

Comparison of Two Types of Solar Heat Collection Loops

by Everett M. Barber, Jr.

Filled-Pressurized w/glycol
&
Partially Filled, non-Pressurized
w/glycol

Among Solar Thermal Folk This Topic Prompts Heated Discussions

- As with many things in life, much of the *heat* is based on lack of awareness of the specific attributes of each system.
- I hope to add the benefit of 37 years of experience with both types to that discussion.

My Experience

- Over the past 37 years I've designed and installed more filled-pressurized indirect systems than partially filled, non-pressurized indirect systems (drain-back).
- I was a strong advocate of the former and critic of the latter for at least 20 years.
- I have been a strong advocate of the latter for about the last 17 years.
- Here's why.....

Outline: What I'll discuss

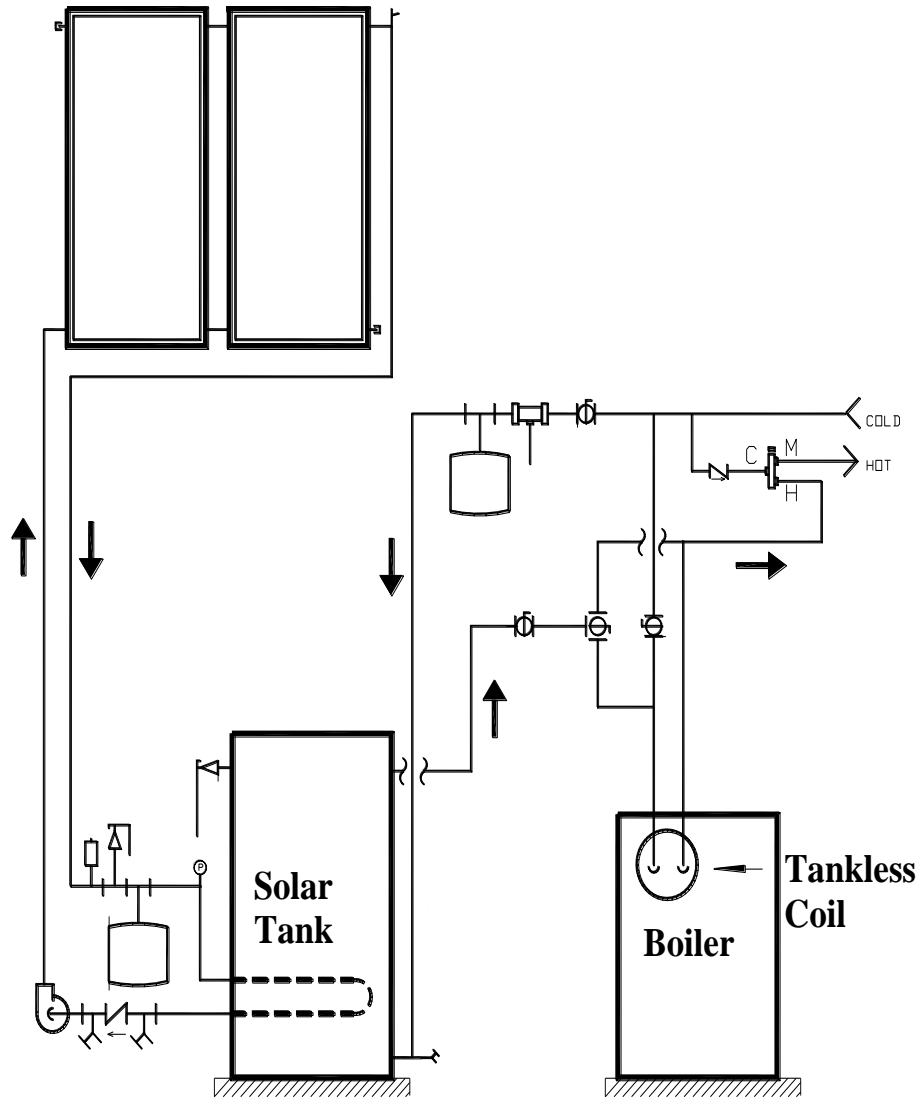
- Schematics of the two system types
- A list of 39 attributes of indirect systems and the characteristics of filled-pressurized and drain back systems.
- Going thru the attributes, one by one, is the best way I know to set forth the specific differences between the two types of systems.

