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Trench Talk

A series of live webinars to serve the geothermal community

Manifold Design

Tuesday February 14, 2023, 4 PM EDT

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SOURCE ROCK GEOTHERMAL

Providing turnkey vertical and horizontal ground loops for the geothermal heat pump market in New York State.

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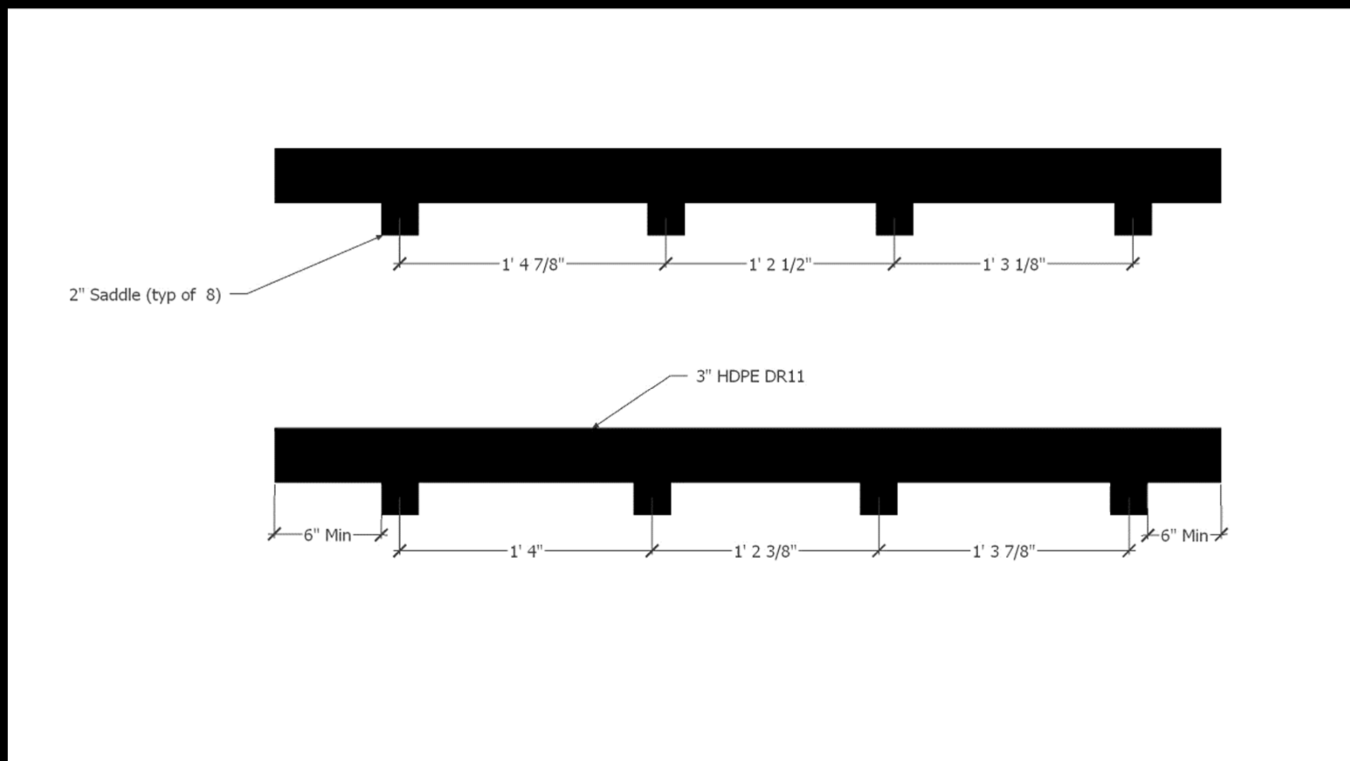
Manifold

A device to distribute a fluid to multiple parallel circuits or conversely a device to collect fluid from multiple parallel circuits.

