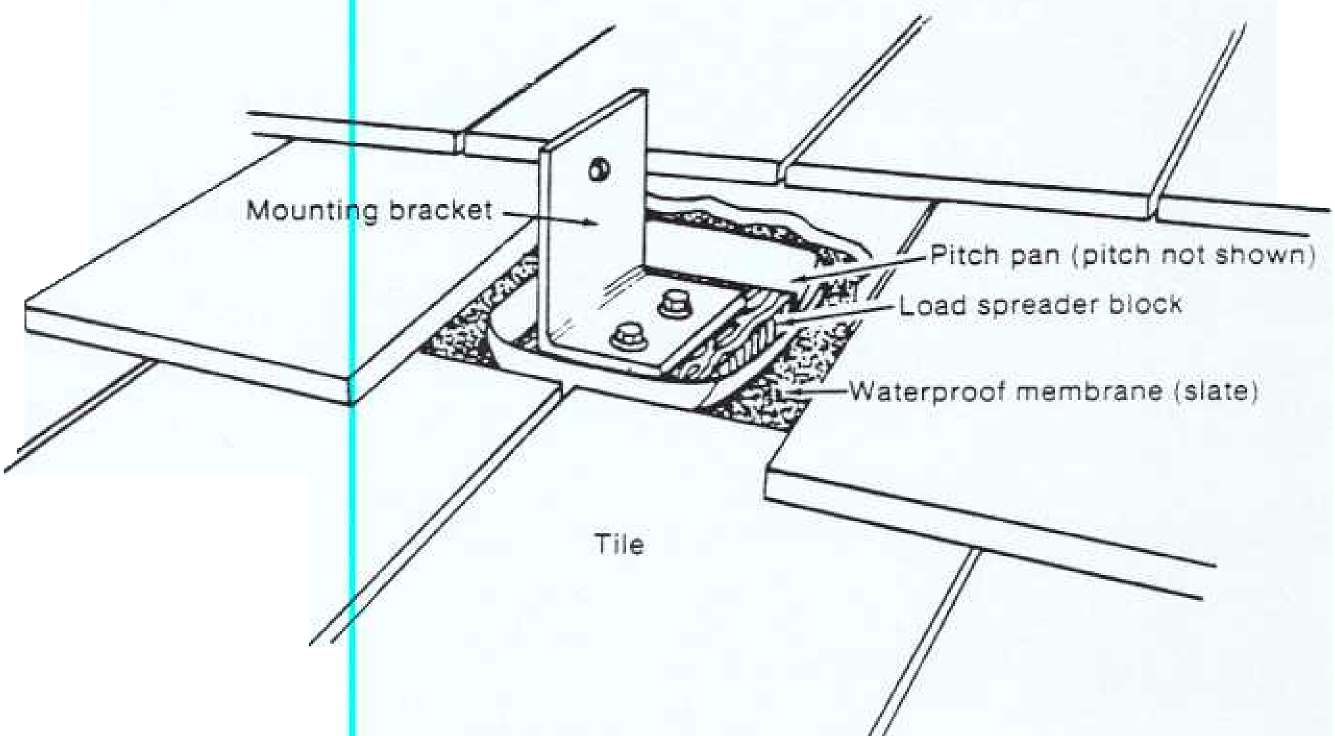


Figure 7.3

Mounting Bracket for the Roof

The mounting location should be free of dust and debris. Roofing mastic should)e applied to the bracket and slate to form a seal when the bracket is drawn down. (Pitch pans around the roof penetrations be required in some areas They are discussed in some detail in Section 5, Volume II of the FSEC Solar Water and Pool Heating Manual.) A substitute for the broken tile may be made from cement mix (using adjacent tiles a: a model) and tinted to match the roof. Aluminum and copper material: should be protected from contact with the cement by a layer of tar to reduce corrosion.

Fastening schemes have been proposed which rely upon sealing the penetration at the tile surface. Since the waterproof membrane is the tile itself but rather the slate membrane beneath, these methods are not effective and should be avoided.

Spanish or barrel tile roofs present another tough collector mount- problem. is extremely difficult to walk on them without breaking tiles, and it is also difficult to make substitute tiles. Some installation contractors add a substantial surcharge to jobs that require the mounting of collectors on barrel tile roofs (Certain ceramic barrel tile costs more than $600 per 100 square feet.)

