Geothermal Project

Forced Air System & Split System

Heating/Cooling System – New Preston, CT

Overview

The heated and cooled area of the house is a roughly 2000 square feet, with another 1000 square feet of basement area that is partially heated and cooled because the basement ceiling is not insulated. The poured concrete walls of the basement have 1.5” foam insulation on the areas that are not below grade. The floor to ceiling distance is 8 feet on all levels. Wall insulation is 3.5” fiberglass with an additional 1” of Styrofoam insulation between the plywood sheathing and the 1” cedar board siding. The attic ceiling insulation is 12” of fiberglass, with an additional 3.5” in many areas. All windows are double glazed. A thermal study done by a professional engineer estimated the heat load would require the heating system to deliver an average of 36,000 BTU/hour.

Two 2.5 Ton heat pump systems are installed (60K BTU/hour total capacity). One heat pump serves the first floor (and effectively the basement) and the other serves the 2nd floor. The prior heating system was baseboard electric heat with one or more baseboard heaters and individual thermostat control in each room. The existing electric baseboard heating system was left in place. The house had no previous air-conditioning units of any kind.

There was no existing ductwork or plumbing for distribution of heated air or water. Because of the difficulty (and loss of living space) required to run ductwork from the basement to the 2nd floor, the 2nd floor air-handler (for heating and cooling) was placed in the attic. Instead of running ground loop water from the basement to a complete heat pump located in the attic, a split-system was installed with the compressor in the basement and insulated refrigerant lines running from the basement to the attic air handler. This has the added benefit of having only quiet machinery located above the bedrooms. The air handler has a single variable speed fan and ½ HP motor.

Ground Loop System Details

The installed Geothermal Ground Loop uses two 400-foot-deep boreholes. These 6” drilled boreholes contain the ground loop piping built with 1.25” HDPE pipe. Per state code, the boreholes are filled with thermally enhanced bentonite. This is a mixture of bentonite and sand that preserves the low permeability of the bentonite but enhances its thermal conductivity.

Reference: Successful Geothermal Grouting: *http://info.ngwa.org/GWOL/pdf/100384208.pdf* Water Well Journal, Feb. 2010

The overall thermal conductivity from the water inside the HDPE pipe to the earth, rock, and water surrounding the borehole is the mechanism used by the heat pumps to either extract heat from the earth or return heat to the earth. https://www.geoexchange.org/geothermal-101/

At this location in Connecticut (41.673024 Lat, -73.344141 Lon, 910’ elev.), the earth temperature below 30 feet is stable at about 53 °F. The geothermal boreholes are used to extract heat and the temperature drops to about 40 °F just after the peak loads of the heating season. The temperature rises to about *tbd*

°F just after the peak loads of the cooling season. The surrounding ground temperature (picture the outer perimeter of a large cylinder around the boreholes) does not change. But closer in toward the center (where the borehole piping is adding or removing heat) the temperature will change up or down as much as °15 F, depending on loading. This temperature change cannot be avoided, as it is the driver of heat flow from the mass of the surrounding earth to, or from, the borehole. The thermal resistance of the ground itself requires a temperature difference to drive heat flow.

There are horizontal ground loop piping runs that connect the borehole piping to the basement of the house. These horizontal runs are closer to the surface, but below the frost line, and enter the house underground through the foundation wall. Additional heat transfer also occurs on these horizontal runs, but it is less than the equivalent length in the boreholes because the lateral runs are closer to surface (up to 10°F colder in winter and 10°F warmer in summer) and the surrounding earth contains less rock and water (less thermally conductive).

The piping loops from the two boreholes enter the house through 4 drilled holes in the concrete foundation wall. Expandable plastic seals are used to protect the HDPE pipe and seal the foundation openings. A simple manifold combines the two 1.25” HDPE loops into 1.5” source and return connections for the basement located heat pumps. The ground loop contains about 135 gallons of fluid, including 4 x 400 feet of piping in the two boreholes plus 4 x 60 feet of lateral piping for a total of 1840 feet. The 1.25” HDPE pipe (1.340” ID) carries 7.33 gallons per 100 feet, yielding just under 135 gallons. The basement piping, pump reservoir, and heat-pump heat-exchangers carry an additional 15 gallons, for a total of 150 gallons.