Solar Heat Collection Loops - Briefly

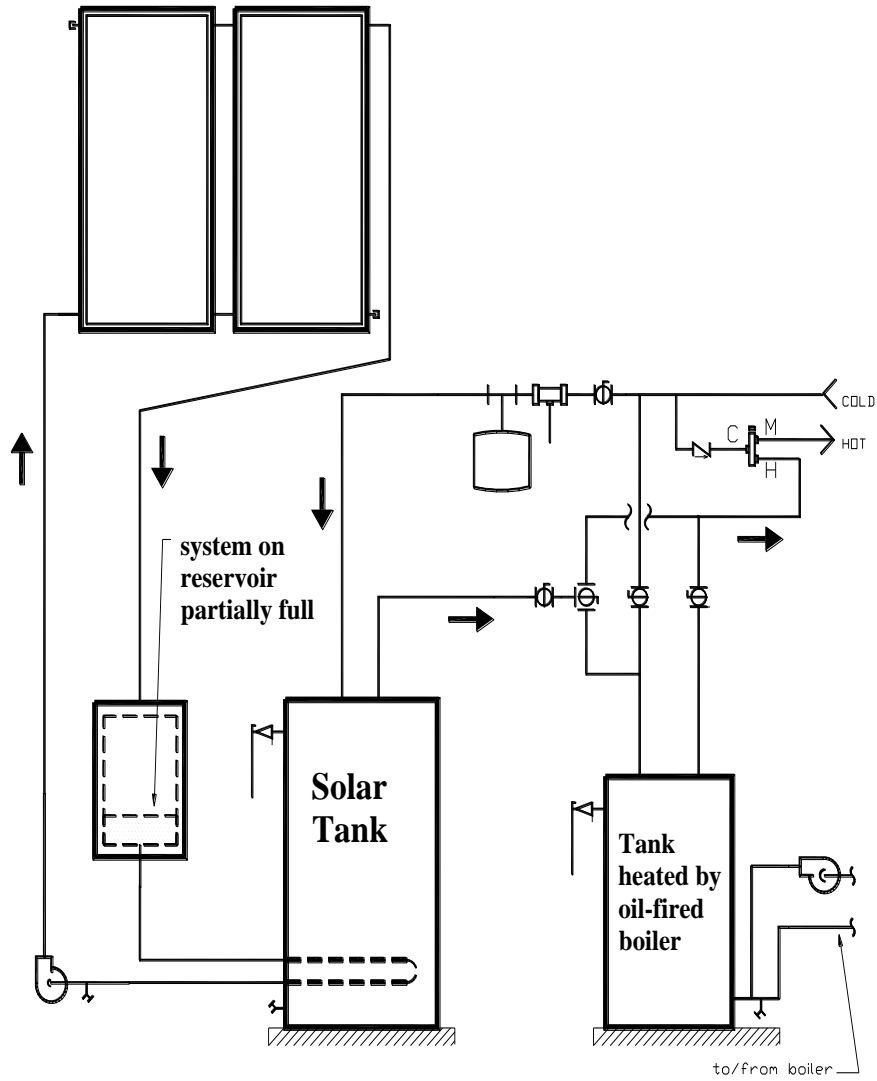
- Air Cooled Collectors
 - The air that cools the collectors is the air that is used to heat the building.
- Liquid Cooled Collectors
 - Direct
 - The liquid that cools the collectors is the liquid to be used in the building, as domestic water.
 - Indirect
 - The liquid that cools the collectors gives up that heat to the fluid, (air or liquid) to be heated via a heat exchanger.

This Presentation is Limited to
Liquid Cooled Indirect type Heat
Collection loops

Schematic of Filled Pressurized Loop



Schematic of Partially Filled, non-pressurized (drain back) w/glycol Loop



Comparison Method

- List of System Attributes (39)
 - Filled-pressurized systems
 - Partially filled, non-pressurized systems

Excluded: drain back systems w/water as coolant

- This position is based on experience with a small % of drain-back system with water that have experienced freeze damage.

Attribute 1:

Freeze protection

- Filled-Pressurized w/glycol:
 - Yes, w/low freeze pt. liquid: glycol/water, silicon oil, Brayco 888.
- Drain-back w/glycol:
 - Yes, w/low freeze pt. liquid:

Attribute 2: Loss of Circulation

- Filled-Pressurized w/glycol:
 - Will overheat, may vent glycol/water charge.
- Drain-back w/glycol:
 - Will not overheat. When power off, coolant drains back to reservoir.

