Three Cases to Test Your Boiler Knowledge

Some boiler-related problems can result in accidents that lead to injury and even death if not handled correctly. Are you up to the challenge of solving problems in these hypothetical but realistic situations?

BY JOHN R. PUSKAR, PE

Statistics from the National Board of Boiler and Pressure Vessel Inspectors indicate that human error and poor maintenance are among the top causes of combustion-related accidents each year. But the proper split-second decision by a well-trained boiler operator or technician can prevent an accident and its aftermath when an emergency strikes or is close at hand.

Here are three case studies that describe realistic situations involving boiler problems. Would you know what to do in each case? Read on and find out for yourself. The answers to each scenario begin on the next page.

Case number one

The equipment involved in this first case is a water-tube-style high-pressure steam boiler. The boiler is a D-type configuration, with maximum allowable working pressure rated at 300 psig. The boiler provides process steam at 185 psig.

A modulating firing rate is observed on the boiler, which 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 previously were in agreement, but now the gauge glass indicates a high water level and the transmitter indicates a dangerously low level.

Which reading can you trust?

Case number two

The equipment involved in this next situation includes a 150 psig, fire-tube high-pressure steam boiler. The boiler produces process steam at 110 psig.

The main process boiler has been running at 100 percent firing capacity all day. The second-shift operator has completed his shift-change checks and everything is normal. The production manager tells him that the production area is going to be cutting back during this shift.

The boiler-firing rate is being controlled by a modulating pressure controller, which controls the fate of 20 different process reactors that are using steam. Suddenly, one of the two safety valves pops at its proper set point.

Steam escapes with a deafening roar and the boiler pressure continues to rise in spite of the valve's relief. A look at the second safety valve reveals that its set point has been exceeded without it opening. The pressure is now 130 psig and has exceeded the high-pressure steam limit control set point. The burner is still on and firing.

What action should you take?

Case number three

The equipment involved in our third scenario includes a high-pressure D-type water-tube boiler with a de-aerator tank and two feed-water pumps (primary and spare). The equipment provides process steam at 135 psig.

In this situation, production is being increased because the 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 low-water alarm sounds. Next, the boiler shuts down via the low-water fuel cutoff.

A check of the gauge glass and the water level reveals the level is so low that it is no longer visible. The feed-water pump has failed and a wisp of smoke is seen coming from one of the bearings. The boiler has been in a low-water condition for at least four to five minutes.

What should you do?

Answer to case number one

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 or nothing issues from the gauge cock, the boiler immediately should be secured.

Assuming that water issued 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, observe the water level in the gauge glass. The column drain valve should be opened to determine if the gauge glass is responding by evidence of a loss of water.

Close the drain valve and the water should rapidly return to the gauge glass. It also is 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 rapidly rises in the gauge glass to a level below the original level, the gauge glass most likely is 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 look at more closely.

When pressure exceeds the steam limit control set point, immediately take the boiler off line at the fuel source.

The next step would be to repair, replace or possibly recalibrate the drum transmitter. The drum level transmitter or gauge glass indication (or possibly both) 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 and sometimes lead to more than one inaccurate water reading.

As good followup practice, make a note about the water-level discrepancy in the boiler's logbook so other operators will be aware of the problem. Repairs involving removing sediments should be scheduled as soon as possible. Occasionally, transmitter sensing lines may become plugged with sediment and also must be checked regularly to ensure they are clean and capable of functioning.

