Pocket Guide to Boiler Care and Operation

Third Edition

FM Global®

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Introduction

Property damage, equipment repair and production downtime are three costly situations that every facility hopes to avoid. The best way to minimize these types of problems is through proper care and operation of critical heating and process equipment, such as boilers, which have the potential to cause large losses.

During a recent 10-year span, 394 boiler incidents were reported to FM Global, with a total gross cost of US$681 million. Of these incidents, 71 were the result of overheating, costing a total of more than US$90 million. There also were 56 incidents involving fuel related fires or explosions with a total gross cost of US$192 million. The human factor was significant in nearly all these incidents. Improper testing, lack of maintenance and operator error were some of the contributing causes.

This pocket guide offers basic guidelines for the proper care and operation of heating, hot water and steam boilers typically found in most small industrial and commercial properties. These guidelines are not intended for use with large, industrial or utility boilers, nor special application boilers such as black-liquor recovery boilers, where specific procedures apply.

Heating Boilers

Start of Heating Season

Before firing boiler:

- Follow written procedure or checklist for start-up. This should be posted or readily available in the boiler room.
- Service automatic controls.
- Make sure the water level is satisfactory, float chambers are clear, electrical connections are tight and wiring is in good condition. Of all items to check, the water level is probably the most important.

Immediately after firing boiler:

- Using either properly trained personnel or a qualified contractor, pressure-test each safety valve or safety-relief valve to ensure it will open at the set pressure.
- Test all safety devices and automatic controls, including feedwater regulator, low-water fuel cutoff (LWFCO) device and alarm, and fuel combustion safety controls.*

*See page 28 for more information on LWFCO device testing.

▶ CAUTION:

DO NOT leave an automatically fired boiler unattended after start-up until it has completed several firing cycles and you have determined all controls are functioning properly.

During Heating Season

Hot water boilers:

Check the pressure and temperature every time you visit the boiler room.

If either the temperature or pressure is not within established operating limits:

Shut off the fuel supply and do not operate the boiler until the cause has been corrected.

▶ CAUTION:

DO NOT add water to a hot boiler until all boiler surfaces are cool enough to touch.

Steam boilers:

Check the pressure and water level every time you visit the boiler room.

If the pressure exceeds the intended operating limit:

Check and adjust the operating pressure and excess limit controls.

If a water level line is not visible in the water gauge glass:

Blow down the glass to see if water appears.

> If it does not appear:
>
> Shut off fuel supply immediately.
>
> If the boiler is fired by hand or stoker:
>
> Stop fuel supply and extinguish burning fuel in accordance with the manufacturer's instructions.

▶ CAUTION:

- DO NOT add water.
- DO NOT lift the safety valve.

When boiler heating surfaces are cool enough to touch:

Add water to normal operating level.

If blow down of the glass shows water level above the top of the gage glass:

1. Shut off fuel supply.
2. Open boiler blow down line to restore water to the correct operating level.

▶ CAUTION:

DO NOT put the boiler back into service until the cause of the problem (low water or high water) has been identified and corrected.

If leakage or other indications of damage are evident:

Notify the boiler inspector without delay. DO NOT start welded repairs to pressure parts until the boiler inspector has been notified.

Once Each Day

- Observe combustion conditions.
- Inspect for leaks.
- Plus:

For hot water boilers:

- Check the expansion tank gauge glass to verify proper air cushion is being maintained.
- Check boiler water temperature. It should never exceed 250° F (120° C).

For steam boilers:

- Blow down the gauge glass to verify connections are clear, as indicated by prompt return of water to the glass.
- Open the boiler blowoff valve for a few seconds to drain off any accumulated sediment.
- After performing daily tests, make sure all drain valves and cocks are tightly reclosed.

Once Each Week

Steam boilers:

Blow down the float (or electrode) chamber of each LWFCO device, low-water alarm and water column. This keeps the chambers free of sediment and also tests the devices by causing them to function. Test LWFCO devices with burner in operation. If the burner fails to shut off, service the device immediately.*

Once Each Quarter

- Manually test each safety valve or safety-relief valve.
- Plus:

  For hot-water boilers:

  - Test low-water fuel tripping devices according to the manufacturer's instructions.
  - Also, conduct an actual working test when the boiler is drained for any purpose.

*See page 28 for more information on LWFCO device testing.