Reasons for Loss of Circulation

- Power failure due to electrical storm or snow storm.
- Someone, unknowingly unplugs the power cord to the pump control.
- Power shut off to house when house vacant.
- Someone, unknowingly turns off the breaker supplying power to the solar system.
- Circulator burns out.
- Loss of Coolant from collection loop.

Attribute 3: Short Term (several days) Overheat Protection

- Filled-Pressurized w/glycol:
 - Heat dump required, passive or active heat dump.
- Drain-back w/glycol:
 - Coolant drains to reservoir when storage high limit is reached.

Overheating of Closed-loop 'Glycol' systems

- These systems often overheat during the summer, when there is little or no demand for hot water (owner's on vacation, one person in house when used to be 3 or 4, etc.) or a power failure.
- Overheating can cause:
 - loss of collection loop fluid;
 - venting of water from the P/T relief valve on the hot water tank;
 - excessively hot water;
 - shortened tank life;
 - annoying 'steam hammering' noise in the collectors;
 - eventual (7 to 10 years) blockage of the tubing in the collector;
 - shorten the life of the antifreeze – becomes acidic;
 - the safety switch on the elect. elt. to trip (in 'single tank' systems);

(Telling a system owner to take 2 showers and call me in the morning, does not work....I've tried. Humor not appreciated!)

Means of Preventing Overheating

- When house is vacant for more than 2 days;
 - Open a hot water tap and let it run until occupant returns
 - Cover the collectors
 - Run the collection loop pump 24/7
 - Install a heat waster to dump the heat
 - Length of finned tube in the basement with 3-way valve
 - Bury a coil of tubing outside in the ground with 3-way valve
 - Use a heat transport oil in the collection loop (high boiling pt.)
 - Let the system overheat, recharge it and mop up when house is occupied again
 - Before going away, drain enough antifreeze from the collectors to empty the collectors; recharge upon return
 - Attach one end of a hose to the end of the drain leg on the P/T valve and run the other end outside (against code)

Attribute 4: Long Term (weeks/months) Overheat Protection

- Filled-Pressurized w/glycol:
 - Likely to lose coolant unless collection loop drained or collectors covered.
- Drain-back w/glycol:
 - Coolant drains to reservoir when storage high limit is reached.

Reasons for Long Term Loss of Use of System

- Owner lives in beach house for the summer.
- Owner goes away (south) for the winter.
- Owner doesn't have the funds to repair the system.
- New Owner doesn't understand the system and decides not to use.
- Home is vacant while it is on the market.

Attribute 5: Pressure to Recharge Coolant

- Filled-Pressurized w/glycol:
 - High head transfer pump required.
- Drain-back w/glycol:
 - Atmospheric Pressure, hence gravity fill may be used.

Attribute 6: System Charging Provision

- Filled-Pressurized w/glycol:
 - Yes, “charging station” or valve between boiler drains required.
- Drain-back w/glycol:
 - No, may pour in coolant though one port when pump is off.

Attribute 7:

Thermal Expansion Provision

- Filled-Pressurized w/glycol:
 - Yes, expansion tank, usually diaphragm type required.
- Drain-back w/glycol:
 - No, ~40 % of loop volume is air. Coolant expands against that air.

Attribute 8: Typical Operating Pressure

- Filled-Pressurized w/glycol:
 - 35 to 75 psi, depends on manufacturer.
- Drain-back w/glycol:
 - Atmospheric pressure: 0 psi.

Attribute 9: A Pressure Gage Required

- Filled-Pressurized w/glycol:
 - Yes, b/c if pressure falls below minimum level, then no circulation, even if pump running.
- Drain-back w/glycol:
 - None required, system operates at ~ atmospheric pressure.

Attribute 10: Prevents Night-time Heat Loss from Array

- Filled-Pressurized w/glycol:
 - Yes, a swing check valve.
- Drain-back w/glycol:
 - None required, since coolant drained from array at night.

Attribute 11: Air venting Provision

- Filled-Pressurized w/glycol:
 - Yes, a manual or automatic air vent required.
- Drain-back w/glycol:
 - None required, ~40% of the collection loop is air.

