New Age For Hydronic System Performance

The newest generation of boilers and contols helps set a fast pace for the industry.

By John Vastyan

The hydronics industry has emerged from its extreme makeover. Consider that, just 15 years ago, manufacturers were cranking out replacement boilers at a slower pace each year. Meanwhile, the new construction market had long since cooled to hydronics.

Today, the hydronics industry is moving at fast pace. And new equipment and market conditions have driven manufacturers to new levels of engineering excellence.

Without question, market forces – chiefly, the push for higher and higher energy efficiencies, and demand for equipment to go where no equipment has easily gone before – are driving the pace for new and innovative hydronic solutions.

The newest generation of equipment – such as condensing technology that extracts heat from condensate within the system – has pushed combustion efficiency into the 95 to 99 percent range. Add new and sophisticated commercial controls to the picture, and system integration with building automation systems, and you begin to see how quickly this market is moving.

With performance like that, building owners are now at attention. When contractors or design engineers can calculate a three- to four-year payback for new equipment (or less), there's real incentive to install new technology.

To help explain this phenomenon, we've tapped the experience and expertise of several industry experts.

- **Bill Root**, vice president of sales and marketing, Laars Heating Systems Co.;
- **Mike Chiles**, president and general manager, Watts Radiant;
- **Tony Radcliff**, building services product segment manager, Grundfos Pumps Corp.;
- **Tim Rosen**, PE, Concept Mechanical;
- **Mark Olson**, CEO and general manager, Caleffi Hydronic Solutions; and
- **Joan Mishou**, manager of applications engineering, Laars Heating Systems Co.

According to this round table, high-performance hydronic heating and volume water heating depends on the interrelationship of six key facets of the boiler system:

1. System Efficiency: How effectively the boiler relates to the total system is determined by its capacity to deliver heat either quickly, or slowly, depending chiefly on the needs of the system and the ability of the boiler to adjust to changes in the system's demand for heat.

The common term is "to size to the load." Also, total system performance is greatly enhanced when the equipment works at peak performance – with fuel consumption happening at the highest levels of combustion efficiency – at all levels of heat demand.

According to Mishou, another important factor is more sophisticated controls that sample changes over time and "learn" the responses of the system to changes in conditions such as heating load, outdoor air temperatures, and firing stages of the boiler(s).

"And there's modulation or staged firing vs. on-off," Mishou added. "Modulating and staged-fired boilers reduce fuel consumption by 'sizing to the load' so that the amount of heat produced by the system precisely matches the need."

Piping and pumping are also key factors in building an efficient system. The most efficient boiler in the world can't make an entire system efficient if the system is not piped and pumped correctly.

And, there's response to outdoor temperatures, water storage temperatures, and system loop temperatures. These, too, are very important contributors to overall system performance. Control systems should take these key variables into consideration.

"Condensing boiler technology is one of the key factors for the dramatic increase we see in boiler/water heater system efficiency," added Root. Condensing commercial boilers are built to encourage the formation of condensate within the system and to withstand the corrosive nature of the liquids that form there. That latent heat is extracted from the moisture that forms in either the primary or secondary heat exchanger, dramatically enhancing combustion efficiency

But efficiency is only one of the advantages of installing these systems. Application of the boiler can play an even more important role. "Their resistance to thermal shock and the ability to accept low return water temperatures puts condensing systems in a category of their own, ideally suited for high-volume, cold-start systems," Root said.

Modulation goes hand-in-hand with the ability to operate in a condensing mode. When boilers can operate with low return water temperatures, and lowered firing rates, the relationship of heat transfer surface to fuel consumed, and the combustion efficiency itself combine to deliver maximum efficiency. And, when multiple boilers are installed, each one handles only a portion of the heating load; that drives system efficiency even higher.

New boiler and controls technology help today's radiant contractor

"Some systems that require higher operating temperatures most of the time may still benefit from a 'lead boiler' that's a condensing boiler," Mishou explained, "while the remaining boilers that provide the bulk of the heat are noncondensing."