Once Every Six Months

For steam boilers:

Test each LWFCO device by slowly lowering the boiler water level until the burner shuts off. Do not allow the water level to fall out of sight in the gauge glass.*

Fuel Combustion Safety Controls

Perform prescribed inspections and tests of the combustion safety system at the interval recommended by the equipment manufacturer. Local ordinances, if any, may require more frequent testing.

For gas- and oil-fired boilers, be sure to:

- Test, at least annually:
  - safety shutoff valves for leakage
  - flame supervision
  - fuel and combustion air interlocks
- Clean flame scanners as required for reliable flame detection.

*See page 28 for more information on LWFCO device testing.

Refer to FM Global Property Loss Prevention Data Sheets for guidance specific to the type of boiler and fuel used (see page 34).

Water Treatment

Consult a reputable water-treatment specialist to determine the extent of water treatment needed to hinder corrosion and/or scale formation during boiler operation. Boiler usage and the amount and quality of make-up water are influencing factors.

End of Heating Season

- Arrange for a competent mechanic/electrician to clean and overhaul all automatic controls.
- Plus:

  For hot-water boilers (steel or cast-iron):

  1. Drain from bottom while boiler is still hot (180° to 200° F [80° to 95° C]) until water runs clean.
  2. Refill the entire heating system and establish normal operating pressure.

If water treatment is used in the system:

Add sufficient treatment compound to condition the added water.

For steam boilers (cast-iron):

1. Drain boiler and flush out with a strong hose stream.
2. Refill to normal operating level with clean water.
3. Clean all external (fireside) surfaces thoroughly.

For steam boilers (steel):

1. Drain boiler and remove closure plates and/or plugs from all access openings.
2. Clean all internal (waterside) and external (fireside) surfaces thoroughly.
3. Leave boiler open to dry and attach a conspicuous sign reading: "BOILER EMPTY—DO NOT FIRE" or equivalent.

If wet lay-up is preferred:

Fill boiler completely with water that is properly treated to hinder corrosive action; consult a boiler-water-treatment specialist.

Logbook

Keep a permanent boiler logbook to record all maintenance work, inspections, tests and other pertinent data.

High-Pressure Steam Boilers

(Boilers with steam pressure greater than 15 psig [1 bar])

Starting Boiler

- Follow manufacturer's manual for start-up and operating procedures, including, but not limited to, the items listed below.
- Determine water level in boiler is satisfactory.
- Check all automatic and manual controls regulating feedwater, draft, damper and interlock systems.
- Check for proper fuel temperature, if oil-fired.
- Purge furnace three to five minutes to fully clear gas passes.
- Check firing equipment, method of changeover if boiler is dual fuel-fired, flame-detection devices, and other safeguards.

▶ CAUTION:

- DO NOT start a boiler if a flame-detection devise indicates flame is present when no fuel is being fired.
- Use positive means of igniting burners. If burner fails to ignite within five seconds, shut off fuel supply and re-purge furnace.
- Follow manufacturer's instructions regarding warm-up period, draft, vents, superheater drains and testing auxiliaries.

As soon as boiler reaches operating pressure:
Test low-water protective devices.*

▶ CAUTION:

- DO NOT leave an automatically fired boiler unattended after start-up until it has completed several firing cycles and you have determined that all controls are functioning properly.

*See page 28 for more information on LWFCO device testing.

Logbook

Maintain a daily log, recording completed inspections, scheduled inspections, repair and testing.

Raising Steam and Bringing Boiler Online

1. Before firing boiler, check water level, interlocks, appliances and auxiliaries.
2. Warm up outlet line from boiler to steam header by opening bypass and drain valve to create backflow from main steam header. Also, open any drip-leg valves in outlet line. This will prevent water hammer.
3. When steam line achieves temperature and boiler reaches line pressure:
    a. Open header valve wide and close bypass.
    b. Open second valve (nonreturn) gradually until boiler is online.
    c. Close drain and drip-leg valves.

d. Check water level and operation of auxiliaries.
e. Test LWFCO devices and safety valves to ensure they are functional.*
f. Increase fuel and regulate draft to establish full boiler load.

