

Monday, October 14, 2019

## Piping Pressure Drop Correction Factors when using Glycol in Hydronic HVAC Systems

Monday Morning Minutes | by Norm Hall, October 14, 2019

The last couple of R. L. Deppmann Monday Morning Minutes introduced the BTUH corrections required when using glycol in hydronic heating and cooling systems. Today we look at the friction loss in pipes when using ethylene or propylene glycols instead of water.

The 2017 Fundamentals handbook from the American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE) uses Bernoulli's Equation to define the friction loss

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X		U	•		Units of Measurement ENGLISH METRIC
mp/Load Cv	Row/Press	ure Drop Length	/Pressure Drop NSPHa	Circuit Setter	Ruid Properties
How/Press	Use Temperate Wate				
4in ×		Pipe Material Steel Pipe	~	>4400	Water
Row Rate	GPM	Friction Loss 3.54 Velocity	Feet/100 Feet	Variable Row Operation     Other Operation     ASHRAE 90.1-2010 Max Rate for Pipe Size Selected	Ruid Temperature 45.00 F
		6.30 Steel Pipe thru 2	Feet/Sec 4" is Schedule 40 6" is Schedule 30	320 GPM Annual Energy Cost Cost/Kin Hour Pipe Length (T.E.L.) 0.10 Sr/KinH S00.00 Feet	Puid Concertration 100 2. Viscosity 1.42 Centrootee
250	GPM	138,575	Reynolds Number	Est. Pump/Driver Bf	Specific Gravity
33.43	Cubic Feet/Min	0.000447	Relative Roughness c/D	80 %	1.00
56.75	Cubic Meters/Hr	Transition Row	Row Type	Hours of Operation/Year 8760	Specific Heat
15.75	Liters/Sec	0.0193	Friction Factor	Annual Energy Cost*	
946.25	Liters/Mn	6.30	Feet/Sec	\$914	Vapor Pressure 0.2 PSIa
56.775.00	Liters/Hr	1.92	Meters/100 Meters	"Pump/Driver cost at 100% load	

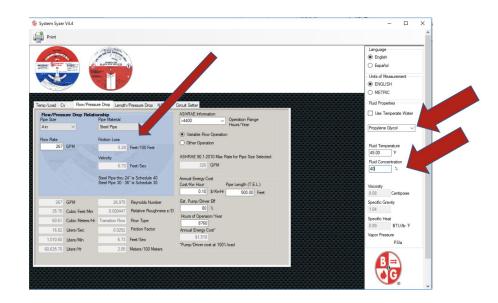
in piping systems. The friction loss depends on a few variables with one of them being the density of the fluid. We understand that the density of a water/glycol mixture is different than 100% water. This difference can make a huge difference when calculating the pump head required. Let's look at the <u>Bell & Gossett System Syzer</u> to see how much of a difference there is.

## **Bell & Gossett System Syzer Pressure Drop Calculator**

Let's look at an example system using 267 GPM of water in 4" steel pipe. The system is chilled water with a supply temperature of 40°F and a return of 50°F. What is the friction loss in the pipe?

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	re Drop Length/Pressure Drop NSPHa			Fluid Properties		
	Use Temperate Water					
How/Pressure Drop Relati Pipe Size	Pipe Material	ASHRAE Information >4400		U use remperate Water		
4in V	Steel Pipe ~	Hours/Year		Water		
		Variable Flow Operation				
Row Rate 267 GPM	Friction Loss	O Other Operation				
261 GPM	4.01 Feet/100 Feet			Fluid Temperature		
	Velocity	ASHRAE 90.1-2010 Max Rate for Pipe Size Selected		Fluid Concentration		
	6.73 Feet/Sec	320 GPM		100 %		
	Steel Pipe thru 24" is Schedule 40	Annual Energy Cost				
	Steel Pipe 30 - 36" is Schedule 30	Cost/Kw Hour Pipe Length (T.E.L.)		Viscosity		
		0.10 \$/KwHr 500.00 Feet		1.42 Centipoise		
267 GPM	147,998 Reynolds Number	Est. Pump/Driver Eff		Specific Gravity		
35.70 Cubic Feet/Min	0.000447 Relative Roughness c/D	80 %		1.00		
60.61 Cubic Meters/Hr	Transition Flow Flow Type	Hours of Operaion/Year 8760		Specific Heat		
16.82 Liters/Sec	0.0191 Friction Factor	Annual Energy Cost*		1.00 BTU/b-'F		
1,010.60 Liters/Min	6.73 Feet/Sec	\$1,105		Vapor Pressure		
	2.05 Meters/100 Meters	*Pump/Driver cost at 100% load		0.2 PSIa		
	2.05 meters/100 Meters					
60,635.70 Liters/Hr				P		
60,635.70 Liters/Hr				• • • •		

