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Thermal Notes

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FLUID HANDLING inc.

Understanding the Properties of Glycol Solutions Prevents Design Errors in Pumping and Piping Applications

Many HVAC and industrial heat transfer systems utilize glycol solutions in lieu of plain water to protect against freezing. It is important that the system designer fully understand the effects of glycol solutions on piping pressure drop and on pump performance. Two dangerous misconceptions are: Misconception 1: Glycol solutions behave similarly enough to water that no correction factors are necessary. Misconception 2: Ethylene and propylene glycol solutions behave similarly, and are interchangeable from a design standpoint.

The failure to understand the properties of glycol mixtures can result in serious design deficiencies.

Density and Viscosity Matter

Water, propylene glycol and ethylene glycol have different physical properties, which determine their behavior in piping and pumping applications. The pertinent properties are:

1. Density, or the weight per cubic foot. Density is sometimes expressed as "specific gravity," which is simply the density of the fluid divided by the density of water at 60°F.
2. Viscosity is technically a measure of the resistance of a given fluid to shear. To paint a mental picture of "viscosity," picture a plastic bottle with a small hole in the bottom. If you filled the bottle with rubbing alcohol, it would run out of the hole quickly. If you filled it with concentrated dishwashing soap, it would run out much more slowly. Concentrated dishwashing soap is highly viscous; rubbing alcohol is not.

Two other properties, *thermal conductivity and specific heat*, also indirectly affect pumping and piping applications. Their effect is to increase the flow rate of fluid required to meet a given heat transfer rate. This subject was addressed in a recent Thermal Notes, so we will not address it here.

(To see that information check out our Web site at www.fluidh.com. You will find the topic listed under "Newsletters.")

Glycol Solutions Increase Pressure Drops

Glycol solutions are typically more viscous than water at the same temperature. Therefore, if the system designer selects piping based on water tables, the pressure drop will be understated unless a correction is made. Note that most common tables are based on water, as are the various "slide rule" devices for sizing piping. Tables 1.1 and 1.2 on page 2 are based on data from the ASHRAE Handbook.[1] They show the pressure drop corrections for various concentrations and temperatures of ethylene and propylene glycol. Note that for all glycol solutions (and for water), the correction factor increases at low temperatures and decreases at higher temperatures. This is because viscosity generally increases at lower temperatures.

For hot glycol systems (which normally operate at over 160°F) little if any correction is required. In fact, for solutions up to 40%, the pressure drops will actually be slightly lower than predicted by pipe sizing tables, which are based on 60°F water. However, note that as the temperatures approach 40°F, the correction factors are significant. Ignoring them leads to errors of 40-60% for 40° propylene glycol.

These correction factors are strictly used for viscosity correction. In addition, safety factors are often added to account for future pipe corrosion and for installation variances from design.

[1] **2000 ASHRAE Handbook, Systems and Equipment Volume, I-P Edition**

See Page 2 for the following tables:

Table 1.1 - Pipe, Valve and Fitting Pressure Drop Correction Factors for Ethylene Glycol Solutions

Table 1.2 - Pipe, Valve and Fitting Pressure Drop Correction Factors for Propylene Glycol Solutions

Table 1.1

Pipe, Valve and Fitting Pressure Drop Correction Factors for Ethylene Glycol Solutions

		% Solution by Mass			
Temp °-F	Water	20%	30%	40%	50%
20°		1.15	1.25	1.37	1.60
40°	1.05	1.10	1.16	1.26	1.34
60°	1.00	1.06	1.10	1.17	1.24
80°	0.96	1.03	1.06	1.11	1.17
100°	0.92	1.00	1.03	1.07	1.13
120°	0.91	0.96	1.00	1.04	1.10
140°	0.90	0.95	0.97	1.01	1.08
160°	0.89	0.94	0.95	0.99	1.07

Table 1.2

Pipe, Valve and Fitting Pressure Drop Correction Factors for Propylene Glycol Solutions

		% Solution by Mass			
Temp °-F	Water	20%	30%	40%	50%
20°		1.23	1.55	*	*
40°	1.05	1.15	1.26	1.42	1.60
60°	1.00	1.10	1.16	1.26	1.37
80°	0.96	1.05	1.10	1.16	1.24
100°	0.92	1.01	1.05	1.10	1.16
120°	0.91	0.98	1.01	1.05	1.10
140°	0.90	0.96	0.98	1.01	1.04
160°	0.89	0.94	0.95	0.98	0.99

