

How to Work Successfully with Engineers

Lisa Meline, P.E.



What Defines a Good Engineer?

- First, do you think you can work with the person?
- Do they have the proper credentials?
- Do they have the proper experience?
- Have you asked for and verified their references?

These are general questions you would ask of any employee. In some ways, especially in a design build contracting arrangement, the engineer or engineering team is an employee. You need to thoroughly review their resume and references.

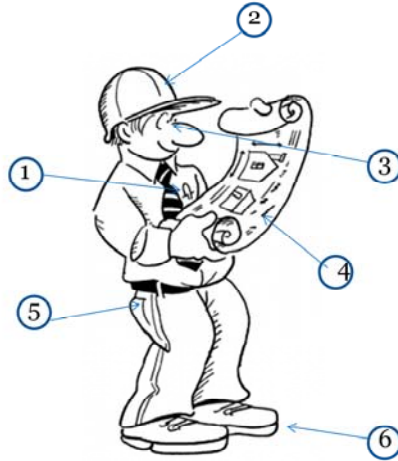
Contrary to popular belief an engineer doesn't have to be the enemy. They can be a valuable team member.

Good Engineer = Expensive(\$)?

- Many high quality engineers are not paid nearly enough
- Mediocre engineers are sometimes paid too much.

The fees requested by the engineer or engineering team are not always commensurate with their abilities. Many very good engineers are worth their weight in gold, but do not always ask for it. The larger engineering firms with large marketing and sales staff have to ask for more money to cover their costs. They are not always better just because they cost more.

Anatomy of an Engineer



First lets talk about how to recognize a good engineer.

- 1) Note the pocket protector. Either this guy is an automobile technician or an engineer. Check the contents of the pocket. If there are pens, pencils, or small ruler this man is likely to be an engineer. If the pocket contains a tire gauge, he is an automobile technician.
- 2) Next, note the hard hat. Most engineers are very good at following rules and have been well schooled on jobsite safety. They are very concerned about protecting their brains.
- 3) Note this engineer does not wear glasses. **SMART ENGINEERS DO NOT NECESSARILY WEAR GLASSES.** Glasses are a sign of poor eyesight, not intelligence. Do not confuse engineers with nerds, although some engineers do also fall into the nerd category.
- 4) Blueprints held in the correct orientation. It is very important that and engineer be able to read blueprints, especially their own, to be an asset to the construction team. By the way, only the older engineers will know what a REAL blueprint is.
- 5) Overstuffed pockets. Not necessarily a requirement but engineers are known to stuff calculators, cell phones, tape measures and other 'tools' of the trade in their pockets. They are also known to carry breathe mints and power bars.
- 6) Finally, sensible shoes. They are not always 'steel toe' but more likely to be tennis shoes or loafers. If you see an engineer with shiny black shoes....

Run! Run from shiny black shoes!



This is not a REAL engineer. This is a salesman or marketing person disguised as an engineer!

And just to be clear...