2. Combustion, Thermal Efficiency: Just a few years ago, many in the industry considered combustion efficiency and thermal efficiency to be the most important factor in determining overall system performance. That's not the case today.

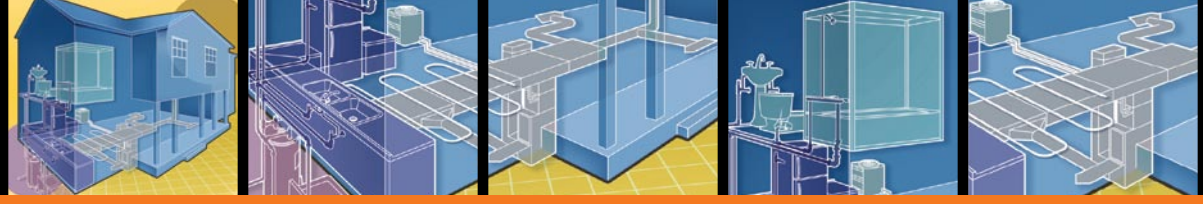
According to Root, transferring heat from a boiler into a total system – and in just the right amount and at just the right time – is a truer measure of system performance.

Manufacturers today put a lot of engineering effort into maximizing heat transfer to water – and that efficiency is a critical aspect of a boiler's performance. The only thing to keep in mind is that many applications do not call for the highest levels of combustion efficiency (condensing equipment) because the water temperatures are too high.

Designing systems with staged firing, modulation, and/or multiple boilers can often produce higher system efficiency than trying to use a single condensing boiler that claims higher combustion efficiency.

"Green" boilers are another facet to the high performance equation. "Today, when this topic is discussed at industry round tables, we look at emissions – NOx, CO, CO_2 – with the real desire see lower levels of pollutants that endanger our atmosphere and indoor air quality," Mishou said. "California's South Coast Air Quality Management District, the states of Nevada and Texas, and selected projects in almost every other state, have set limits for emissions, especially NOx. And, being able to take 100 percent of the air for combustion from outside the building is also required in many installations."

3. Information Exchange: How well does the boiler act as part of a system in terms of both accepting and responding to external sources of information? "Information exchange," if we really put it to the test, refers to the boiler's ability to both receive external information – such as outdoor air temperature, new



instructions from a BAS, and system zone information – and to send information back to the BAS – such as inlet and outlet water temperatures, operating cycles, fuel consumed, pump operation, etc.

According to Root, these functions play an important role in the exchange of information to and from the system:

• Ability to accept communication signals from BAS (BACNET, LON, Metasys, Echelon).

• Ability to report information back to the BAS.

• Collect data that provide management information about operating statistics and efficiency, such as inlet and outlet temperatures, run time, percent load, domestic tank temperatures, system loop temperatures, etc.

• User interfaces – How well, and how easily the user can change operational settings is important. Consider how easy is it to learn the boiler's command system? Also, function and usability of keypads, displays, and convenience of access.

4. **Installation And Service**: High on a field technician's or building maintenance supervisor's wish list will be:

• Easy access to all components.

• Easily accomplished field wiring of thermostats, field inter-locks, accessory equipment and BAS control.

• Convenient access to water, gas and electric at different sides of the boiler.

• Combustion air that's filtered, with filters that can be washable and reusable.

• Options that include sidewall and vertical venting, as well as a boiler's installation outdoors.

5. Multi-speed Circulation: One of the most important facets to optimal circulation for hydronic systems is for design engineers and installing contractors to match a pump's performance, or flow characteristics, to the specific job that it needs to perform within the system.

According to Radcliff, a single-speed pump has one performance curve. But new multi-speed circulators offer a much broader range of performance. With the flick of a switch, various speeds can be chosen, easily changing head and flow to meet the specific needs of the system.