*** Simple correction factors are not applicable for these entries due to laminar flow. Consult a detailed engineering reference or call Fluid Handling for case-specific corrections.**

Table 2.1

Pump Correction Factors for Glycol

For 40°F Ethylene Glycol (30-50% Solutions)

Pump Flow	Flow	Head	Power
<100 GPM	1.05	1.02	1.33
100+ GPM	1.0	1.02	1.16

For 190°F Ethylene Glycol (30-50% Solutions)

Pump Flow	Flow	Head	Power
<100 GPM	1.0	1.0	1.06
100+ GPM	1.0	1.0	1.03

For 40°F Propylene Glycol (30-50% Solutions)

Pump Flow	Flow	Head	Power
<100 GPM	1.1	1.05	1.35
100+ GPM	1.0	1.02	1.25

For 190°F Ethylene Glycol (30-50% Solutions)

Pump Flow	Flow	Head	Power
<100 GPM	1.0	1.0	1.05
100+ GPM	1.0	1.0	1.0

Glycol Solutions Also Affect Pump Performance

Glycol solutions also affect pump performance. High viscosity decreases flow, decreases the head capability, and increases the power requirements of a given pump. Pump curves are generally based on water, so correction factors must be applied to selections made from standard curves. Note that these correction factors are entirely separate from *and in addition to* the factors used to correct the piping pressure drop!

Table 2.1 was derived from a rather complex procedure published by the Hydraulics Institute for general viscosity corrections to pump performance. While some accuracy was sacrificed in order to construct simple tables, the correction factors shown should be quite adequate for HVAC and process applications using glycol solutions. Note that the pump correction factors are negligible to minimal for higher temperatures, but considerably greater for lower temperatures. Note also that viscosity affects power requirements to a greater degree than it affects the flow and head.

A logical question might be "Why are the factors different for applications involving less than 100 GPM from those involving more than 100 GPM?" The reason is that the Hydraulic Institute treats small pumps differently from large pumps, and uses an arbitrary dividing line of 100 GPM. The logic is that viscosity has a larger effect when passageways are small.

Example Problem

The use of the factors is best illustrated by the following example:

You are designing a closed chilled water system for Buffalo Chips, Inc., a small electronics manufacturer in western N.Y. You wish to pump 55 GPM of 40% propylene glycol solution at 40°-F. The piping system consists of a pump, a chiller, a chilled water coil, and pipe, valves and fittings. The computer selections for the coil and chiller provide pressure drops that have already been corrected for glycol. The coil pressure drop is 4.0' and the chiller pressure drop is 8.1'. Using *tables based on water,* you have calculated the pressure drop for the pipe, valves and fittings at 10'. Select the appropriate pump for this project. Assume a 15% safety factor is to be applied for corrosion and for variances from design.

Example Problem Steps

Step 1: Correct the Pipe, Valve, and Fitting Pressure Drop

From Table 1, note that the correction factor for 40°-F propylene glycol is 1.42. Therefore, the corrected pressure drop is 1.42 X 10' = 14.2'.

Step 2: Determine the System Pressure Drop

Chiller Pressure Drop	8.1'
Coil Pressure Drop	4.0'
Pipe, valve and fitting Pressure Drop	14.2'
Total	26.3'
Safety Factor	x 1.15
Total Pressure Drop	30.2'

(Note that had we neglected the glycol correction, we would have erroneously calculated the system pressure drop at 22.1' X 1.15 = 25.4')

Step 3: Select a pump that fits the application, assuming the fluid is water.

From Figure 1, above right, we can see that a Taco model 1919 pump with a 6.4" impeller would deliver 55 GPM at 30'. The operating brake horsepower would be about 0.9, so a 1 BHP motor would be adequate with water (Point 2 on curve).

