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Boiler Safety Intuition

Diagnosing boiler problems sometimes takes almost all the senses.

It smells funny, it sounds funny, it looks funny and it even feels funny. What is it, is your boiler about to become unsafe? Diagnosing boiler problems sometimes takes almost all of the senses. Developing a safety intuition regarding boilers embeds certain things into all of your senses. With this safety intuition, the next time you are around a boiler, your skills will be complimented by a well-honed sixth sense that includes enhanced listening, smelling, and observation skills. There will be signals coming at you from a new set of highly developed senses.

Strange odors from a boiler could mean burning paint from a hot spot, or more commonly, flue gasses coming back into a room instead of going out. If it is a gas smell, this could mean a whole new problem. Here is an example of a burning paint problem:

> Carbon steel starts to change properties at about 850F. Since fuels typically burn at 2,800–3,500°F, it is easy to understand why steel near burners and fire boxes needs to be protected. This protection comes from refractory. This ceramic-like material can take thousands of degrees of temperature and insulate the steel structure that supports the boiler drum and tubes.

Recognizing refractory

If refractory becomes compromised, there will be problems. The obvious signs are peeling and scorched paint. Eventually, when the damage is bad enough, warping or buckling of parts can be seen on the boiler structure. This is nothing to fool with. Eventually this kind of failure can cause a burn-through, or a hole that actually develops in the fire box. This can create conditions where flue gasses can either come out of the firebox into the room or room air can be drawn in. These situations can cause a fire, carbon monoxide poisoning or even an explosion under the right conditions.

Conduct a pre-start walk around to evaluate the condition of boiler equipment before starting. There are also certain things to observe and think about during a start-up. Walking around and casually evaluating the outside structure and shell of boilers should be an important part of a pre-start ritual. If there is a rectangular firebox, make sure it is still square and that there are no new bulges or distortions.

Refractory is installed in boilers a couple of different ways. It is usually done with precisely dimensioned individual tile pieces located at a burner outlet or throat. These are specific to a particular boiler and burner design. Fire tube boilers' back walls or doors usually contain a cast refractory. This is a difficult field repair. Many people say they can do it, but few do it right. Refractory repairs are sometimes done with a water based mixture that has to dry out in a very

slow and controlled manner. If this dry out is not done perfectly, retained moisture expands to steam and breaks the refractory upon start-up.

The most common cause of refractory failure is excessively rapid heat-up or cool-down times. Most boiler manufacturers publish a start-up or heat-up procedure that involves taking time to bring a boiler up to temperature. The reason for this is that refractory expands and contracts at much different rates than the metal it is attached to or surrounded by. When the refractory is heated too fast, it grows and expands before the steel and ends up cracking itself.

Discard the refractory if the flame is out of control. Constantly impinging directly onto refractory overheats certain sections, which eventually degrades the refractory material and results in localized overexpansion. A quick look into the firebox through a site port under a number of different firing conditions can reveal whether or not this is a problem. Observing flames is more of an art than a science.

Before looking into a firebox, make sure the unit is started. Never put your head to a sight glass and ask for a light off, this is asking for trouble. Make sure you are looking at a flame coming at you. Not every boiler or firebox has this capability. Before bending down to look through a sight glass, make sure you are wearing safety glasses and a long-sleeve shirt. Make sure to feel around the sight glass first to make sure no flue gasses are leaking. When looking at an oil flame, a colored filter lens can protect your eyes from the brightness. There are five key things to look at when you observe a flame:

- **Color:** Most natural gas flame colors not associated with low Nox burners should be blue with little orange or yellow flickers. Dark orange or all yellow are very bad.
- **Shape/movement:** The flame should have a consistent shape with some movement to it. It should not appear lazy. The flame should have good definition with edges that are definable. There should be no appearance of smoke or haze in the firebox.
- **Impingement:** The flame should not be driving into anything. It should not hit sidewalls, tubes or the backwall. Impingement could make for failed tubes or refractory in short order.
- **Stability:** The flame should stay lit in a consistent manner under all conditions from low fire to high fire. There is a problem when some parts are lit and other parts are occasionally extinguished.
- **Consistency/Uniformity:** Make sure that everything looks consistent and symmetrical inside. There should be no glowing red spots or dark spots on the burner. Unsymmetrical glowing red spots usually mean flame is touching steel. This is destroying the burner. Dark spots are usually cool spots. This could mean that refractory has fallen out.

