Boiler Maintenance to Prevent Combustion-Related Accidents

Safety Note

Human error and poor maintenance are the number one causes of combustion related accidents among boilers each year, according to the National Board of Boiler and Pressure Vessel Inspectors. The majority of these can be prevented with appropriate training. While there are numerous circumstances that can cause explosions, fires and outages, a split second decision by a few staff members could prevent loss of life or injury, and the continuation of business operations.

It would be impossible to list every boiler or fuel system-related upset scenario and the methods to address them. However, below are three case studies that address common issues. These examples are presented to showcase potential emergency preparedness training you can provide at your facility. Regular training is a requirement by law in every state and within every boiler code.

The American Society of Mechanical Engineers (ASME) suggests that good training programs include some element of emergency upset drills. Please carefully review these cases and share them with fellow employees to prevent an accident at your facility.

1. Case No. 1: A high-pressure steam boiler, water-tube style. The boiler is a D type configuration, rated at 300 PSIG maximum allowable working pressure. Application: Providing process steam at 185 PSIG.

You have a modulating firing rate on your boiler and it is operating at 75 percent capacity. There are three water level indicators, a drum level transmitter, gauge cocks and a gauge glass. The drum level transmitter and the gauge glass were in agreement last week when you checked the boiler. Now the gauge glass indicates a high water level and the transmitter indicates a dangerously low level. Which should you trust?

Action: The first order of business is to determine the true water level. Since the boiler may be in a low water condition, time is of the essence. The initial action is to manually open the lowest gauge cock to see if water comes out. If it does, the water level in the boiler is high enough to be safe for now. If the gauge cock cannot be operated or if steam and/or nothing discharges from the gauge cock, the boiler should be shut down immediately using established original equipment manufacturers (OEM) safe emergency shutdown procedures.

Assuming that water came out of the lowest gauge cock, the next action would be to blow down the water column and then the gauge glass. To achieve this process, look at the water level in the gauge glass. The column drain valve should be opened and you should determine if the gauge glass is responding by loss of water in the gauge glass. Close the drain valve and water should return rapidly to the gauge glass. It is also necessary to ensure that no lines are plugged and that the water level is responding by opening the gauge glass drain valve.

If the water rises rapidly in the gauge glass to a level below the original level, your gauge glass is most likely now providing a true boiler water level. With the gauge glass now indicating a proper water level and the drum transmitter showing a low water condition, the drum transmitter is the next most likely area to examine. The next step would be to repair, replace or possibly recalibrate the drum transmitter.

What Happened? The drum level transmitter or gauge glass indication could have been incorrect. The try cocks give a definitive reading of the water level. The steam or water connecting piping to either the water column or the gauge glass connections could have become blocked with sediment, leading to an inaccurate water reading.

Follow-up: Make a note about the water level discrepancy in the boiler logbook so that other operators are aware of the problem. Ensure blow downs occur daily or even every shift. Schedule maintenance as soon as possible to clean reoccurring sediment. Occasionally, transmitter-sensing lines may become plugged with sediment and must also be checked regularly to ensure they are clean and capable of functioning.

Case No. 2: Safety valve run away load "Pop:" High pressure steam boiler – Fire tube 150 PSIG; Application: Produces process steam at 110 PSIG.

The main process boiler has been running at 100 percent of firing capacity all day. As the second shift operator, you have completed your shift change checks and everything is normal. The production manager tells you that the production area will cut back during this shift. The boiler-firing rate is being controlled by a modulating pressure controller, which controls 20 different process reactors using steam.

Suddenly, one of the two safety valves "pops" at its set point. Steam escapes with a deafening roar, and the boiler pressure continues to rise in spite of the valve relieving. Looking at the second safety valve, you see its set point has been exceeded without it opening. The pressure is now 130 psig and has exceeded the steam limit control set point. The burner is still on and firing.

Action: Follow the OEM's established safe shutdown procedures. Take the boiler off line immediately at the fuel source. If provided, press the emergency stop button. Close, lock and tag all the combustion train components. Wait until the pressure in the boiler has decreased to approximately 5 psig and then open the boiler vent. This will prevent a vacuum from being formed in the boiler.

What Happened? You have a number of issues that need to be addressed. Of course, the most pressing is why both the high-pressure steam limit didn't shut down firing and why the second relief valve didn't open. Other issues are a possible failure of the firing rate controller and the possibility that the process control system has slammed shut 20 process valves at once, making for an immediate reduction in load with the boiler system unable to keep pace.

The first safety valve lifted due to over-pressurization as it was designed to. Possible causes are the sudden closing of process valves, or failure of the firing control to reduce the firing rate with the loss of load. The boiler firing control should have gone to a low fire position with a sudden reduction in load. Most steam boilers have a high-pressure limit controller. This is designed to shut down burner firing if a pressure set point is exceeded. In this case, the control didn't work. In many cases, we find these important safety interlocks have failed.

Many are found to have been installed without siphon loops, which are designed to protect the switch from steam. When this mistake is made, the sensing diaphragms become unresponsive and don't let the switch do its job. In other cases, these controls are set inappropriately. Your site should decide a strategy for where this device should be set to lift. Some installations have them set before, while others are after.

Follow-up: Test, reset, and possibly replace the high steam pressure interlock switch. Verify that it is installed as per the manufacturer's requirements. Both safety valves should be replaced (or tested and repaired), by a certified valve company. The second valve is a major concern since it never lifted.

