Calculating System Flow Requirements

To select a pump, we need to know the flow rate (the amount of fluid to be pumped) and the system resistance or "head." In the U.S., flow rates are given in gallons per minute, or GPM. **The GPM is a function of the heat loss (or gain) of the building space served by the pump or the process load that is to be met by the pumped systems. It is ALSO a function of the design temperature change of the fluid as it travels through the hydronic system**. The temperature change is commonly called the "Delta T," or ΔT, where the triangle is the Greek symbol for the word "Delta."

Heat Load

Determining the heat load of a building, a zone, or a process is beyond the scope of this paper. Once a time-consuming manual procedure, computer software now simplifies building load calculations considerably. You can download trial versions of some software from the Internet.

Loads are expressed in British Thermal Units Per Hour, or BTUH. Other units of measure are:

1. MBH = 1,000 BTUH
2. Tons = 12,000 BTUH (used for cooling applications)
3. Cooling tower tons = 15,000 BTUH*

*This term is used only when the tower serves an electric chiller or other refrigeration system. In this application, the cooling tower must handle a building load of 12,000 BTUH per ton **plus** the compressor heat of about 3,000 BTUH/ton.[1] This is conservative in light of today's chiller efficiencies, which often consume less than 3,000 BTUH/ton.

Design ΔT (Design Temperature Drop)

The system designer determines what ΔT he/she will use in the design. "Normal" T's for comfort systems are:

Heating Systems	Cooling Systems	Cooling Towers
20, 30, or 40 °F	8, 10 or 12 °F	10 Degrees

Note that these figures are only typical and are common in the HVAC industry. For specific HVAC applications and many process applications, the chosen delta T might be outside these ranges.

Assuming that the chosen fluid will be water, once the ΔT is chosen, the GPM of the pump can be determined by the following formula:

Formula 1:   GPM =   BTUH / 500 X ΔT

Note that as the chosen ΔT goes up, the GPM goes down. This results in smaller pumps and smaller piping. However, larger ΔT's tend to result in larger terminal equipment in the form of more rows of coil, more fan horse power, longer lengths of fin tube, etc.

Note that the "500" factor in **Formula 1** applies only to water. This is derived from the formula BTUH = #/HR X BTU/# X ΔT X S.H. where ΔT is given deg-F and S.H. is "Specific Heat" in BTU/#-Deg F.   Note that #/HR of water = GPM X 8.33 #/GAL X 60 MIN/HR = GPM X 500; The S.H. for water = 1.0 at normal HVAC temperatures. Combining these equations and doing the appropriate algebraic substitutions yields **Formula 1.**

For hydronic systems, we often use glycol mixtures to guard against freezing piping and coils that may be exposed to outside air.[2] These mixtures have different densities (#/GAL) and different specific heats (S.H) than water. So for various glycol mixtures, use the factors from Table 1 instead of 500.

For other fluids, the more general formula applies:

Formula 2: GPM = BTUH /(500 X S.G. X S.H. X ΔT) where S.G. is the fluid's specific gravity.

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[1] Single stage steam absorption chillers require about 3.6 GPM/Ton and have a heat rejection of around 30,000 BTUH/ton. Two stage absorption chillers require about 3.6-4.0 GPM/ton and have a heat rejection of around 22,000 BTUH/ton.

[2] Freeze and burst temperatures for various concentrations of ethylene and propylene glycol are listed in Appendix I at the end of this chapter.

TABLE 1

Load Factors for Propylene Glycol

Temp. deg. –F	Volume %				
	10%	20%	30%	40%	50%
20	N/A	481.7	469.1	453.3	433.5
40	491.0	482.8	471.0	455.6	436.7
60	491.5	484.0	473.1	458.1	439.7
80	491.6	485.1	474.4	460.3	442.4
100	492.0	485.6	475.4	462.2	445.2
120	491.6	486.0	476.5	463.7	447.1
140	490.8	485.5	476.8	464.4	448.8
160	489.7	485.1	476.7	465.2	450.0
180	487.7	484.4	476.8	465.7	451.4
200	486.0	483.3	476.0	465.7	451.8

Load Factors for Ethylene Glycol

Temp. deg. -F	Volume %				
	10%	20%	30%	40%	50%
20	N/A	464.4	447.4	428.7	407.4
40	479.5	466.3	450.4	432.2	411.4
60	480.7	468.4	453.0	435.4	415.7
80	481.5	469.7	454.8	438.2	419.2
100	482.1	470.8	456.8	440.8	422.9
120	481.8	466.4	458.6	443.1	425.8
140	481.7	471.8	460.1	445.2	428.7
160	481.3	472.5	460.6	447.3	431.1
180	480.1	472.2	461.4	448.7	433.6
200	479.0	471.6	461.9	449.7	435.2

Once the flow rate in GPM is determined, the next step in selecting the pump is to determine the head requirement. A discussion on this topic can be found as a separate topic within the "Technical Data" section of this website.

Appendix 1---Freeze and Burst Temperatures for Glycol Solutions

Temperature °F	Percent (volume) Glycol Concentration Required	
	For Freeze Protection	For Burst Protection
	DOWFROST and DOWFROST HD	DOWFROST and DOWFROST HD
20	18%	12%
10	29	20
0	36	24
-10	42	28
-20	46	30
-30	50	33
-40	54	35
-50	57	35
-60	60	35

Note: Dowfrost products are <u>propylene</u> glycol based.

Temperature °F	Percent (vol.) DOWTHERM Fluid Concentration Required			
	For Freeze Protection		For Burst Protection	
	Volume % DOWTHERM SR-1	Volume % DOWTHERM 4000	Volume % DOWTHERM SR-1	Volume % DOWTHERM 4000
20	16.8	17.3	11.5	11.9
10	26.2	27.1	17.8	18.4
0	34.6	35.7	23.1	23.8
-10	40.9	42.2	27.3	28.1
-20	46.1	47.6	31.4	32.5
-30	50.3	51.9	31.4	32.5
-40	54.5	56.3	31.4	32.5
-50	58.7	60.6	31.4	32.5
-60	62.9	64.9	31.4	32.5

Note: Dowtherm products are <u>ethylene</u> glycol based.

Note: "Dowfrost" and "Dowtherm" are registered trademarks of the Dow Chemical Company. The information above is from Dow's 1996 Engineering and Operating guides for their Downtherm and Dowfrost products and is included here for illustration.