Modified Trickle Down Solar Heating

By

Richard Heiliger

I built and installed these MTD (Modified Trickle Down) collectors I assembled to help heat my home. The basic concept of trickle collectors comes from Harry E. Thompson design from back in the '60's. The design presented here is called MTD. MTD is a concept of John Canivan. The principal is to eliminate the loss of heat from condensation that the original Thompson design had. Johns MTD design incorporates an inner cover over the water trickling down under the outer glaze. This eliminates the water vapor condensing on the outer glazing of the collector, and loosing heat to atmosphere.

The collector may be framed with wood or metal. John and I have chosen to work with wood because it's easier to work with, less expensive, and has some insulation value as well. John likes to work with cedar decking material and I like to work with OSB. A piece of solid insulation is pressed into the frame. This insulation is also used as a backing material. Why waste money on an expensive backing material that no one will see? After the insulation is in place a TDM (Trickle Down Matt) is installed. This TDM is the heart and soul of the collector. John and I have built numerous experimental models with "built in place TDMs", but they all developed leaks. Our external MTD designs have been leak free for the last 3 months. We have avoided using copper absorber plates and copper flow tubes to save money on construction materials. John and I worked on this concept most of last summer. We investigated many materials for the construction of the collector. We may not yet be at the ultimate design, but the results are very functional.

Since the Trickle Down Matt is so important a major portion of this article will be devoted to the details of its construction. John originally used a nylon screen sandwiched between two layers of heat resistant plastic. The screen did help distribute water inside the TDM but John was never satisfied with the hot spots that developed in places of non uniform flow so I came up with the idea of using a thin black water absorbing material under a clear plastic film. We are both using TDM designs based on this concept although John's version differs somewhat from mine.

TDMs replace metallic absorber plates and copper flow tubes with three layers of light inexpensive plastic materials. The bottom layer contains a waterproof underlayment. The middle layer contains black, water distributing membranes such acrylic or polyester felt. The water that trickles through this felt is heated directly by the sun so that heat transfer from a copper absorber plate to copper flow tubes is unnecessary.

The outer layer of the absorber is clear. This allows a majority of the sunlight to pass thru to directly heat the absorber. It also eliminates the condensation problem of the original Thompson design. We are using either polypropylene or polyester for this clear inner glaze. This inner glaze is in direct contact with the felt. I will describe the material selection criteria later.

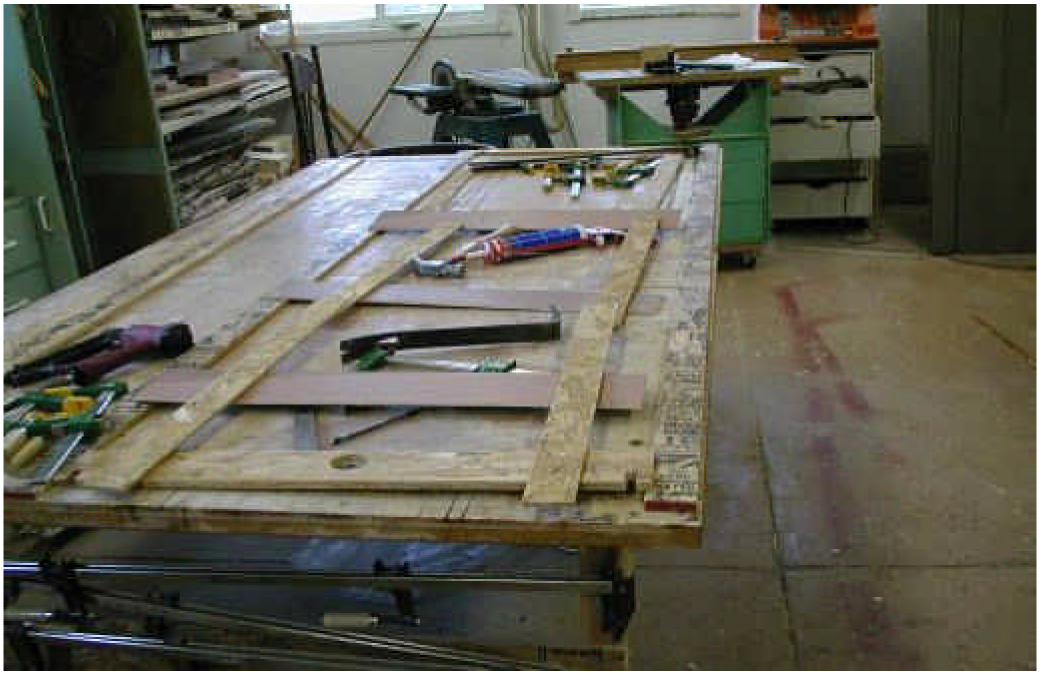
Basic Framing:

John and I came up with variations on the basic framing methods to accommodate differences in our TDM design. Both our frames are 2'x8' and both frames are designed to fit Suntuf glazing and half sheets of 4x8 Tuff-R isocyanurate insulation. These 2x8 units are light (about 30lbs) easy to build and easy to install. They are modular and may be flush mounted as an array on a roof. John sells a book on the construction of his MTD frame designed for his Trickle Down Matt construction, as well as his version of a pre assembled TDM that's ready to be installed

FRAME ASSEMBLY

There is an inner and an outer frame. The inner frame is made from 7/16 OSB, and ¼" Luan plywood. This inner frame is primarily to support the Tuff-R insulation and have something to attach the TDM to. The outer galvanized steel frame provides the majority of the strength and protects this frame from the elements. I did all of the design in a 3D cad system so everything would fit.

Notice the notches in corners for an egg crating type corner.

