The Glitch & The Fix — August 2008

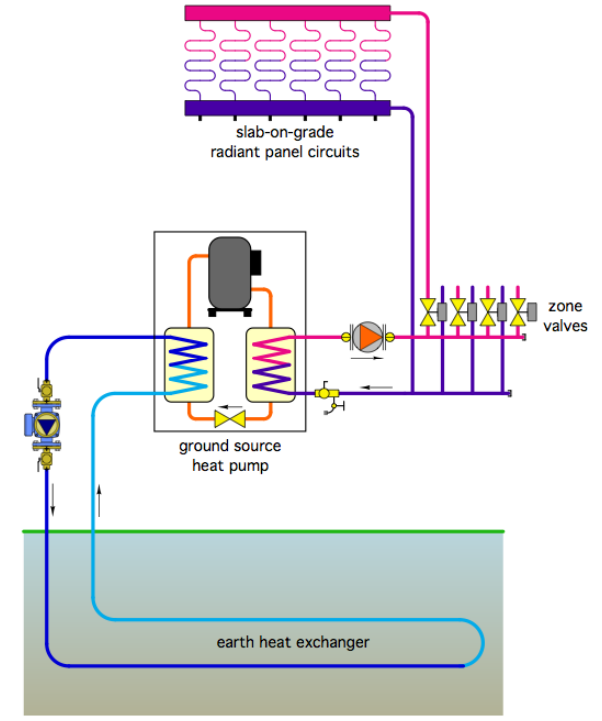
Boiler Substitute?

The Glitch

Overview: As the price of fuel oil skyrockets, there is increasing interest in geothermal heat pumps as a heat source for hydronic radiant floor heating. A geothermal water-to-water heat pump operating with a seasonal average COP of 3.0 in an area where electricity costs $0.10/kwh is equivalent to #2 fuel oil purchased at $1.16/gallon and used at a seasonal average efficiency of 85%.

Given these numbers, it's not surprising that some installers would view such a heat pump as a substitute for a boiler — and follow up by piping it as a plug-and-play substitute for a boiler as shown below. Unfortunately this can lead to some significant operating problems.

Exercise: Use your knowledge of heat pump operating characteristics and basic hydronics to identify at least 5 design errors in this schematic.



The Fix

The vast majority of geothermal water-to-water heat pumps are single-speed "on/off" devices. When on, they produce heat output at or near their rated output (depending on the exact entering temperatures and flow rates on both sides of the heat pump). There is very little thermal mass in a heat pump to store any heat that's produced but not immediately sent to the load.

The distribution system shown is zoned with valves, and thus flow rates and rates of heat delivery can change drastically as the zones turn on and off. This will almost surely cause “out of range” operating conditions within the refrigeration circuit of the heat pump, leading to internal safety switch trips (or worse).

To stabilize the situation, it’s imperative to include a well-insulated buffer tank between the heat pump and the zoned distribution system as shown in the fix drawing. The heat pump cycles on and off based on the setpoint temperature of the buffer tank and the temperature differential across which the tank needs to operate. The load circuits can now operate completely independently of the on/off cycling of the heat pump.

Other errors in the original design include:
- The lack of air separation on both sides of the heat pump.
- The lack of an expansion tank on both sides of the heat pump.
- Lack of differential pressure control on zoned distribution system
- Failure to provide counter flow through the evaporator (earth loop) side of the heat pump.
- Failure to route the coolest water (leaving heat pump evaporator) through the upper portion of the horizontal earth loop.

Details that correct these conditions are shown in the fix drawing.