After the initial flush and purge, a 30-gallon charge of propylene-glycol (PG) anti-freeze was added to achieve a 20% anti-freeze content (and an equivalent amount of water was removed). The PG solution protects against freezing down to 19 °F. The ground loop is sized to ensure the water temperature in the ground loop piping will not drop below 32 °F even during winter extremes. Note: The ground water surrounding the entire vertical length of the boreholes will freeze if the loop temperature drops below 32 °F. This will not stop the loop from working as a heat source (ice is actually a better thermal conductor than water), but the efficiency of the heat pump drops as the loop temperature drops. Ground loop temperatures below 35 °F can cause a low-pressure cutout on the compressor suction line as the evaporator output gas temperature and pressure drops.

One negative effect of the use of 20% PG in the ground loop piping is the need for more pump pressure, especially when the ground loop temperature drops below 35 °F. The viscosity of 20% PG at 32°F is 3.32 times the viscosity of water at 50°F. The viscosity has the most effect in the larger diameter, and longer, borehole and lateral feed piping. Each borehole has 920 feet of 1.25” DR-11 HDPE pipe (1.340” ID). An online pipe pressure drop calculator (http://www.pipeflowcalculations.net/pressuredrop.xhtml) was used to calculate the required head pressure for the ground loop alone. To force 10 GPM of 50°F water through each external ground loop requires 9.5 psi of head pressure. To force 10 GPM of 32°F 20% PG and water through each external ground loop requires 11.65 psi of head pressure.

Two Grundfos UP26-99 pumps are used in series for each heat pump. At 10 GPM, these pumps each deliver 11.8 psi. Effectively, one pump takes care of the head pressure for the ground loop piping and one pump generates the additional head pressure for the basement piping, valves, and each heat pump’s water-to-refrigerant heat-exchanger coils. At a 40 °F ground loop temperature, each heat pump gets approximately 10 GPM. The Grundfos motors are 1/3 HP motors and will add a maximum of 245 watts of power consumption per pump. This pump power is not wasted in heating mode but adds heat to the ground loop that eventually ends up in the house. Each pair of Grundfos water pumps that feed each refrigerant heat-pump consumes 384 watts (measured), or 192 watts per pump – or 78% of the rated 245-watt maximum power.

Geothermal Heating Concepts

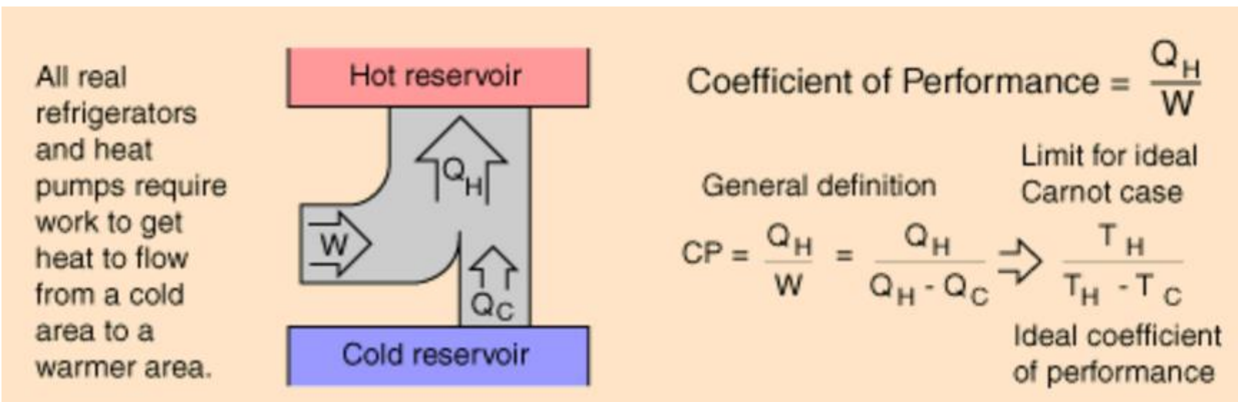
The amount of heat delivered into the house is the sum of the electrical energy consumed by the heat pump system (E_{KW}) plus the heat extracted from the Cold Reservoir (Q_C).

$$Q_H = Q_C + E_{KW}$$

The Cold Reservoir is the earth and the water from the ground loop piping picks up heat from the earth/ground and delivers it to the basement heat pump.