Instruments and Control

- Check all auxiliaries, feedwater and steam-flow meters, thermometers, draft gauges, combustion safeguards, etc., on a regular basis. Maintain in good operating condition.
- Test feedwater regulators, LWFCO devices and alarms daily by draining float (or electrode) chambers.*
- Test flame failure controls regularly for proper operation.
- Test each LWFCO device at least every six months by gradually lowering boiler water level until burner shuts off. Do not permit water level in gauge glass to fall out of sight during test. Conduct test in accordance with instructions furnished by manufacturer of device or boiler inspector.*
- Restore normal operating water level before returning burner to operation.

*See page 28 for more information on LWFCO device testing.

Water-Gauge Glasses

- Keep water-gauge glasses clean and well lit.
- Blow down at beginning of each shift and note promptness of water returning to glass. If sluggish, connections probably are obstructed. Shut down boiler and clear connections promptly.
- Replace dirty, leaking or defective water glasses immediately.

When Water Level Cannot Be Determined

If water is not visible in gauge glass:

1. Blow down the column or gauge glass to determine if level is low or high.
2. Check water level recorder.

   <u>If water level is below safe level:</u>

   a. DO NOT introduce cold water into hot boiler.
   b. Shut off source of heat and allow boiler to cool.
   c. Shut main steam line header valves when boiler is cool.

d. DO NOT open safety valves manually to reduce steam pressure.
e. Conduct hydrostatic test.
f. Inspect carefully for leakage and other signs of overheating.
g. Notify boiler inspector immediately if damage is evident.
h. Determine cause and correct condition before resuming normal operation.
i. Repair or replace LWFCO device.

<u>If water level is high:</u>

1. Shut off feedwater, fuel and air supply.
2. Blow down boiler to proper level.
3. Determine cause and correct condition before resuming normal operation.
4. Purge and restart boiler following normal start-up procedures (see page 11).

▶ CAUTION:

- DO NOT add cold water to any type of boiler when it is overheated. This is extremely dangerous. The thermal shock and possible steam explosion can cause serious damage.
- NEVER close dampers tightly at any time, because combustible gas may accumulate and cause an explosion.

Foaming

Surging water in the gauge glass may indicate foaming resulting from a high concentration of solids in the boiler water. To correct this condition, blow down boiler and feed with fresh water repeatedly.

If further action is required:

1. Shut off fuel and air supply.
2. Continue blowing down and feeding until satisfactory water conditions are obtained.
3. Check feedwater supply system for source of contamination.

4. Correct the cause of the foaming promptly.
5. Restart the boiler following procedures outlined on page 11.
6. Test guage glass, instrumentation, operating controls and safety devices for proper operation.

Safety Valves

Through routine maintenance and testing, keep safety valves clear of obstructions, discharge pipes free of deposits, and drain lines open for drainage.

To test by pressure:

1. Select a time when steam demand is low.
2. Throttle the main steam valve to increase steam pressure in the boiler.
3. For boilers with multiple safety valves, gag each valve after it operates and record the popping pressure.
4. Remove all gags after testing and re-open main steam valve.

5. Observe if actual popping pressure varies from that indicated on nameplate. If it does, the safety valves should be adjusted by qualified personnel and in accordance with applicable jurisdictional regulations.

▶ CAUTION:

Conduct pressure tests only with properly trained personnel and a certified safety valve company present.

Note: Valve can also be tested by a certified safety valve company using a hydraulic or pneumatic-lift-assist device.

To test by hand (for boilers with set pressure less than 400 psig [28 bar]):

1. With a boiler pressure of at least 75 percent of the valve set pressure, raise the manual lift-lever until fully opened and release suddenly to allow valve to snap closed. DO NOT strike valve body to free working parts if valve fails to operate properly.
2. If valve fails to open or close, remove boiler from service and repair or replace valve.

▶ CAUTION:

Conduct hand tests only with properly trained personnel.

Safety Valve Test Frequency

If set pressure is less than 400 psig (28 bar):

- Manual lift test every six months.
- Pressure test annually.

If set pressure is 400 psig (28 bar) or greater:

Refer to jurisdictional requirements; NBIC or equivalent (see page 35).

As an alternate to periodic testing:

Replace valves annually or at a frequency acceptable to the jurisdiction. Have a certified valve company perform a full function test, rebuild as necessary, calibrate and reseal removed valves for use at next replacement time.