What's so hard about designing a pipe with a bunch of smaller taps



The Secret to Manifold Design

- It’s all about the flow requirements of the circuits
  - Required Flow (gpm)
  - Pressure Drop (Feet of Head)

Considerations

- Sole purpose of a geothermal loop field is to transfer heat
- Temperature is the main driver, not flow rate
- All circuits will receive the same temperature fluid
- Turbulent flow is important, Re > 2,500 (Reynolds Number)
  - Transition from Laminar to Turbulent occurs between 2,000 & 4,000 Re
  - Is only important at Peak Load Conditions
- Once turbulent, increasing flow rate has little effect on heat transfer
- Having a minimum flow is more important than balanced flow
- Excessive flow, means higher pressure drop and more pumping energy, not necessarily more heat transfer
- Balance Valves are only accurate to +/-5%, at best, and impose a minimum pressure drop of at least 2 psi (4.6 FOH) in a wide open position (if you are lucky).

Speaking of Pressure drop

Darcy-Weishbach fundamental theoretical pressure drop formula:

$$\Delta p = \lambda \, (l \, / \, d_h) \, (\rho_f \, v^2 \, / \, 2)$$

λ = *Darcy-Weisbach friction coefficient*

l = *length of duct or pipe (ft)*

v = *velocity of fluid (ft/s)*

d_h = *hydraulic diameter (ft)*

ρ_f = *density of fluid (slugs/ft^3)*

Hazen Williams Formula

Empirically derived more commonly used pressure drop formula:

$$h_{100ft} = 0.2083\ (100 / c)^{1.852}\ q^{1.852} / d_h^{4.8655}$$

c = *Hazen-Williams roughness constant*

q = *volume flow (gal/min)*

d_h = *inside hydraulic diameter (inches)*

There is a simpler method

If you already know a reference flow rate and corresponding pressure drop you can easily calculate the pressure drop at a different flow rate:

$$PD_{NEW} = PD_{REF} \times (Flow_{NEW}/Flow_{REF})^2$$

Using Reference Data

Reference Flow (gpm)						
Size/DR	7.4	9	11	13.5	15.5	17
3/4	2.9	3.3	3.7	3.8	4.1	4.2
1	4.5	5.2	5.7	6	6.5	6.6
1 1/4	7.2	8.2	9.1	9.6	10.3	10.5
1 1/2	9.4	10.7	11.9	12.5	13.5	13.8
2	14.7	16.7	18.5	19.6	20.9	21.5
3	32	36.3	40.2	42.6	45.4	46.6
4	52.7	60	66.3	70.4	75.1	77.3
6	114.5	130	143.9	152.6	162.7	167.2
8	194.4	220.5	244.4	258	276.8	284.2

Reference Pressure Drop (Feet of Head/100' of Pipe)						
Size/DR	7.4	9	11	13.5	15.5	17
3/4	2.58	2.402	2.3075	2.122	2.0684	2.0301
1	1.944	1.8619	1.7314	1.651	1.6214	1.5656
1 1/4	1.491	1.3904	1.3182	1.2665	1.2218	1.1884
1 1/2	1.285	1.1785	1.123	1.0693	1.0441	1.0208
2	2.893	0.9059	0.8558	0.829	0.7906	0.782
3	0.6227	0.5764	0.5437	0.5274	0.5025	0.495
4	0.4609	0.4295	0.4036	0.3928	0.3749	0.3713
6	0.2944	0.273	0.2573	0.2499	0.2383	0.2352
8	0.2169	0.2008	0.1898	0.1827	0.1762	0.1737

For 1-1/4" DR 11 Determine the Pressure Drop at 12 gpm:

Start with (12/9.1) = 1.319

Then square it $1.319^2 = 1.739$

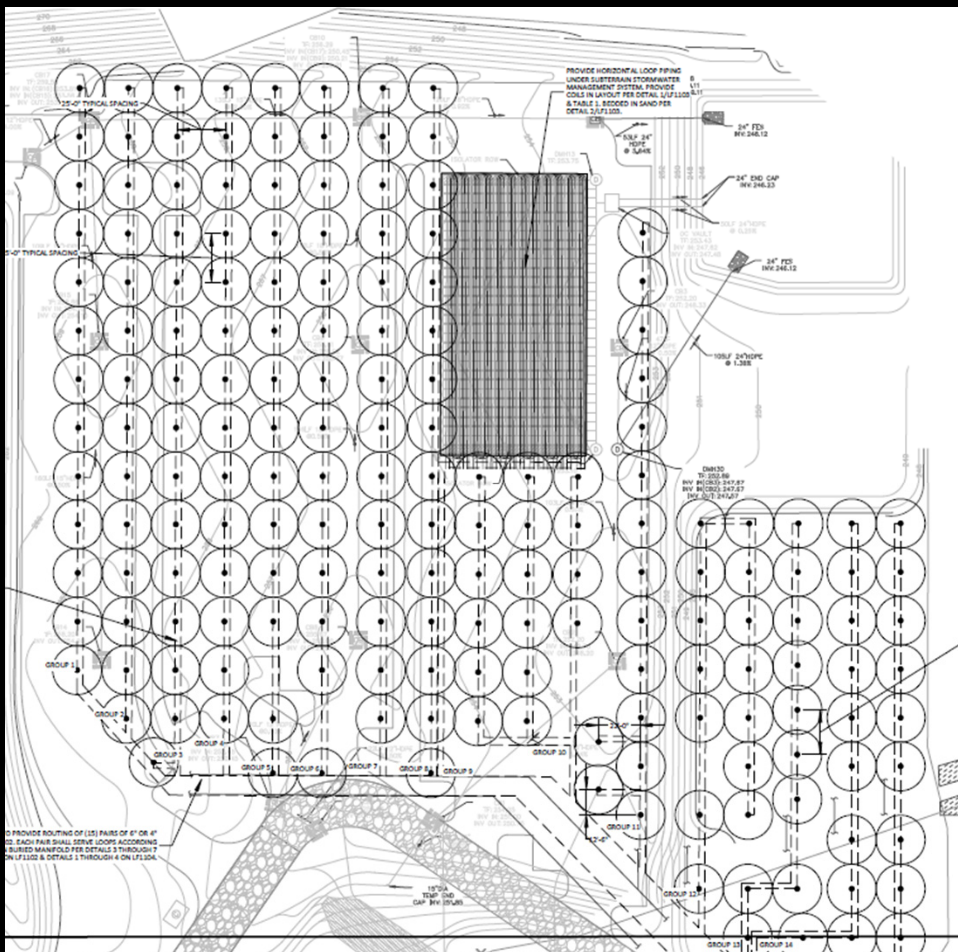
Then Multiply by Ref PD
1.739 x 1.3182 = 2.292 FOH/100'

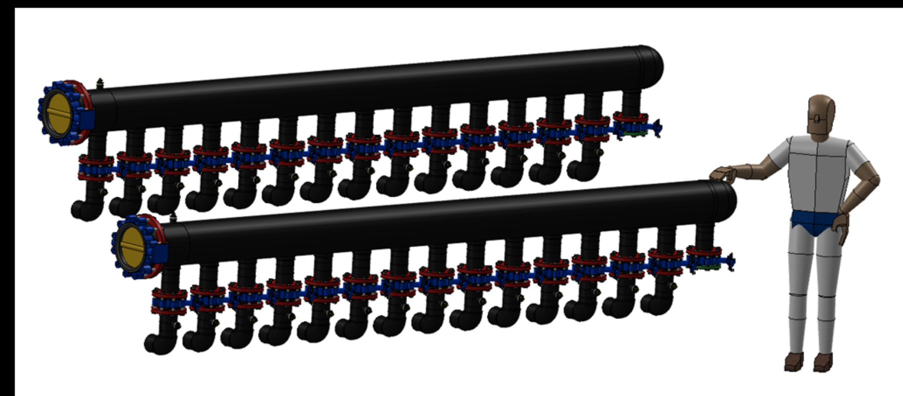
To Adjust for a Length of 800 ft

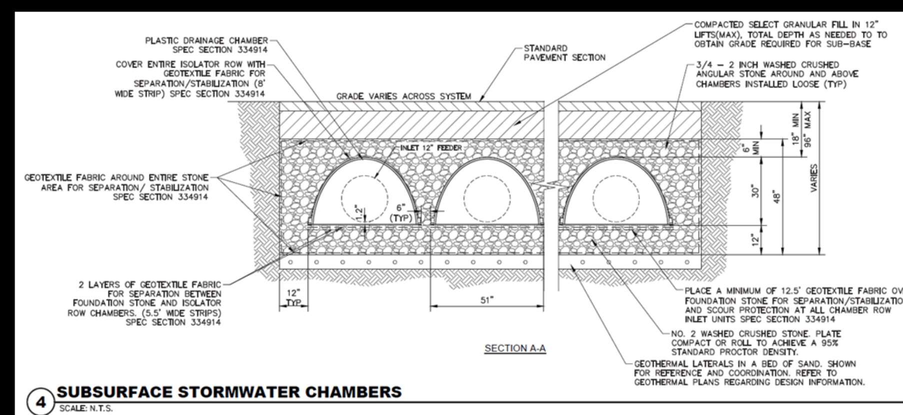
Multiply by (800/100)