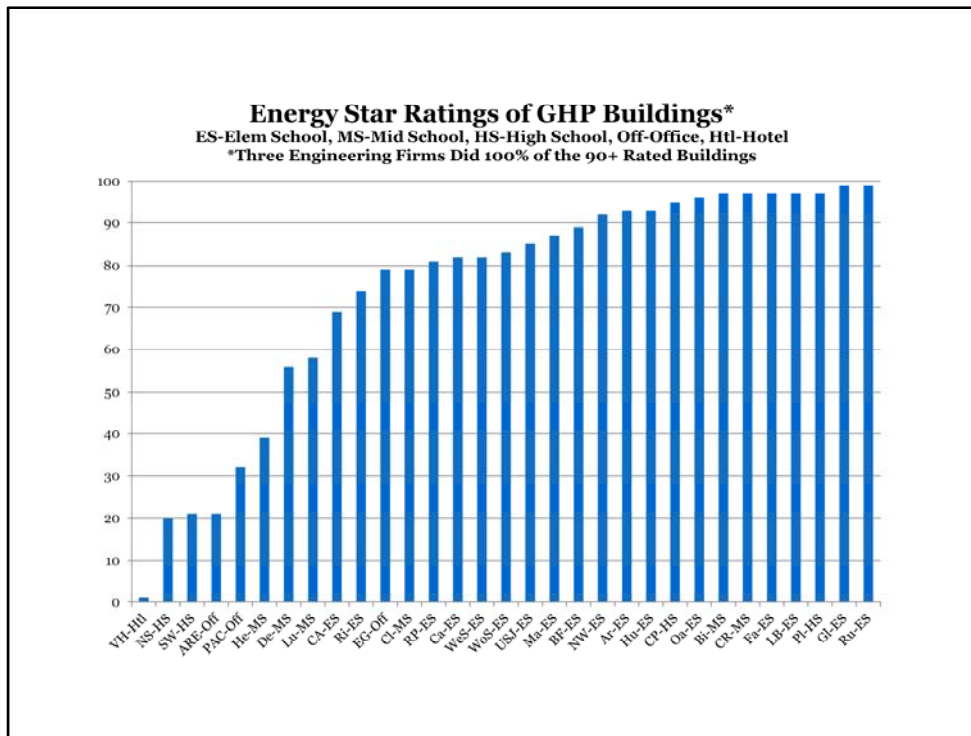


Women engineers are not geeks or nerds. They are exempt and are included in the “cool” category.

Engineering Quality

- How do we know the difference between good engineers and the mediocre ones?
- Who is keeping track of this?
- Should someone (IGSHPA, BBB)?
- Is it more than completing the project on time and within the budget?

So how do you weed through the marketing materials, press releases and websites to find a good engineer. How do you find someone or a firm that will provide the services required to keep your customers satisfied and potentially provide repeat business or referrals to your business?



Certainly one way of evaluating engineers is by looking at the performance of the buildings for which they provide designs. This data is borrowed from Steve Kavanaugh who is currently working on a research project funded by EPRI. The project is collecting data on various existing buildings with GHP systems. Seems to me that you would want to hire the engineer whose buildings is performing in the 75+ rating range.

If I may borrow a baseball analogy from Steve, we like to look at the performance of baseball players with a specific set of “metrics”

- Hitting – Average, RBIs, Home Runs, Slugging Percentage
- Pitching/Fielding – Won/Loss, Earned Run Avg., Saves, Fielding Percentage
- Base Running – Runs, Stolen Bases
- Durability – Career Totals, Games Played

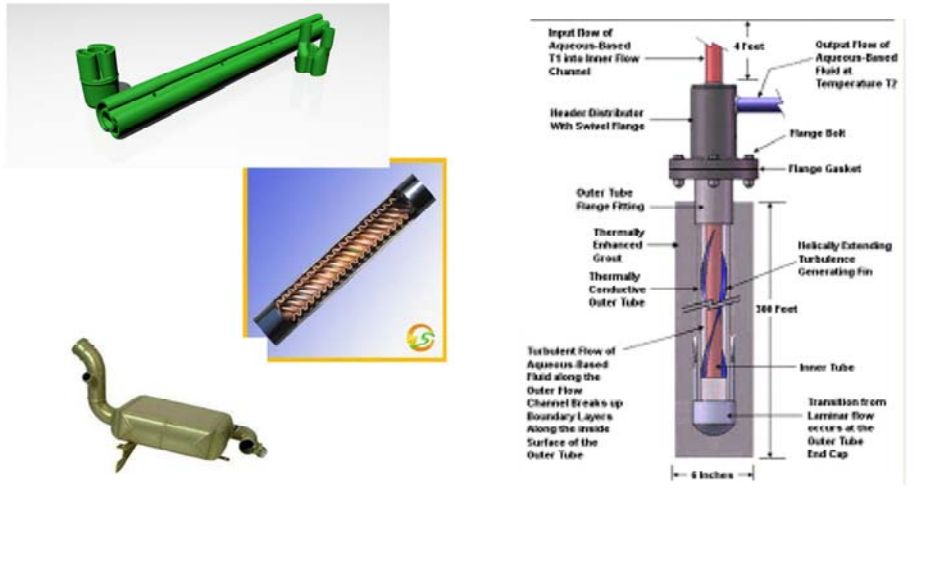
NOT SUGGESTING ENGINEERS SHOULD BE PAID AS MUCH AS Alex Rodriguez but...
 STATS ARE NEEDED!!!

