Hydronics WORKSHOP

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Don't Write Them Off

Cast-iron boilers still have a future.

As boilers with compact stainless-steel and aluminum heat exchangers have entered the North American market over the last 15 years, some heating pros may be thinking that the age of cast-iron boilers is all but over. After all, everyone knows that cast iron can't be used for condensing boilers, right?

I used to think that way. My reasoning went like this: The acidic nature of condensed flue gases corrodes cast iron. Eventually, the scale created by this corrosion significantly reduces heat transfer within the boiler. It can also eat through galvanized vent piping in a matter of months. We've discussed this many times in past columns, and looked at details on how to pipe boilers and control cast-iron boilers so that sustained flue gas condensation is avoided.

Same Old, Same Old: For decades, cast-iron boilers have operated as on/off devices. Anything that created a circuit between the T T terminals on the limit controller fired the burner at full capacity. Break this circuit and the burner was off. The boiler's thermal mass smoothed the pulses of heat production into a reasonably stable range of output temperatures. When a cast-iron boiler supplied a low temperature load such as slab-type floor heating, designers included a mixing device between the distribution system and boiler to protect the latter from sustained flue gas condensation.

Because this scheme worked well and has been used on millions of installations, it's easy to assume that it's the only way cast-iron boilers can be applied. At least that's what I thought until I was shown what was purported to be a condensing cast-iron boiler.

When I heard the words *cast-iron* and *condensing* in the same sentence, my gut reaction was BIG MISTAKE. However, some follow-up research convinced me that with the right approach, it is possible to build a mod/con boiler with a cast-iron heat exchanger that offers some unique benefits.

Here's a summary of the concept. Cast iron still corrodes when wetted with condensate. The chemistry between acid and iron hasn't changed. However, the rate of corrosion can be reduced through features such as a down-flow heat exchanger (see Figure 1), spreading the condensation over a greater surface area, thicker section walls and post-purge air flow that drives condensate off the sections at the end of each firing cycle.

Figure 1

Photo courtesy of Mestek.

Independent testing has shown metal loss rates are such that the cast-iron sections remain in conformance with ASME safety factors for more than 20 years, even under sustained condensing-mode operation. Under partial condensing-mode operation — more typical of real installations — measured metal loss rates suggest that the cast-iron heat exchanger could remain within the ASME spec for upwards of 100 years!

A Different Narrative: These findings change the context of the situation. Instead of simply dismissing cast iron as a material that corrodes when exposed to flue gas condensation, the relevant questions become:

1. Are other mod/con boilers with stainless-steel or aluminum heat exchangers going to provide service lives equal to or beyond those provided by a condensing cast-iron boiler?

2. Will *any* mod/con boiler installed today be serviceable 20 years from now?

3. Will we have the same fuels available to operate these boilers 20 years from now?

Although the final point might seem extreme, I think it's relevant. Given the current changes in global fuel supplies and environmental legislation, the heating business, as we now know it, could look very different two decades from now.

With these thoughts in mind, it's reasonable to conclude that cast-iron condensing boilers, with "managed metal loss" design details, are as viable as any other currently available boiler option.

Restoring Old Charms: Besides the high thermal efficiency associated with condensing-mode operation, cast-iron mod/cons bring two other desirable characteristics to a system: low head loss and high thermal mass.

Low head loss is a trait the North American hydronics industry enjoyed, without much appreciation, until the appearance of residential-size condensing boilers. Cast-iron boilers create extremely little head loss, even at substantial flow rates. This is a direct result of their sectional design with large internal water passageways. As a result, we routinely piped them such that the entire system flow passed through the boiler.

The appearance of wall-hung boilers with very compact heat exchangers ushered in an era in which a dedicated boiler circulator was typically required. Although the installed cost of this dedicated circulator may be under $300, its projected operating cost over a nominal 20-year life is often more than $1,000. That extra cost certainly nullifies part of the fuel savings. For better or for worse, designers of many compact mod/con boilers conceded low head loss as a necessary sacrifice for a compact and light design.

Thermal mass was another characteristic of cast-iron boilers that was often cursed, and yet provided an often unrecognized benefit. Sure, a 500-pound boiler is not something you just pick up and carry into a building. It takes a bit more logistics and sweat to place one of these heavyweights relative to boilers that are attached to a wall.

Based on my calculations, a typical cast-iron boiler rated at 75,000 Btu/hr.-output has about 12.5 times more thermal mass due to its metal and water content, compared to a compact mod/con boiler of the same peak capacity. All that metal and water content make cast-iron boilers "self-buffering" in most installations. Buffer tanks are simply not required.

Our industry has found work-arounds for the higher head loss and low thermal mass of compact boilers. In most cases we add a dedicated boiler circulator and install a hydraulic separator or buffer tank. This works, but usually not without added floor space and never without added cost.

Back To The Future: Consider the simplicity of system design shown in Figure 2 on page 28.