The electrical energy consumed by the heat pump system (E_{KW}, or W in the diagram below) includes the power consumed by all of the following:

- Heat pump refrigerant gas compressor (vapor compression heat pump)
- Fan motor used to circulate air through a refrigerant to air heat exchanger (refrigerant piping with fins) and into the house
- Water pump used to circulate water through the ground loop and the heat-pump water-to-refrigerant heat exchanger (a pipe within a pipe, or coil in coil, heat exchanger)



If the air within the house is at 70°F (294.26°K) and the ground water is at 40°F (277.59°K), the maximum possible coefficient is 17.65, as given by the equation below. Temperatures must be expressed in degrees Kelvin, or °K. 0 °K = –273.15 °C or -459.17 °F.

$$COP = \frac{Q_H}{W} = \frac{Q_H}{Q_H - Q_C} = \frac{T_H}{T_H - T_C} = \frac{294.26}{294.26 - 277.59} = 17.65$$

Above figure and equations were obtained from:

http://hyperphysics.phy-astr.gsu.edu/hbase/thermo/heatpump.html

The surprisingly high theoretical maximum COP of 17.65 is not practically achievable. Real heat pumps deliver a COP in the range of 3 to 4 in the above conditions. This is not too bad – you pay for 1 kWhr of electricity and get 3-4 kWhr of heat transferred into the house. The tradeoff is the capital expense needed to implement the system.

Cooling, or summer time air-conditioning, is much more efficient. In this case, the ground loop temperature is actually lower than the desired house temperature. The heat-pump operates like a standard air-conditioner but the heat-sink is the cool earth, not the warm (or hot) outside air. It should work exceptionally well, but there is a catch to summer time cooling and that is removing water from the air. There is a lot of stored energy in the warm water-vapor that must be extracted and sent to the earth. (Note: This is also why winter time humidifiers consume heat – the energy it takes to vaporize the water must be supplied by the heating system and will then lost due to air exchange with the outside air). At a room temperature of 75 °F, the heat exchanger coils must be driven down below 55 °F to get below the dew point at 50% humidity. If the coils do not get colder than the desired dew point, the air will get cool but will stay humid.

Heat Pump Operating Concepts

The heat pump system is comprised of a 3.5HP electric motor powered vapor compressor (i.e. the compressor), a coil-in-coil water-to-refrigerant heat exchanger, a finned coil air-to-refrigerant heat exchanger, a 4-way refrigerant valve, and a TXV (Thermostatic eXpansion Valve). Refrigerant flows in the inner coil and the ground loop water flows in the outer coil of the water-to-refrigerant heat exchanger. Refrigerant flows in the coil of the air-to-refrigerant heat exchanger and air is blown past the fins on the coil. To switch between heating and cooling, the 4-way refrigerant valve reverses the flow of refrigerant through the system. The valve position is controlled by a solenoid. The valve has a default position (typically heating in a heat pump system) and the other position is activated by supplying 24VAC to the solenoid coil of the 4-way refrigerant valve. The compressor must be operating and generating pressure to complete the transition of the gas switching elements inside the valve. The coil is usually connected to the “O” thermostat wire.

In heating mode, “O” is not energized and the default-position of the 4-way refrigerant valve is “Heating Mode”.

- In heating mode, the 4-way refrigerant valve routes hot high-pressure refrigerant gas from the compressor output to the refrigerant-to-air heat-exchanger. The air heat-exchanger operates as a refrigerant condenser and air heater (cooling and condensing the refrigerant gas into a liquid and adding heat to the air).
- The 4-way refrigerant valve also routes cool low-pressure refrigerant gas to the compressor suction input from the refrigerant-to-water heat-exchanger. The water heat-exchanger operates as a refrigerant evaporator and water cooler (heating and boiling the refrigerant liquid into a gas and extracting heat from the ground loop water).

In cooling mode, “O” is energized (24VAC) and the powers the solenoid coil of the 4-way refrigerant valve. The valve moves to the “Cooling Mode” position as soon as the compressor generates gas pressure.

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- The 4-way refrigerant valve also routes cool low-pressure refrigerant gas to compressor suction input from the refrigerant-to-air heat-exchanger. The air heat-exchanger operates as a refrigerant evaporator and air cooler (heating and boiling the refrigerant liquid into a gas and extracting heat from the air – i.e. cooling the air and condensing water out of the air).

