GO WITH THE (ASHRAE) FLOW!

by Rod Brandon

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As HVAC system technologies advance and software automates a lot of the traditional cognitive work previously performed manually by experienced system design experts, it's wise to stand back and take a holistic view of the system, to ensure "best engineering practice" is not over-looked.

Traditionally, HVAC heating systems were based on constant volume primary circuits connected directly to large cast iron radiators with independent temperature regulating valves. Up to 100 per cent excess system flow was bypassed from boiler discharge to supply, depending on the load at any given moment. Energy was cheap and fluid flowrate had very little impact on system operating cost.

In time, HVAC design experts learned – often by trial and error – what flowrates worked well for various application conditions.

Today the environment has changed, ecologically as well as technologically. We now have energy-efficient variable volume pumping and terminal units ranging from high-flow water source heat pumps to very-low-flow radiant ceiling panels.

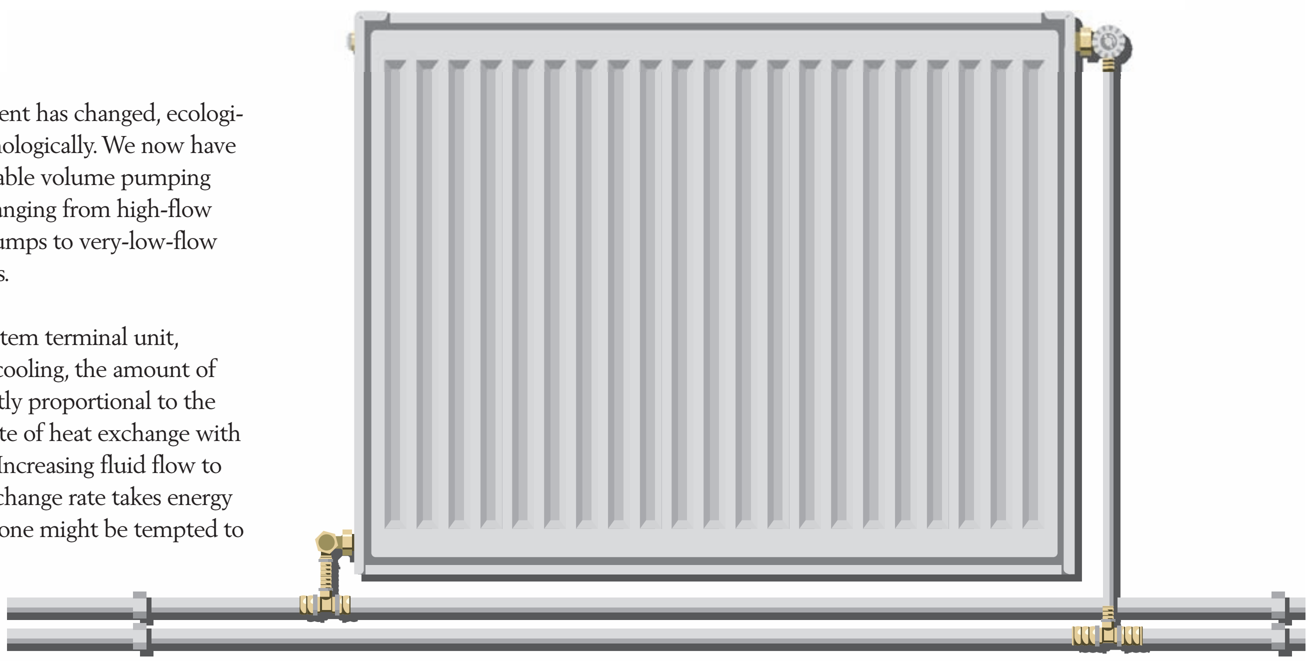
For any hydronic system terminal unit, whether heating or cooling, the amount of heat transfer is directly proportional to the fluid flowrate and rate of heat exchange with the surrounding air. Increasing fluid flow to increase the heat exchange rate takes energy and costs money, so one might be tempted to reduce the flow to reduce operating costs. This is especially attractive with radiant panel design, where the heat exchange is passive and has no operating cost at all (but it does affect the capital cost based on physical size and form of the unit).

Regardless of system design, whether active or passive heat exchange, one thing still holds true, HVAC systems perform better when designed to ASHRAE guidelines.

continued on page 52

Pipe Size	½"	¾"	1"	1 ¼"	1 ½"	2"
Min GPM	1.6	3.2	5.5	8.2	11.4	19.8
Max GPM	3.2	6.5	10.9	16.3	22.9	39.6

ASHRAE Recommends…
For type M copper pipe up to 2", ASHRAE recommends that fluid flowrates for nominal pipe sizes correspond to a flow velocity between two and four feet per second.