Deposits on Waterside Surfaces

Scale and other deposits on waterside surfaces can cause overheating and failure of pressure parts, and reduce boiler efficiency. To ensure proper control of scale:

- Refer to a competent feedwater-treatment consultant.
- Carefully check condensate returns for contamination from process equipment, fuel oil heaters and steam-operated machinery. Deposits of oil or grease in a boiler are especially dangerous.

  <u>If oil or grease has entered the boiler:</u>

  1. Remove the boiler from service immediately.
  2. Thoroughly clean all surfaces.
  3. Clean the entire feedwater system.
  4. Locate the source of contamination.
  5. Correct the condition before resuming operation.

▶ CAUTION:

- If chemical cleaning is necessary to remove oil or scale, ensure it is done under the close supervision of experienced water-treatment specialists who are thoroughly familiar with the hazards involved.
- Deposits on fireside surfaces
- Keep fireside surfaces as clean as possible to ensure economical operation. Deposits of soot and slag hinder heat transfer, increase stack temperatures, and cause higher fuel consumption.

Blowdown

To remove harmful sediment:

- Blow down boilers by fully opening the blowdown valves once every 24 hours unless otherwise governed by water analysis, surface blowdown or manufacturer's instructions.
- Conduct blowdown in accordance with manufacturer's specific instructions.

- Keep blowdown valves in good condition and free of leakage.
- Check temperature of blowdown line on discharge side of valves occasionally. High temperature while blowdown valves are closed indicates leakage through the valves. Cool blowdown lines during or immediately following blowdown indicates either a valve problem or line pluggage.
- Ensure valves are tightly closed after completing blowdown.

▶ CAUTION:

- Blow down preferably while boiler is under low steaming rate.
- DO NOT leave valves unattended while blowing down boiler.
- DO NOT overblow. Keep close watch on water level in gauge glass at all times.

Leaks

When minor leaks occur:

Locate and repair as soon as boiler can be removed from service.

When serious leaks develop:

1. Shut down boiler immediately by shutting off fuel supply. The serious leak will quickly reduce steam pressure.
2. Shut down forced draft fan and reduce speed or shut down induced draft fan.
3. Leave dampers open.
4. Maintain water level if possible.
5. Close main steam stop and non-return valves and open drain line between these valves.
6. Open furnace door for cooling.
7. Notify boiler inspector.
8. DO NOT attempt to repair any part under pressure or any electrical component while energized.
9. Complete all welded repairs to pressure parts in accordance with applicable jurisdictional regulations. Notify boiler inspector before starting any welded repair.

Setting

When boiler settings (refractory) develop cracks in outer wall, air leaks can occur. This results in burning of additional fuel and impeding the draft.

- Repair such cracks as soon as possible.
- Examine lagging (outer metal casings) frequently for “hot spots” indicating breakdown of inner-casing insulation.
- Shut down unit if a serious inner-casing leak is discovered and make repairs.

Boiler Inspection

1. Shut off fuel. If boiler is oil-fired, also shut off atomizing steam or air supply.
2. Purge the furnace.
3. Maintain water level.
4. Close both main steam stop and non-return valves and open drain line between these valves.
5. Cool boiler slowly until setting is sufficiently cool to prevent damage.

6. Open boiler vent and drain valves.
7. Remove all manhole and handhole plates necessary for inspection.
8. Follow confined-space and lock-out tag-out entry procedures.
9. Remove all inspection plugs from gauge glass and water column cross connections.
10. Clean internal surfaces of boiler and flush out all loose scale particles and sediment.
11. Remove ash from furnace and sweep clean tubes and furnace tubesheets.
12. Remove soot and slag from gas passes.
13. Do not direct hose stream on or step into a pile of ash until you are sure it is cool.
14. Service automatic controls, making sure float chambers are clear, electrical connections are tight and wiring is in good condition. Replace covers on all electrical boxes after servicing.
15. Remove all tools, waste, etc., from boiler after cleaning.

Laying Up Boilers

When boilers are to be laid up for indefinite periods, dry storage is preferable.

1. Cool and clean as outlined on page 9.
2. Keep internal surfaces dry by:

Method 1

- Placing a desiccant, such as quicklime at the rate of 2 lb. for 30 ft.^{3} (1 kg/m^3) of boiler volume or silica gel at the rate of 5 lb. for 30 ft.^{3} (2.5 kg/m^3) of boiler volume, in trays inside the boiler drums and tightly closing the boiler.
- Check effectiveness of desiccant at regular intervals.
- Keep boiler tightly closed (except when checking desiccant).