The vapor ⇔ liquid phase change of the R-410A refrigerant is a potent heat source and heat sink. A large amount of energy is required to force a liquid to change phase (i.e. condense from a gas or boil to a gas). Some insight into how much energy a phase change requires can be gotten from looking at the behavior of water. For example, it takes 4.186 joules of heat to warm 1 gram of water 1 °C, or 418.6 joules to heat

1 gram of water from just above freezing to just below boiling. However, it takes 2261.11 joules to boil that 1 gram of water into a gas, starting with the water already heated to just below boiling. In other words, 5.4 times more energy is needed to boil the water (without any appreciable temperature change) than to heat the water from freezing to boiling. A phase change is a powerful mechanism to source or sink heat with very small temperature differences.

Design Implementation Details

Thermostat Controls

Most modern thermostats handle 2 stages of cooling and heating and some can control three stages of heating. However, the 3rd heating stage is usually just an auxiliary electrical heater in the air flow to handle peak heating needs.

The thermostat control outputs have traditional names and colors (not rigorously followed):

- Y1 (yellow): Cool Stage 1 (both Heat/Cool for heat pumps)
- Y2 (light blue, or other): Cool Stage 2 (both Heat/Cool for heat pumps)
- G (green): Fan
- O or B (orange or blue): Heat/Cool Select: On most heat pump systems, “O” is energized for “Cooling”.
    - In heating mode, “O” is not energized and the default-position of the 4-way refrigerant valve is “Heating Mode”.
    - In cooling mode, “O” is energized (24VAC) and the powers the solenoid coil on the 4-way refrigerant valve moves it to the “Cooling Mode” position.
    - To prevent overheating the solenoid coil when the compressor is OFF, the coil should not be energized unless “G” or “Y1” is also energized (even if “O” is continuously ON from the thermostat)
- R (red): 24VAC control power
    - Rc (red): 24VAC power for Cooling
    - Rh (red): 24VAC power for Heating
- D (any color): Dehumidifier demand
    - Miami HP units run the compressor in Cooling Mode, compressor on Stage 2, but Fan on the lower speed normally used for Stage 1
    - This delivers low cooling effect, but still condenses moisture from the air on the unusually cold evaporator coil
    - Dehumidifier run time must be limited (usually by the thermostat) to avoid freezing water on the evaporator coil
- H (x): Humidifier demand – not supported by heat pumps
- C (black): Common – return wire for 24VAC power
- W1 (white): Heating Stage 1
- W2 (brown): Heating Stage 2
- X or AUX (any color): Auxiliary or emergency heat for exceptional or extreme conditions

Split-System Details

The split-system heat pump compressor, coil-in-coil water-to-refrigerant heat exchanger, 4-way refrigerant valve, TXV, and control electronics and relays, are located in the basement.

The finned tube air-to-refrigerant heat exchanger is located in the attic. A refrigerant line set pair connects the basement equipment to the attic equipment. The total length of the line set is 44 feet, with a 27-foot vertical rise. The liquid line is 3/8” OD and the vapor line is 3/4” OD. The line set dimensions were recommended by the manufacturer and the HVAC technician, based upon the 2.5 Ton compressor and the line length and rise.

Line set sizing is tradeoff. Larger diameter tubing results in less pressure drop during operation and would improve system efficiency, but can cause other problems. The gas velocity in the larger gas line has to be fast enough to prevent the compressor oil from pooling in low spots along the line set. Too large a diameter can cause refrigerant pooling and oil trapping.

A larger diameter liquid line also needs more system refrigerant and this can cause problems with liquid refrigerant pooling in the compressor when the unit is off. Too much liquid refrigerant in the compressor can cause startup problems such oil dilution and liquid injection into the compression mechanism. The Emerson Copeland Scroll compressor (model ZPS31K5E-PFV) in the 2.5 Ton Miami HP unit has a maximum refrigerant charge rating of 128 oz., as per Emerson Application Bulletin AE4-1311 R8 (1.5 to 5 Ton ZPS*K4 and ZPS*K5 Copeland Scroll UltraTech™ Compressors, July 2013).

A refrigerant charge greater than this value requires a crankcase heater and/or an accumulator. The crankcase heater boils the liquid refrigerant in the off system and causes it to accumulate in other areas where it will not cause a startup problem. The installed split-system required an R-401A refrigerant charge of 100 oz. and neither a crankcase heater or accumulator were installed.