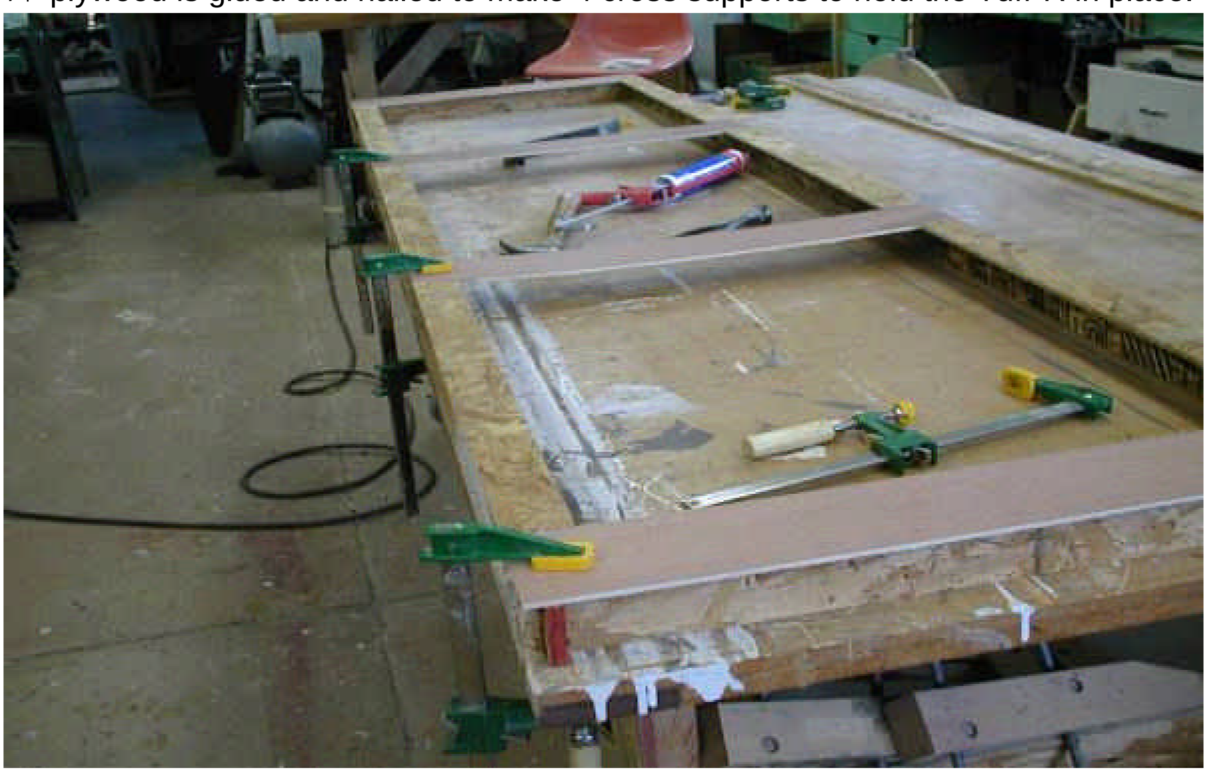


Pieces of framing laid out for assembly. A pneumatic brad nailer and construction adhesive is all that is used. A square table is nice to get the frame assembled square.

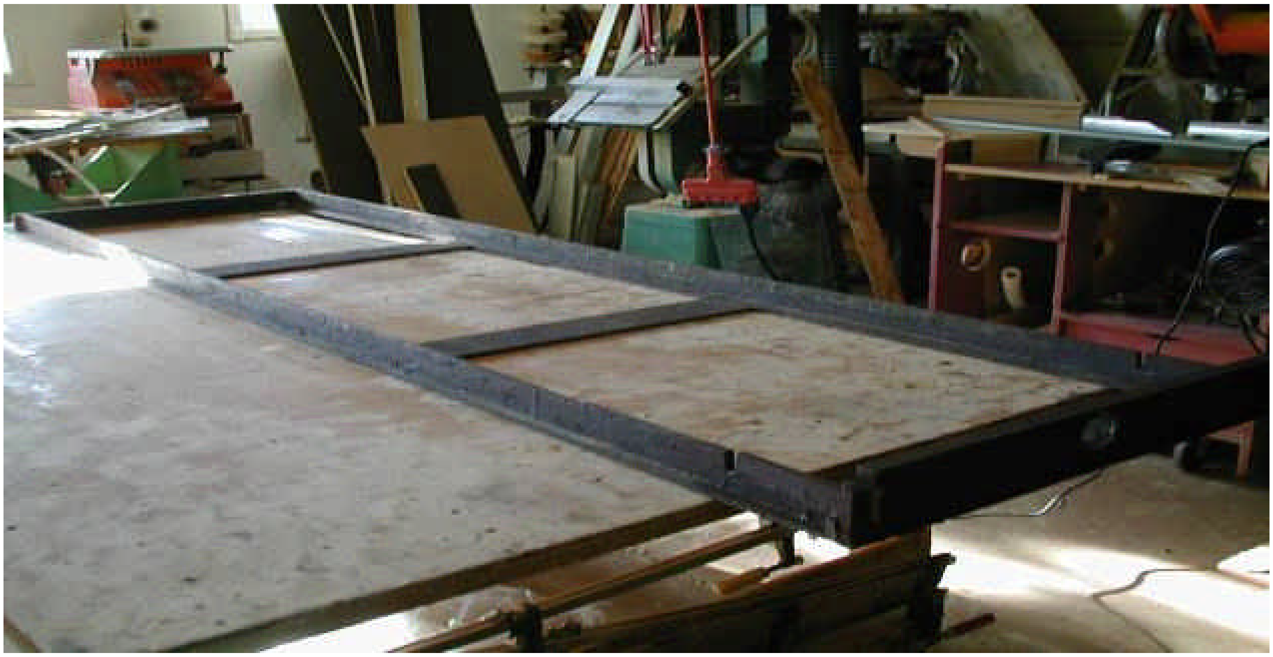
Basic frame set together with construction adhesive clamped to table to keep it square. The hole shown is the central drain.

A bead of construction adhesive along the perimeter to glue and brad nail the ¼" plywood to the frame. The plywood is needed to retain a sheet of 1" Tuff-R insulation board. The frame is 24" wide so that one 4x8 sheet of can be cut in half to make two collectors.

¼" plywood is glued and nailed to make 4 cross supports to hold the Tuff-R in place.

