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Modularity White Paper

A Case for Modular, On-Demand Steam Boilers: Benefits and Operation Strategies for Facility Engineers and Operators

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Modular, on-demand boilers are not exactly new. They have been in use since at least the 1980s and have proven to be reliable, highly efficient alternatives to larger boiler systems. Yet many engineers, designers and facility operators seem reluctant to adopt them, despite their unique combination of high-pressure output, low energy consumption and space-saving compact design. There is no longer any reason to hesitate harnessing all their advantages.

Those advantages are certainly well established. In fact, the Federal Energy Management Program issued a bulletin stating, "If building loads are highly variable, as is common in commercial buildings, designers should consider installing multiple small modular boilers… modular systems are more efficient because they allow each boiler to operate at or close to full rated load most of the time, with reduced standby losses."

Perhaps the reluctance to use modular boilers stems from the perceived lack of a strong track record and from the conservative attitudes we as engineers are trained to cultivate. This is understandable. In our profession, being conservative is being conscientious. A great deal rides on the work of engineers, not the least of which are public safety, environmental concerns and financial responsibility. But with thousands of modular, on-demand boilers now in use in virtually every type of industry and facility, the time is right for wider acceptance. The technology is a viable, proven choice backed by a solid track record in everything from breweries and hospitals to distilleries, laundry services, chemical plants and food-processing plants.

Divide and Conquer

If you look at modular on-demand boiler systems compared to conventional systems, you'll find that they are superior in reducing the energy consumption needed to meet demands, especially demands that vary over time. They do this by dividing output capacity among multiple small units–and by achieving outstanding efficiency. For example, a conventional boiler is rated at 240,000 Btu/hr of energy lost through the boiler's exterior. By comparison, energy losses with on-demand boilers are rated at only 60,000 Btu/hr when fully operational.

While modular, on-demand boilers are ideally suited to installations in which steam demand varies, they are certainly no less-well suited for other purposes. Advantages like their compact space-saving design, fuel efficiency and cost savings are of value in virtually any environment. Typically, a modular boiler requires just half the space of a conventional boiler and can generate the same amount of BHP in 50 to 60 percent of the space required by larger boiler systems.

In addition, facilities with modular boilers can save, on average, 10 percent in energy costs versus conventional boilers. Modular systems can often extend component life because the individual boilers can be alternated during periods of lower loads, reducing wear and tear.

Corporate or university campuses are outstanding examples of facilities that can capitalize on the versatility offered by modular boilers. With large, centralized campus heating facilities, a great deal of steam is lost as it travels throughout the campus in underground piping. Using a series of smaller boilers positioned in strategic locations around the campus presents a much more efficient alternative for fluctuating load demands.

As a case in point, Duke University recently replaced dated, bulky, coal-fired boilers with a series of gas-fired modular boilers to heat campus buildings. This resulted in significant reductions in both costs and environmental impact.

Quick Response

Modular, on-demand boilers are ideal for situations that require a fast response to changing steam-load demands. For example, imagine a facility that requires 50 horsepower at 8:00 in the morning, 300 horsepower fifteen minutes later, 1,000 horsepower at 2:00 in the afternoon then 50 horsepower again in the evening. This is an environment in which modular boilers thrive. Their "once-through" vertical-tube design means they can go from room temperature to full production in less than five minutes. This is in comparison to conventional boilers with a 60 to 90minute startup. This quick power-up, power-down capability allows the boilers to respond quickly and efficiently, saving energy and money.

A comparison may be made to instantaneous hot-water heaters. These, like modular boilers, are low-water-content designs, which almost by definition respond very quickly when needed. That is a key to their effectiveness and cost efficiency.

Design Decisions

When designing a boiler system for a specific facility, many engineering decisions are made that have long-lasting consequences. If large boiler systems are chosen, you've got one shot to get it right–and you've got to live with your decisions for a very long time. So the inclination is to design for the worst-case scenario, one in which every piece of equipment is at maximum load at the same moment.

