Routine and Emergency Boiler Operation

Learning Outcome

When you complete this module you will be able to:

Describe the routine safe and efficient operation of a packaged boiler.

Learning Objectives

Here is what you will be able to do when you complete each objective:

1. Describe the proper routine care and operation of a boiler.
2. Describe common emergency conditions in boilers and the required responses.
3. List the main types and causes of boiler explosions.
4. Discuss the need for boiler operating and maintenance logs, and the type of information that should be recorded.

INTRODUCTION

Due to the large variety of boilers, firing equipment, and boiler controls, it will not be possible in this module to give specific instructions for each particular type or model of boiler. Out of necessity, the instructional material has to be limited and, therefore, will only be presented in a general way.

Even though the instructions in this module may be applicable, without change, to most packaged boilers, they should be considered as general guidelines only. Boiler operators are well advised to study the instructions supplied by the manufacturer of the boiler in their plant or building. The manufacturer's instructions may vary in certain details from the instructions given in this module.

ROUTINE OPERATION

Although most packaged boilers are now fully automatic, it is necessary that they are given regular attention to assure safe and dependable operation. Below follows a general list of daily routine procedures to be performed by the operator.

Water Level

THE MOST IMPORTANT RULE IN THE SAFE OPERATION OF STEAM BOILERS IS TO KEEP WATER IN THE BOILER, AT THE PROPER LEVEL. NEVER DEPEND ENTIRELY ON WATER LEVEL CONTROLS, EMERGENCY WATER FEEDERS, OR AUTOMATIC ALARMS.

The gage glass, water column and connecting lines should be blown through daily. After blowing through, the level should quickly return in the glass. The low water level alarm should be checked at the beginning of each shift. On boilers that are in continuous service, a spring loaded, temporary boiler shutdown bypass switch must be held closed during the test procedure.

Keep the gage glass clean. A clear and accurate indication of the level is vitally important. Appearance of rust in the glass is an indication of corrosion that should not be ignored. Check the boiler water to be sure that the water treatment chemicals are at the proper concentration. Also check the return line and other parts of the system for evidence of corrosion.

Make sure that the water level is relatively steady. A wide fluctuation of the water level may indicate that the boiler is foaming or priming. This may be caused by the water level being carried too high or, especially in low-pressure boilers, by a very high rate of steaming. Foaming may also be caused by an excessively high concentration of dissolved or suspended solids in the water or by the presence of oil.

Mild cases of foaming can be controlled by the use of antifoam chemicals. More severe foaming is usually controlled by blowdown. Lower the level in the boiler 5 - 7.5 cm (2 - 3 in.) and refill to the normal level. Repeat this several times. In persistent cases, it may be necessary to take the boiler out of service and to cool, drain, and wash it out thoroughly. Then refill the boiler and put it back into service.

Steam Pressure

Whenever going on duty check the boiler steam pressure. In order to maintain the boiler pressure at the desired value, the amount of fuel burned must correspond to the boiler load. That is, if the boiler load (the rate of steam demand of the boiler) increases, then the amount of fuel burned in the boiler furnace must be increased and if the boiler load decreases then the amount of fuel burned must also be decreased.

The amount of fuel admitted to the furnace is normally controlled by an automatic system which senses changes in steam pressure and adjusts the fuel feed accordingly. The operator must, however, be able to take over from the control system in case of failure of the automatic arrangement and therefore should be familiar with the method of changing over from automatic to hand control.

Burner Operation

Check the condition of the burner flame. It should be predominantly blue, but some orange colouring at the flame tip is unavoidable and considered acceptable.

Check the stack for any signs of dark coloured smoke. A white plume is due to the presence of water vapour from the combustion process, and is not a problem, unless the ground shows signs of accompanying white ash. If smoking occurs, check the air intake to the boiler room first. It may have become obstructed by snow and ice build-up, paper or plastic. If the intake is clear but smoking persists, the burner nozzle may be dirty (oil firing), the fuel temperature may be too low (heavy oil firing), or the fuel/air ratio may be incorrect (gas or oil firing).

Stack Temperature

Check and record the stack temperature daily.