This bar chart is one example of things you can ask for when evaluating engineers. Ask them for the Energy Star Score for their projects.

REPORT CARD				
GRADING PERIOD	1	2	3	4
READING	A+			
WRITTEN COMMUNICATION	A+			
MATHEMATICS	A+			
SCIENCE/HEALTH	A+			
SOCIAL STUDIES	F			
ART	A+			
MUSIC	A+			
PHYSICAL EDUCATION	A+			

It's sort of like a report card for good engineering

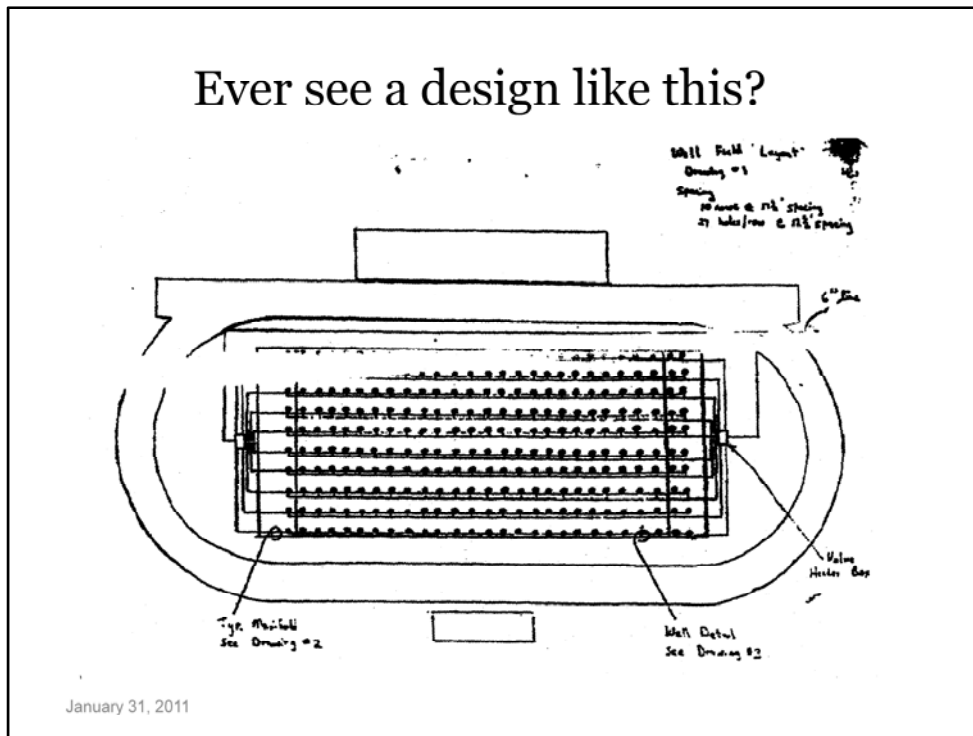
Some things to watch for...



So now let's talk a little bit about some of the things you should look for when evaluating an engineer or their work. The easiest way to weed out the good engineers from mediocre ones is to look at their ground heat exchanger design.