The line sets are PDM GelCopper Pre-Insulated copper lines. The lines are insulated with ½" low-density, closed-cell, polyethylene foam that is rated for high-temperature R-410A use. The 3/4" line has an outer diameter just under 2". Both the 3/8" line and 3/4" lines were run inside interior 2x4 stud walls, and each line is run in 2" EMT (Electrical Metallic Tubing) as a protection against nails, screws, picture hooks, etc. that could conceivably be used in future.

The copper line sets are brazed to the copper tubing of the compressor in the basement and the copper tubing of the air-handler in the attic. Brazing is performed at a temperature of approximately 1200 °F. Copper corrodes rapidly in the presence of oxygen at this temperature. In order to prevent the formation of copper-oxide soot inside the lines, they must be purged of oxygen and a low flow of nitrogen gas must be continuously run through the line sets while the brazing is performed. Failure to do this contaminates the interior of line with copper soot that can clog filters or internal TXV ports, or damage the compressor scrolls.

Controls and Accessories

Crankcase Heater – As per recommendation by the compressor manufacturer, a crankcase heater is needed when the system refrigerant load exceeds the 120% of recommended maximum charge. This installation has a refrigerant charge of only 78% of the recommended maximum, and so does not need a crankcase heater. The heat pump manufacturer and the HVAC contractor felt that a basement located compressor (where the temperature is always above 50 °F) does not need a crankcase heater. The systems have no crankcase heaters at present. Under consideration is the addition of crankcase heaters that can be switched on in specific conditions. For example, if the system has been off for an extended period and/or the basement has gotten cold during a prolonged power outage.

Forced Y2 (2nd stage switch) – Even when the outside temperatures are relatively cold (15 to 20 °F range), the Nest thermostat often chooses to run in Stage 1. This results in longer run times (not really a problem), but more significantly, the temperature of the heated air is reduced. Stage 1 operation gives a 19 °F temperature rise and Stage 2 Operation gives a 28 °F temperature rise (even with a higher CFM airflow). A non-scientific observation is that the room *feels* better when Stage 2 is run when the outside temperature is cold. The SWAG (scientific wild ass guess) is that Stage 2 operation raises the wall temperature more and the makes the room feel warmer. A planned addition is a switch on the basement control panel that would allow Stage 2 Operation to be: OFF, Auto, or ON. This sounds nice, but it will cost a little electricity.

Y2 Delay – When the Nest thermostat chooses to run in Stage 2, the compressor is started with the Stage 2 solenoid energized. This does increase the starting surge. Adding a 60-second time delay from the activation of Y2 (Stage 2 call) until the compressor Stage 2 solenoid is engaged is planned.

Compressor Cutout on Loss of Water Circulation – Instead of relying on compressor protection using the HP Cutout if the ground loop water circulation fails, normally closed pressure switches were installed on the input side of the heat pump refrigerant-to-water heat exchanger. If the pressure is less than 10 psi, the FS (Flow Switch) fault contact to the heat pump controller is interrupted. If this contact is open for 30 seconds while the compressor is running, an AUX fault stops the compressor. This will automatically retry 3 times before the fault requires a power cycle to reset.

Ground Loop Plumbing Leaks – In addition, a DiversiTech WetSwitch was placed on the floor between the heat pumps and the ground loop flow center. If a water leak from any source coats the floor with water, the ground loop circulation pumps are disabled, which in turn will disable the heat pump compressors. Rather than risk emptying the ground loop of water through a major leak, it was decided to shut down all pumps for any detected leak.

System Testing

The heat pump system was tested in Stage 1 and Stage 2 to verify operation in both stages. More heating and cooling effect is delivered in Stage 2, but Stage 1 is also effective. The Emerson Copeland scroll compressors deliver about 67% capacity in Stage 1 and 100% in Stage 2. The Copeland 2-stage compressor runs in Stage 1 unless the compressor’s Stage 2 solenoid coil is energized to close a gas bypass valve located inside the compressor. To achieve Stage 2 operation, 24VAC is supplied to a connector on the side of the compressor. Note: The connector contains a rectifier that supplies rectified AC (essentially DC) to the internal coil, because a low-current coil needs less voltage to operate on DC than AC.

The installed Nest 3rd Generation thermostat (and most modern thermostats) runs the system in Stage 1 unless the set temperature is far away from the room temperature (e.g. over 3 °F) or if the thermostat senses that the system is not moving toward the set temperature fast enough.