Maintain Proper Heat Transfer

In order that the greatest possible amount of the heat produced in the furnace is transferred to the boiler water, it is necessary to keep the heating surfaces free from soot and ashes. This is done by means of sootblowers. The sootblowers should be operated when required but usually once a shift is sufficient. The boiler load should be above 50% of maximum when sootblowers are in service. This ensures that the burner flame is strong enough to be stable and also that the fine dust will be carried rapidly from the furnace before an explosive mixture forms.

Another cause of poor heat transfer is the formation of scale on the heating surfaces. This scale can be prevented by proper treatment of the feedwater and the boiler water and proper regulation of the amount of bottom and continuous blowdowns. For this reason the operator must take regular tests of water conditions as outlined below.

Water Treatment

Take samples of the boiler water, deaerated feedwater, and condensate, and perform the required tests at the intervals laid out in the water treatment program. From the results of these tests, determine the amount of chemicals required to give the boilers and the system the greatest protection; fill the mixing tanks and pot feeders accordingly and start feeding. Blow down the boilers as needed. If any external water treatment equipment is used, monitor this equipment; backwash and/or regenerate when required.

Continuous Blowdown

The continuous Blowdown, or CBD, should be opened just enough to keep the concentration of dissolved and suspended solids below the maximum allowed. Keep in mind that excessive blowdown is wasteful and will increase operational costs. Record the CBD setting in the daily log.

Inspection

Make a full inspection of the boiler. Check for leakage from safety valves, manhole, handholes, clean-out plugs, valves and pipe connections. Determine the cause of any unusual noises or conditions, initiate work requests, and record these in the daily log.

Other Equipment

Check the operation of the auxiliary equipment in the boiler room such as feedwater, condensate, and vacuum pumps. If the boiler is oil-fired, check the operation of the fuel pump, clean the filter if necessary, and check the fuel level in the tank.

Housekeeping

Keep the boiler room and equipment clean. wipe up oil spills immediately. Remove all articles that may present a fire hazard. Store materials needed in the boiler room in such a way that they cannot cause an accident.

Boiler Log

Maintain the Boiler Room Log and record the various routines and tests performed.

EMERGENCY CONDITIONS DURING BOILER OPERATION

The following situations are rare occurrences if the boiler has been receiving proper routine operation and care. Nevertheless, when upset conditions do occur, they can develop rapidly into serious situations. The operator must be prepared to act calmly but efficiently, and this requires a prior knowledge of emergency procedures. The following list is again only general in nature, every operator must become completely familiar, and at ease, with the specific procedures in his or her plant.

Low Water Level

A rapidly falling water level in the boiler may be caused by a faulty feedwater level controller, feedwater or condensate pump failure, interruption of the water supply to the pump, or leakage from the boiler due to ruptured tubes or open blow-off valves.

Normally, when the level drops to the low-water cutoff point, the boiler will shut down automatically. However, should the cutoff fail to shut the boiler down, the water level may drop to a dangerous level.

If the operator finds the boiler in operation while unable to see the water level in the gage glass, it may be that the glass is either completely full or empty. This should be checked quickly by opening the drain on the glass. If the level is found to be below the gage glass, the boiler should be shut down immediately.

Caution: Do not feed water into the boiler to raise the level, and do not open the safety valve or vent valve to release pressure.

Let the boiler cool slowly until it is at hand-touch temperature. Drain the boiler and open it to inspect for damage due to overheating. If no damage is found, the boiler can be closed up again and filled. However, it should not be put back into operation until the cause of the feedwater shortage and the failure of the low-water cutoffs to shut the boiler down is found and corrected.

If it appears that damage has been done, the Boiler Inspector should be notified.

High Water Level

Should the water in the gage glass of a boiler show higher than normal or even climb out of sight, the level should be brought back to normal to prevent carry-over of the water with the steam. This can be done either by shutting off the feedwater or condensate pump or, more quickly, by draining the excess water through the blow-off valves.

Neither of these methods should be used to maintain normal water level while continuing boiler operation. The first method requires the boiler operator to manually control the operation of the feedwater pump while the second method is wasting too much water.

The cause of the trouble, usually a defective level control system, should be repaired as soon as possible. It may be necessary to put the level control system in the manual mode while the fault is being found and repaired.

