The cost of **Improper Boiler Operation**

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With the cost of energy on everybody's mind, it would be wise to provide your customer with a hot water heating system that operates efficiently. One area in particular that has gone on unnoticed is short cycling, which is an efficiency destroyer. And it can hit in two areas: mechanically and economically.

The mechanical problems will occur because of the rapid on/off cycling of the boiler. All of the various components found on an oil-fired boiler have an expected life cycle. When a boiler is short cycling, the components are seeing all these cycles in a very short time span. This leads to premature control failures, nuisance lock-outs, service calls and frustrated customers. If you want to destroy a brand new boiler in a short period of time and frustrate your customer along the way...short cycle it!

The economical problem is often unknown and certainly under-appreciated. There is an old rule of thumb that states, "A short cycling boiler will operate at least 15% below its rated efficiency when said boiler is not short cycling." The loss of fuel efficiency can be staggering. That means the wasted fuel consumption is paid for by the unsuspecting homeowner with the new high efficiency boiler.

So if you want to prevent short cycling, what can you do? The first step is to ensure that the boiler is not oversized! When a boiler is too big, it will always produce more energy (BTUs) than the system needs. And by being too big it reaches its high limit very fast, a condition that does not allow the boiler/burner to operate in a "steady state fashion". And the best way to make sure that a new boiler is not too big is to perform an accurate heat loss on the house. There are several software heat loss programs available that will help you establish the heat loss of any building. By using this information, you can then select the right size boiler for the house instead of using the "looks a lot like" method or the famous "read the label on the old boiler" method.

Unfortunately, as the expression goes, "...no good deed goes unpunished." A boiler can still short cycle *even when it is sized properly*. Do you know why? Load and zoning are the reasons. A properly sized boiler is sized for design conditions. This means when it is very cold outside (design outdoor temperatures), the boiler is capable of keeping the occupants at design indoor temperatures. But these design outdoor conditions exist for less than 5% of the total heating season. Which means for the remainder of the heating season, even the properly sized boiler is too big and can possibly short cycle.

One of the many advantages and selling features of hydronic a system is their ability to be zoned very easily. Most homeowners like the idea of being able to control sections of their house, even right down to a room-by-room control. But this, unfortunately, can also lead to short cycling. If one or two small zones are calling and the boiler fires in response, the energy output of the boiler is too great compared to the needs of the smaller zones. In that case, the high limit is reached very rapidly and the boiler shuts off. The zones continue to call and the water temperature drops, the limit control responds and the boiler fires up again. Of course, the high limit is again reached quickly and the boiler turns off. So even though the hydronics industry promotes zoning capabilities, and homeowners enjoy the comfort and control offered by zoning, it can impact a boiler's potential operating efficiency.

If you were to ask any boiler manufacturer what would be an acceptable firing on-time that would eliminate short cycling and all its downfalls, a minimum of 10 minutes "on -time" would be the answer. So what can we do to achieve this 10 minute firing "on-time"? Here are a couple of ideas:

One would be to improve the controlling operation of the system. And a system it is...for a long time we have allowed the individual zones to operate independently and therefore, randomly. The net result is inconsistent and very uneven loading of the boiler, which often leads to harsh boiler short cycling. Granted the occupants upstairs are still relatively comfortable but at what expense? There are thermostats available on the market today that synchronize with each other (i.e., they talk to each other). By synchronizing, they all call for heat at the same time at the beginning of each new heating cycle. Naturally, how long each one runs for is determined by that particular zone's needs. The benefit of this is the boiler is seeing a reasonable load/

flow rate that it can work with, thus minimizing the short cycling.

Another benefit of these "new thermostats" is they also can request a water temperature back to the boiler control. The control receives these requests from all the various zones and makes a decision based upon the zone with the highest temperature requirement. The other "lower temperature" zones then calculate their own on-time with the higher temperature water to maintain their desired setpoint.

The other option would be to provide some mass to the system so that each time the boiler fires, it would have to raise the temperature of this mass X number of degrees. If the added mass is calculated correctly, the boiler would not short cycle! This added mass is known as a "Buffer Tank." So how much mass is needed? How big should this Buffer Tank be? It is actually a rather easy number to establish. It is based upon a couple of conditions:

1) the minimum firing on-time of the boiler (usually 10 minutes);

2) BTU/H output of the boiler;

3) the minimum btu/h load of the smallest zone calling and

4) the desired/acceptable temperature rise (delta T) of the tank (usually 20-40 degrees F).

When you plug in all the necessary numbers, the answer will be the suggested size of the buffer tank in gallons. For example, if we had a boiler with a Btu/h input of 150,000 and the smallest zone load was 5000 Btu/h and the system could accept a 40°F rise, what size buffer tank would be needed?

$$\frac{V=10\ (150{,}000\sim5{,}000)}{40\text{x}500} = 72.5 \text{ gallons}$$

In this particular system, with a 72.5 gallon buffer tank and the smallest load calling, the boiler would run for a minimum of 10 minutes and operate more efficiently.

Some might say that the additional cost of the tank would be prohibitive, but when compared against the life of the system, the cost of energy and the efficiency points gained by the longer "on-times", I think the benefits outweigh the additional equipment costs.

If you have any questions or comments, e-mail me at gcarey@fiainc.com or call me at FIA. 1-800-423-7187.