"We've standardized on multi-speed circulators because we feel they do the best job," says Tim Rosen, PE, a partner in the plumbing and mechanical contracting firm, Concept Mechanical, based in Avon, Co. "Three-speed circulators give us greater control and versatility." He says he always does the math, calculating heat loss, flow rate, and pressure drop for each pump.

"I use this information and the stated pump curve to select the proper pump for each load," he continued. "In the past, we might have three or four different pump models on one job, all selected to match the exact needs that we've determined. With multi-speed pumps, I can use one pump and select the speed to match the flow and head that we want. And, the use of multi-speed pumps allows for future expansions, changes, and retrofits in stride."

6. Enhanced Piping Solutions: Another advanced device combines a hydronic separator and distribution manifold and serves as a low-loss header. These are available from Buderus, Viessmann and Caleffi. The Callefi HydroLink and hydraulic separators, for example, are attached to hydronic heating or air-conditioning systems to permit different heat adjustments for separate, multiple zones when there is only one boiler or chiller.

Its configurations are compact and can easily be designed into any type of hydronic circuit. Says Olson, the key, operating principle is that when a single system contains a primary generating circuit, with its own circulator, and a secondary circuit, with one or more distribution pumps, conditions may permit interaction between the circulators, creating unwanted flow rate and pressure abnormalities.

The device provides a low pressure loss zone, enabling both primary and secondary circuits to be hydraulically independent of one another. The HydroLink combines both a low loss header and a distribution manifold. A low loss header is critical for high flow-resistant low-mass boiler installations because it moves the point of lowest pressure drop from the boiler to the unit's low pressure chamber. The distribution manifold has closely spaced tees which connect the secondary circuit to the primary loop internally so that flow in the primary loop has very little tendency to induce flow in the secondary circuit.

"Because the unit's openings are so close together, there is almost no pressure difference between them, thus the pressure differential across the internal headers is close to zero," added Olson. "The pressure increase created by a given zone circulator is almost entirely depleted by the time the flow returns back to the distribution manifold. This arrangement prevents interference between the boiler circulator and whatever zone circulators are operating."

7. Heat Distribution: The hydronic industry's renaissance is, in part, due to the reemergence of the radiant heat industry. In the commercial sector, large radiant heat systems place unique demands on a boiler, or series of boilers. According to Chiles, these systems were historically characterized by cold starts with long boiler run times, high water volume, high mass, cooler required supply water temperatures, and short boiler cycle-times when the mass is at temperature.

Of course, large radiant systems require a boiler or boilers with high output. A key advantage is that when the thermal mass of a floor or heated surface has reached temperature, shorter and less frequent boiler cycle-times are required. Better yet, a boiler system with modulation permits the heating, and later heat-maintenance of the heated surface. Either a fully modulating burner, or the lead-lag staging of boilers, would allow a system to meet ever-changing load requirements for optimal system efficiency.

Another option is to add mass to the piping system to increase boiler run times during periods of low demand. For this, water tanks can easily add mass to a piping system.

"Snowmelting systems pose a different challenge – high demand and high mass with extremely cold water/glycol temperatures," Chiles added. "Here, the challenge is not short-cycling of the boiler. Thermal shock happens when freezing return-water temperatures come crashing into the heat exchanger in a long, hard, cold start."

Fortunately, the new generation of condensing boilers takes this brutal jab in stride. Many modern boilers aren't susceptible to thermal shock, due to the materials of their waterways and heat exchangers. Others can be easily protected from thermal shock with the use of a boiler bypass, which can be built to operate automatically, with the addition of a control system, or can be a manual, fixed-temperature system.

Quite a difference in just 15 years. We now have smart technology, getting smarter. Inspired professionals responding to market needs. And customers who see the value of contemporary hydronic solutions.

About the author: John Vastyan, a journalist whose work focuses on the plumbing and mechanical and radiant heat industries, owns Common Ground, a trade communications firm based in Manheim, Pa. He can be reached at 717/664-0535, or cground@ptd.net.

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