Sounding off

Any experienced boiler operator knows that just listening to the sounds of pumps and/or fans can mean that everything is OK. Sounds such as banging pipes, bearings rattling, and/or shifting frequencies in rotating equipment can mean trouble ahead. A big “whoompf” sound during start up is never good. This happens when we are getting delayed ignitions. One would think that delayed ignitions would not be possible with an automated boiler controller since the

burner management system controls everything in a precisely timed sequence, including the light-off. Surprisingly, the pre-set timing in a burner management system doesn't necessarily guarantee safety.

Burner management systems are the small single-purpose controllers we all rely on for a safe start-up and to manage the safety of our combustion systems. These typically are factory preset to allow 10 seconds to light a pilot and 10 seconds to light a main flame when natural gas is being burned. The fact that an off-the-shelf safety device allows this much time for flame establishment implies to the average person that if a burner lights in nine seconds there is not a problem.

This is not true. In some cases, a light off in seven or eight seconds can cause damage. Watch the display of the burner management system, if it is readily accessible, to see that you actually light off in two to three seconds for both the pilot and the main flame. The longer it takes the pilot or main burner to light, the greater the indication that there may be a problem.

Remember, there are three steps to having an explosion: 1) The accumulation of a flammable mixture; 2) its confinement; 3) and then the all-at-once ignition. When a trial for ignition starts and the timer starts timing, there is a release, or accumulation, of gas and air into the firebox. This occurs while a spark igniter or pilot flame is trying to light off the mixture. The longer you wait to ignite, the more stored energy goes off at once. Some common causes of delayed ignitions include igniters that are corroded, worn out or not installed properly. There can also be problems with fuel-air mixtures and/or low-fire settings on burners.

The "whoompf" sound mentioned means that a significant accumulation of a fuel-air mixture has accumulated and then lit off at once. This is one step below actually having a serious explosion that can hurt people or equipment. When this happens, shut down the equipment immediately and diagnose the problem. Then, re-start in increments, evaluating things by first starting with ***only*** the pilot on, leaving the main flame fuel valve off. Most burner management systems can be switched for operation in a test mode. The technician should shut the main fuel valve and put the unit in test so that it only lights the pilot. Once there is a successful pilot light off, and the pilot is full and stable, carefully proceed to checking other issues. This is the time to call in experienced burner professionals for further evaluation.

Another interesting bad sound is a cross between a jet engine and a train at some point between high fire and low fire. When heard, a combustion rumble is happening. Instead of a constant stable flame out of the burner, there is combustion, then no combustion in short sequential spurts. This makes for a series of pressure pulses that follow each other in sequence. This can be very severe and very scary. It is obviously never good to continue to run this way. There is most likely a regulator, automatic gas valve and/or linkage adjustment—fuel air ratio—problem. Again, experienced repair help here is a must.

Intuition

Intuition is a great thing that develops after many years and many issues. Hopefully, learning boiler smells, sounds, looks and feels will speed your development of intuition. This development becomes like a sixth sense for good boiler operators and service personnel. These senses can be developed so that walking through and evaluating a few things in a boiler room is all that is needed for a sense of safety.

Again, the key issues of a pre-start walk down of the equipment include:

1. Is the firebox and/or is the back door of the boiler still straight? Any bulges or buckling?

2. Any paint burned off anywhere? Or fresh paint added?

3. Any evidence of burned conduits or control elements? Any odor of burned paint or overheating?

After start-up:

1. Was there an audible ignition? How long did it take to light off pilot/main?

2. How did the flame look?
   a. Color
   b. Shape
   c. Impingement
   d. Movement
   e. Stability
   f. Consistency/Uniformity

There is no replacement for a walk down of boiler systems with a specific checklist. Pilots have a pre-start checklist. These help to keep the airline industry one of the safest modes of transportation we have ever known. There are certain things in life that cannot be undone, like hitting a start button on a boiler. Once done, hopefully you will have already minimized the chances of bad things happening.