7.2 PIPE COLLECTORS

Solar collectors made of lengths of black pipe are common and easy to install, especially on flat roofs

To stabiliz spacing, the pipe should be laid on support cradles that raise it off the roof surface. These cradles can be made from 2" x 4" or 2" x 6" rot-resistant wood (plastic supports are available from some manufacturers). Holes equal to the pipe diameter (OD) are drilled with a hole saw through the wood at the appropriate spacing, and the wood is then sawed lengthwise to produce two cradles. The cradle rests on the roof surface, and the pipe rests on the cradle. Supports are required near the ends and at approximately four- to six-foot intervals to minimize sagging. The supports should be placed over roof rafters whenever possible.

Wind loads in Florida can exceed the dead weight of the collector pipes even when they are filled with water so they should be secured to the roof. This can be accomplished by running straps over the pipes and fastening them securely to cradles that are anchored into the roof supports. Figure 7.4 illustrates the preceding instructions.

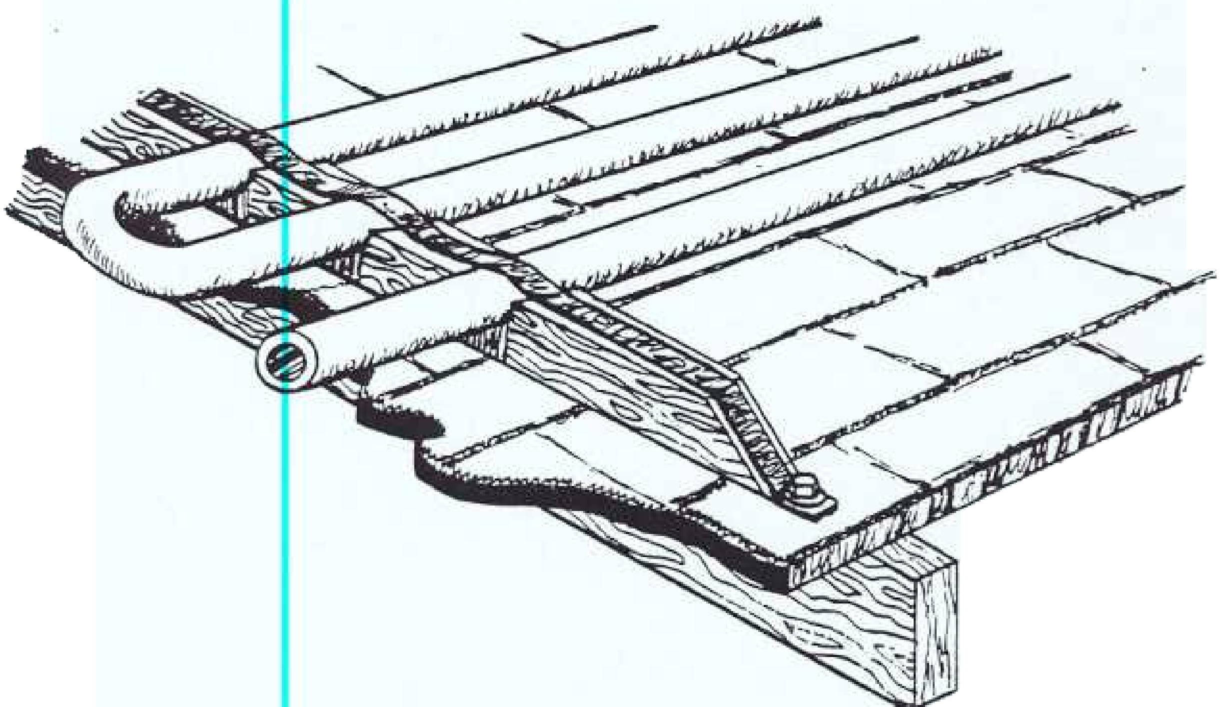


Figure 7.4

Pipe Collector Mounting

As in the case of flat plastic collectors, the first step in pipe collector installation involves bringing the materials up to the roof and laying out the pipe in a location as free from shade as possible Spacing between th lengths of pipe will depend upon the type of return bends used to join the ends, but a gap equal to one pipe diameter (OD) generally is left between lengths to reduce shading

Once the collector location has been established, the support cradles should be secured so that they span several trusses or run lengthwise along the truss. This distributes the collector weight evenly and properly spaces the parallel pipe runs. The retaining brackets now should be installed. On flat, builtup roofs, the gravel should be scraped off down to the tar beneath

Clean the area well. When all the gravel has been removed in an area large enough to accommodate the cradle, set the cradle in a bed of mastic and bolt it to the rafter(s) beneath it. Be sure to completely cover exposed bolt heads. (Pitch pans may be required for some installations.) Thoroughly scrape and clean the area at least four inches out from the outer edges of the pitch pan, bed it in a layer of mastic, and seal the flange with two layers of tar paper and mastic and cover the installation with gravel. Fill the pan with roofing tar which will remain pliable over time without cracking.

