Modular Boilers or Two-Boiler Design, Which is Best?

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Engineers are faced with many decisions when designing a comfort heating plant. One of the most important decisions includes the number and size of boilers to be used in the heating system. Building comfort and system efficiency are the ultimate goals to be achieved. How these goals are achieved warrant careful and thoughtful consideration.

The ability to deliver heat in a reliable fashion must also be addressed in the overall system design. Reliability is achieved with boiler redundancy. This is true for both the two boiler and the modular boiler design options. The question, then, is which of these designs affords the greatest degree of efficiency along with redundancy?

Traditionally, design engineers have utilized a two-boiler system to satisfy building comfort and to provide a measure of redundancy. The boilers that are selected are typically sized at 60 to 80 percent of the calculated heating load. Should one boiler fail, for whatever reason, the second boiler should be able to carry the load to a limited degree. If one boiler fails on the coldest day of the year the second boiler should be sufficient enough to prevent freezing. "While this design and system concept is proven to be quite functional, it is prone to inefficiency." (Moore, Jul 1999)

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A viable option to the two-boiler system comfort heating application is the use of smaller modular boilers. In this scenario, the engineer seeks n+1 redundancy. The "n" in the equation refers to the number of modular boilers needed to satisfy the peak load plus one additional boiler module for redundancy.

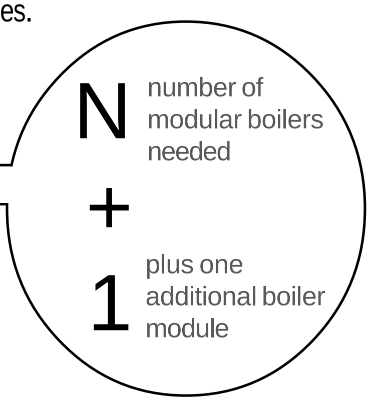
Much of the design depends on the climate and intended use of the system. In our territory, we typically suggest three boilers at 33% of n. This not only protects the building in the event of a boiler failure on the coldest day of the year, but also is easier on the overall budget.

It would stand to reason that multiple boilers would offer the greatest insurance against unforeseen failures. However, the methods in which modular boilers are piped and controlled determine just how much back up they will offer. For example, some modules may be designated for the production of domestic hot water. If the piping and controls for these units do not provide the flexibility to contribute to the heating load, the advantages of redundancy are minimized.

The two-boiler design is most susceptible to inefficiency when the boilers are operating at a partial load. According to Kenneth Elovitz, PE, “At part load, fixed losses, such as standby and jacket losses, constitute a bigger percentage of useful heat output than they do at full load.” (Elovitz, Jun 2001) Smaller module boilers reduce jacket losses for two reasons. They present a lower jacket-surface area, which results in smaller jacket losses and “because each one loses heat through the jacket only when it fires, and each one fires only as required.” (Wilkinson, Mar, 2001)

Modular boilers also allow greater efficiencies when wide load swings are prevalent. “The comparatively short start-up time required by modular boilers is an important factor in the higher efficiencies obtained by these systems.” (Rozman, Apr. 1994) These smaller boilers have less mass to be heated and, therefore can be brought online in a shorter period of time. This also eliminates short cycling commonly associated with the larger boilers used in a two-boiler design.

Short cycling occurs when an oversized boiler satisfies the demand for heat within a short time period and shuts down. During this shut down period, the boiler cools until the heat demand brings the boiler back online. When this occurs the mass of the boiler needs to be reheated. This continual short cycling results in excessive radiant losses as well as undue wear and tear on boiler controls and heat transfer surfaces.



The n+1 design that is “based on average temperature, allows for longer burning cycles as the heat load and boiler capacity are closely matched. Firing of a boiler, sized to meet capacity, will result in longer cycles of operation – maximizing efficiency.” (Moore, Jul 1999) In addition the by extending the operating cycle of the boiler, there is the added benefit of extending the life of the boiler through longer, more consistent use.

These efficiencies may also be improved upon when staged burners are added to either of the designs. With the two-boiler design scenario, the addition of low-high-low burners provides four firing steps resulting in greater efficiencies than on-off burner designs. This can be attributed to the fact that switching between low and high fire is more efficient than stopping and starting the burner. “There are no additional pre-purge or post-purge losses. Standby losses also go down because the boiler is not standing by. In addition, boilers tend to be more efficient at low fire than at high fire. Flue-gas flow is reduced so the flue gas has longer resident time in the heat exchanger…. therefore, continuous operation at low fire is more efficient than is alternating between high fire and off, even if standby losses and pre-purge/ post-purge considerations are eliminated.” (Elovitz, Jun 2001)

The same concept holds true for modular boilers. By staging combustion modular boilers can offer a greater turndown that will result in greater efficiencies. As the demand for heat increases these units will supply heat in stages. In the case of the Patterson Kelly Modu-Fire boilers that offer a five to one turndown feature, the boiler can modulate through five stages before another module is pulled online. This works especially well in winter months when the demand for heat in the early morning is higher than the demand when a building is at full occupation during the day. By bringing the heat on in stages small demands can be met with less over-firing.

Because modular boilers are smaller in physical dimension, they are easier to install in retrofit applications. They may be physically transported into an existing boiler room with a hand truck and can fit through standard doorways. This ability reduces the cost of installation that is associated with tearing out walls to drop larger boilers into place. However, it should be noted that, because of the number of modules employed, the size advantage might not be as significant as one might imagine. This is due to the service area required around each module and the multiple connections needed.

As boiler/burner technology continues to advance, engineers will have more options to choose from both in the traditional two-boiler design as well as the modular option.
But each heating plant presents its own unique challenges. There is no one size fits all solution. However, in many instances, modular boilers allow design engineers flexibility in redundancy, efficiency, installation ease and physical boiler room layout.

References -

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