Taco Inc. pump stations move heating-system fluids at the Midtown Exchange, Minneapolis.

Owners Warm Up to Hydronic Heating Retrofits

John Vastyan

Technology has made boilers an efficient and versatile option for heating needs. Controls, piping, and pumping make up an energy-efficient system.

Many commercial buildings constructed before the 1960s were heated hydronically, that is with hot water or steam heat. Forced-air systems then moved in vigorously during the next several decades. Hydronic systems began a comeback in the 1990s, with the rise of ultra-high-efficiency hydronic systems along with the popularity of in-floor radiant heat.

Today, the hydronics industry has returned to replacement and retrofit work, especially in commercial buildings, thanks in part to federal and state energy-improvement incentives. Boiler replacements, pump-system retrofits, and piping enhancements are the three primary undertakings by owners who seek improved flow, system efficiency, and more comfort and convenience for building occupants.

A heat plant that is 20 years old, even if it has been routinely maintained, probably loses 10% to 20% of its BTU output. If there are performance issues, it is likely that the old boiler is throwing away more than that. It is not at all uncommon for older boilers to cough and sputter through many seasons at less than 50% efficiency.

As many boilers reach the end of their useful life, acids from flue-gas condensate corrode exhaust stacks, and combustion chambers and near-boiler piping deteriorates. If that is happening, it might be time for a systemic overhaul.

The newest generation of hydronic equipment has pushed combustion efficiency to the 95% to 99% range. New, sophisticated controls and integration with building-automation systems create more efficiencies. When a design engineer can calculate a three- to four-year payback for new equipment, there's real incentive to install new technology.

Some commercial modulating-condensing systems have the ability to meet peak demand for space heat and domestic hot water simultaneously. Fantasyland, Canada's largest luxury hotel (located in Edmonton, Alberta), replaced several old heating systems with high-efficiency Rheos boiler/volume water heater

units from Laars Heating Systems Co., Rochester, NH. The modulating function of the unit gradually increases or decreases firing based on the call for heat. That is a huge improvement over old and wasteful, full-fire, on-off operation. Boiler controls monitor the demand for hot water and automatically adjust each unit's capacity to meet the required heating load, from 1.2 million to 2.4 million BTUs with modulation variability between 100% and 25% of the input rate.

The small footprint of the new boilers allowed the hotel to install three new units in place of the two older ones. The high-efficiency boilers reduce the amount of natural gas required to heat the domestic water, thus reducing energy consumption and operating costs. Moreover, NOx and CO gas emissions are much lower.

A contractor puts a Taco circulator on a Watts Radiant Hydronex panel.

Besides the boilers, new piping has its advantages. The new system at Fantasyland Hotel was designed so that the mechanical-room piping also enhanced overall efficiency and operation. The primary/secondary piping system was designed with serviceability in mind. Bypass piping means that any piece of equipment within the system can be isolated for maintenance without disrupting the supply of hot water to the hotel. In addition, the installation was set up with lead-lag redundancy, exercising each of the boilers uniformly and permitting non-disruptive off cycles for preventive maintenance.

Shoreline Community College, Seattle, replaced all boilers with high-efficiency units by Laars.

Four facets of a boiler system

In the commercial market, green (and to some extent, high performance) hydronic heating and volume water heating depends on the interrelationship of four key facets of the boiler system: system efficiency, combustion and thermal efficiency, emissions, and the boiler itself.

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.

Controls today are more sophisticated. They 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 boilers, said Joan Mishou, manager of applications engineering, Laars Heating Systems Co.

"And, of course, there's modulation or staged firing versus on-off," said Mishou. "Modulating and stage-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 itself is not piped and pumped correctly.

Watts Radiant PEX tubing is installed as part of a hydronic heat system.

"Condensing boiler technology is one of the key factors for the dramatic increase we see in boiler/water heater system efficiency," added Bill Root, vice president of sales and marketing for Laars. "Condensing boilers, like our new Rheos+, are built to encourage the formation of condensate within the system and to withstand the corrosive nature of the liquids that form there."

Latent heat is extracted from the moisture that forms in either the primary or secondary heat exchanger, dramatically enhancing combustion efficiency.

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 the boilers in a category of their own and opens up many new possibilities for high-volume, cold-start systems.

"One example is a commercial snow-melt system," Mishou said. "A condensing boiler takes very low inlet temperatures in stride. The lower the temperature of incoming water (or a water/glycol mix), the higher the combustion efficiency of the boiler."