Experienced roofers state that the single most common cause of leaks when installing devices on the tar and gravel roof is failure to strip away all the gravel before making the installation. Some leaks are very difficult to find after the penetrations have been covered with gravel Thus pays to make roof penetrations with great care

PIPING

ola in poo lle :toı lesign to th high

flo th bj in ipin olar

to vid hi 'olı fl th lo' th

po :b:

to olle :to

lo' erature coll :to la ti pipe ed in th

pl in th pool to th la: coll :to 'V AB

ıpe 40 th onl ed :terıals thıs tic

ılar ıp. rfo tisf :torily N th :terial

th tem eratur n to th derate op tin

ture: ıp in ulati is

empe tu: coll :toı uir ing

In al :tioı flo th gh typıcal dıum

tu: lle all le: p th tem tu: coll

th th :tu: will (alth gh th ill

of 'V AB da this tu: tempe tu: which

is ally .00°F Ho if th flo' :toı hile th

:ining th in th coll :toı ıch 200 Wh th

fl es blis th 200° is gh to la: ti

C tl: co per ip uld be ed th la:

of th th tire :tu: lin Wh pe ip

to ely lum :dı empe tu coll is

all with to in in ulati whi

ult gr datioı UV

'ra pin tap ıre aila to ro th rh :ti

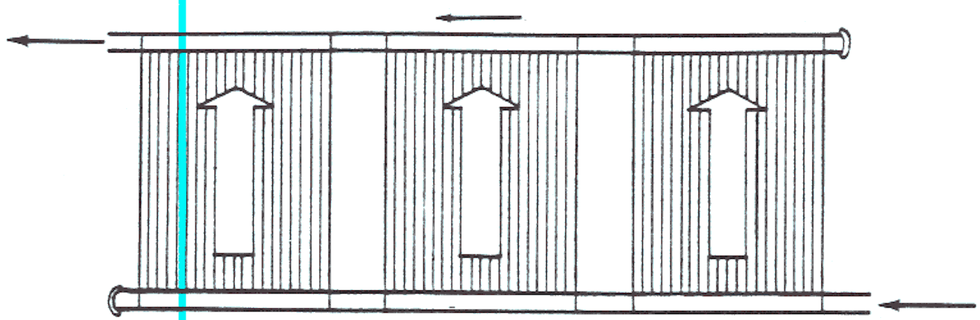
pipe whıc xp to th

Local plumbing requirements should be adhered to when installing piping leading :o and from the collectors Since large-diameter pipe is quite heavy when filled with water, sturdy supports will be required cuts should be deburred before assembly to reduce resistance to Leaks can be avoided by using the correct cement for the pipe involved and by properly preparing joints Because plastic expands and contracts considerably with temperature changes, allowances should be made for change in length. Your pipe supplier can provide you with specific data on the kind of pipe used for a particular job

7.3.2 Piping Between Collectors

About the same amount of water should pass through each collector. On large installations it is necessary to divide the solar collecting panels into groups and connect the groups with pipe. This requires the piping layout be carefully designed and constructed Most situations encountered can be satisfied using principles discussed in section, but for extremely complicated cases it may be wise to consult a hydraulic flow specialist.

Pool heating collectors almost always are connected in parallel Parallel connections are shown in Figure 7.5a series connections in Fig- 7.5b. In the series arrangement, water passes through one collector and then through the next, increasing the pumping horsepower required to maintain adequate flow as well as causing the downstream collectors to operate at higher, less efficient temperatures. Parallel connections, in which the water is returned directly back to the pool after passing through one collector, are the better choice because those difficulties are avoided.