Notice I have changed the fluid temperature for the water. The friction loss is 4.01 feet of pressure drop per 100 feet of pipe. What happens if we change to a 40% propylene glycol (PG) solution?



This would be a real issue if we missed this in the calculations! The friction loss changed to 5.28 feet per hundred of loss. This is a 32% increase in friction. There is even more to be



concerned about. In the September 23<sup>rd</sup> <u>R. L. Deppmann Monday Morning Minute</u>, I indicated the need to change the flow rate from 267 GPM to 284 GPM to get the same heat transfer load we had when the system used water only. If we change the flow rate to 284 GPM in that 4' pipe, the friction loss will once again increase and will be 5.90 feet per hundred. This is another 11% increase over the 32% increase. Not something we want to miss.

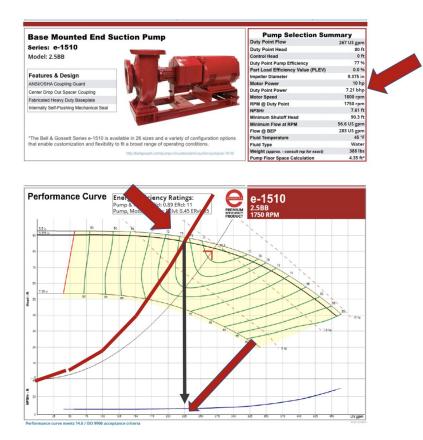
## Pump Curves and Flow Rate if we miss the Glycol Corrections

We cannot use the 4" pipe correction as a universal correction since the velocity and Reynolds number also affects the change in friction loss. That said, it is close enough for this example. Let's assume the pump was selected for 267 GPM at 80 feet of head but the engineer forgot the glycol corrections. What will happen when the balance contractor reads the pump at the design temperatures? If we assume the correction factor of 5.90/4.01 = 47% for the entire 80 feet and correct the flow rate, we will now need 284 GPM at 117 feet.

The water selection below shows a 9.375" impeller and a 10 HP motor with a brake horsepower (BHP) at design of 7.21 HP. The pump would be variable speed, but we will just show the constant speed curve for clarity. What would the pump look like?

## **Propylene Glycol Needs More Horsepower than Water**

Glycol is heavier than water at this temperature. If I start by keeping the 267 GPM at 80 feet selection and change from water to 40% PG, there is a pump correction. It takes more horsepower to move the glycol than water. The water HP shown above is 7.21. Just changing to glycol and keeping the same capacities results in BHP increasing to 7.84 HP. That is an increase of almost 9% before we even change capacities. Now let's look when we correct the pump requirement to 284 GPM at 117 feet.



The red curve above is the system curve for the new capacities. The pump will only be able to produce 225 GPM of 40% PG at 45°F. If this was a variable speed pump, could we Overspeed it and make up the difference? To get the 284 GPM, we would have to speed up the pump to 2894 RPM. This is well above the manufacturer's suggested maximum of 120% of speed. In addition, the 10 HP motor would be too small. We would need a 15 HP motor for the design. This is a no-win mistake.

Remember to always correct the flow and head for fluids other than water. Also, remember to indicate the required fluid and temperature used on the pump curve. It may make a difference in horsepower!