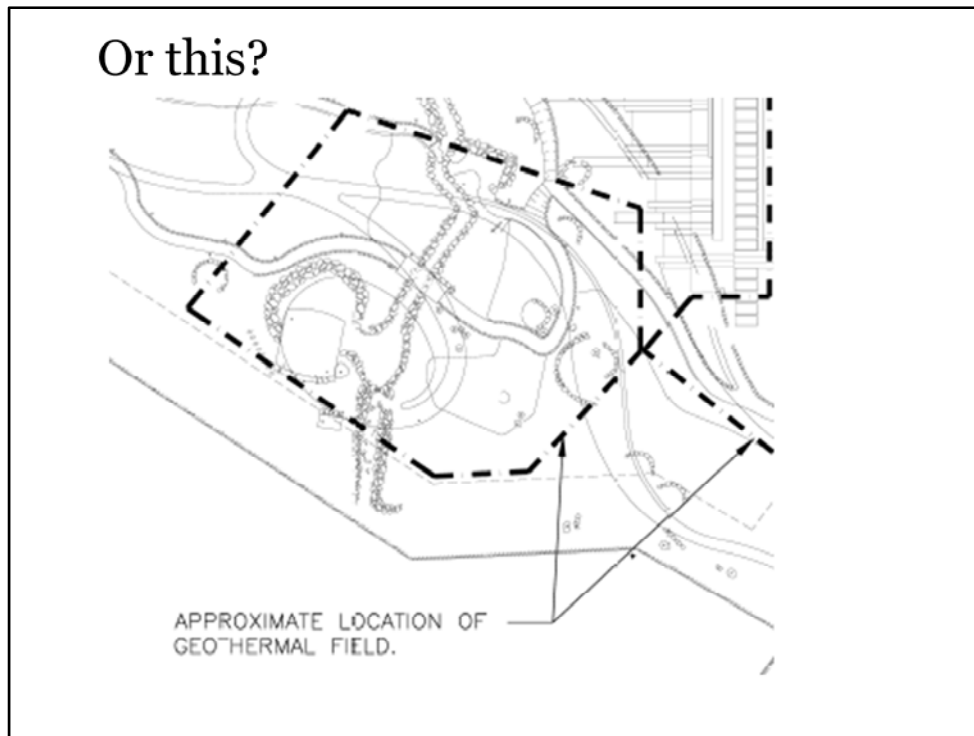
Does the engineer you are 'interviewing' really understand basic heat transfer? Are they able to convey their knowledge and experience through their work product (drawings and specs)?

Ever see a design like this?



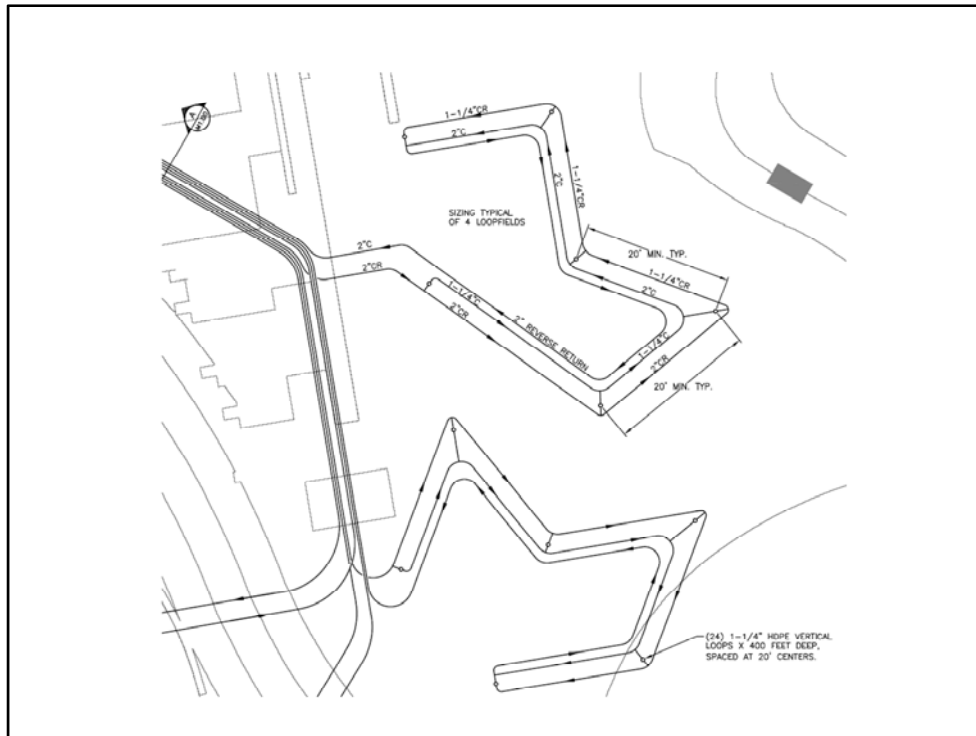
If the engineer you are looking to hire for a project gives you a ground loop design like this, make him or her do it over.