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. When multiple boilers are installed, each one handles only a portion of the heating load; that drives system efficiency even higher.

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

Combustion efficiency and thermal efficiency. Just a few years ago, these two efficiencies were considered to be the most important factors in determining overall system performance. That is not the case today.

According to Root, transferring heat from a boiler into a total system is a truer measure of green efficiency and high performance. One 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.

Emissions. To consider the boiler system

green, the reality of emissions must be taken into consideration. "Today, when this topic is discussed at industry round tables, we look at emissions—NOx, CO, CO_2—with the real desire to see lower levels of pollutants that endanger our atmosphere and indoor air quality," said Mishou. "California's South Coast Air Quality Management District (SCAQMD), the states of Nevada and Texas, and selected projects in almost every other state have set limits for emissions, especially NOx. Being able to take 100% of the air for combustion from outside the building is also required in many installations."

The boiler, in context. Of course, what exists beyond the boiler jacket and near boiler piping will affect overall system performance. Consider circulation, control solutions, and heat distribution. New technology and intelligent system design are the key players here.

Overhauling a pump system

If pumps are old, deteriorating, noisy, or otherwise showing their age, it may be time to consider a bigger, better resolution. Drop-in pump replacements are one thing, designed chiefly to solve an immediate need. Pump and circulator technology have come a long way in the past several years. A more attractive solution for a building retrofit, especially one driven by a desire to enhance overall system performance and reduce energy consumption, would be to study the option of a pump system overhaul. New pumps can provide quick ROI (return on investment) and payback, save space, and simplify and improve operation of the pumped system.

One of the first considerations should be to look at the impact that variable-speed pumps could make. The smart circulators can be set to meet the specific needs of a pumped system rather than pumping furiously to meet the need, exceeding it, then shutting off.

Taco Inc., Cranston, RI, offers LoadMatch, a hydronic heat retrofit option that is cost effective. The single-pipe solution mimics the leading hydronic design used worldwide: primary-secondary pumping (such as the design used at Fantasyland Hotel).

A condominium building is retrofitted with a Watts Radiant SubRay system.

The single-pipe LoadMatch system, with its single-pipe primary main, uses terminal units configured with decoupled secondary piping circuits. Maintenance-free wet rotor circulators replace control valves to provide temperature control for each zone. Because the circulators also provide the differential pressure to direct water through the secondary system, there is no need for energy-consuming control valves or Venturi Ts.

Because control valves and balancing valves are eliminated, a single-pipe system also has lower head loss than a conventional two-pipe system. This reduces up-front and replacement costs, saves energy and space, and simplifies operation and design.

Alternatives to copper, steel pipes

If a building has a two-pipe heating system, this may be the time to consider a single-pipe design retrofit. In the process, consider replacing leaky, corroded, occluded piping with PEX and EPDM synthetic rubber tubing. One supplier of this technology is Springfield, MO-based Watts Radiant, a subsidiary of Watts Water Technology. PEX and EPDM tubing replace copper and steel pipe distribution systems. The durable, flexible, and continuous tubing can be routed between a source and points of delivery in a fraction of the time it takes to get the job done with metal, and at less cost.

Some building owners might find it feasible to use the tubing to deliver heat into floors, walls, ceilings, or radiant panels. Efficiency of flow and heat distribution improves overall system efficiency and comfort.

If parts of a building are being renovated, low-temperature, radiant heat might be the proper solution, especially in high-ceilinged spaces.

In district heating applications, old piping can be replaced with heavily insulated R-Flex, a Watts Radiant product that includes a single, large, underground tube containing large-diameter, PEX pipes for supply and return flow. Essentially no heat is lost, even in long runs above or below ground to points of distribution.

In the great outdoors, embedding radiant tubing under driveways, walkways, ramps, stairways, and helipads melts snow in the winter. Snowmelt systems can be far less costly than using people and equipment to clear and dispose of snow and ice. Automatic snow-melting systems also reduce the need for chemical melting agents, which can kill plants, contaminate waterways, and be tracked into interior floors.

Hydronic heating systems provide a wide range of economical comfort solutions inside and outside commercial buildings. cbp

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For more information about boilers from Laars Heating Systems, circle 13 or visit www.cbpmagazine.com

For more information about pump systems from Taco Inc., circle 14 or visit www.cbpmagazine.com

For more information about synthetic rubber tubing from Watts Radiant, circle 15 or visit www.cbpmagazine.com

Rheos boilers by Laars Heating Systems are installed at a ski resort in California.