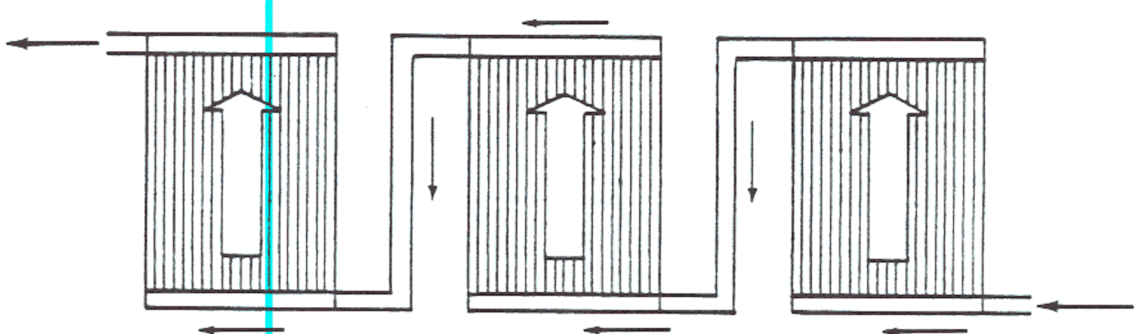
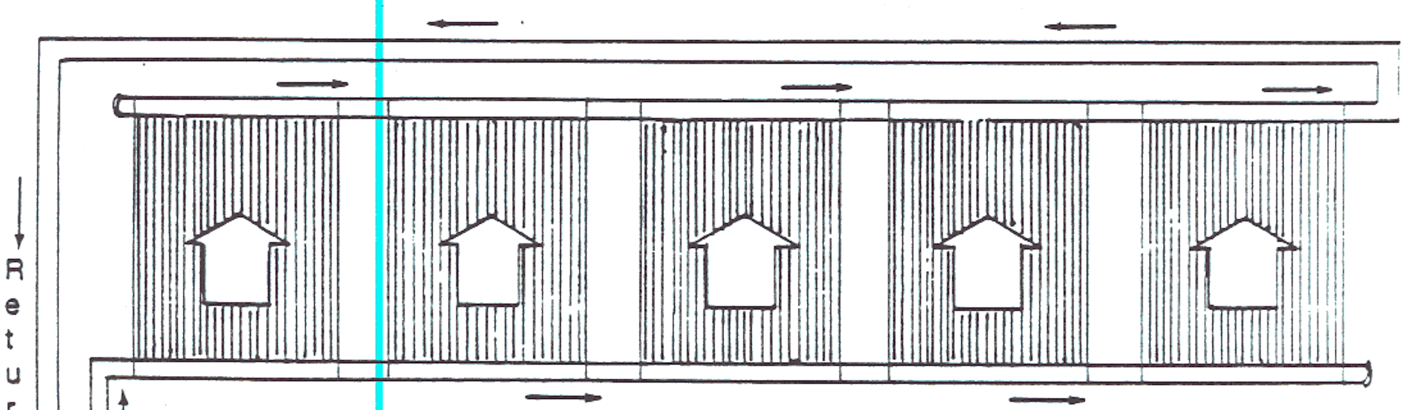