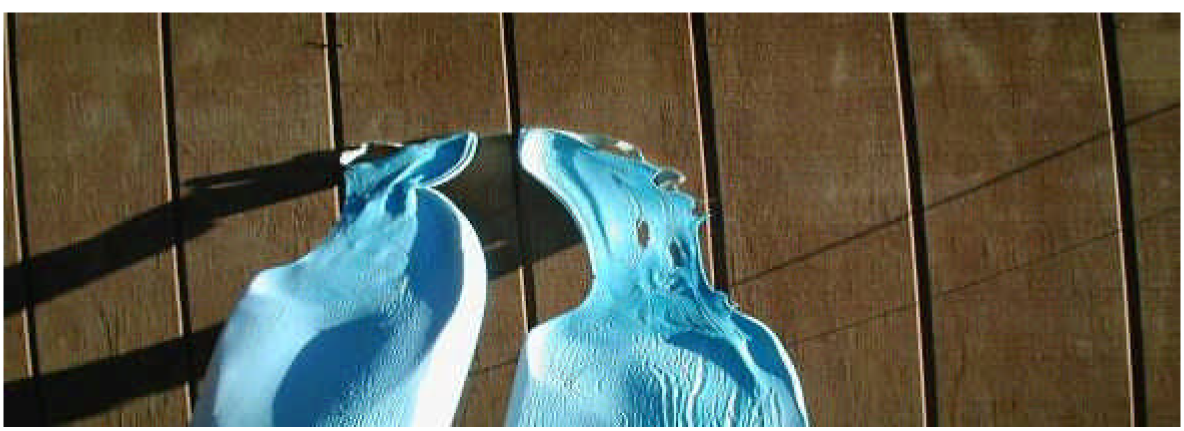


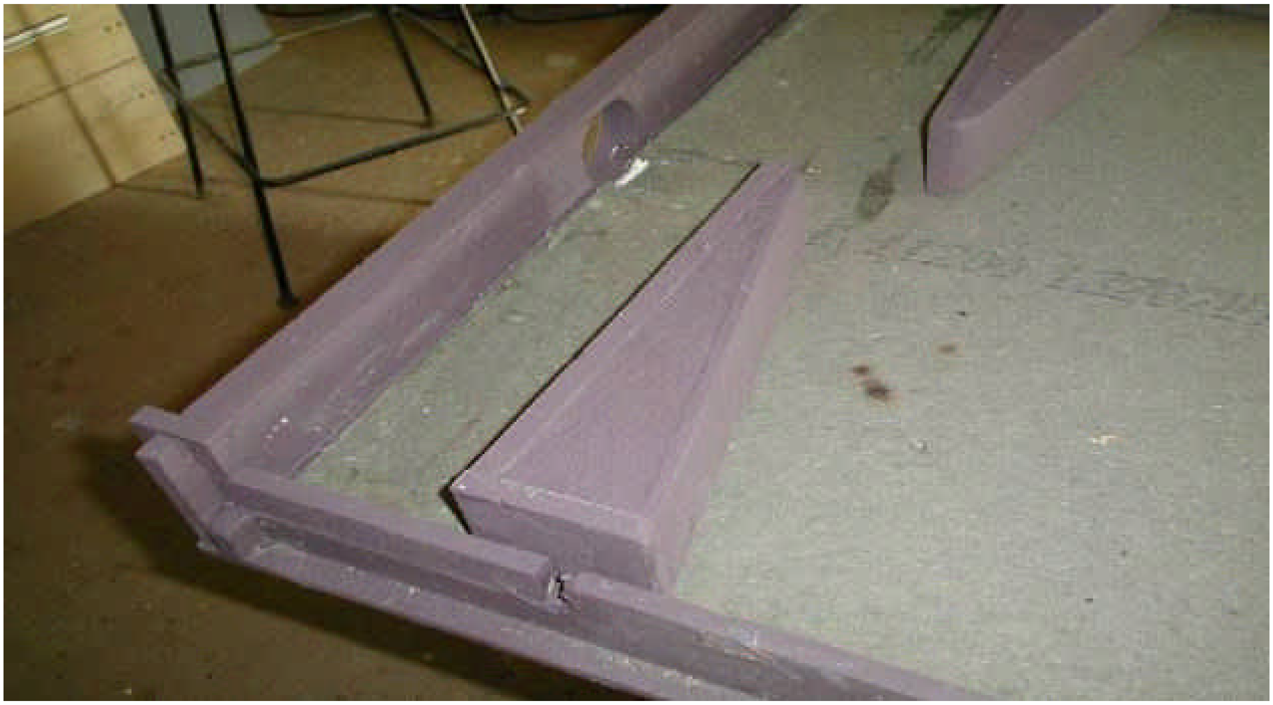
The finished frame should look something like this:



Be sure to paint your collector with something to preserve the wood.

I had a hard time finding suitable solid insulation in my small valley. I would have preferred using the Tuff-R brand with an aluminum skin, but no one would order it. I found one yard that had this Firestone brand with a fiberglass matt on both sides, originally intended for built up roof application. I tried polystyrene, but the below photo shows what stagnation does to it!!!





These wedges are supports for a central funnel drain. Johns trickle collectors use a gutter system to collect the water as it runs out the bottom of the collector. My system uses a funnel to collect the water inside the collector and feeds it into standard ABS drain system. Once the collectors were mounted all I had to do was connect the six collector drains to my ABS plumbing.

The wedges are screwed in from the bottom with a couple sheet rock screws.

A small wedge at the top of the collector to slope the top of the trickle matt up to insure the water will not leak out of the top.

Trickle Down Matt Construction:

I tried a large number of materials for the water proof backing. I even tried painting the entire inside of the collector frame with elastomeric roof compound, it always developed leaks. I have two collectors that use silver polypropylene tarp as the back, still surviving, and the least expensive. John Canivan uses a polypropylene is his collectors. This material has a tendency to shrink at high temperatures. This shrinkage can be useful in getting the films to lay flat. John's design takes this shrinkage into account, and he has resolved all leakage problems. I could not use his method with my funnel design and came up with this method.

My current design uses 600 denier urethane coated polyester. A material used in making back packs, etc. The notches at the bottom reduce the bulk when folding up the funnel. The black acrylic felt is held on with any good spray type adhesive.

A close up of the polyester fabric cut and laid out to form the funnel. The felt is cut back a bit to allow the water to drip out into the funnel. The slope is 3". I found that less than this will cause pooling near the outer edges.

Top of the Trickle Down Matt “TDM”. The felt is cut long so that it can be folded back down over the trickle tube.

The shiny film to the right is Mylar. I found a source for 40” wide Mylar in 50 foot rolls at a reasonable price. The Mylar is actually polyester drafting film. It comes in either matt or clear. I don’t think it really would make a difference as to which is used, but chose the clear. I used a fabric adhesive that comes in rolls ¾” wide to seal the Mylar to the polyester. It is basically hot melt glue on a paper tape. Do an initial tack with a dry steam iron with the paper backing on. Then peal off the paper lay the Mylar down and finish the bond by running the iron over the seam. I do a double seal ending with something that resembles a standing seam, as in metal roofing.


The side seams finished with the first half of the standing seam.

Note that the funnel is still open at this point. The bottom of the Mylar has the first seam heat sealed at this point. Leaving the notch in the center open for the drain in the funnel.

The hot melt glue used to seal the Mylar to the polyester is visible here. I made a punch for the funnel drain from a piece of ¾" black pipe. Cut square and ream the inside until a sharp edge is formed.

Put a wood block under the polyester and give the punch a few sharp raps and you get a very neat round hole.


Starting the funnel seal. The fabric adhesive tacked down, paper still on. Use an iron on the linen setting, about 250 degrees.

Fold up the funnel and heat seal down with the iron. Do not seal the top lip of the funnel at this time. Leave it open so that the drain tube can be inserted.