Pressure measurements are most significant in Stage 2. When running in Stage 1, the HP gas discharge pressure from the compressor will be lower and the LP gas suction inlet pressure will be higher (as compared to Stage 2 pressures). LP or HP pressure cutouts will predominately occur when running in Stage 2.

The Emerson Copeland Application Bulletin AE4-1311 R8A has the following statements:

- A low-pressure cut-out is recommended on all ZPS*K5 applications for the highest level of system reliability. The low-pressure cutout should be set no lower than 20 psig (1.4 bar) for heat pumps and 55 psig (3.8 bar) for air-conditioning units.
- A high-pressure cut-out is not required for UltraTech applications, but recommended for the highest level of system reliability. If a high-pressure cut-out control is used the maximum setting should not exceed 650 psig (45 bar).

Setup for water-source systems, the Miami HP HPX heat pump pressure cutouts are as follows:

- LP cutout: OPEN below 50 psi, CLOSED above 65 psi
- HP cutout: OPEN above 550 psi, CLOSED below 400 psi

When the compressor has been off for enough time for pressures to equalize (i.e. HP and LP are the same or within a few psi) and the system temperature has stabilized (30 minutes or so), the system pressure is essentially a refrigerant thermometer. For example, a system pressure of 160 psi with R-410A refrigerant means that the temperature of the system is approximately 56 °F. This can be determined by looking up the temperature of 160 psi saturated liquid/vapor R-410A refrigerant on an R-410A Saturation Properties Table. Note: Some R-410A tables use psig (psi gauge) and some use psia (psi absolute). Absolute pressure is higher than the gauge pressure by the surrounding atmospheric pressure value – about 14.7 psi.

Unit	GPM	EWT	LWT	Absorption	Stage	Kw (Compressor)	COP
1st Floor	11.75	44.1	39.1	26,621	2	2.68	3.91
2nd Floor	11.75	45.1	40.4	28,469	2	2.66	4.14

Figure 1 - Heating COP Data Points

Figure 1 above shows actual data and performance for the two installed heat pump systems. The absorption value is the BTU/hour absorbed from the geothermal ground loop. The kW values shown in the table are for the compressor only. The heat transferred into the house is the absorbed heat from the ground loop plus the kW consumed by the compressor. Other system power consumption elements are the air handler fans (300W on Stage 2, full power) and the water pumps (384W). Both of these power consumption values end up as heat transferred to the house at 100% efficiency. However, they are 100% system losses in summer cooling mode because the air handler fan puts heat into the house which must be removed and the water pump energy ends up in the ground loop (stealing some of the system capacity to remove heat from the house).

Appendix

LRA - Locked Rotor Amps: The current you can expect under starting conditions when you apply full voltage. The current builds up in milli-seconds when the compressor contactor closes at start up and decays to the running current over 100-200 milli-seconds (the time it takes for the motor to start spinning at a significant fraction of running speed). Note: The running current is affected by starting in Stage 1 or Stage 2, but the initial LRA current surge into a non-spinning motor is not affected by what stage is enabled.

RLA - Rated Load Amps: The maximum current a compressor should draw under any operating conditions. Often mistakenly called running load amps which leads people to believe, incorrectly, that the compressor should always pull these amps.

MCC – Maximum Continuous Current: RLA x 1.4 (for Emerson Copeland Scroll Compressors). This current rating is used as the minimum for sizing wiring and circuit breakers.

Example: 2.5 Ton Copeland ZPS31K5E-PFV

- LRA is 83A
- RLA is 17.9A
- MCC is 25.1A
- Actual Stage 1 run current is 7.3A (heating)
- Actual Stage 2 run current is 11.3A (heating)

TXV - Thermostatic eXpansion Valve: The TXV is a complex control element using temperature and pressure feedback to meter refrigerant flow. Warm, condensed liquid, high pressure refrigerant is metered through a controlled orifice to a saturated liquid/vapor mix at lower pressure and lower temperature. The TXV monitors the temperature and pressure at the suction input to the compressor and controls the flow of liquid refrigerant through the TXV to achieve 10-15 °F of super-heating above the saturation temperature at the compressor input (suction) pressure. TXV component failure, poor thermal coupling of the TXV to the suction line, internal or external clogs, the wrong refrigerant charge, and operating temperature extremes can prevent the TXV from achieving the desired super-heat.