Attribute 12: Prone to Air Blockages

- Filled-Pressurized w/glycol:
 - Common Problem, frequent cause of ‘call backs.’
- Drain-back w/glycol:
 - Not a problem.

Attribute 13: Prone to Glycol Solidification in Absorber.

- Filled-Pressurized w/glycol:
 - Observed in serpentine flow path absorbers w/small ID tubes. Problem develops in 7 to 10 years. Absorber, or collector, must be replaced.
- Drain-back w/glycol:
 - Not observed where grid pattern absorbers used.

Attribute 14: Circulator Wattage (ac)

- Filled-Pressurized w/glycol:
 - Lower wattage compared to drain back systems.
- Drain-back w/glycol:
 - Higher wattage (3 to 4 times higher) on start-up, but with 2 circs. In series, 2 nd can be shut off after start, or variable speed pump can reduce wattage to ~ same as filled sys.

Attribute 15: Suitable for PV Module Powered Circulator

- Filled-Pressurized w/glycol:
 - Yes. (must include storage high limit)
- Drain-back w/glycol:
 - Seldom done, due to higher wattage required on start-up, thus more costly PV module and dc circulator.

Attribute 16: Circulator Volute Material/Cost

- Filled-Pressurized w/glycol:
 - Cast Iron volute, thus low cost
- Drain-back w/glycol:
 - Cast Iron volute, thus low cost.

Attribute 17: Minimum Pipe Size Limitation

- Filled-Pressurized w/glycol:
 - None other than due to length of pipe run and flow volume. ($\frac{1}{2}$ & $\frac{3}{4}$ in. common in residential SDHW)
- Drain-back w/glycol:
 - None other than due to length of pipe run and flow volume. ($\frac{1}{2}$ & $\frac{3}{4}$ in. common in residential SDHW)

Attribute 18:

Suitable for use with Plastic Tubing

- Filled-Pressurized w/glycol:
 - No. (due to possible surge at 300 deg. F @ 75 psi)
- Drain-back w/glycol:
 - Not within 10 feet of the collector on feed and return sides, otherwise OK.

Attribute 19: Pipe Pitch Necessary

- Filled-Pressurized w/glycol:
 - No, but desirable for draining and recharging the system.
- Drain-back w/glycol:
 - Yes, from drain back reservoir to collector inlet.

Attribute 20: Drain-Back Reservoir Required

- Filled-Pressurized w/glycol:
 - No.
- Drain-back w/glycol:
 - Yes.

Attribute 21: Installer Familiarity

- Filled-Pressurized w/glycol:
 - All Experienced Installers should be.
- Drain-back w/glycol:
 - Fewer experienced Installers are familiar with this type of system.

Attribute 22: Collector Array Placement with respect to Storage

- Filled-Pressurized w/glycol:
 - Above or Below.
- Drain-back w/glycol:
 - Above, yes. If below, the drain back reservoir must be below the collectors to permit draining when pump off.

Attribute 23: Design Difficulty

- Filled-Pressurized w/glycol:
 - Moderate.
- Drain-back w/glycol:
 - Moderate, but will require more learning time for those unfamiliar with drain back systems.

Attribute 24: Net Positive Suction Head (NPSH) Requirement

- Filled-Pressurized w/glycol:
 - Not a consideration, since pressurized system
- Drain-back w/glycol:
 - Yes, and NPSH increases with pump hp and coolant temperature.

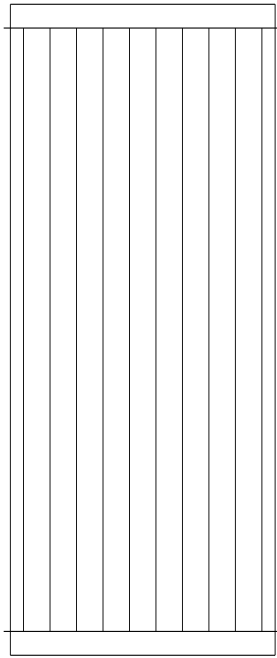
Attribute 25: Collector Absorber Construction

- Filled-Pressurized w/glycol:
 - Any serpentine or grid pattern absorber can be used.
- Drain-back w/glycol:
 - Any drainable serpentine or grid pattern absorber can be used.

