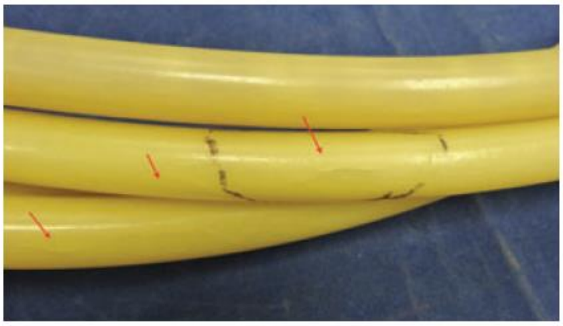

Regardless of the piping material, oversizing the pump can result in system failure.

HOT WATER recirculation

Pump and piping considerations for effective operation

By Bill Hooper

Domestic hot water return or recirculation (DHWR) lines continue to be designed as a best practice in commercial applications. Over the last few years they have become more popular in residential applications as well.

Adding a return line to the domestic hot water system creates a closed loop path that allows the water to circulate back to the water heating source to keep the lines warm when fixtures and other loads are not in use. DHWR piping provides hot water to the various loads in the system very quickly upon demand, even if the hot water has not been required for a long period of time. It's like the system is placed on "idle", waiting to accelerate into action with system water pressure behind it. While all hot water taps / loads are closed, the loop is pressurized / equalized to the system water pressure and therefore a pump is needed to move the water (creating a difference in pressure) from the loads and back to the heat source to keep it on its "idle" temperature – ready to spring into use.

This recirculation concept has many

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System on 'idle' when not in use

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benefits, primarily less water energy consumed overall. Less water down the drain while waiting for warm water to arrive is less waste, and in some cases (where drains are metered) can save money.

That is why it makes for a design "best practice" and there are guidelines that help with good design. The American Society of Plumbing Engineers (ASPE) has a procedure in their design manual on domestic water systems that shows how to calculate required DHW recirculation flow rates based on BTU losses of these "closed" loops.

Sizing considerations

Important sizing considerations are sometimes set aside in lieu of rules of thumb that could be inaccurate. I mention this because I have spent a great deal of time in the pump world, where many times I would simply send a quote for the bronze pump that appeared on the schedule where (so I believed) all the work and thought of the selection was complete. Admittedly, I didn't spend a lot of time thinking about DHWR pump sizing – yet now I am starting to see the end results of oversized pumps on DHWR lines in all types of tubing materials.

Sized correctly, a recirculation pump needs to keep the recirculated water at the design temperature, using the smallest possible circulator. Keep in mind:

If we undersize the pump, recirculated hot water will not stay warm enough. Too little flow would not allow the water to maintain its temperature since the heat losses in the line would exceed the replenishment rate of heat; or cause an inability to re-heat the water fast enough.

Since these pumps need to be constructed of non-ferrous materials (bronze and stainless steel are common), too large a pump can be very expensive in comparison to a smaller unit that is more applicable. Larger motor sizes also play a role in cost if single-phase power is the only available feed.

> "This recirculation concept has many benefits, **primarily less water energy consumed overall**."

Too much flow (high velocity) has the potential for much more sinister repercussions to the system that are often hidden from us until there is a failure – especially if the chlorine content of the system is higher than needed. Keep in mind that these lines are insulated and inspections after the installation would not happen often, if at all.

Adding a smart pump

Smart Pumps have the ability to sense temperature, adding to overall system efficiency in reduced motor power consumed to circulate the water and reduced controls cost since temperature sensing controls are integrated. The right programming and sizing with smart pumps can truly optimize a DHWR system.

Adding a smart pump will help maximize system efficiency.

Based on the importance of these sizing/selection issues, I believe that every technician and designer needs to be keenly aware of what the oversizing issues are and what needs to be done about them if they are re-piping a failed system – or upsizing a smaller pump to the right model for that matter. It makes good sense to be somewhat aware of the pump/piping network combination for early warning signs of oversized pumps; where the inconvenience of an undersized pump will surface in complaints without potential system damage. Let's make it a goal to take into account the combination of the pump being integrated with the piping network on systems we are asked to design and install!

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Maintain design temperature with smallest practical circulator

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The piping network

Now that we have covered the pump issues around flow, we can involve the piping network in the equation. We use piping all the time to get water from one location to another, but we need to be aware that domestic hot water is fresh (with entrained oxygen) and does not go through an air separator while circulating. The combination of relatively hot water, the presence of chlorine, and entrained air can have a scouring effect that is amplified at high velocity.

