APPENDIX 2:
Expansion Tank Sizing for Solar Collection Circuits:

During its service life, almost every closed-loop solar collection system will experience stagnation conditions, where bright sunshine strikes the collectors without flow through the absorber plates. Under such conditions, the fluid within the collectors can change to vapor. In addition, the fluid within the piping to and from the collector array could be filled with very hot fluid.

To prevent the relief valve from opening under these conditions, the expansion tank must absorb the liquid volume expansion plus the fluid displacement volume caused by vapor formation in the collector array. The following procedure determines the minimum volume of a diaphragm-type expansion tank volume to accommodate this situation.

Step 1: Calculate the potential expansion volume of the entire collector circuit using formula 5a.

Formula 5a

$$V_a = 1.1\ (V_c + V_p)\, e + V_c$$

Where:
V_a = expansion volume to be accommodated (gallons).
V_c = total volume of collector array (gallons)
V_p = total volume of collector circuit other than collector array (gallons)
e = coefficient of expansion of collector circuit fluid (e = 0.045 for water, or e=0.07 for glycol)
1.1 = safety factor of 10% to allow for system volume estimates

The volume of the collectors is usually listed in the manufacturer's specifications, as is the volume of the heat exchanger. The volume of the piping can be estimated using data from table 1 in appendix 1.

Step 2: Calculate the static pressure at the location of the pressure relief valve. This is the pressure caused by the weight of fluid in the collector circuit above the pressure relief valve location. It can be calculated using formula 5b.

Formula 5b:

$$P_i = H\,(0.454) + 5$$

Where:
P_i = initial pressure at the relief valve location (psi)
H = height of collector circuit above location of pressure relief valve (feet)
0.454 = constant based on the density of 50% propylene glycol
5 = allowance for 5 psi gauge pressure at top of collector circuit

Note: The air chamber in the expansion tank must be pressurized to the pressure calculated using Formula 5b before fluid is added to the collector circuit.

Step 3: Calculate the minimum required expansion tank volume using formula 5c.

Formula 5c

$$V_T = V_a \left(\frac{P_f + 14.7}{P_f - P_i} \right)$$

Where:
V_T = minimum required expansion tank volume (gallons)
V_a = expansion volume to be accommodated (from step 1) (gallons)
P_i = initial pressure at the relief valve location (from step 2) (psig)
P_f = maximum allowed pressure at the relief valve location (psig). Recommended value is pressure relief valve rating minus 5 psi

Example: Determine the minimum expansion tank volume for the following system:

- 4 collectors, each having a volume of 1.5 gallons
- Total of 120 feet of 1-inch copper tubing between heat exchanger and collector array
- Heat exchanger volume = 2.5 gallons
- Height of top of collector array above relief valve location = 25 feet
- Pressure relief valve rating = 60 psi
- Collector circuit fluid = 50% solution of propylene glycol

Solution:
– Total collector array volume:
4 x 1.5 = 6 gallons

– Total piping + heat exchanger volume:
120 ft x (0.0454 gallon/ft) + 2.5 = 7.95 gallons