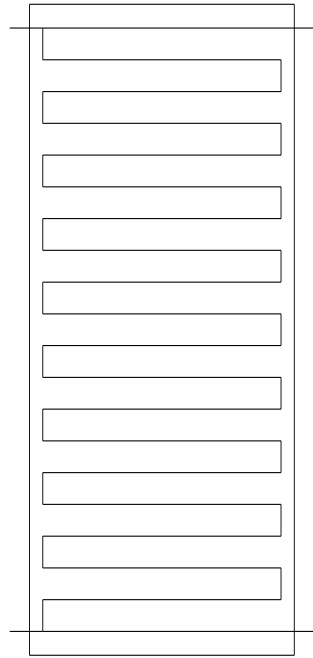
Absorber Types

- Flow Connection
 - Parallel flow connection: minimizes temperature rise across array = higher efficiency;
 - Series flow connection: minimizes piping across an array, but temp increase with each collector = lower efficiency.
- Two common flow patterns:
 - Serpentine (most are not suitable for drain back operation)
 - Grid (suitable for drain back operation)

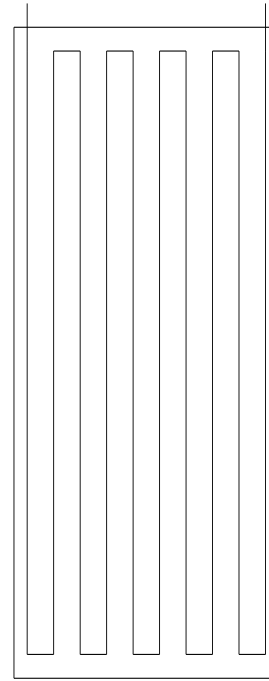
Parallel & Series Flow in Absorbers



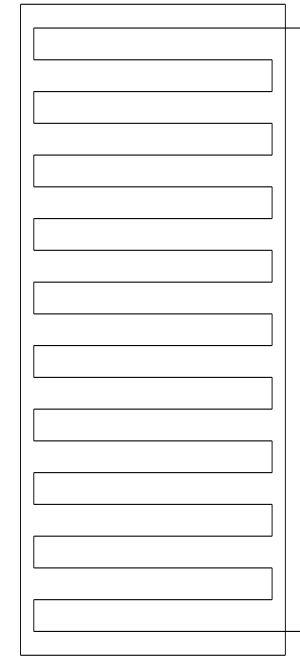
GRID



SERPENTINE
W/SIDE CONNS.



SERPENTINE
TOP CONN.