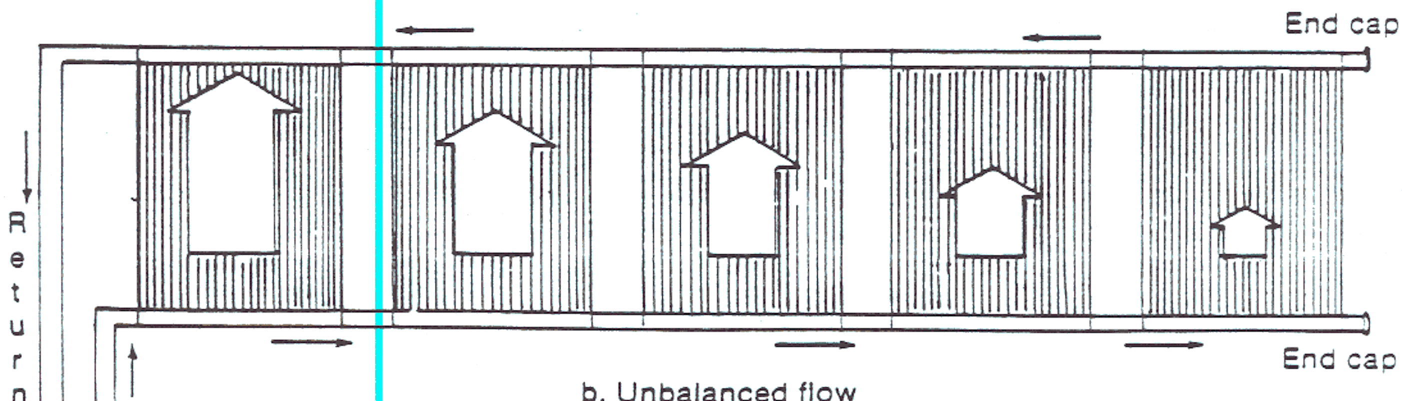
Figure 7.5

Collector Connections

The feed and return lines leading to each collector should b approximately the same length. Figure 7.6a illustrates the preferred arrangement, and Figure 7.6b shows a common, but less efficient connection where the flow tends to be short-circuited through the firs few collectors and those at the end are starved for flow (causing reduction of their performance). Of course, if the pressure drop in th headers is very low compared with that in the panels, little imbala caused by the piping arrangement pictured in in 7.6b. In Figure 7.6a the length of the water path is the same for all collectors, so the flow is evenly distributed. This style of piping will require extra pipe, but improved collector performance usually compensates for the additional cost.



a. Balanced flow



b. Unbalanced flow

Figure 7.6

Flow Balancing in Collector Groups

Groups of collectors at different heights should be plumbed in such a way that they all receive water from the lowest point in the system and return it from the highest point. Figure 7.7 illustrates a properly plumbed system. The dashed line indicates a tempting, but unsatisfactory, arrangement. If the return lines do not come from a common height, flow through the panels will be uneven, causing a reduction in performance. Even with this piping layout a balancing valve may be required to reduce the flow rate in the lower collector(s).