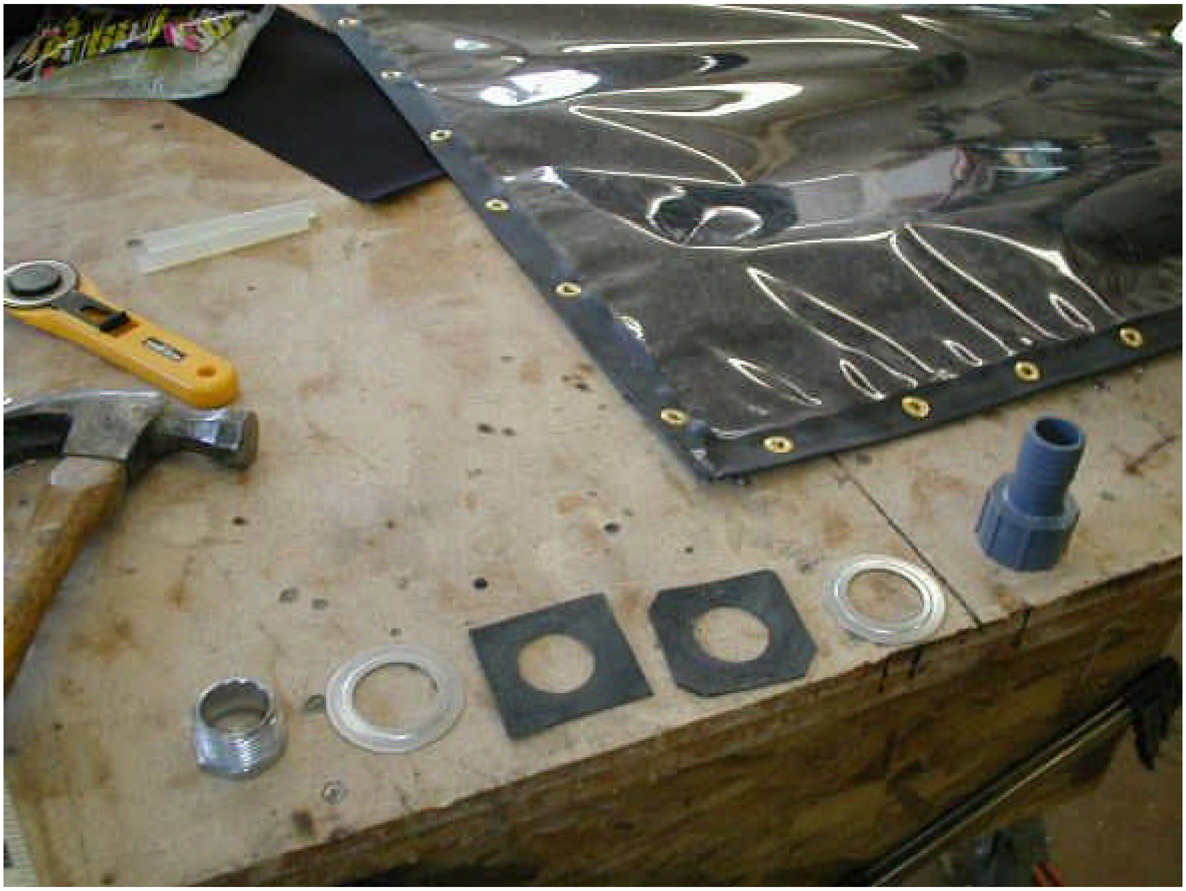
Fabric adhesive applied, paper backing still on. This forms the second seal of the standing seam edge.

How I made the second seal. Fold the edge of the polyester up over the fabric adhesive, paper removed. Iron down and follow along behind with a wood block. This holds the lip down long enough to allow the fabric adhesive to cool and hold. This can be done at a pretty fast rate.

Sides glued down and second standing seam along bottom of funnel done. Top of funnel is still open.


I added a hem of polyester across the top of the Mylar at the top of the TDM. A bit of reinforcement.

The funnel is still open. The hole for the drain tube is seen in the bottom of the funnel.

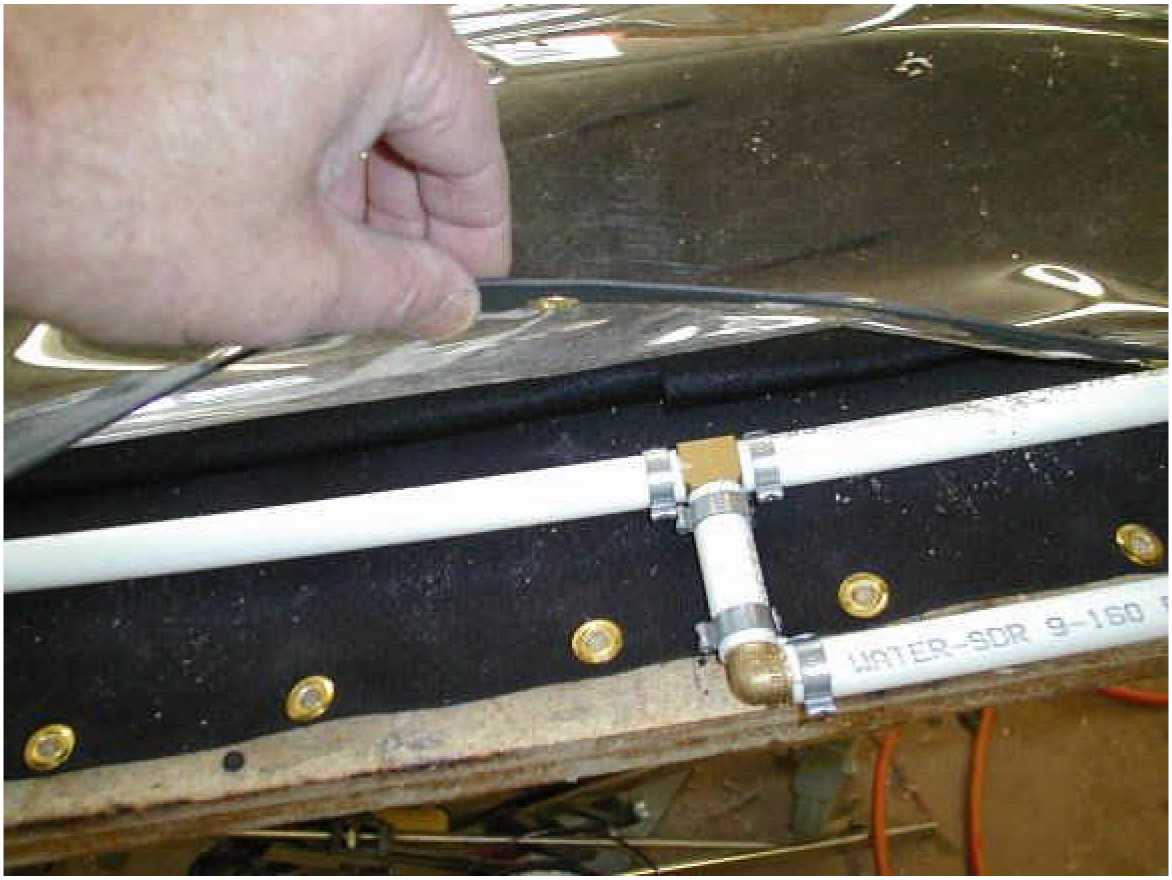


I used grommets for added strength along the edge. Large pan head sheet metal screws are used to hold the TDM to the frame. I had problems with other materials shrinking and pulling thru the screws and battens. I have found that with the polyester, the grommets may need not be spaced this close as the shrink is minimal. Also shown is how the drain tube is constructed. An electrical chase nipple two 1” x 1 ¼” electrical reducing washers, two EPDM rubber washers “made with the punch, and a 1” poly pipe adaptor.