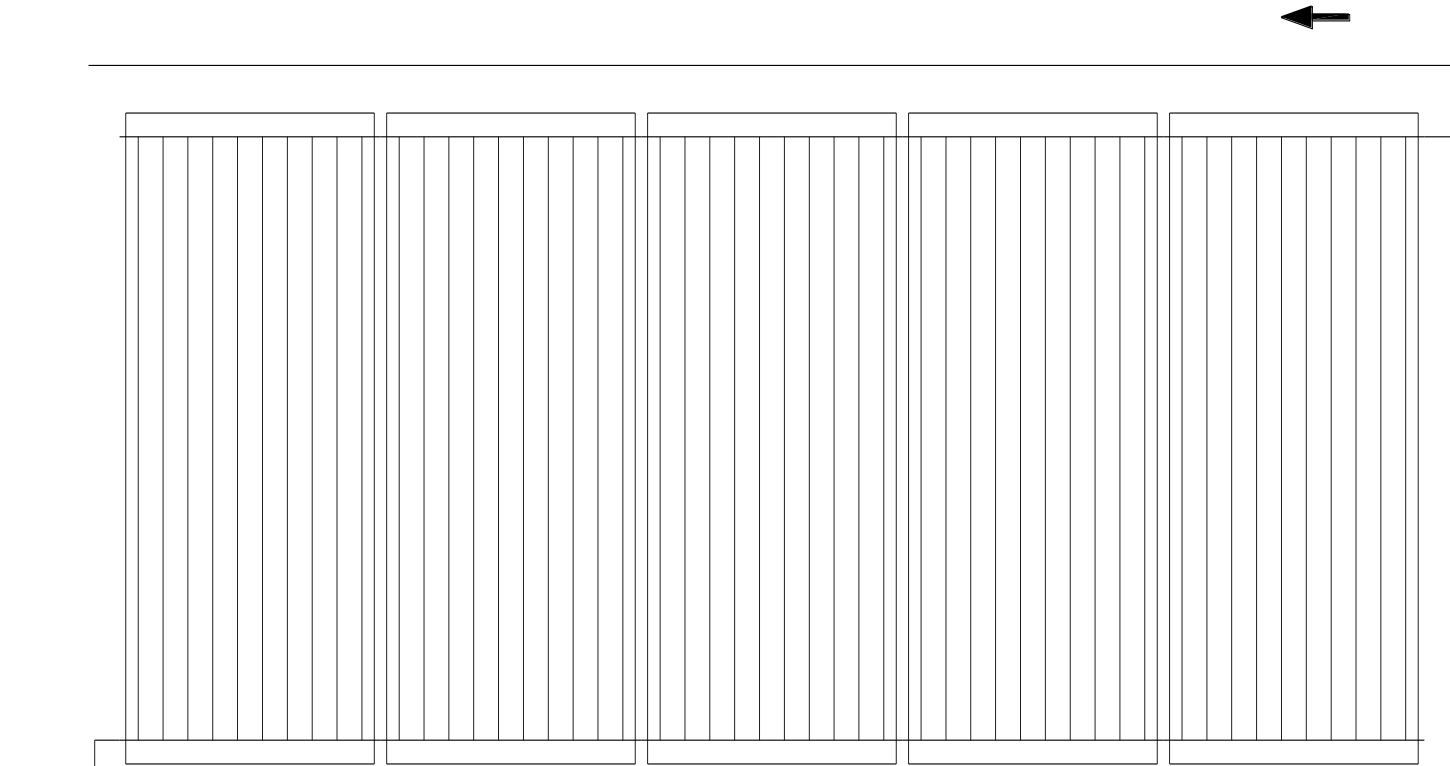


SERPENTINE
SIDE CONN.