Method 2

- Continuously circulating dry air through the open boiler.

When boilers are to be placed in standby condition for short periods of time, or when it is likely that a standby boiler will be needed on short notice:

- Employ an accepted wet-storage method.
- Consult with boiler inspector and chemical water-treatment specialists.

▶ CAUTION:

- Wet storage is not recommended in unheated areas where freezing temperatures may occur.

Low-Water Fuel Cutoff (LWFCO) Device Testing

Documentation

Always record results of slow and quick drain tests in the boiler operator's logbook.

Frequency

Steam boilers:

- Slow drain test at least once every six months and at planned shutdown.
- Plus:

  For high-pressure steam boilers:
  Quick drain test at least once each day.

  For low-pressure steam boilers:
  Quick drain test at least once each week.

Hot-water boilers:

For hot-water heating boilers:
Test low-water fuel tripping devices at six-month intervals. Follow manufacturer's instructions.

For all other hot-water boilers:
Test low-water fuel tripping devices quarterly. Follow manufacturer's instructions.

Slow Drain Test

All steam boilers:

With boiler operating at low load/steam demand, shut off the feedwater supply while the burner is in operation. This will allow the water level to drop gradually, causing the LWFCO device to function. (The boiler blowdown valve also may be used to lower the water level.)

For boilers with dual low-water cutoff devices:

Test each cutoff device independently.

For coil-type watertube boilers:

Test thermally actuated low-water or low-flow cutoff devices as recommended by the manufacturer.

Quick Drain Test

Blow down the float/electrode chamber while the burner is in operation to simulate a low-water condition and cause the LWFCO device to function.

▶ CAUTION:

The burner should shut down when the LWFCO device actuates during both slow drain and rapid drain testing. Failure of the burner to shut down is a serious operating deficiency. Shut down the boiler and do not resume operation until it is properly repaired.

- Never conduct a slow drain test when the boiler is operating at high capacity.
- Be sure to take every precaution to ensure that water remains visible in the gauge glass during a slow drain test and a minimum safe water level is maintained while the LWFCO is being tested.
- Should the water level reach the bottom of the gauge glass during a slow drain test before the burner shuts down, shut down the boiler and do not resume operation until the cause of the problem has been identified and corrected.

- If, while conducting a slow drain test, the water level in the gauge glass stops falling while blowdown is continuing, immediately shut down the boiler and do not resume operation until the cause of the problem has been identified and corrected.
- A second operator should be present at the sight glass when it is not visible from the blowdown valve location.
- Never leave an open blowdown valve unattended.
- Close all blowdown valves upon completion of tests.
- Confirm water level returns to normal following completion of tests.
- After a LWFCO device has failed to function and the cause has been corrected, prove proper operation of the LWFCO by satisfactorily completing two slow drain tests.

- When boiler operation is essential, provide constant operator attendance until cause of the LWFCO failure to operate has been corrected and performance proven satisfactory.
- Configure drain piping to prevent pockets or low points. Water in drain piping can cause water hammer during blowdown and damage the LWFCO device.
- DO NOT perform quick drain tests if LWFCO device manufacturer indicates unit may be damaged by such testing.

Additional Resources

If you have additional questions or concerns about the care and operation of your boiler, please contact your local FM Global engineer or client service team or refer to the following FM Global resources:

- *Approval Guide* (www.approvalguide.com)
- *Understanding the Hazard Kit: Boilers* (P0673k)*
- FM Global Property Loss Prevention Data Sheet:
  - 6-0, *Elements of Industrial Heating Equipment*
  - 6-4, *Oil- and Gas-Fired Single-Burner Boilers*
  - 6-5, *Oil- or Gas-Fired Multiple-Burner Boilers*
  - 6-12, *Low-Water Protection*
  - 6-13, *Waste Fuel-Fired Boilers*
  - 6-14, *Waste Heat Boilers*
  - 6-22, *Firetube Boilers*
  - 6-23, *Watertube Boilers*
  - 12-43, *Pressure Relief Devices*

- *Low-Water Cutoff Tag* (P6611)
- *National Board Inspection Code (NBIC)***

* Available to FM Global clients only.
** Available from the National Board of Boiler and Pressure Vessels Inspectors (www.nationalboard.org)

Notes

Notes

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