A view from the inside of the funnel. The chase nipple a reducing washer and an EPDM rubber washer installed.

Funnel drain tube from the outside of the funnel. The assembly is screwed together and clamps to the polyester funnel. Have never had a leak with this system.

After the drain pipe is screwed on the top of the funnel is sealed shut with a couple strips of the fabric adhesive. I added a bit of hot melt glue at the outer edges for good measure.

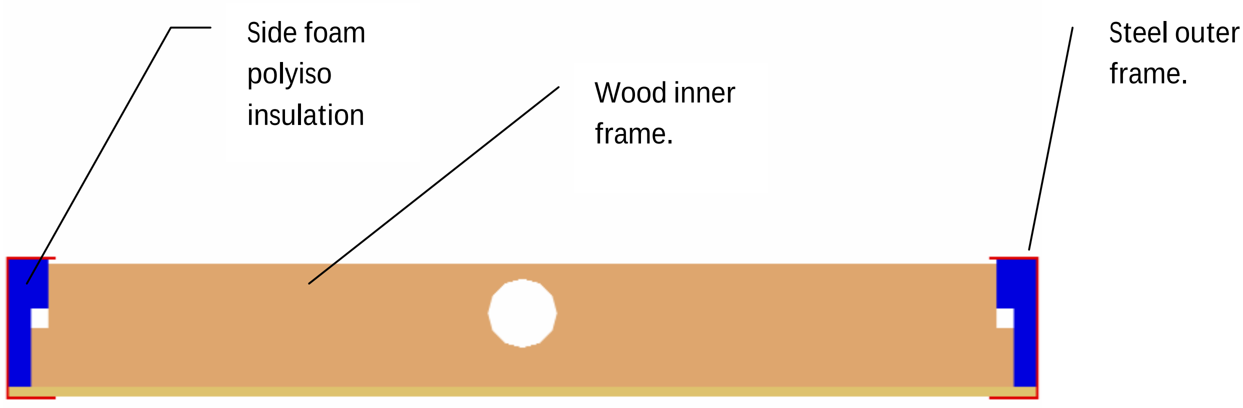


View of the top of the TDM showing how the trickle tube is installed. There are five 5/32" holes, evenly spaced across the tube. One drilled into the bottom of the pex tee. All ½" pex. The feed tube runs to the left side of the collector and is hidden under the metal outer frame. Since the pex does not fair well to UV exposure, it needs to be protected. Since the outer glazing is Sun-Tuff, it protects the pex. Time will tell if it will indeed survive. Perhaps ½" heater hose would be a better choice for the trickle tube and feed tube inside the collector. I use a bead of silicon across the top where the grommets are, then screw it down onto the wedge seen on the frame assembly.

The extra length of felt is folded up over the trickle tube. Just showing how the tube is installed in this pic.

Outer Metal Fame:

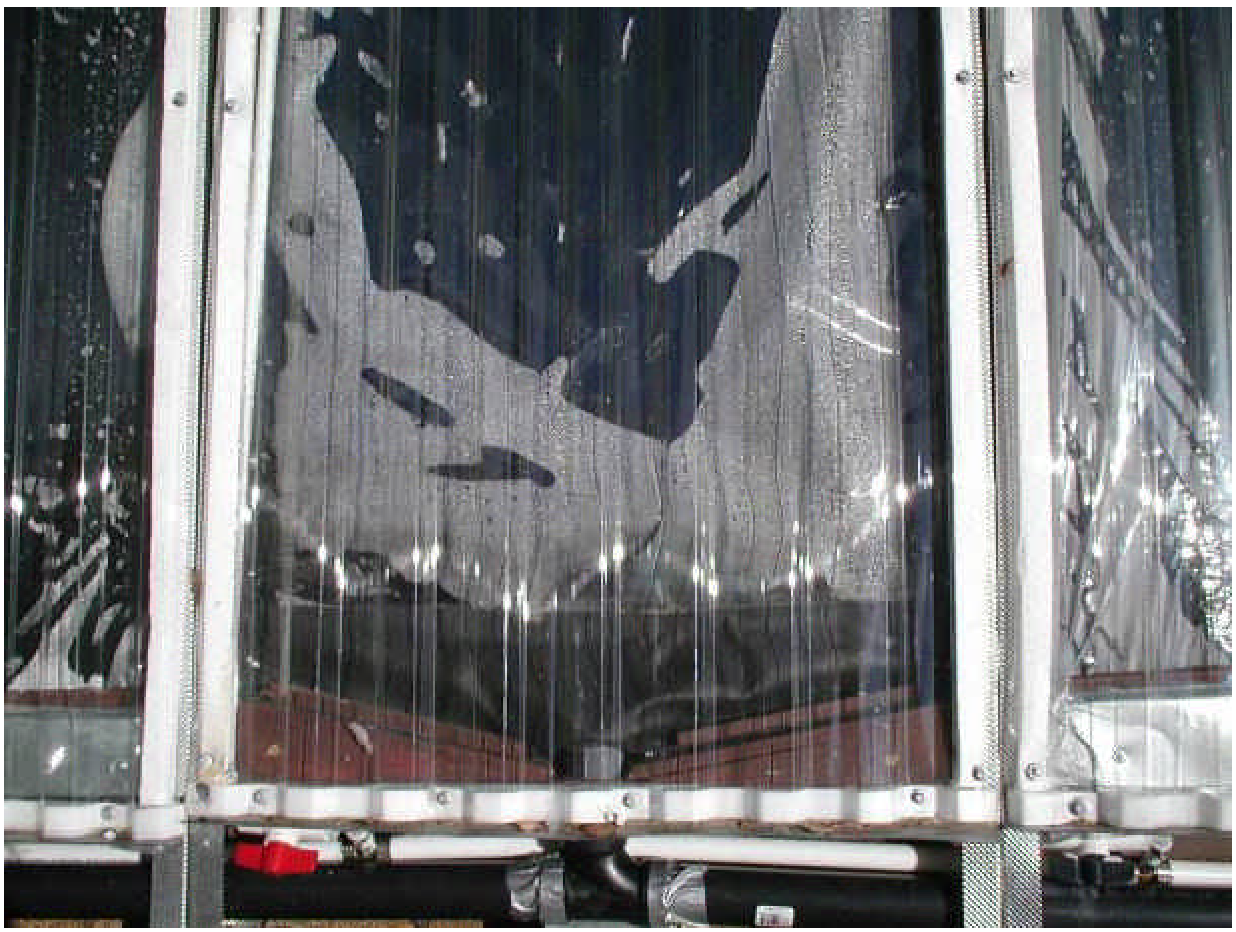
I unfortunately did not do a set of photos of the side and top insulation, or the steel frame getting put on. Hope that the drawing and pics of finished assembly will suffice. I cut 3 ½" wide insulation strips to add insulation to the sides and top (shown in blue). This fits inside the steel outer frame. They are notched to fit along the outside of the inner wood frame. I used steel stud rail as the outer frame. Not the steel studs, but the rail used as top and bottom headers in wall construction. The studs have holes cut in them. The rail is 25 ga. Galvanized steel, and comes in 10' lengths. The inner wood frame is 26" wide and the stud rail is screwed to the bottom ¼" insulation retainers. I folded some corner reinforcement brackets from the stud rail and they are screwed on with pan head sheet metal screws as well. I have found that wood frames do not hold up well in collectors. The wide temperature fluctuations tear the joints apart, and the wood eventually cracks and splits. I may at some future time figure out how to eliminate the wood inner frame as well. But for now I need something to screw the TDM to.