PARALLEL FLOW CONNECTION

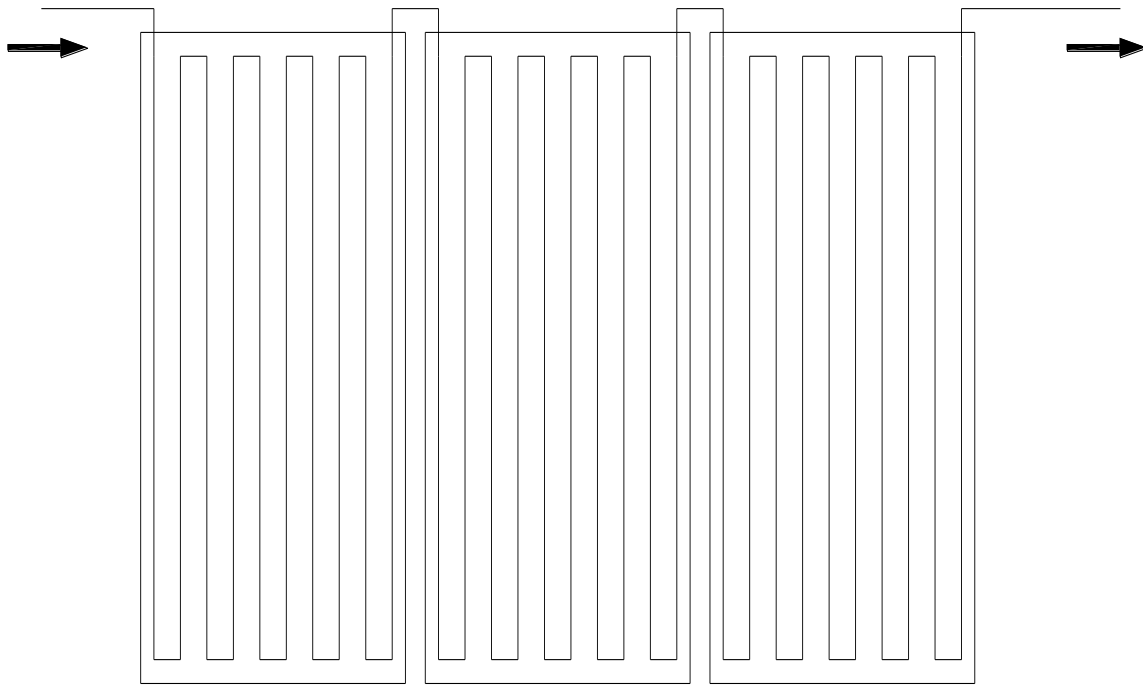
SERIES FLOW CONNECTION

SELECTED ABSORBER FLOW PATTERNS



INTERNALLY MANIFOLDED COLLECTORS
w/GRID PATTERN ABSORBERS

PARALLEL FLOW



Serpentine Pattern
Absorber

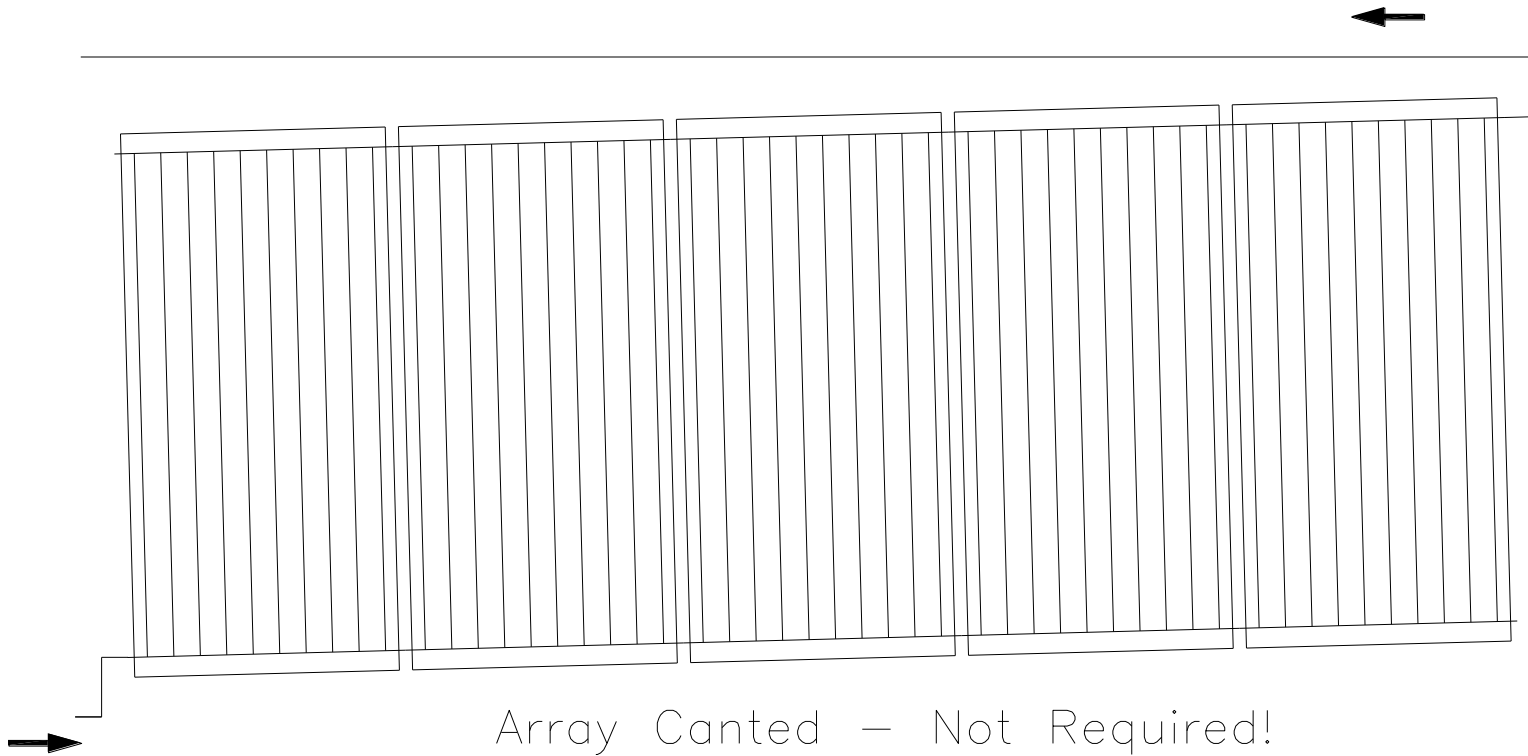
Series Connection

Attribute 26: Evacuated Tube Collector Limitation

- Filled-Pressurized w/glycol:
 - No. Can be used with all evacuated tube arrays.
- Drain-back w/glycol:
 - Yes, few evac. tube collectors can stand full sun and empty absorbers.