The burner firing controls should be checked for proper operation and connection. If the modulating firing rate controller is found to be at fault, remember that fuel air ratios need to be "set" by experienced burner tuning technicians. Linkage set screws or locking nuts and fixtures can come loose through vibration or intentional "tinkering". If it is determined that linkages are out of adjustment, they must only be corrected by someone with the proper experience and flue gas measurement tools.

ABOUT US

Honeywell Combustion Safety is a part of Honeywell Thermal Solutions, an industry leader in commercial and industrial combustion solutions. Honeywell Combustion Safety, formerly known as CEC Combustion Safety, has been in business since 1984. With engineers and staff members that sit on Code committees such as NFPA 56, NFPA 85, NFPA 86, and NFPA 87, our inside expertise is integrated within all of our practices, and our global reach ensures that customers around the world are kept safe. Honeywell offers testing and inspections, engineering & upgrades/retrofits, gas hazards management, training, and field services for all industrial facilities and different types of fuel fired equipment. By assisting organizations and their personnel with the safe maintenance and operation of their combustion equipment, Honeywell aims to save lives and prevent explosions while increasing efficiency and reliability of combustion equipment.

The firing rate modulating motor must be checked for "full range" of motion, which can be accomplished by attempting a dry light off. This process includes closing the firing gas valve and pilot supply, starting the light off sequence and observing the motor through purge and low fire positioning. Make sure that process engineers consider the closing rate of control valves and what this may do to a steam system that can't respond as quickly.

Case No. 3: "Dry Fire" could mean danger. High pressure "D" type water tube boiler, with a de-aerator tank, and two feed water pumps (primary and spare). Application: Produces process steam at 135 PSIG.

Production is being pushed because your company has just received a new order and the delivery date is tight. Everyone is working hard to meet their shift quotas. The boiler is running at 100 percent high fire day after day. Everything has been operating smoothly when the boiler's low water alarm sounds. Next, the boiler shuts down via the low water fuel cutoff. You check the gauge glass and the water is no longer visible. The feed water pump has failed and you see a wisp of smoke coming from one of the bearings. The boiler has been in a low water condition for at least four to five minutes.

Action: Follow the OEM's established safe shutdown procedures. Shut down the boiler immediately at the electrical power and fuel sources. Note: Some boiler controls require keeping the combustion air fan operating for post purge. This also helps ensure gradual cooling and minimize the risk of tube/shell metallurgy fatigue, warping, and/or damage. Close the feed water inlet valve, close, lock and tag all combustion train components, and shut off all electric feeds to boiler feed water systems. Do not, under any circumstances, add water.

Next, close the boiler stop valve where steam normally exits. Evacuate the immediate and adjacent premises, or perhaps a larger area, depending upon the boiler size. Giving the boiler enough time to cool sufficiently can take many hours; be patient. Wait until the pressure in the boiler has decreased to about 5 psig and then open the boiler vent. This will prevent a vacuum from being formed in the boiler. Allow the boiler to cool sufficiently and then drain it. Once finished, close, lock and tag the bottom blow down valves. This is good practice and becomes necessary when the blow down valve is piped with other boilers. Finally close, lock and tag all steam valves.

What Happened? The feed water pump failed, which led to a low water condition. You should never introduce water to a hot boiler that is in a low water condition. The boiler may have hot heating surfaces exposed above the water level. Incoming water can immediately flash to steam when it hits these surfaces resulting in a catastrophic explosion. Even if incoming water does not flash into steam, the heating surfaces can become warped and distorted. Allowing the boiler to cool naturally will minimize damage to the boiler.

Follow-up: Open the boiler and inspect the waterside and fireside for damage. It may also be necessary, and certainly prudent, to contact the site's jurisdictional- or insurance-related boiler inspector and have them inspect for damage. Repair damaged areas as required; examples may include refractory breakdown, tube failures and ruptures. After the repairs are complete, perform a hydrostatic pressure test of the boiler. These are usually conducted by a qualified contractor in the presence of your jurisdictional boiler inspector.

Although you may have a spare feed water pump, the primary must be fixed. Try to determine the cause of the bearing failure. For example, if the mechanical seal was leaking, it could have been the cause of the bearing damage. There are a variety of reasons that bearings fail including: improper or no lubrication to bearing; loss of cooling water if water cooled the bearing housings; pump/motor/drive is out of alignment; or the age and service life of the bearing.

Production will need to rely on another boiler until this one is properly fixed. This process may take days. Local practices vary, but usually you will be able to operate only after you receive the jurisdictional inspector's approval.

Conclusions

The three examples cited routinely occur. If not handled properly, they can lead to catastrophic events. Often, split second thinking from trained individuals makes all the difference. Note that the example responses provided are hypothetical. You need to work out what the best response is for your facility and equipment. The actions suggested will not be correct for every facility in every instance.

Regular training is required by law. Training should include emergency upset drills that prompt operations and maintenance staff to think through the kinds of situations presented above for their site's actual equipment and conditions. This effort should be thorough and should not stop until everyone on every shift understands the correct responses for the chosen upset drill conditions.

Remember, this equipment only gives you one chance to make the right call. When that time comes, you want to make sure that you have prepared your staff appropriately.

For more information

Learn more about Honeywell Combustion Safety, contact info@combustionsafety.com, visit www.combustionsafety.com or contact your Honeywell Sales Engineer.

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