Shows the steel stud rail outer frame. Note the corner reinforcement brackets. Also shows that the steel stud frame extends below the wood frame far enough to form a box for the drain and feed piping. If I had it to do again, I would not add the box to the collectors. I would build the drain feed on the roof and set the collectors onto the box. Also shown is the foam seal for the Sun-Tuff polycarbonate outer glaze. I cut polystyrene strips and glued them along the edge of the steel frame for side seals.

Outer Glaze:

The outer glaze is Sun-Tuff polycarbonate. It has a coating that gives 100% UV protection. The UV protection is very important since the Mylar and acrylic felt are subject to degradation from Ultra Violet rays. A few sheet metal roofing screws with sealing washers hold it on. I should note that I tried using polycarbonate glazing without the UV protection and it yellowed within a week in our hot July sun in Northern Utah. Also note that polycarbonate will degrade when exposed to water in excess of 140*F. This is from a note on the Sun-Tuff web site. I also tried to use polycarbonate in place of the Mylar on the TDM. After 10 days of testing with some days of stagnation the polycarbonate turned brittle and could be crushed in my hand. I would not recommend using polycarbonate without the inner glaze provided by the Mylar on the TDM. The Mylar is good to over 300*F and will not absorb water.



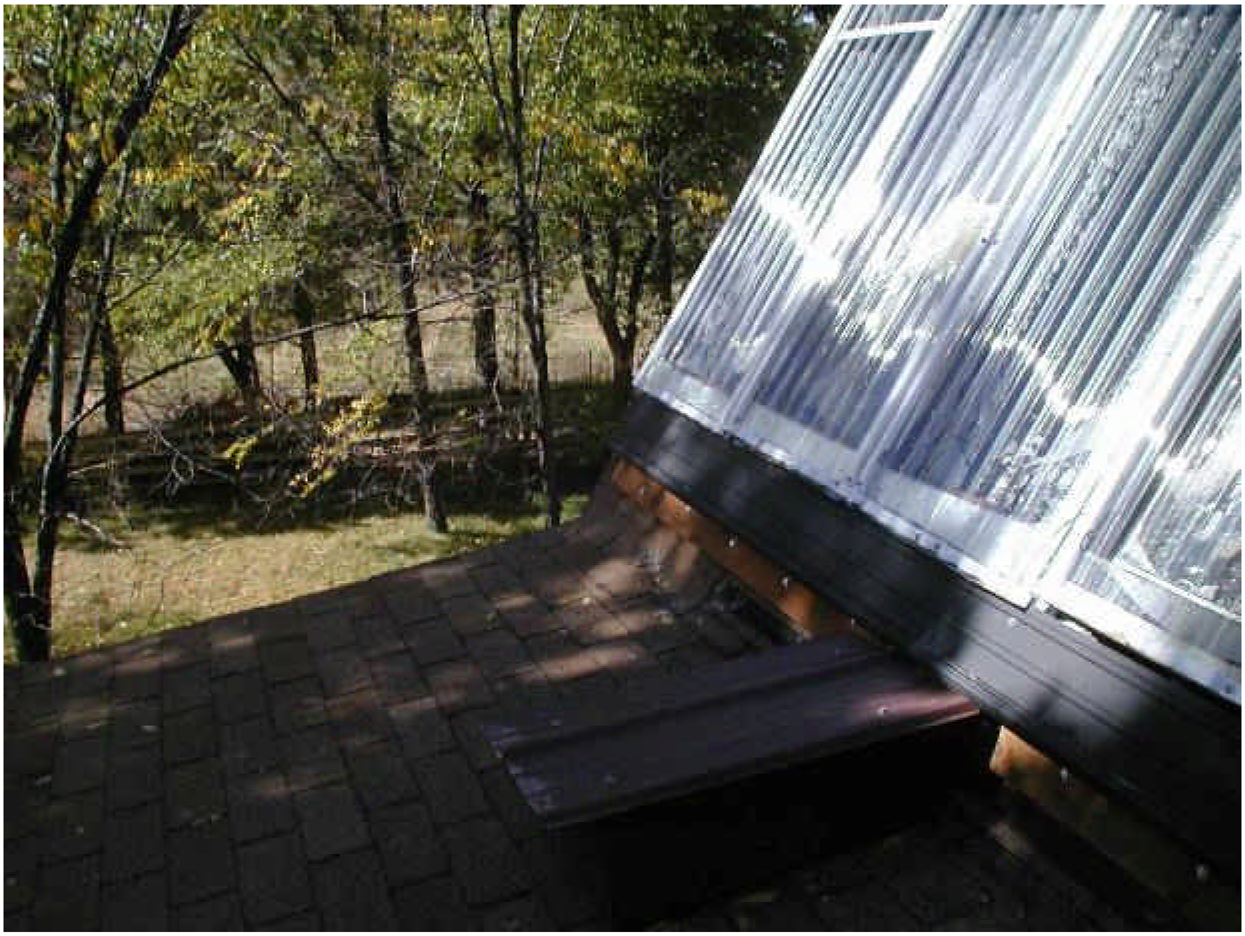
Roof Mounting, Drain and Feed lines:

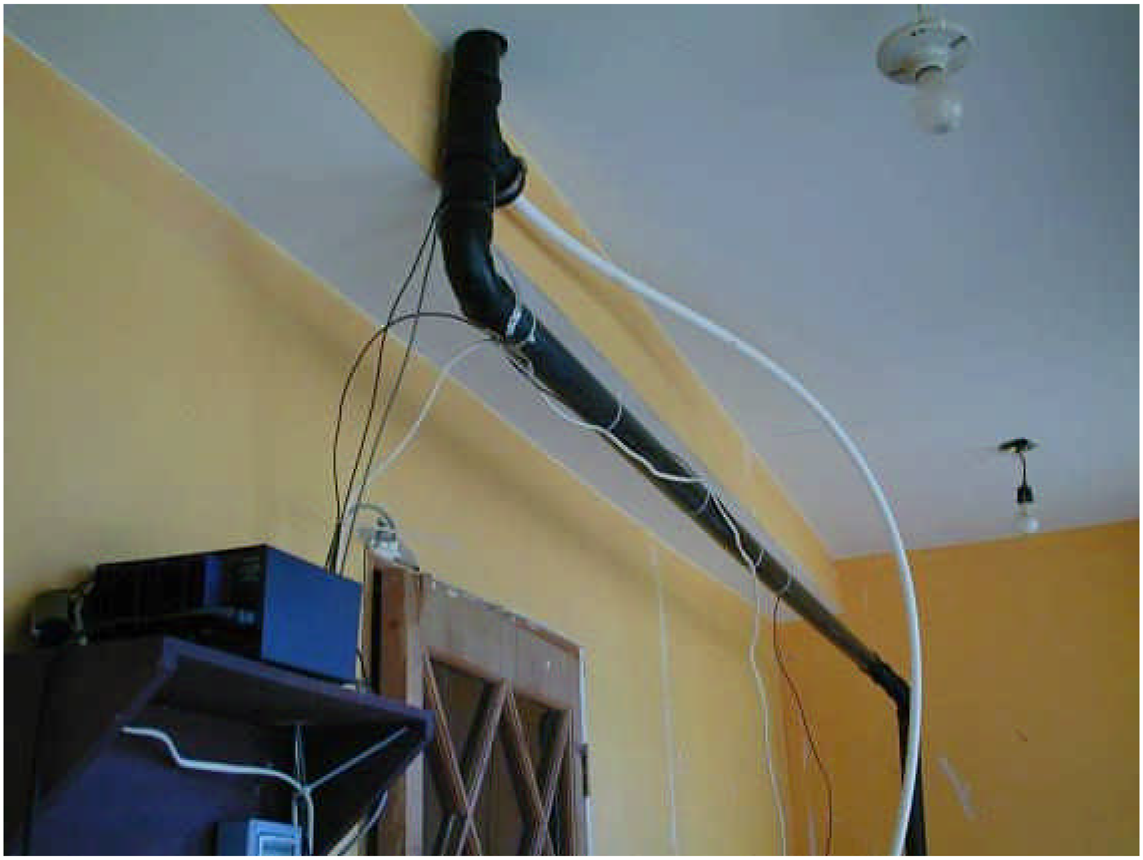
Back in the 70's I had a large hot air collector. And an appropriate slope of the roof above an added sun room remained from then. There is a pair of pressure treated 2x4's lag bolted to the rafters at the top and bottom. The collectors sit on top of the 2x4 and are lag bolted thru the steel frame to the 2x4,s. The main drain going thru the roof is 2"

ABS. This is reduced to 1 ½" ABS at the tee and the 1 ½" collects from 3 collectors on each side. I used a slope of ¼" per foot on the drain. The main feed to the collectors is ¾" pex. It comes up thru the 2" ABS drain line, resulting in only one roof penetration. The ¾" pex is center tee'd and extends out each direction to 3 collectors on each side. Shown are valves that I thought I would need to balance the flow in the collectors. With the feed lines being oversized enough for the actual flow I found they are not needed. The hole size and number of holes control the flow very well, and the collectors have very evenly balanced flows. Be sure to give the same ¼" per foot to the feed line so that it will drain when the pump shuts off. The trickle tube feed inside the collectors is ½" pex. Also shown, the wire going to a temperature sensor that is pushed up thru the drain on the center left collector. The sensor is positioned between the Mylar and felt. About 6" from the bottom.

Drain cover:

Near the bottom of the picture is a small insulated box with a metal roofing top top for the 2" ABS drain shown in the previous pic. Also a cover made from a section of metal roofing cut to fit over all six collector drain boxes. It is not insulated. Since it is black it acts like a small hot air collector and keeps the drain boxes warm.




The feed and drain lines feed down thru the roof from the collector. The feed line enters thru a sanitary tee and a rubber test cap.

Storage Tank:

This is the first temporary setup for the pump and insulation on the tank. It is a used fuel oil tank. I flushed it out and coated the inside with rustoleum paint. Likely will eventually rust out, but then it was FREE! There are two layers of poly encapsulated R13 fiberglass just laid over the top (see below for the upgrade). I originally used a Rule 2000 brand pump mounted into the end of the tank. It had more than enough pressure to pump up 18 feet to the top of the collectors, and maintain about 6 gpm thru the collectors. When it was not run because of clouds etc. for a couple days it would sometimes not start, had to thump it to get it to start. These are bilge pumps and have a relatively short life expectancy.

I made a frame from some OSB to staple the fiberglass insulation into, and form a box around the tank. This gives me an R26 on the top and one side. There is 2” of polystyrene on this end. The bottom has 12” of fiberglass batting. The other end and side are against inside walls. It definitely could use more insulation on all sides. This winter has been pretty cold and all the glass in the sun room lets it drop into the 40’s over night. Been thinking of how to move the storage into a living space, as an water wall thermo siphon arrangement.