Do you think an experienced geothermal contractor could install a functional ground heat exchanger from a plan like this? How about an inexperienced one?



Wow, did the engineer really design the ground heat exchanger? Did he or she get paid to create this nebulous design. What he or she has done is relinquish all responsibility for the ground heat exchanger to the contractor. The last time I checked, a good geothermal heat pump design included carefully design and coordination of the ground heat exchanger, pumping system, heat pump equipment selection, controls and the building distribution system.

When a similar presentation was given at ASHRAE this past January in Las Vegas, it became quite apparent that the quality engineers attending the meeting were looking for "single point responsibility." They want to be responsible for the ENTIRE system. Not just the mechanical system design inside the building. You want an engineer like that!



A good design will include information so that the system can actually be constructed. Information like:

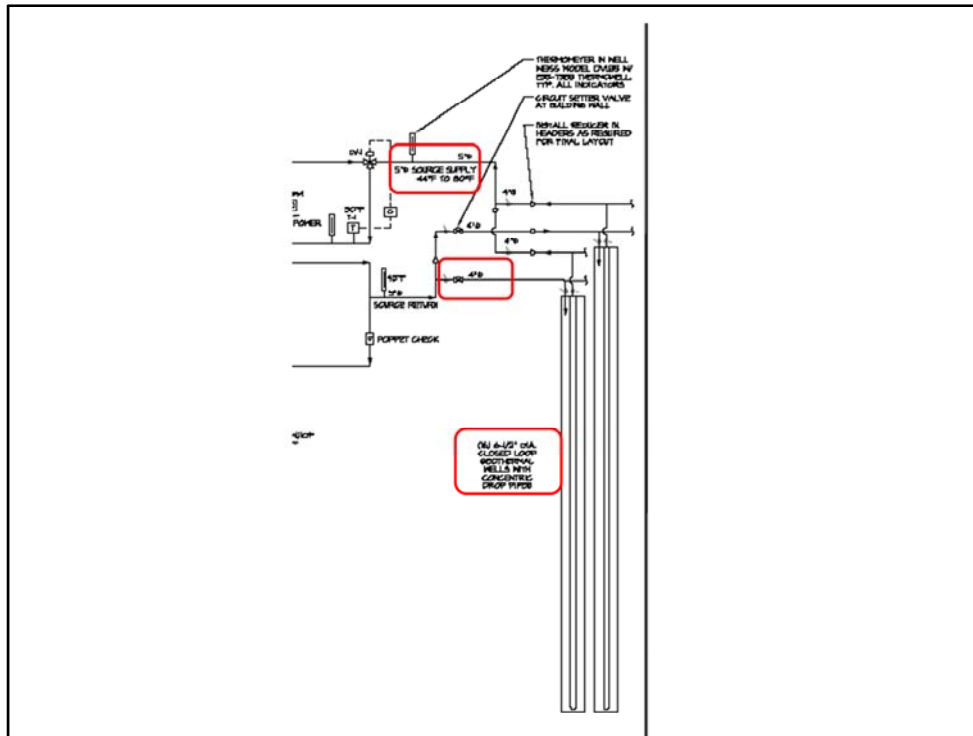
The total number of vertical boreholes and their depth. The type of grout, the spacing between vertical boreholes, etc.

