



SIZING

PIPES FOR FLOW RATES

What information do the designers of hydronic heating/cooling, snow and ice melting, plumbing, and geothermal systems need to know to make good decisions for sizing pipes? They know that the pipe must transport a specific fluid at the required flow rate and temperature over a certain length, but what else?

The adversary is friction. Friction requires the use of circulating pumps to overpower it, and circulators use electricity, an important operating cost. Selecting larger pipes reduces friction, but increases costs associated with bigger fittings, hangers, transportation, etc. How do we decide the right pipe size?

When sizing pipes, we need to do some important calculations to find the optimum size, the balance of cost, pumping and thermal efficiency, and longevity.

Up to now, designers relied on manufacturers' tables or graphs to calculate factors like velocities and friction loss, but there is always the chance of miscalculating the total loss for the exact length of pipe involved. Also, if we are using an antifreeze mixture for hydronics, that changes the frictional loss.

Designers can do manual calculations when armed with intimate knowledge of the pipe's exact inside diameter and smoothness, the specific characteristics of the exact fluid being used (e.g. viscosity, density), and the fluid temperature.

There are many possible antifreeze mixtures, so that's a lot of data, and another chance to miscalculate.

To help streamline the pipe sizing process for plastic pipes, designers can now go to www.plasticpipecalculator.com for new online software that does these calculations quickly.

THE PLASTIC PRESSURE PIPE DESIGN CALCULATOR

Developed by the Plastic Pipe Institute's Building and Construction Division (BCD), the Plastic Pressure Pipe Design Calculator is a free tool that allows users to calculate such values as pressure or head loss for PEX, PE-RT and CPVC piping systems.

PPI members collaborated to provide this calculator by reviewing established formulas and manufacturers' design factors.

The tool can also calculate thermal expansion/contraction and pipe weight and volume. It can even help designers specify the lengths of expansion arms or loops, especially important for larger diameter piping systems.

Programmed by Avenir, a well-known developer of software for the mechanical and plumbing industry, the calculator gives users access to significant calculating power based on information from ASTM and CSA standards for the three most commonly used plumbing and heating pipe materials. The tool displays in either inch-pound (US) or metric (SI) units of measure.



CHECK THE VELOCITY

Steel or copper pipes have maximum velocities for hot water, typically 4 and 5 fps, respectively. These limits were agreed to long ago to prevent erosion corrosion, noise and vibration. Excessive velocity will actually wear away the inside of metal piping, leaving horseshoe-shaped deformation inside where material is washed away. Eventually, erosion corrosion thins the pipe walls, often near fittings or when there is extra turbulence.

Plastic pipes, like PEX, PE-RT and CPVC, have an inherent resistance to erosion corrosion, vibration and noise, so higher velocities can be tolerated by the pipes without harm, but friction is still a factor and must be accommodated with a correctly-sized circulator.



WATCHING THE MIDDLE

For pipes intended to transfer heat through the wall, like pipes used in geothermal, radiant heating/cooling, or snow and ice melting systems, there is another concern. If those pipes are oversized and the flow rate is too slow, laminar flow can develop.

Laminar flow sounds great, but the potential problem is that slow-moving fluid can cling to the inside of the pipe wall in a so-called boundary layer, effectively insulating the faster fluid in the middle of the pipe and reducing heat transfer through the pipe wall.

It's like the BTUs are trapped inside the pipe and can't get to the wall to escape.

Imagine a busy five-lane highway with off-ramps on the left and right; the middle lane would move the fastest, but it would be difficult to merge from the middle lane to get off the highway.

Having all traffic at the same speed facilitates merging, just as having turbulent flow within a pipe helps heat transfer through the pipe wall. But how do we calculate this?

USING THE CALCULATOR

Let's use a hydronic distribution example, where we are sizing a pipe to carry 180°F fluid from a boiler to a fan coil that requires 30,000 BTUH. The owner wants to use 30 per cent PP glycol to prevent a frozen system in case of an extended power outage.

The universal hydronic flow rate formula tells the designer that the fan coil needs at least 3.3 GPM to maintain a temperature drop of 20°F or less (about 10 per cent higher flow rate than if we were using straight water). The fan coil is 80 ft. from the boiler.

We'll start the design using 1" CTS PEX tubing, and see if this is a good size.

PRESSURE DROP / HEAD LOSS

Input

Pipe Selection: PEX (ASTM F876/CSA B137.5)
SDR 9 1"

Flow Rate: 3.3 USGPM

Length of Pipe: 80 ft

Fluid Type (Water or % Glycol): 30% Propylene Glycol

Average Fluid Temperature*: 170 °F

*This calculation uses the Darcy Weisbach equation which includes temperature as a variable. As a result some published tables using the Hazen Williams equation with a standard temperature may show different results.

Fittings (Optional)

	Quantity	Equivalent Length
Couplings:	8 x	1 ft = 8.0 ft
90° Elbows:	4 x	2 ft = 8.0 ft

Results

Flow Regime:	Turbulent	
Pressure Drop:	0.8 Psi	5.6 kPa
Head Loss:	1.9 ft water	
Velocity**:	1.8 ft/s	0.6 m/s

Calculation Details [Print](#) [Email](#)

We can also include 8 couplings and 4 elbows in the pipeline, taking the head loss through the fittings from the manufacturer's data, expressed as equivalent pipe length. This shows that adding these fittings is equivalent to adding 16 ft. of pipe length.

When we click



we get our answer:

Based on the calculator, using 1" PEX for this pipe will result in a head loss of just 1.9 ft. per 80 ft. of pipe length, a total of 3.8 ft. The velocity is just 1.8 ft/sec, not a concern. The flow regime is

turbulent, but that's not a concern for a heat distribution pipe. The pipes will be insulated.

We can also check results for 3/4" or 1-1/4" PEX, or change everything to metric units with the click of a button.

If needed, we can click print, or email this data directly to the customer who might be making this decision on the job. It works great on mobile devices, so they can do this in the field.

SAVE TIME



There are many aspects to designing plumbing and heating pipelines, and head loss is just one factor. As a frequent designer of piping systems, I rely on this calculator to provide accurate and precise answers and save a lot of time. Give it a try and share your feedback.

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