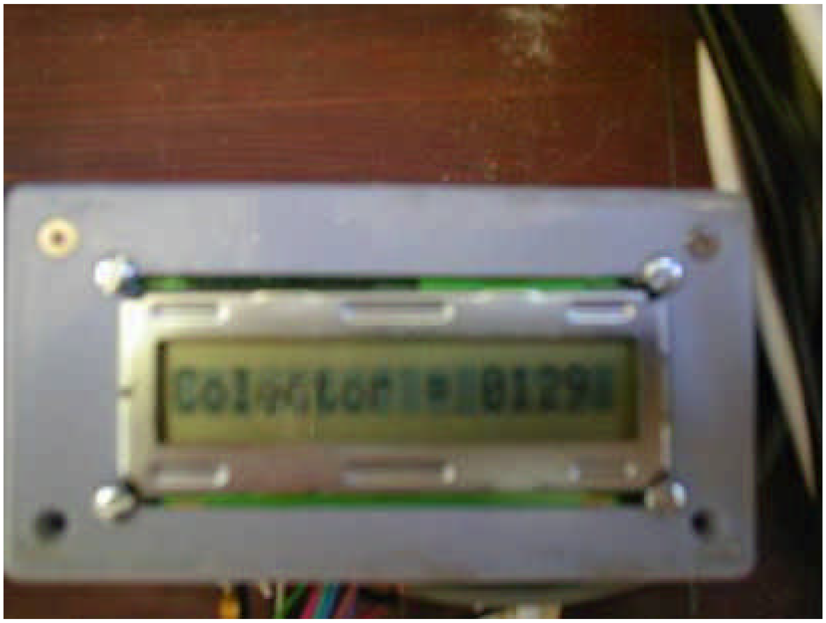
Pumps:
I found some Grundfos pumps on ebay with enough capacity for my system. The upper one is for the collector, the lower for heating the house. They are 110vac so I had to add relays to run them off my 12vdc control. It would have been nice to have 12vdc pumps so I could eventually run them off a PV panel, but at $25 apiece I couldn't pass them by. These pumps pull less total power than the Rule 2000 pump. They are three speed pumps. I run the one for the collector at speed 2 and the one for the house on speed 1. These are very quiet pumps compared to the Rule. Since installing these pumps I have not measured the flow rate but it seems to be about the same as with the Rule 2000. There are Gems flow sensors mounted in the lines so I can eventually be able to record the flow rate. The collector pump pulls from the bottom of the tank and returns to the top to help maintain some stratification in the tank. The tank top temperature stays about 15*F higher than the bottom.

Differential Control:

There are two controls shown, both home made. I used to do microcontroller programming for a living, so I etched my own circuit boards and programmed my own differential control.

There is a second control for the house heating. The heating control has a temperature sensor in the house and one in the top of the tank. When the tank is above set point (~85*F) and the house is below set point the circulation pump turns on. The pump pulls from the hotter top of the tank and returns to the bottom to try to maintain the stratification that develops in the tank.

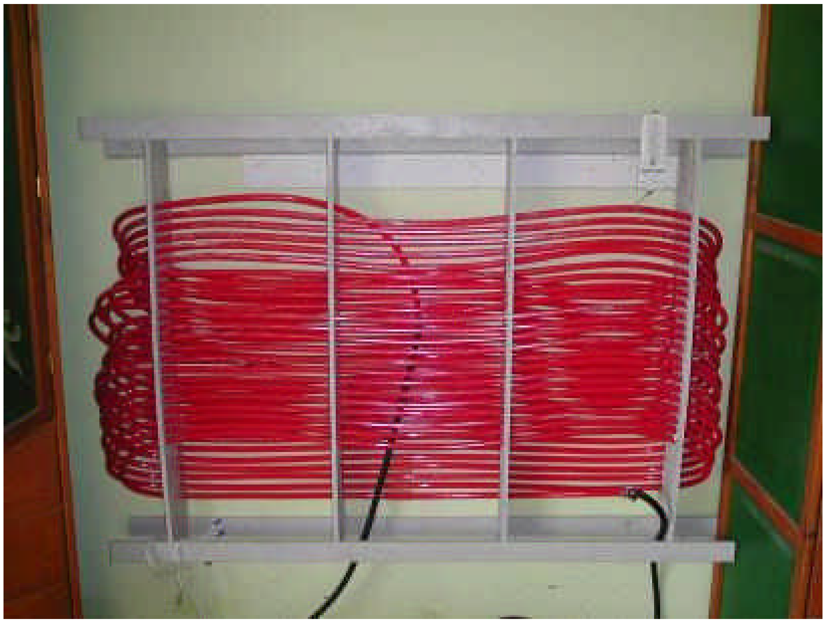
The 12 vdc power supply was to run the Rule DC pumps on the system. Since I am using AC pumps now I only use a 12vdc wall wart supply for the controllers.



My differential temperature controller. Both the on and off differential settings can be set. I currently have the pump turn on at collector 20 degrees above storage tank, and off when the collector falls to within 5 degrees of storage. The storage temperature sensor in is the bottom of the tank. This control also has freeze and boil set points. Also has an input for a solar flux sensor and input for the flow rate sensor I have installed. When I get time the control can calculate BTU and Efficiency of the system.

Using the heat:

I used an automotive heater core and a 500 CFM fan I had to extract the heat from the tank into the living room. It worked extremely well. But, I got tired of listening to the fan run and wanted something quiet.



So, I made this pex radiator. Not something I would ever do again. A real pain to get the stiff pex threaded thru all the holes. It is silent, and the radiant heat feels pretty good on these cold nights. There is about 200 feet of radiant heat pex in it. There is a cloth curtain to go over it sometime. For now just the color makes the room warmer. I may eventually do a radiant floor.

MTD Material Selection Criteria:

I used several criteria in selecting materials for the collectors.

Temperature –

After several failures due to high stagnation temperatures I began testing them in my oven at 250*F for an hour. I also looked for specs on the plastics that would survive in a stagnant collector. I narrowed the types suitable down to polypropylene, acrylic, polyester, Teflon, polycarbonates and some urethanes. PVC does survive my 250*F oven test but is very soft.

Water absorption –

I found that fiberglass will take on water and deteriorate. Also polycarbonates will degrade in water temperatures above 140*F.

UV tolerant –

Very few plastics survive Ultra Violet rays, unless some protection is applied. The only reason most plastics can be used inside the collector is because the Sun-Tuff polycarbonate outer glaze has 100% UV protection. If glass where to be used, the materials we used for the MTD would deteriorate in less than a year. I have one collector with 4 mil PVC in place of the Mylar. The PVC is less tolerant of stagnation than the Mylar, but is significantly easier to use, since it is more flexible. Kind of hoping it will survive in a UV limited environment. John is currently using some 3mil clear polypropylene.

Shrinkage –

Many of the plastics I tried shrunk, especially under stagnation. Polypropylene had the most shrinkage of all. The polyester has shrink but needs to be above 250*F before any significant shrinkage occurs. PVC films also shrink but don't seem to create as much tension as the polypropylene. John's TDM design incorporates allowances for this shrinkage.

Cost and Availability -

This was the criteria that most controlled the materials I ended up using. I was able to buy both the urethane coated polyester and acrylic felt at a local fabric store. The polyester was a bit pricy, I then found some on ebay for ¼ the cost. The PVC I am trying is just the plastic window film one can buy from near any hardware store. The Mylar took a bit of searching, but many drafting supply companies handle it. The Sun-

Tuff polycarbonate outer glaze is available from Home Depot, as is the steel stud rail, and OSB for the inner frame. The polyiso insulation was a bit tricky to find, but I think many of the lumber yard counter guys don't know the difference between polystyrene and polyisocyanurate, let alone know how to pronounce it.

Source for MTD & TDM books and materials:
http://www.jc-solarhomes.com/

I do not have a web site. Much of the information is available thru John Canivans site. If you have specific questions on my design, you may contact me at the below email address.

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