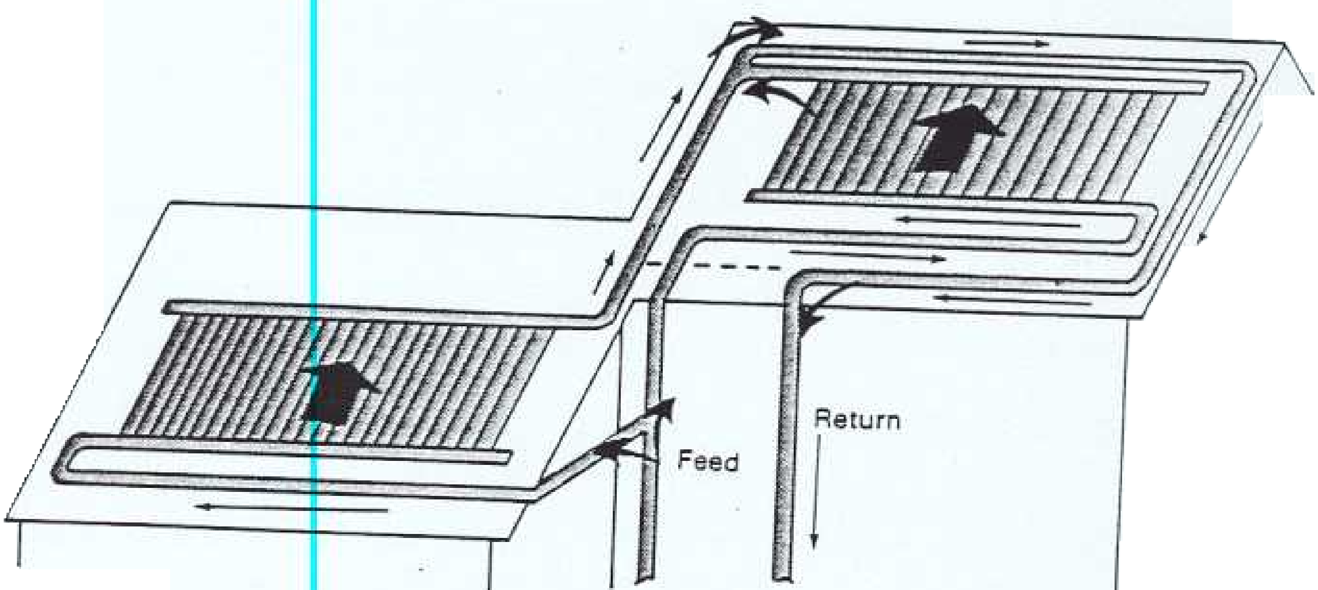


Figure 7.7

Plumbing Collector at Different Heights

Balan :ing al b d to obtain unif flo dis rib ti

th dif icul tuati which h te quir ak

impracti al alan th fl ith im p bing rrangem

alancing al (d flo m if economics p rmi) ul

tall d th d lin to ch group of coll to tartin with all

al pl tel op gradı ally clo th approp te al til th

ired flo f ch gro p is obtain d A le curate (also les

expensiv) alt tiv to th of flow is to m th tl

emperatu of vario llecto group d dju th alancing

al til th emp tu are ithin few d gr f ch th

Connec b tween collector d plumbing pip commonly

d with yn tic rubb pling th slid th

ting pip d th tightly clamped by tainle el

In d to ommoda th rmal xpansion and misalignm th

uplings g than tho d betw panels

A elief valv y b requir d in th f dlin

lle to group dmi air into th ys tem wh th h ts do

d th to th llectors to drain If ary

heigh dif lief val b in talle on mo th

group of to cilitate drainag Th elief al

dmi into th during p op tio it doe

th y m be is d will amoun ch

cal d to tan bblin also will p gr i

balan th d d th tatic h d

m th al m b in talled poin th y

is ho tmosp ric p This requir cal ulatic

y in tall f multi to y building th

water flowing down the return pipe may cause a vacuum to form in that pipe (if it is more than about 33 ft long in vertical distance).

A special note of caution is in order when plumbing medium-temperature collectors: During stagnation, these collectors can turn to steam the water they contain. This creates a hazardous situation In order to prevent possible damage or injury, pressure and temperature relief valves should be installed on each group of collectors Plumb the discharge line to a safe drain, away from people and away from roofing materials, which may be discolored by steam or high-temperature water

7.3.3 Flow Control and Safety Devices

One of the most important components in the flow control system is the control valve normally installed in the main filter flow path after the collector feed line and before the collector return (Figure 4.1b) Although this valve can be as simple as a manually-operated gate valve, for convenience, it is generally operated automatically

Several types of control valves are available. Among those most frequently used are gate valves, bladder-type pinch valves or specially constructed variations of irrigation valves

The pinch valve is one of the earliest automatic valves used on solar swimming pool systems It consists of a flexible rubber cylinder that accepts pipe at either end and that has an inflatable rubber bladder inside. The bladder can be pressurized to shut off the flow. Small plastic tubing through which the bladder is inflated and deflated is connected to a fitting on the valve and terminated at the control box.

In one control strategy, the valve is operated by an electronic control that measures collector temperature and compares it to pool temperature The upper (collector) sensor is mounted in a black plastic housing that has an absorptivity for solar energy approximating that of the solar panel. Since the sensor temperature should simulate the collector temperature, it should be mounted alongside a collector panel and fastened to the same surface to which the panels are fastened Wires to the sensor carry low-voltage electricity only; an electrician is not required for their connection. All wire connections should be made secure and watertight, preferably with heat-shrinkable insulating tubing or durable sealant

The lower sensor, which measures pool temperature, should be protected from direct contact with the pool water to prevent galvanic corrosion. This may be accomplished by encapsulating it and its lead wires in a durable potting compound (epoxy for example), or installing it in a "well" installed in the pipe between the pool and the circulation pump As a las resort the sensor may be taped to the outside surface of the same pipe and thoroughly insulated. It is important to ensure that the "cold" sensor registers the temperature of the pool water not that of the ambient air or that caused by the sunshine warming the sensor capsule

The electronic control itself requires electrical power Sometimes it can be connected in parallel with the pool pump or timer, but since 120V or 240V electricity is involved you should consult your local building officials to find out if an electrician is required to make the connection. Approved conduit should be used for this wire

The final step in the installation of the control system is the connection of two pressure lines between the pool pump and the control box. Small-diameter (1/8-inch) plastic lines generally are used most pool pumps have a 1/4-inch, threaded pipe plug in the side of the strainer housing (near the bottom), the low-pressure line usually is attached to an adapter at that point The high-pressure line should be tapped into the pipe on the discharge side of the pump

When the upper sensor signals that the collectors are warmer the pool water the electronic control opens the line from the discharge side of the pump and inflates the bladder in the pinch valve diverts flow through the solar system. When the upper sensor signals that the collectors are cooler than the pool water, the line from the suction side of the pump is opened, forcefully deflating the bladder allowing flow to bypass the collectors. Such rubber pinch valves have operated successfully for many years

Another popular control valve, the irrigation style valve, achieves the same results but operates in a slightly different fashion It is plumbed into the system by standard piping procedures A suction line is tapped into the pump inlet strainer housing, but in this case it is connected to the valve body itself A pressure line is not used. A low-voltage wire also connects a small solenoid valve mounted on the valve body to the control box.

