How to Calculate the Proper Flow Rate for any Hydronic System

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In the business of hydronic heating and cooling, there are certain formulas that are used on a regular basis. An important one deals with a system that uses water as its means to deliver comfort in GPM (gallons per minute). Water is the way in which heat is distributed from the boiler room out to where the people are.

How much water determines the flow rate and GPM. An accurate assessment of heat loss in a building is very important to establish the design load conditions. Once the load is established, then we can calculate the necessary flow rate.

GPM = Heat Load/ 500 ^T

GPM describes the flow rate; the heat load is expressed as BTU/H, which is the heat loss of the building at design conditions. ^T is the temperature difference that occurs from the supply to the return when water is circulated through the radiation. Five hundred is the constant for standard water properties at 60°F and it comes from multiplying the weight of one gallon of water at 60°F which is 8.33 pounds x 60 minutes (1 hour).

The complete calculation is then:

GPM = BTU/hr

8.33lb./gal x 60 min x ^t°F

The formula indicates a water temperature of 60°F. However, since 60°F water is too cool for a hot water heating system and too warm for a chilled water system, to calculate the correct flow rate, the formula should be based upon more appropriate water temperatures for each type of system, such as the specific heat of the water or the density changes that occur with changing water temperature. Also, the volume of the water changes when it gets hotter or as it cools down. As you can see from the example that follows, the differences are so minimal that the standard formula works fine for all of our heating and cooling applications.

An example

The formula we use to determine system flow rate assumes a mass flow rate of 500 lbs per hour for each GPM, which means at a 20°^T, 1 GPM will convey 10,000 BTUH (500 x 20) referenced to 60°F water. What happens to the heat conveyance of 1 GPM at 20°F ^T when the circulated water has an average temperature of 200°F? Water at 200°F has a density of 8.04 lb/gallon instead of 8.33 as at 60°F; however, its specific heat goes up to 1.003 from 1.0 as at 60°F. The heat conveyance for 1 GPM at 20°^T will then be:

8.04 x 60 x 1.003 x 20 = 9677 BTUH

The net effect is not significant, but there is another factor that needs to be considered for a complete evaulation. As water temperature rises, it becomes less viscous, and therefore its pressure drop is reduced. When water is circulated at 200°F, the corresponding pressure drop or "head loss" is about 80% of water at 60°F for typical small hydronic systems. When calculated using a system curve, the flow increases by about 10.5%. Now you can multiply the new heat conveyance just calculated by the percentage of flow increase:

1.105 x 9677 = 10,693 BTUH

As you can see, with regards to heat conveyance, the simple "round number" approach will result in design flows very close to the "temperature corrected" flows, providing the results from the "round number" approach aren't corrected from the original 60°F base for both the heat conveyance and piping pressure drop. The plus and minus factors very closely offset one another.

This article provides an accurate formula to calculate the flow rate in gallons per minute (GPM) for hydronic heating and cooling systems.

Choosing the right circulator

GPM plays a major role in ensuring that your heating system performs as expected. You need the right size circulator to be able to move the heat from the boiler and deliver it out to the system where the people are. In selecting the proper circulator, not only do you need to know the correct GPM, you also need to know the required pressure drop to circulate the necessary GPM.

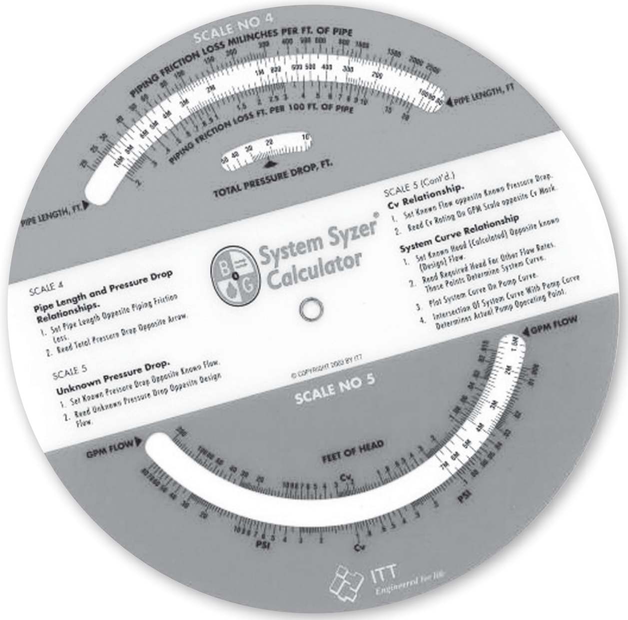
As water flows through the pipes and radiation, it "rubs" against the pipe wall causing frictional resistance. This resistance can affect the performance of the heating system by reducing the desired flow rate from circulating, thus reducing the heating capacity of the system. By knowing what this resistance will be, you can select a circulator that can overcome the system's pressure drop.

Typically in today's systems, we use "feet of head" to describe the amount of energy needed so that the required GPM is delivered out to the system. There are pipe sizing charts that have calculated the pressure drop in foot head of energy loss for any flow rate through any size pipe. There are standard piping practices in which the industry references to limit the amount of GPM for a given pipe size. This is based on two reasons:

1. Velocity concerns (how fast the water is moving inside the pipe) that can create noise problems, and in extreme conditions, erosion problems.

2. The required head loss can become so excessive that the required circulator's HEAD capacity makes for a very "unfriendly" system selection which can lead to control valve and velocity noise problems. The industry standard is to select a pipe which offers the frictional resistance between 1' – 4' for every 100' of piping.

On a side note, *Bell & Gossett* has provided a tool for the hydronics industry for more than 50 years called The System Syzer. This tool is very useful in calculating GPM,



Bell & Gossett's The System Syzer is helpful to determine gallons per minute (GPM).

the proper pipe size to support the GPM and the corresponding pressure drop and velocity for any application.

If you have any questions or comments, e-mail me at *gcarey@fiainc.com*, follow me on Twitter at *@Ask_Gcarey* or call me at FIA 1-800-423-7187. **ICM**