The low head loss, cast-iron mod/con boiler allows full system flow to pass directly through the boiler. A single variable-speed, pressure-regulated circulator provides flow through the boiler and the entire space-heating distribution system. It automatically adjusts speed to maintain constant differential pressure on the distribution system as the thermostatic radiator valves on the panel radiators open and close. For a typical residential system, this circulator would have a peak power consumption in the range of 40 to 60 watts. Under partial load conditions, wattage could drop into single digits.

The boiler is equipped with an outdoor reset control that ensures it operates at the minimum possible temperature and maximum possible efficiency for the prevailing load conditions.

Domestic water heating is treated as a priority load, the same as with other mod/con boilers. The boiler operates at an elevated temperature during this mode. When the tank reaches its setpoint, the boiler returns to outdoor reset control for space heating.

This approach is reminiscent of a time when most residential and light commercial systems used a single boiler and single circulator for space heating. However, hidden beneath that simplicity are state-of-the-art subsystems for combustion, control and distribution. Together, they provide stable operation and peak energy efficiency on both the thermal and hydraulic sides of the system.

I urge you to not dismiss cast iron as a viable boiler material for the present and future. It may not take the form of a dry-base, atmospheric design, but when cast iron is combined with the latest combustion, control and distribution system technology, it can still carry the flag for generations of future hydronic systems.

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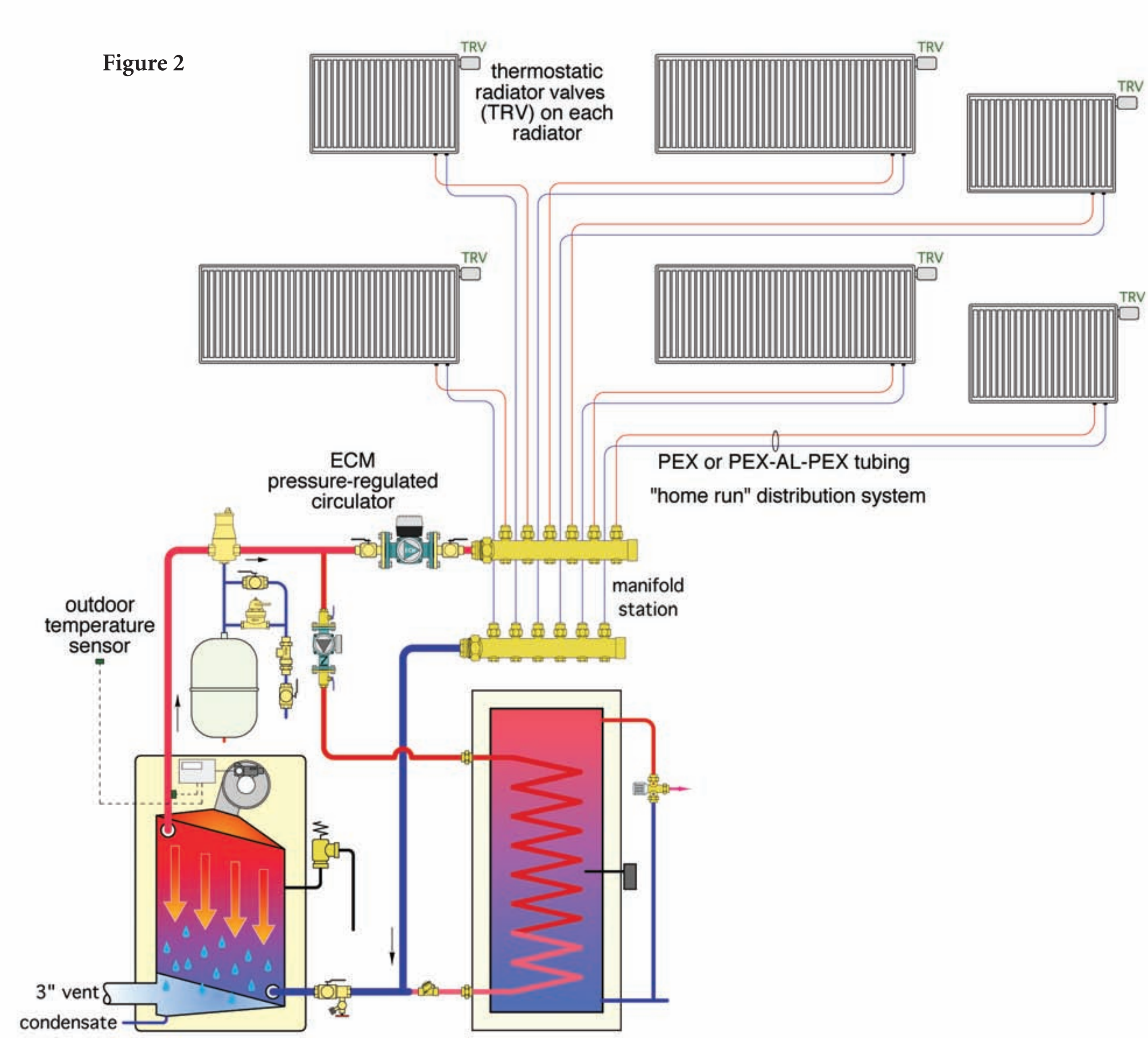
Figure 2



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