GROUND LOOP INSTALLATION SPECIFICATIONS

SPECIFICATIONS WRITTEN WITH REFERENCE TO CLOSED-LOOP/GEOHERMAL HEAT PUMP SYSTEMS DESIGN AND INSTALLATION STANDARDS 2010 PUBLISHED BY IGSHPA

1. THE GROUND LOOP DESIGN FOR THIS PROJECT IS BASED UPON THE FOLLOWING PROPERTIES
 - A. SOIL THERMAL CONDUCTIVITY: 1.21 BTU/HR-FT-F
 - B. SOIL THERMAL DIFFUSIVITY: 0.83 FT²/DAY
 - C. GROUND TEMPERATURE: 64.0F
 - D. BOREHOLE DEPTH: 400 FT
 - E. BOREHOLE SPACING: 20' O.C. MINIMUM
2. COORDINATION AND WARRANTY
 - A. GENERAL CONTRACTOR SHALL BE RESPONSIBLE FOR ALL TRENCHING AND BACKFILLING OF TRENCHES, INCLUDING THE TRENCHES FROM THE LOOP FIELD TO THE MECHANICAL ROOM.
 - B. ALL TRENCHING FOR GROUND LOOP AND HEADERING SHALL BE A MINIMUM OF 24" WIDE.
 - C. LOOP CONTRACTOR SHALL BE EXPERIENCED IN LOOP DESIGN AND INSTALLATION AND SHALL BE CERTIFIED BY IGSHPA. LOOP CONTRACTOR SHALL BE RESPONSIBLE FOR ALL PERMITS AND INSPECTION OF THE LOOP FIELD.
 - D. AS-BUILT DRAWINGS OF THE LOOP FIELD SHALL BE PROVIDED BY THE LOOP CONTRACTOR.
 - E. THE GROUND LOOP SHALL BE WARRANTED AGAINST LEAKS FOR 25 YEARS BY THE PIPING MANUFACTURER, INCLUDING ALL PARTS AND LABOR.
3. BOREHOLE DRILLING
 - A. VERTICAL BOREHOLES SHALL BE DRILLED BY A C57 LICENSED DRILLER EXPERIENCED IN GROUND LOOP DRILLING AND GROUTING PROCEDURES.
 - B. HEADERING AND ALL OTHER GROUND LOOP PIPE CONNECTIONS SHALL BE COMPLETED BY AN IGSHPA CERTIFIED CONTRACTOR EXPERIENCED IN THE CONSTRUCTION OF GROUND LOOPS.
 - C. CONTAIN, MANAGE, AND DISPOSE OF DRILL CUTTINGS IN ACCORDANCE WITH LOCAL REGULATIONS.
 - D. AFTER THE LOOP INSTALLATION, BOREHOLES ARE TO BE IMMEDIATELY BACKFILLED WITH THERMALLY ENHANCED BENTONITE GROUT (CONDUCTIVITY, $K = 0.85$ BTU/HR-FT-F MINIMUM).
 - E. DRILLING CONTRACTOR TO GUARANTEE THAT THE BOREHOLES ARE COMPLETELY BACKFILLED.
4. GROUND LOOP (HEAT EXCHANGER AND HEADER) MATERIALS:
 - A. PIPING MATERIAL SHALL BE HIGH DENSITY POLYETHYLENE (HDPE) PE3408.
 - B. PIPE WITH A DIAMETER OF 2" OR LESS SHALL BE MANUFACTURED IN ACCORDANCE WITH ASTM D-3035 WITH A MAXIMUM DIMENSION RATIO (DR) OF 11.
5. PIPE FUSION AND CONFIGURATION
 - A. ALL BURIED PIPE SHALL BE HEAT FUSED BY BUTT, SOCKET OR ELECTROFUSION IN ACCORDANCE WITH THE PIPE MANUFACTURER'S PROCEDURES. ALL JOINING TO BE PERFORMED BY FACTORY-TRAINED INSTALLERS WITH CURRENT IGSHPA FUSION CERTIFICATION DOCUMENTS.
 - B. VERTICAL PIPES SHALL BE FUSED TO THE LATERAL, REVERSE-RETURN HEADERS FOUR (4) FEET BELOW FINISH GRADE.
 - C. SUPPLY AND RETURN PIPING FROM THE LOOP FIELD TO THE MECHANICAL ROOM SHALL BE AT THREE (3) FEET BELOW FINISHED GRADE.
 - D. WHERE REQUIRED, PIPING OUTSIDE OF A BUILDING OR IN AN EXTERIOR WALL SHALL BE PROTECTED FROM FREEZING, AND SLEEVES SHALL BE INSTALLED WHERE PIPING PASSES THROUGH MASONRY, CONCRETE, OR ANY FIRE SEPARATION PER 2007 CMC SECTIONS 1201.2.7.8.9 AND 1201.3.5.5.
 - E. SHUT-OFF VALVES AND FUSED CONNECTING FLANGES TO BE PROVIDED AT THE SUPPLY AND RETURN LINE TERMINATION POINTS IN THE MECHANICAL ROOM.