Sub-Cooling – Liquid refrigerant at the condenser output has been cooled below the saturation temperature at the compressor output pressure - refrigerant is all liquid. The amount of cooling below the critical liquid/gas saturation temperature is called Sub-Cooling. Sub-Cooling of 5-10 F° is desirable because it prevents the liquid from flashing to gas until it passes through the TXV orifice and all possible heat of condensation has been released by the refrigerant. Too much sub-cooling is unnecessary and reduces the efficiency of the system.

Super-Heat – Gas refrigerant at the evaporator output (and suction input to the compressor) has been heated above the critical liquid/gas saturation temperature – refrigerant is all gas. The amount of heating above the critical liquid/gas saturation temperature is called Super-Heat. Super-Heating of 10-15 °F is desirable because it ensures that no liquid enters the compressor and all possible heat of vaporization has been absorbed by the refrigerant. Too much super-heat reduces the efficiency of the system.

PG, or Propylene Glycol, ($C_3H_8O_2$) PG Is a viscous colorless liquid which is nearly odorless but possesses a faintly sweet taste (Wikipedia). It has very low volatility (will not easily evaporate) and low toxicity (which is why the local regulations often require its use in geothermal ground loop piping). PPG, or Polypropylene Glycol, is more toxic.

PG Properties at 20% Concentration in water by Volume

Property	Value	Units	Conditions	Water
Thermal Conductivity (1)	0.277	BTU/Hr-Ft-°F	50°F	0.338
Specific Heat	0.970	BTU/Lb-°F		1.002
Density	64.23	Lb/Ft^3		62.38
Viscosity	2.79	cP		1.310
Thermal Conductivity	0.272	BTU/Hr-Ft-°F	40°F	0.332
Specific Heat	0.968	BTU/Lb-°F		1.005
Density	64.03	Lb/Ft^3		62.42
Viscosity	3.41	cP		1.546
Thermal Conductivity	0.267	BTU/Hr-Ft-°F	32°F	0.327
Specific Heat	0.966	BTU/Lb-°F		1.009
Density	63.92	Lb/Ft^3		62.42
Viscosity	4.23	cP		1.794
(1) W/m-K x 0.5782 yields BTU/Hr-Ft-°F				

Accumulator or Receiver

The tank on the suction line between the evaporator and the compressor is a suction accumulator. The tank on the liquid line between the condenser and TXV is a liquid receiver. They do look similar but they serve two completely different purposes.

The primary function of the suction accumulator is to catch and hold any liquid refrigerant that didn’t boil off in the evaporator. Liquid refrigerant getting to the compressor can damage the pistons or scrolls. This liquid will also dilute or even flush the oil out of the compressor crank case. This loss of oil will prevent proper lubrication to the compressor, causing compressor damage or failure. Liquid slugging can occur even on a properly installed system with the loss of air flow. Improper evaporator air flow due to dirty filters, coil or loose belt will have the same effect. Low suction temperatures such as on a heat pump in the heating mode can also cause liquid slugging of the compressor. Many heat pump manufactures utilize suction accumulators as standard equipment.

The accumulator function is quite simple. The suction gas leaving the evaporator enters the accumulator at the top and passes through a baffle or screen. Any liquid present collects on the screen and falls to the bottom of the accumulator. Inside the accumulator is a U-shaped tube that will allow only the refrigerant vapor to exit and enter the compressor. A small orifice in the bottom of the U tube will allow any oil that collected in the accumulator to exit and return to the compressor through the suction line. Accumulator failures are rare on properly maintained systems. A plugged orifice in the U tube would be the most likely problem. This plugged orifice would prevent oil from returning to the compressor.

An accumulator is inexpensive and can be added to almost any system that has experienced compressor slugging. The cause of the slugging should still be determined and corrected if possible. Systems that run under low load conditions may be a good place to add an accumulator. Parker recommends that the accumulator be replaced when a compressor is being replaced. Contaminated oil from the old compressor may be in the old accumulator. Also, a considerable amount of oil may still be in the old accumulator. This oil combined with the oil from the new compressor may create an oil overcharge.

Proper accumulator sizing is important when replacing or adding. The pressure drop across the accumulator should be kept as low as possible. The accumulator's internal volume must be sufficient. On a heat pump system with a fixed metering device the accumulator should be capable of holding 70% of the system charge. In a TXV system the accumulator should be able to handle 50% of the system charge. Refer to sizing charts for proper sizing. The accumulator should never be sized by connection sizes.

https://www.behler-young.com/tech-tips/accumulator-or-receiver-that-is-the-question/