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The engineer may calculate that 779 horsepower is needed in a situation like this. The inclination then is to round that number up to 800 horsepower, "just in case." Then the engineer may wonder, what if my calculations were off a little bit, despite my best efforts? What if the equipment has a higher radiation? What if they want to increase their process capacity by 5%? Then, the inclination is to specify perhaps 900 horsepower. And maybe a supplier offers a great deal on a 1,000-horsepower system that is available immediately. Why not do that?

In trying to plan for anything that might happen, suddenly you've gone from 779 horsepower to 1,000 horsepower in an effort to reduce the risk of under-designing. And you've got to live with that decision for perhaps thirty years.

It is also important to understand that the average steam load, when operating, is only 30 to 40 percent on a system that is right-sized. The more you oversize a boiler, the lower the average load becomes for that system. Even with a burner that can turn down to 10 percent of the maximum capacity, the boiler operates even less efficiently during the periods that are below their average load.

With a modular system, on the other hand, you have a lot more flexibility. You can design a smaller system today, leaving space in the facility design for the addition of more modular boilers in the future, if needed. In the above scenario, perhaps three 200-horsepower modular units could handle the load 90 percent of the time, with one backup boiler to cover contingencies on demand. So you've got redundancy at a much lower price then if you were to design for complete replication of an entire big-boiler system. And if space is left in the facility design for future expansion, any currently unforeseen need could be met simply by the addition of one more, relatively inexpensive modular boiler.

In sizing a modular, on-demand boiler system it is important to know the maximum demand, minimum demand and average demand. The smallest individual module should be sized to meet the minimum demand. Some modular systems may need the same module sizes for best performance; however newer technology (like Miura's new BP-201 Steam Ops controller) can even accommodate different size modules to be easily controlled.

In short, there is much less risk involved when using modular boilers. This technology provides a solution that allows end-users to spend money more wisely instead of spending it all at one time, only to find out later they didn't really have to.

Simply put, big-boiler systems are not very flexible. Once you spec it and buy it, that's pretty much it. The decision is cast in stone. But with a modular system, units can be added or subtracted as needs change.

Evolving Technology

Modular boilers do not rely on static technology. Recent developments include the creation of advanced communication systems to control a series of modular boilers. These systems permit modular systems to, in effect, function as a single, highly efficient unit with the output of the boilers being automatically adjusted within seconds according to the need.

This type of system is managed by a controller that uses a sensor to monitor steam demand. The system can then automatically bring boilers online, regulate their output and shut them down as required. The master controller's sophisticated software sends commands to individual terminals to adjust the boilers' operation for maximum overall efficiency.

Combustion Rotation Function

The controller automatically brings boilers on line, regulates outputs of other units, or switches off boilers as needed.

In addition, many modular boilers have become more efficient by the addition of variable speed drives (VSDs). This includes our own company's LX-series boilers. The VSDs slow the fan speed down in low-load situations and increase it when more air/fuel is needed. This conserves electricity and reduces cost of operation significantly, especially considering that these boilers achieve a fuel-to-steam efficiency rate of 85 percent.

Modular boilers have also become increasingly easy to use over the years. While they are rather complex devices, this ease of use–combined with very low maintenance requirements–makes them simple to operate on an ongoing day-to-day basis. In addition, the support that manufacturers often offer makes initial installation rather straightforward. Our own company, for example, is not just a boiler producer but a complete steam-solutions company, offering extensive support during design and installation as well as providing ancillary equipment for the complete boiler room.

There is no longer any reason not to take advantage of the many benefits modular, on-demand boilers offer. In today's world of environmental concerns, pressures to reduce costs and the need to do more with less, they indeed seem made to order.

About the author: Nick McBride serves as Assistant Vice President of U.S. Engineering for Miura America Company, a leading manufacturer of modular, on-demand boilers and has spent his entire career in designing, manufacturing and marketing products for steam systems. With a background in sales, engineering and engineering management, he previously worked for Lockwood Products of Atlanta. Mr. McBride is a graduate of Southern Polytechnic State University (now part of Kennesaw State University).