Their plans will include information about the ground loop design. Here is an excerpt from a ground loop design, the first 5 of 9 installation specification on the drawing. If you review section 5 of the IGSHPA Standards, you will note that there have been additions. The requirements for information to be provided on the construction documents is clearly defined. If you haven't looked at the changes to the IGSHPA Standards in awhile – get a copy!



What do you think of this ground loop design? I took it from a rather complicated system schematic produced by another engineer. The names have been removed from these examples to protect the unenlightened.

1- note the source water temperatures (44 – 80 EWT). This is a project from New England.

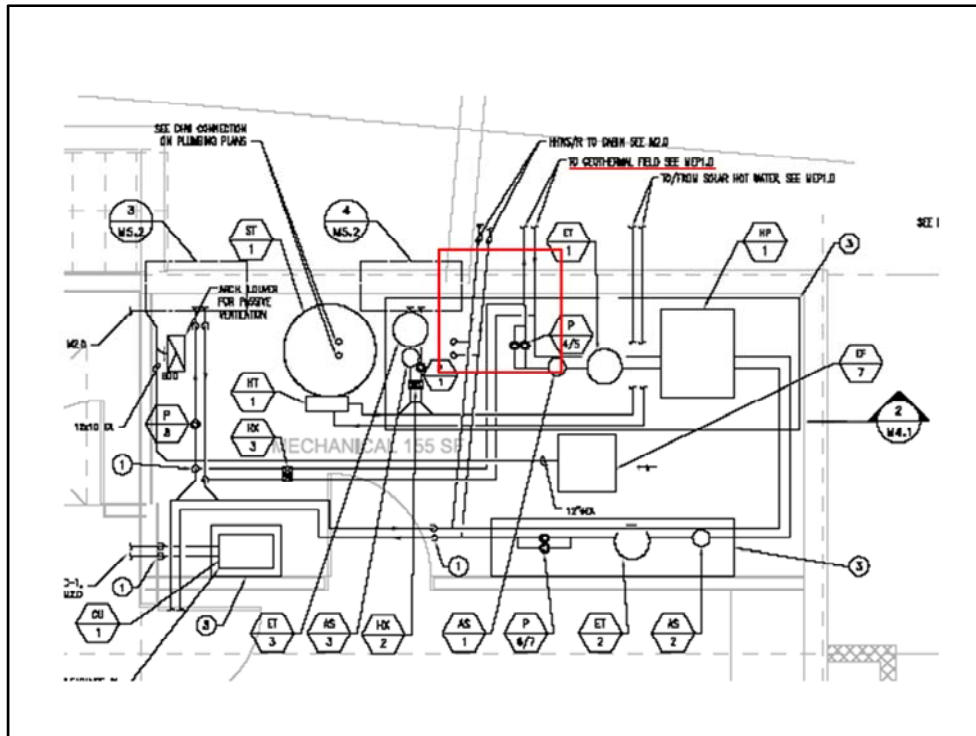
2- the mains out to the 16 vertical loop is 5 inches (hmmmm, do they make 5" HDPE?). Well, I don't have any data for that so let's look at the 4" HDPE sub-header. With a good design flow/pressure drop of 4 ft of head per 100 feet of pipe a maximum flow rate of 220 gpm could be expected.

3 – there are 16 vertical loops. No information about depth, pipe size, spacing or grout. There is a 6-1/2" concentric drop pipe. Not sure what that is. Let's assume these are deeper loops at 1-1/4". Let's also assume that we are going to be pushing:

$$=@ 4 \text{ ft hd}/100 = 15 \text{ gpm}/\text{loop} \times 16 = 240 \text{ gpm} \text{ (seems to match a 4" header)}$$

4. Finally from the mechanical equipment schedule, the total connected heat pump capacity (peak not peak block) is 71 tons. **You** do the math (71/16)!

