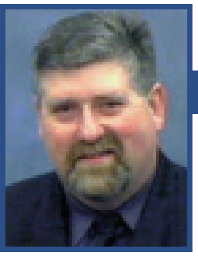
BY MARK EVANS



ARE WE FULL OF HOT AIR?

Hydronics enthusiasts often proclaim the benefits of hydronic systems over forced-air systems in single-family residential applications. One of the most compelling and common arguments is the comparative efficiency of hydronic versus forced-air systems, and the resultant energy savings.

Figures ranging from 20-30 percent are bandied about. Where do these numbers come from?

In addition to more traditional research, the industry has provided input to this article. With Dan Holohan's permission, the question of comparative efficiencies was posted on *The Wall* at www.heatinghelp.com. Excerpts of some responses are included here.

This investigation focuses on new, single family detached residential construction with the assumption that a high performance furnace performs as well as a high performance boiler and vice-versa.

THE THERMOSTAT AS A HIGH LIMIT

In a typical forced-air system, effective system operation depends on the correct location of the thermostat. A single thermostat location is the norm, which increases the possibility of a room or rooms being overheated.

On the other hand, hydronic systems typically have a multiple zone, and hence a multiple temperature system with varied room setpoints. This is where the hydronics enthusiast will tell you that you would save three to five per cent for every degree of offset from the average (68 versus 72 would equal four degrees and a 20 per cent saving of energy for the room or rooms).

THE CONTROL EFFECT

It is common in hydronic systems for the system operating controls to be external of the boiler. Not counting setback thermostats, there are many choices of brand and control strategies. With the exception of digital thermostats, most furnace installations do not utilize external controls.

While you can get furnaces with variable speed blowers and modulating gas valves, the level of control applicable to most residential forced-air systems is less evolved than is common in many hydronic installations. The typical hydronic control system can measure, compare and control more devices than its forced-air cousin. This is only a plus if the controls are properly selected and applied.

RANDOM FACTORS

In hydronic systems it is common to see the production of domestic hot water integrated with space heating. The consumer gains the efficiency differential between the hot water tank that would be installed to accompany the furnace alternative.

A posting on *The Wall* from Mark Adams dealt with this issue: "The furnace requires me to install a DHW heater and the best I can find in a tank type with the performance I need has an EF= 0.62. So let's assume the total system efficiency for the boiler is 83 per cent (mid-efficient compared to his furnace which is a 92 per cent condensing unit). The total system efficiency for the FHA and DHW is (assuming 30 per cent of the gas use is for hot water and 70 per cent is for heat):

$0.92 \times 0.7 + 0.62 \times .30 = .83$

or 83 per cent equivalent efficiency."

In Adams' example, the relative inefficiency of the hot water tank degraded the overall system efficiency for the furnace/hot water tank combination. Keep in mind that he was comparing a mid-efficient boiler to a high-efficient furnace. If the boiler is as high or higher efficiency than the furnace and the same hot water tank was used, then the overall system efficiency would be greater.

Compare that to a high-efficient boiler with an indirect tank. If properly sized and controlled, then the boiler/indirect combination would have an even higher combined system efficiency.

TEMPERATURE GRADIENTS AND YOU

When we talk about comfort, we refer to mean radiant temperature, operative temperature and the effect of wall surface temperatures on heat loss and system efficiency. To apply this, see *Figures 1 and 2*.

What are *Figure 1 and 2* telling us? They support the claim of benefits with zoning and varying room temperature setpoints. The operative temperature in a hydronic radiant floor heating system, for example, would be lower than in a forced-air system. This allows us to set the thermostat lower and still maintain the same relative comfort, all the

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FIGURE 1

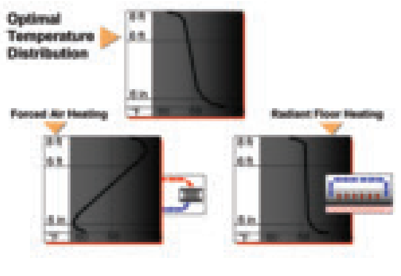
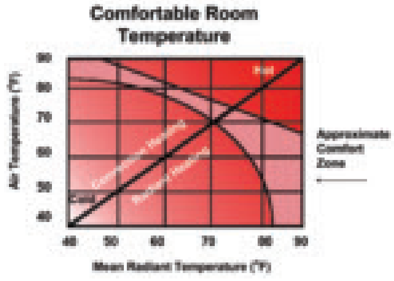


FIGURE 2



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while saving that three to five per cent per degree differential.