ASHRAE Flow

Continued from page 50

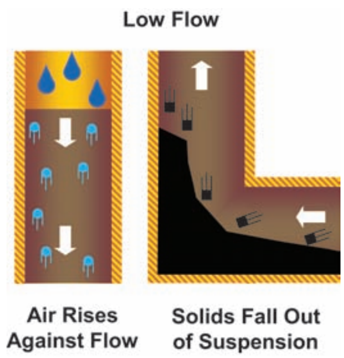
Manufacturers in the HVAC industry usually comply with these recommendations as a basis of design for the various system components they produce.

But what happens if a terminal unit manufacturer bases design on a fluid flowrate outside of these guidelines to take advantage of the heat exchange characteristics of a particular model?

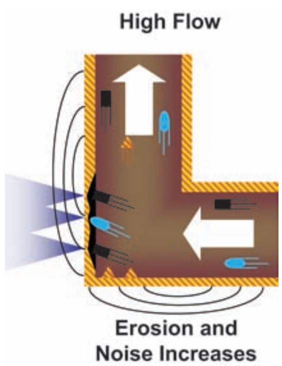
In theory, the terminal unit may work quite well, at least initially. However, ASHRAE guidelines for flow velocity are intended to ensure that the system operates at optimum performance. Flow velocity also affects the ability to transport air and dirt to central extraction equipment, the amount of noise generated within the system, and the rate of corrosion and erosion of system components.

CBV on page 53

When the design flows are within ASHRAE guidelines, the flow stream carries entrained air and dirt to central automatic extraction equipment that helps the system run efficiently and trouble-free.



If the design flow is reduced to the extent that flow velocity is below two feet per second, entrained air will rise against fluid flow in vertical sections, causing total air in the system to increase. Additionally, solids that are supposed to be carried by the flow stream to the dirt extractor will fall out of suspension and plug system components.



Conversely, when design flow is increased above four feet per second, excessive fluid velocity may result in unacceptable noise levels being transmitted from system piping and components. This may also accelerate flow-induced erosion of system components, thereby reducing the life expectancy of the system and increasing maintenance costs.

CBVs & Low Flowrates

Low flowrates can present an interesting dilemma for circuit balancing valves.

When these valves are line-sized and design flowrates are within ASHRAE guidelines, the aperture between valve disc and seat is optimal for a typical pressure drop across the valve (one to three feet).

However, without provision for low-flow applications, standard flowrate valves have to be throttled down to the point where the aperture is virtually closed. In operation, this small gap can cause the valve to partially or completely plug very early in system life, sometimes even before the owner takes possession. Additionally, as a standard flow variable orifice valve is throttled, flow measurement accuracy worsens to as much as plus or minus 15 per cent deviation. Even more alarming is that as the valve is restricted by dirt accumulation, even though the flowrate is reduced, the pressure drop increases. Using the published valve Cv causes the flow measurement accuracy to worsen to the point where a very high flowrate can be measured, despite the valve being completely plugged and no flowrate actually being present.

Avoid the Air

Excess entrained air in hydronic fluid:

1. Creates unnecessary noise, even at low flowrates.
2. Reduces the output of the emitter.
3. Contributes to excessive corrosion of ferrous system components.
4. Increases the concentration of iron oxide particles within the hydronic fluid, and the risk of plugging.
5. Leads to overall reduced life expectancy of the entire system.

Therefore, for low-flow applications, a circuit balancing valve should have a smaller disc to allow dirt in the low velocity fluid flow stream to easily pass. Additionally if the valve incorporates a fixed orifice flow measurement element, the valve will accurately report a dirt restriction, thereby assisting system troubleshooting.

In the photo, both valves are for 1/2" nominal pipe size. The valve disc/stem assembly on the left is for standard flow within ASHRAE guidelines. The assembly on the right is designed specifically for low flow applications still using 1/2" pipe. The smaller disc diameter increases the disc/seat gap, thereby reducing the risk of being plugged with dirt in the hydronic fluid.

When defining terminal unit flowrates within an HVAC system, if the design software only considers the impact of the flowrate on the theoretical terminal unit performance, the designer must intervene to consider how the selected flowrate will affect the whole system. Should design flowrates outside of ASHRAE guidelines be chosen, care should be taken to specify system components that are well suited to the resultant operating conditions, which may be outside the optimal range for standard products.