Step 4: Correct the Selection for Glycol

Now that we have a tentative pump selection, we need to refine it. From Table 2.1, far left, we obtain the following corrections:

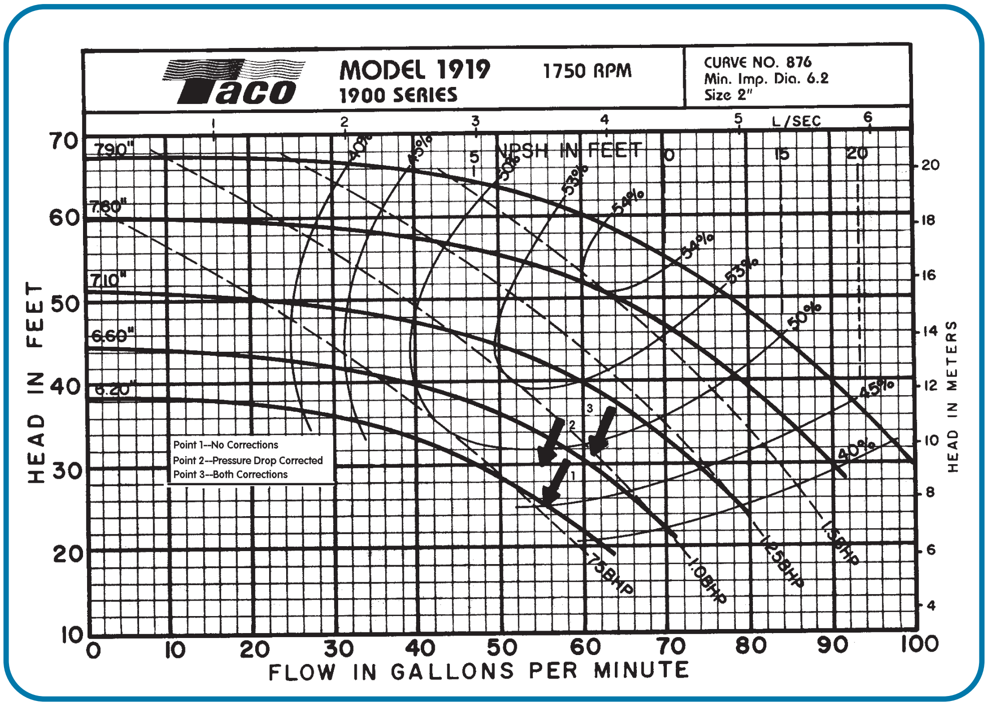
Flow Correction = 1.1
Head Correction = 1.05
Power Correction = 1.35

To make a corrected selection, we must reenter the pump curve at the following values:

Corrected Flow = 55 GPM X 1.1 = 60.5 GPM
Corrected Head = 30' X 1.05 = 31.5'

Enter the pump curve at these revised conditions (Point 3 on curve). We see from the Model 1919 curve that to meet the corrected requirements, we will need to furnish a 6.7" impeller, not a 6.4" impeller.

Figure 1



The curve shows a BHP draw of 1.0, but this is for water. We need to correct for glycol. The corrected power is 1.0 X 1.35 = 1.35 BHP. Therefore, we will need to furnish a 1.5 HP motor.

Conclusion: Both Pressure Drop and Pump Performance Must Be Corrected

Had we neglected to make correction factors for *both the piping and the pump,* we would have selected a pump for 55 GPM at 25.4' (Point 1 on curve). The selected impeller would have been 6.2" in diameter vs. the correct 6.7". The motor selected would have been a 1.0 HP motor in lieu of the correct 1.5 HP.

The designer must therefore be certain to *correct for both piping pressure drop and pump performance.* If pump performance is provided by vendors, he/she should verify that performance values are not simply pulled from standard pump curve for water.

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We now are on the Web! In addition to normal information such as who we are, what we do, who we represent, and links to our principals' Web sites, we have attempted to add useful information for our customers. If you visit our site, you will find a small (but growing by the week) technical library containing data and articles such as the one on the previous pages.

Feedback

Your feedback is important to us. If you would like to comment, please call or fax us. Better yet, go to our Web site and visit the "Contact Us" page.

Intermediate Steam Class Offered!

Fluid Handling will present its "Intermediate Steam" Class on March 7, 2001. This 6 hour class covers everything from basic steam thermodynamics to sizing steam piping, to proper application of condensate pumps, pressure reducing valves, and steam traps. Our steam board will be used to demonstrate many topics. We will also demonstrate equipment for testing steam traps. Price of the class is $75.00. If you want more detail, or if you would like to register, call Bill Armstrong or visit the "Classes" page of our Web site. This class will be offered again in August.

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