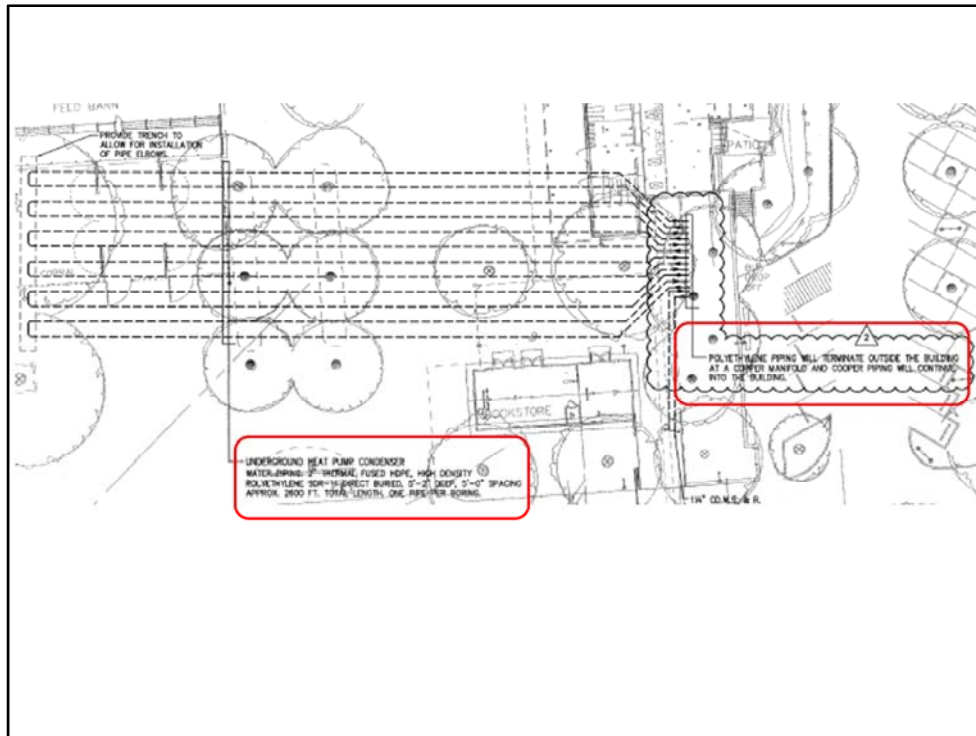
Would you honestly hire this engineer again?



Ok, let's look at a system after it has gone in. This is a diagram of a very complicated residential project. It has solar, geothermal, sand bed and DDC controls. It's roughly 3500 sq. ft. This mechanical room is in the basement.

Where will the contractor connect to perform the flush and purge of the system?

If the pumps shown are not flow centers, I think there may be a problem.



Finally my last example of things to look for when evaluating engineers. This is a horizontal loop system. The loop field is comprised of (6) 2" horizontal loops buried to 5 feet deep and spaced a 5 feet centers (out and back). The total length of pipe was designed for 2600 linear feet. The connected equipment is 30 tons. So if we do the math let's consider

$2600/30=87$ feet per ton. You should hire an engineer who has some ideas of the industry 'rules of thumb' and perhaps a little common sense wouldn't hurt, eh?

How well do you think this system performed? Well, within three hours the entering water temperature to the heat pumps was over 110 deg F.

Another side note I would like to share is the note about the system manifold, "Polyethylene pipe will terminate outside the building at the copper manifold and copper piping will continue into the building." Hmmmm... not sure if I think that is such a good idea either.

An engineer who understands the maintenance and operation of a geothermal heat pump system is the kind of engineer you want on your team!

To be Successful

- Find an engineer that you like and think you can work (for better or worse).
- Verify references and ask to see examples of their 'work product.'
- Make sure the engineer is experienced in the technology and/or willing to learn.
- Ask to see their project's Energy Star Scores or similar system performance data.
- Look for practical engineer, one with common sense.