Ends and elbows take the brunt of the punishment from changes in direction of the water, but experience tells us that most mechanical failures are random - we can only control the primary operational environment - not where they show up as failures.

The tables in Fig. 1 (copper systems) and Fig. 2 (PEX systems) give some guidance on DHWR systems with regard to how the pieces of the puzzle fit together. For existing systems,

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Fig. 1: Type L copper piping in DHW recirculation applications.

Copper Type-L for DHW Recirculation Piping		Flow @ 3 fps (Maximum)**	Friction Loss / 100 '	Typical Pump Sizes for 100 ft. of pipe, with system balancing
Nominal Dia.	½"	Up to 2.15 GPM	9.28' + fittings / balancing	Series 100B, S-25B, 225SSU, SSF-22, UPS-15-58S, 007SF5, Star 21BZ
Inside Dia.	0.545"			
Nominal Dia.	¾"	Up to 4.58 GPM	5.87' + fittings / balancing	Series 100B, S-25B, SSF-22, UPS-15-58S, 007SF5, 225SSU, Star 21BZ
Inside Dia.	0.785"			

Comments: Velocity is not always the deciding factor for flow rate, as pressure drop also comes into play. Always ensure the pump has the right flow and head performance. The above value is for 100 ft. of piping, so if the run is longer, more head to overcome friction is required. A means of balancing is highly recommended. Chlorine concentration should also be considered.

** Maximum Velocity as per CDA Publication A4015-02/16: Copper Tube Handbook, Page 14 shows a recommended range of 2-3 FPS for DHW Recirculation velocity.

Fig. 2: PEX piping in DHW recirculation systems.

PEX Tubing for DHW Recirculation Piping		Flow @ 2 fps (Maximum)	Friction Loss / 100 '	Typical Pump Sizes for 100 ft. of pipe, with system balancing
Nominal Dia.	½"	Up to 1.10 GPM	4.53' + fittings balancing	SSF-9, UPS-15-10BU, 005SF5, 225SSU, Star 21BZ
Inside Dia.	0.475"			
Nominal Dia.	¾"	Up to 2.20 GPM	2.94' + fittings / balancing	SSF-9, UPS-15-10BU, 005SF5, 225SSU, Star 21BZ
Inside Dia.	0.671"			

Comments: Due to the 2 fps velocity restriction, the flowrate comparing size for size with copper will be less. The flow values should always be compared to the required flow rate to keep the lines warm (BTU Loss method). The above value is for 100 ft. of piping, so if the run is longer, more head to overcome friction is required: always ensure the pump has the right flow and head performance. A means of balancing is highly recommended. Chlorine concentration should also be considered.

Oversizing can cause damage

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does the pump seem too large? For systems being designed, does the system on the plans seem to be over/under-sized?

Further to these piping fact charts, another chart could be developed using pressure drops at various flow rates per 100 feet in 1/2" line, 3/4", 1", 1-1/4", etc. This chart could show how certain pump sizes fit to serve as a good beginning reference point for installers and trouble-shooters. More on that sometime soon!

Sizing summary

We can summarize DHW recirculation system sizing as follows:

- Btu loss sizing would be considered a preferred method as the rationale behind recirculation is to offset the Btu/h losses in the loop. More flow is not necessarily better.
- In the real world, the best practice application for existing piping networks with missing information can be a difficult and time consuming venture – and could require additional engineering support.
- For identified trouble locations, use circuit-balancing valves and/or augment the use of balancers with "smart" replacement line sizing to equalize pressure drops in loops to limit velocities.
- Make sure Btu's are accounted for. PEX tubing will hold less water volume than copper for the same size and that will to come into the equation for Btu losses in this type of system
- There are many pitfalls in using larger pumps than required as increased velocity to the system – and initial cost of the pump – are factors to consider. It is best to apply the pump after system water volumes, furthest fixture lengths/pressure drops, and anticipated Btu losses are analyzed. Pumps that continually operate close to shut-off head tend to experience more bearing thrust, which may affect life span.

I believe it is better to consider asking more questions about a system like this and get it verified then to install it and have problems later. Leaking systems can cause a lot of expensive damage that could be avoided with good design and foresight.

Bill Hooper is a certified engineering technologist with many years experience in hydronic heating. He is a former chairman of the Canadian Hydronics Council, was involved in creating the CSA B214 Hydronic Heating Code and has worked with ASHRAE. Today Bill is Atlantic Region manager for Uponor Ltd. He can be reached at *bill.hooper@uponor.com.*