Attribute 27: Canting of Collector Array Required

- Filled-Pressurized w/glycol:
 - No. But level is desirable for draining/recharging.
- Drain-back w/glycol:
 - No. But level is desirable for draining when pump shuts off.



Array Canted – Not Required!
INTERNALLY MANIFOLDED COLLECTORS
w/GRID PATTERN ABSORBERS

PARALLEL FLOW

Attribute 28:

Array Tilt from Horizontal Limitation

- Filled-Pressurized w/glycol:
 - No, except 0 deg. tilt has air venting problems.
- Drain-back w/glycol:
 - No, except 0 deg. tilt has air venting problems.

Attribute 29: Collector Orientation (Portrait or Landscape) Restrictions.

- Filled-Pressurized w/glycol:
 - No.
- Drain-back w/glycol:
 - No.

SDHW Cheshire, CT





Attribute 30: System Efficiency Limitation

- Filled-Pressurized w/glycol:
 - Sometimes, by piping multiple collectors in series, the collection efficiency becomes less with each subsequent collector.
- Drain-back w/glycol:
 - No, since collectors are piped in parallel.

Attribute 31: Pump Control Requirement

- Filled-Pressurized w/glycol:
 - Required, unless PV powered circulator used with tank high limit cut-out.
- Drain-back w/glycol:
 - Required, one with separate outputs to two pumps desirable.

Attribute 32: System Reliability

- Filled-Pressurized w/glycol:
 - Good, but coolant loss problems and more parts to fail.
- Drain-back w/glycol:
 - Excellent. Fewer parts to fail.

Attribute 33: Structural Concerns

- Filled-Pressurized w/glycol:
 - If array is roof-mounted, roof must be capable of supporting the dead load and wind load.
- Drain-back w/glycol:
 - If array is roof-mounted, roof must be capable of supporting the dead load and wind load; and weight of drain back reservoir is a consideration for commercial systems.

Attribute 34: Resistant to Long Term Settling of Building

- Filled-Pressurized w/glycol:
 - Minimal Concern, until array must be drained/recharged.
- Drain-back w/glycol:
 - Minimal concern, but it can limit extent of drain back.

Attribute 35:

Thermal Shock to Absorber

- Filled-Pressurized w/glycol:
 - Minimal normally, but yes when system has been off, (as for repairs) and is restarted mid-day on a clear day.
- Drain-back w/glycol:
 - Minimal normally, but yes when system has been off, (as for repairs) and is restarted mid-day on a clear day.

Attribute 36: Noise When Operating

- Filled-Pressurized w/glycol:
 - No. Only noise occurs when system is overheating, then ‘steam hammer’ heard.
- Drain-back w/glycol:
 - Yes, soft gurgling sound when system is collecting heat.

Attribute 37: System Control Complexity

- Filled-Pressurized w/glycol:
 - Moderate, because must include heat dump/over heat provision.
- Drain-back w/glycol:
 - Simpler, pump(s) are either on or off. If two pumps used then control with two outputs is desirable.

Attribute 38:

Ease of Confirming Heat Collection

- Filled-Pressurized w/glycol:
 - Easy for an experienced tech, not always so easy for a layperson.
- Drain-back w/glycol:
 - Easy for experienced tech or layperson. If can't hear the gurgling in the drain back reservoir then the system is not returning heat from the array.

Attribute 39: Freeze Damage Potential if Circulator Runs 24/7

- Filled-Pressurized w/glycol:
 - No, unless a heat exchanger that is external to the tank is used.
- Drain-back w/glycol:
 - No, unless a heat exchanger that is external to the tank is used.

Summary Comparison

- Filled-Pressurized w/glycol:
 - Pro:
 - Most installers are familiar with this system type.
 - Generally reliable
 - Can use pV powered circulator
 - Con:
 - Frequent customer complaint about excessively hot water.
 - Special provision required for periods of no heat demand.
 - More frequent service required.

Summary Comparison

- Drain-back w/glycol.
 - Pro:
 - Very reliable
 - Minimal complaints about too hot water.
 - Simple to service.
 - Copes well with no demand for heat.
 - Con:
 - Fewer installers are familiar with the system.
 - PV powered pumps are costly

Questions?