The control compares collector temperature with pool temperature as before. If solar heat is available, an electrical signal causes the solenoid valve to open the suction line. This suction closes the valve diaphram diverting flow through the collectors. When solar energy is not available, the solenoid valve remains closed, the valve diaphram (which is spring loaded) opens, and the flow bypasses the collector array (In another version the spring loading keeps the valve diaphram closed and the solenoid induces its opening.)

ACTIVATING THE SYSTEM

After installation is completed, it is necessary to activate and test the system for proper operation. A few of the most important checks are discussed here

7.4.1 Purging the System

Bits of plastic from rough pipe cuts, sand and other debris should be flushed from the system to avoid clogging small fluid passages in the collectors Purging can be accomplished by leaving open one or two strategically placed joints The circulation pump can be turned on briefly to flush water through the system; then final connections can be made Small amounts of pool water can be discharged onto grass or sand, but large volumes should be piped to safe drains.

7.4.2 Pressure-Testing

The entire system should be pressurized to the maximum operating pressure; this can be accomplished in a number of ways

If piping passes through critical areas (like an attic) where a leak during the test could cause significant damage, the system should be pressurized with an air compressor Leaks can be located readily by listening for the hiss of escaping air

Installations where all piping is routed through areas where a temporary leak will do no harm may be pressure-tested by turning on the circulating pumps The appropriate valves in the circulation system should be partially closed to produce higher than normal operating pressures in the new piping Be sure to have someone standing by ready to turn off the pump in the event a leak is discovered

During th pressure check, every connection should be visually inspected and shaken to ensure that it is well made

7.4.3 Testing Control Devices

Automatic control devices should be checked for proper operation Consult the manufacturer's specifications for the controls being used and determine the possible operating modes. Test in all of these modes and make a permanent record of the results. Checking control operation immediately after installation can prevent costly call-backs later

7.4.4 Testing Flow Rates

Proper flow through the collector array and filtration system is required. Inexpensive flow meters are available and should be used to confirm that desired rates have been achieved. As previously mentioned, turn-over time must not be increased above an acceptable level

7.4.5 Testing Temperature Rises

The temperature difference between the feed line to the solar system and the warmer return line should be checked Remember--the temperature rise on even a sunny day should be quite modest, approximately 10°F, for low-temperature collectors. Thermometers installed in these lines can be used to make accurate readings

If the temperature rise to too large, it indicates that not enough water is passing through the collectors. Check the system thoroughly and correct the problem, because collector efficiency drops dramatically as the operating temperature rises Lots of water warmed slightly is a less costly option than a little water warmed a lot

CLEANUP

Whether you found the installation site clean or messy, leave it clean.

Make sure that you have repaired any damage occurring during installation (like broken roof tiles) or make arrangements to have it Ask the owner to look things over to be sure he or she is satisfied Let the owner see how well you have cleaned up

Sometimes such thoughtfulness on the part of the installer makes the difference between a satisfied customer, who will speak highly of your work, and a dissatisfied one (who won't).

INSTRUCTING THE POOL OWNER OR MANAGER

There are several important reasons to spend a few minutes instructing the pool owner or manager on the operation of the new solar pool heater. First, it will enable the owner to ascertain whether the system is operating and thus reduce "false alarm" callbacks. Second, it will enable the owner to explain the new unit to friends and associates Third, it will equip the owner to make minor adjustments and reduce service calls for the installer. Provide an owner's operation and maintenance manual which includes minor trouble-shooting and correction instructions

Explain the operation of all valves and controls and how the water circulates in the various modes It is desirable to spend a little time on the automatic control so that the owner can make seasonal or other adjustments that may be required

It is very important to explain that the amount of energy being delivered to the pool is the product of the temperature rise and the flow rate. High temperature rises feel impressive, but they cause the collectors to operate inefficiently and deliver less heat to the pool Sometimes this point is difficult to make, so you may have to explain it in several different ways.