DISTRIBUTION DEBATE

A posted response from Geoff McDonell of Omicron Engineering, a contributor to *HPAC Magazine*, dealt with distribution efficiency. "Start with the basic physics: thermal capacity: water can hold 3400 times more energy than air (specific heat) and you can flow the same amount of energy (Btuh) through a 3/4" pipe as a 14" round duct. So, advantage water as an energy transport method."

In the same vein, Jerry Scharf posted this comment: "For rough numbers, a one-inch water pipe (1.25 OD) in a system with a 20 degree Delta T can carry comparable Btus to a 16" round duct running 70 degree Delta T (assuming some generally accepted flow limits due to noise). The surface area is 2 x pi x r x h. This says that the duct has 12.8 times as much surface area to lose heat in distribution.

Scharf continued, "Once you de-rate the fibreglass, which is the most common duct insulation, for real world airflow issues and include relative difficulties of reaching ideal insulation, that number only goes up. So saying a five to 10 per cent increase in distribution energy loss for all delivery piping run outside the insulated part of the building is quite conservative."

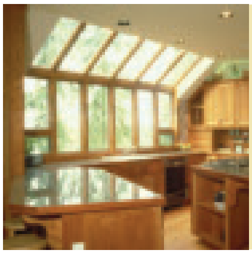
ACHIEVING SAVINGS

The issue of distribution efficiency improvement has been studied at great length. In a recent press release, ASHRAE announced ANSI-ASHRAE Standard 152, Method of Test for Determining the Design and Seasonal Efficiencies of Residential Thermal Distribution Systems.

This standard can be applied to either a forced-air or hydronic system and can be used to compare relative efficiencies. According to the chairman of the standard committee, Mark Modera, "Field studies have shown that sealing and insulating ducts in existing homes can result in savings of 10 to 35 per cent."

Distribution efficiency in a hydronic system is reduced by convective energy loss and conductive energy loss. These are easier to measure than the metrics of the forced-air system distribution losses as they are strictly functions of temperature and flow.

The convective and conductive losses seen are less than those of a ducted system, as the surface area of the pipe is far less. By using non-metallic piping (PEX) for distribution, this can be mitigated even further. Add to this the energy saved by the circulating pump(s), which have become much smaller with the advent of fractional horsepower wetrotor circulators. A hydronic system pump can use only 25 to 35 per cent of the energy required to move the same number of Btus with a blower.



"To gain efficiency in heating systems, whether they are hydronic or forced-air, improvements to the building envelope quality are necessary."

MITIGATING INFILTRATION

Duct leakage is a significant issue. Industry estimates, supported by research from the US Department of Energy, indicate there is an energy savings potential of 1.33 quadrillion Btus per year to be had by improving distribution system efficiency. According to the National Association of Home Builders (US), 96 per cent of homes had ducted systems in 1999.

In a forced-air system, this means solving the duct leakage problem to mitigate infiltration and increasing the amount and effectiveness of insulation. It is safe to say that duct leakage may go unnoticed, where a leak in a hydronic distribution pipe will normally cause a notable drop in performance or a drastic increase in energy consumption and will not go undiagnosed and uncorrected for any significant period of time (floods notwithstanding). Increases in infiltration not only lower system efficiency, but affect the relative humidity of the system. While impacting the RH may or may not directly affect energy consumption, it will impact occupant comfort.

Where there are duct or piping losses within the insulated part of the building, there is also what is known as thermal regain. As much as 50-60 per cent of the system distribution losses, whether from the ducts in the forced-air system, or from the hydronic piping mains, are regained as heat in the conditioned space.

OTHER CONSIDERATIONS

To gain efficiency in heating systems, whether they are hydronic or forced-air, improvements to the building envelope quality are necessary. A better building envelope (windows and insulation) reduces the required heat load and moves us toward the ultimate heating system.

When we try and sell a boiler-based heating system against a forced-air alternative, we are drawn like flies to the efficiency argument. Keep in mind that this is only one, and sometimes a very minor, reason for a consumer to choose hydronics over forced-air. The biggest reasons should be comfort and utility. These are features that translate into an everyday reminder of why consumers choose "wet" heat.

The message is: When selling hydronics, do not get too caught up in the "how." Sell the "why." HPAC

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