2.292 x 8 = 18.3 Feet of Head

University of Albany







Using a Calculator

Manifold Design Worksheet

Number of Circuits: **15**

Antifreeze: Water (32 F Freeze Point)

Factor: 1.00

Average PD: 2,018 gpm

Ckt #	Design Flow (1,999)	# of loops	Loop Diam	Loop Length	Loop DR	gpm/ loop	Ref gpm	Ref DP	S/R Length	S/R Diam	S/R DR	Ref gpm	Ref DP	Loop DP	S/R DP	Ckt DP (9.1)	with Antifreeze (9.1)	Flow gpm	Deviation	gpm/ loop	Re
		Loop Data							Supply/Return Data									Adjusted Flow to Equal DP			
1	130	13	1 1/2	1,000	11	10	11.9	1.12	770	6	15.5	162.7	0.2383	7.9	1.2	9.1	9.1	130	100.2%	10.0	13,191
2	140	14	1 1/2	1,000	11	10	11.9	1.12	700	6	15.5	162.7	0.2383	7.9	1.2	9.2	9.2	140	99.8%	10.0	13,145
3	150	15	1 1/2	1,000	11	10	11.9	1.123	630	6	15.5	162.7	0.2383	7.9	1.3	9.2	9.2	149	99.6%	10.0	13,116
4	140	14	1 1/2	1,000	11	10	11.9	1.123	630	6	15.5	162.7	0.2383	7.9	1.1	9.0	9.0	141	100.5%	10.1	13,235
5	140	14	1 1/2	1,000	11	10	11.9	1.123	580	6	15.5	162.7	0.2383	7.9	1.0	9.0	9.0	141	101.0%	10.1	13,300
6	140	14	1 1/2	1,000	11	10	11.9	1.123	530	6	15.5	162.7	0.2383	7.9	0.9	8.9	8.9	142	101.5%	10.2	13,366
7	140	14	1 1/2	1,000	11	10	11.9	1.123	520	6	15.5	162.7	0.2383	7.9	0.9	8.8	8.8	142	101.6%	10.2	13,379
8	150	15	1 1/2	1,000	11	10	11.9	1.123	430	6	15.5	162.7	0.2383	7.9	0.9	8.8	8.8	153	101.9%	10.2	13,414
9	99	18	1	590	11	5.5	5.7	1.731	730	4	15.5	75.1	0.3749	9.5	4.8	14.3	14.3	79	80.0%	4.4	8,377
10	160	16	1 1/2	1,000	11	10	11.9	1.123	340	6	15.5	162.7	0.2383	7.9	0.8	8.7	8.7	164	102.4%	10.2	13,481
11	150	15	1 1/2	1,000	11	10	11.9	1.123	230	6	15.5	162.7	0.2383	7.9	0.5	8.4	8.4	156	104.3%	10.4	13,734
12	140	14	1 1/2	1,000	11	10	11.9	1.123	130	6	15.5	162.7	0.2383	7.9	0.2	8.2	8.2	148	105.8%	10.6	13,932
13	100	10	1 1/2	1,000	11	10	11.9	1.123	70	4	15.5	75.1	0.3749	7.9	0.5	8.4	8.4	104	104.3%	10.4	13,734
14	100	10	1 1/2	1,000	11	10	11.9	1.123	90	4	15.5	75.1	0.3749	7.9	0.6	8.5	8.5	104	103.5%	10.4	13,627
15	120	12	1 1/2	1,000	11	10	11.9	1.123	70	4	15.5	75.1	0.3749	7.9	0.7	8.6	8.6	124	103.1%	10.3	13,570

If you want a copy of the spreadsheet, put your email in the Chat

Q&A

Please complete our short evaluation Poll