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Are modulating burners worthwhile?

Consider low-high-low burners on your next replacement.

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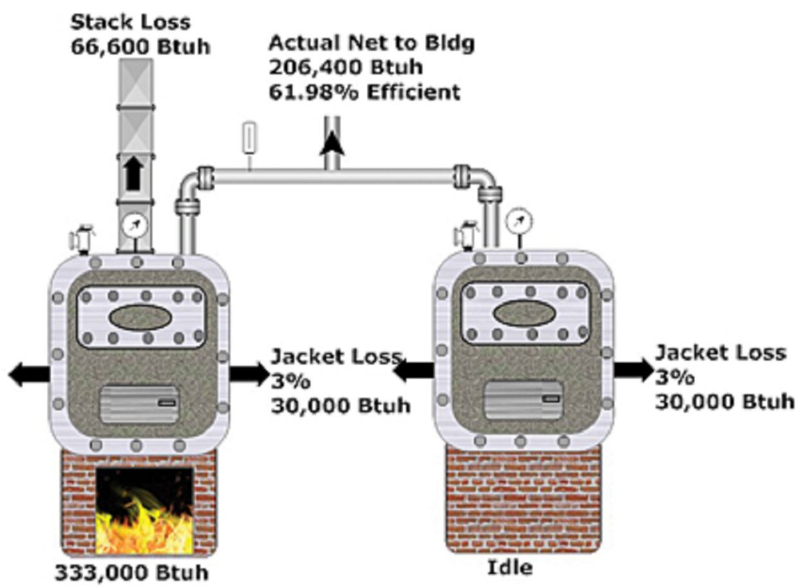
August 22, 2013



For years we have designed boiler rooms consisting of two oversized boilers with fully modulating burners. The idea was that the boilers could “loaf” along at low fire because we were told they were more efficient at low fire. I think it is time to rethink that strategy.

According to the EPA, “Boilers are most efficient when operated between 50-80% and boiler efficiency drops significantly when operated below 50%.” I know that this may require a paradigm shift but bear with me while I explain.

Fully modulating burners are designed to safely operate throughout their firing ranges from high fire to low fire. The most common turndown ratings in commercial boilers range from 3-to-1 up to 10-to-1. Turndown is how far the burner firing rate can be lowered and still effectively fire. For instance, a 3-to-1 turndown burner means the burner will be able to drop to 33% of its firing rate. A 10-to-1 turndown will be able to reduce its firing rate to 10%.

High turndown is used to reduce the burner cycling and maintain a consistent temperature or pressure in the boiler. This is crucial if the boiler is used in an industrial process that requires a consistent temperature or pressure. It is not as crucial in a commercial space-heating environment — except to the control tech who can and will track the temperatures to within four decimal points of the setpoint.

When a power burner starts, it has a prepurge period that ranges from 30 seconds to several minutes. During this prepurge, the burner fan pushes air throughout the combustion chamber for a period of time required to provide four air changes inside the combustion chamber. This is to "purge" the combustion chamber and flue of any leftover fuel.

Some of the older boilers required seven air changes, which prolonged the process. Many of the older, larger boilers also had a postpurge, which pushed air through the combustion chamber after the call for heat ended. While this air movement through the boiler does take heat from the boiler and send it outside, it is less wasteful than oversized boilers idling at low fire.

Jacket loss

Traditional estimates suggest that a boiler will lose between 2% and 5% of its rating through the boiler wall into the boiler room at any time that the boiler is warm. Let us assume we have a boiler with a rated input of 1 million Btuh and it has a jacket loss of 3% from the boiler into the boiler room (see Figure 1). That equals 30,000 Btuh for every hour the boiler is warm.

Now, consider what happens when the burner drops to low fire. The boiler will still lose 30,000 Btuh because the boiler jacket does not know the boiler is at low fire. It just knows that the boiler is warm. If the burner is a 3-to-1 turndown and drops to a low fire setting of 330,000 Btuh, that 30,000 Btuh loss just tripled the jacket loss percentage to 9%, dropping the efficiency of the boiler from 80% down to 71%.

If we have a 10-to-1 turndown burner, the jacket loss percentage just jumped to 30% of the firing rate. The boiler efficiency is now at 56%.

If another boiler is in the boiler room and is not isolated from the system, that boiler will have jacket loss as well because it also is warm. This could drop the efficiency even lower. For example, if the system had two boilers at 1 million Btuh and only one was firing at low fire or 33%, the jacket loss would be 18% or 60,000 Btuh and the system efficiency would be 62%.

Table 1 (see pdf below) indicates the heating plant efficiency with both standard and condensing boilers at low fire. We will compare boilers sized at 1million Btuh input: two at at 80% efficiency and two at 90% efficiency. Each boiler will have a 3% jacket loss into the boiler room.

According to Honeywell, a low-high-low burner is 15% more efficient than a modulating burner. It uses a firing rate control like a modulating burner but only has two settings, low fire or high fire. The burner will go between the two settings to meet the needs of the facility.

Combustion analysis

A modulating burner will take much longer to check and adjust than an on-off or low-high-low burner, which increases the maintenance costs. In addition, it is almost impossible to get the same efficiency throughout the entire range. The new linkage-less controls make the setup somewhat easier.

When adjusting the fuel-to-air ratio at low fire, a subtle change has taken place in the industry. Many burner manufacturers have found that when burners stay on low fire for extended times, damage to the burner heads may occur. In addition, the fuel and air do not mix as well, leading to elevated carbon monoxide readings.

To get better mixing and better burner protection, many burners now require more air at low fire. In some instances, it may be 20% to 40% more at low fire. This could lower the efficiency by 1% to 2%. In addition, extended operation at low fire in standard boilers could allow the flue gases to condense, destroying the boiler.

I have found in many instances that several smaller boilers piped primary/secondary and with low-high-low burners can offer better seasonal efficiency than two large boilers with modulating burners. This concurs with the findings of the International Energy Conservation Code, which recommends isolation of the idle boiler(s).

Each boiler room will be different, so keep an open mind on your next replacement.

For read the article in pdf form click here.

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