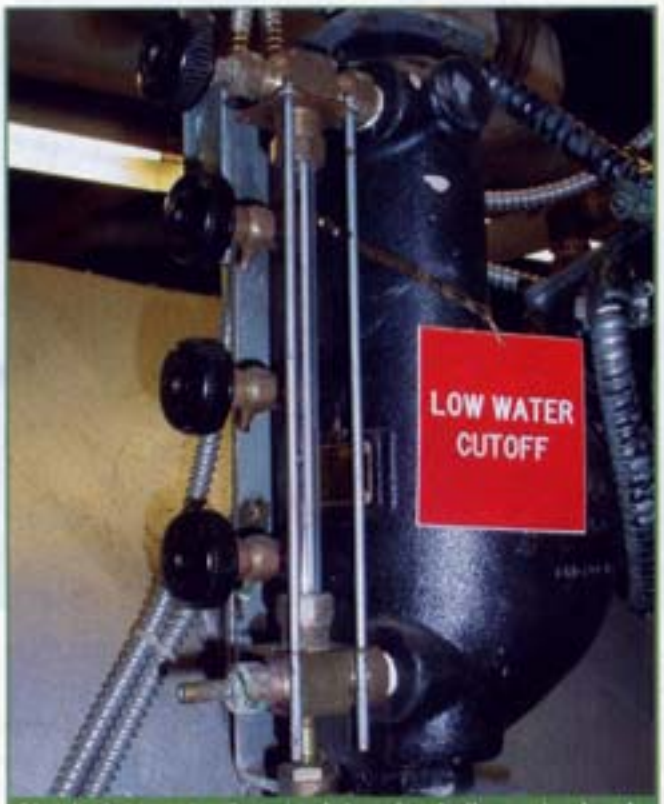
Answer to case number two

Immediately take the boiler off line at the fuel source. If provided, press the emergency stop button. Close, lock and tag all combustion train components. 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.

Now that the emergency has ended, a number of issues and possible problems need to be addressed. The most pressing of these is why the high-pressure steam limit didn't shut down firing and why the second relief valve didn't open.

Other related 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, instantaneous reduction in load with the boiler system not able to respond as quickly.

The first safety valve lifted due to over pressurization as it was designed to do. Possible causes are the sudden closing of process valves, or failure of the firing control to



Check the gauge glass to determine boiler water level to help decide your course of action.

reduce the firing rate with the loss of load. The boiler firing control should have at least 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, these important safety interlocks fail. Many are installed without siphon loops, which are designed to protect the switch from steam. When this mistake is made, often the sensing diaphragms become unresponsive and don't let the switch do its job.

In other cases these controls are set inappropriately. Facility staff should formulate a strategy for where this device should be set. In some cases it would be before safety relief valves would function. In other cases it could be after they function.

As a good follow-up procedure, test, reset and possibly replace the high-steam pressure interlock switch. Verify that it is installed per the manufacturer's requirements. Also, both safety valves should be replaced or at least tested and repaired by a qualified and certified valve company. The second valve is a major concern because 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 tampering. If it is determined that linkages are out of adjustment, only someone with the proper experience and flue gas measurement tools can correct it.

Check the firing-rate modulating motor for full range of motion by attempting a dry light-off procedure. This process includes closing the firing gas valve and pilot supply, starting a 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.

Answer to case number three

First, immediately shut down the boiler at the electrical power and fuel sources. Close the feed water inlet valve and close, lock and tag all combustion train components and all electric feeds to the boiler.

Under no circumstances would you add water. 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.

Give the boiler enough time for it to sufficiently cool. Wait until the pressure in the boiler decreases to about 5 psig and then open the boiler vent. This would prevent a vacuum from being formed in the boiler.

Experienced burner-tuning technicians should set fuel-air ratios.

Allow the boiler to sufficiently cool and drain. Once the boiler is drained, close, lock and tag the bottom blow-down valves. This is good practice and becomes necessary when the blow-down valve is piped in battery with other boilers. Finally close, lock and tag all steam valves.

In this situation, the feed-water pump failed, which led to the low-water condition. Never introduce water to a hot boiler that is in a low water condition. The boiler may

Repair damage such as refractory breakdown or tube failures and ruptures as required.

have hot heating surfaces exposed above the water level. Incoming water can flash to steam when it hits these surfaces and possibly result 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 the risk of this kind of damage to the boiler.

As good followup practice, open the boiler and inspect the waterside and fireside for damage. It also may be necessary and certainly prudent to contact the site's jurisdictional- or insurance-related boiler inspector and have him or her inspect for damage. Repair damage such as refractory breakdown or tube failures and ruptures as required.

After repairs are complete, perform a hydrostatic pressure test of the boiler. A qualified contractor usually does this in the presence of the jurisdictional boiler inspector.

Although a spare feed-water pump may be available, 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.

There are a variety of reasons that bearings fail, including improper or no lubrication to bearing; loss of cooling water if water-cooled bearing housings, pump/motor/drive are out of alignment; or the age and service life of the bearing.

Rely on another boiler until this one is properly fixed. This entire process may take days. Local practices vary, but typically a facility will be able to operate only after the jurisdictional inspector's approval has been granted.◆

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