Blower Failure

Should the blower or fan fail, the supply of combustion air will cease. The fuel supply must be shut off immediately to prevent a furnace explosion. Modern automatically-fired packaged boilers are equipped with a low-air cutoff switch that will cut off the power to the solenoid fuel valve as soon as the pressure at the blower discharge drops below the minimum safe value.

Flame Failure

Some of the reasons why the flame may fail during operation are:

- Insufficient fuel oil supply due to plugged filter
- Water in the fuel
- Excessive air supply
- Insufficient gas pressure

When flame failure occurs, the flow of the fuel to the burner must be stopped immediately to prevent the furnace from filling with unburned fuel which could cause an explosion. Most boilers are now equipped with flame detection devices which will shut off the fuel supply within a few seconds after the flame fails. Regular testing of the operation of these devices is a must.

BOILER EXPLOSIONS

Boiler explosions may be listed under two general classifications: furnace explosions and pressure explosions. **In both cases, the results of an explosion are almost always extensive damage to property and either personal injury or loss of life.** The operator must know the basic causes of explosions and refrain from unsafe practices that lead to them.

Furnace Explosions

These are explosions which occur when an accumulation of combustible gases ignites and explodes within the furnace or gas passes of the boiler. This may be caused by:

- Insufficient purge of the furnace before lighting up. According to insurance company statistics this is still the number one cause of furnace explosions.
- Admission of the fuel to the main burner before the pilot flame or other ignition source is established
- A weak pilot flame
- Failure of the main fuel valve to close when the main burner flame is lost
- An insufficient amount of combustion air resulting in incomplete combustion
- Attempting to light burners from hot refractory

Pressure Explosions

Pressure explosions occur when a pressure part of the boiler such as the shell, furnace, or firetube bursts due to too high a steam pressure or a structural weakening of the metal. This weakening may be caused by:

- The effects of corrosion
- Overstressing of the material due to heating the boiler up too quickly during start-up
- Overheating of the heating surfaces due to a low water condition (low-water fuel cutoff failure)
- Scale and sludge build up

Also, failure of the boiler operating controls combined with an inoperative safety valve may cause the pressure to rise far above the maximum allowable working pressure.

Even though most boilers are fully automatic, the boiler operator should pay regular attention to the operation of the boiler and should conscientiously follow the instructions regarding testing and maintenance of fittings and controls in order to prevent the occurrence of an explosion.

If an explosion does occur, then the person in charge of the boiler or pressure vessel must notify the proper authorities.

The Boilers Acts of the various provinces state that, in the event of an explosion, the person in charge must fully report all particulars concerning the explosion including the exact place or location, names of persons killed or injured, and the cause of the explosion if known. In addition, the Acts state that nothing shall be moved or interfered with at the scene until an inspector has investigated the accident and determined the cause of the explosion, unless it be for the purpose of saving life or limb, protecting property, or for the removal of the dead.

BOILER ACCIDENTS

Although not all boiler accidents are preventable, accident investigations show that the great majority of accidents with boilers could have been prevented, and that the number of such mishaps can be effectively reduced through the proper application of operating and maintenance logs.

Some reasons that boiler accidents occur are:

1. The misconception that no supervision is required for automatically-fired boilers.

2. The inexperience or lack of training of operating personnel.

3. Inadequate maintenance of boilers and controls.

The most common cause of boiler accidents is overheating of the heating surfaces due to a low water condition. This condition is mainly caused by failure of operating or protective controls.

Although automatically-fired packaged boilers are well protected by automatic devices, it should be kept in mind that these devices are only as good as the maintenance they receive.

Since these boilers require little attention during operation, regular checking of operating and protective devices is easily forgotten and the controls may become inoperable without the knowledge of the operator. This, of course, means trouble when adverse conditions develop in the boiler operation.

BOILER OPERATING AND MAINTENANCE LOGS

The best method of determining that adequate attention is being given to the boiler and its control equipment is to provide a boiler log on which is recorded sufficient information to indicate that the boiler is receiving the necessary attention.

To be effective, a boiler log must provide a continuous record of boiler operation, testing, and maintenance. It is common practice to use a weekly or monthly log sheet to record routine operational checks, tests, and minor maintenance. The boiler and auxiliary equipment should be checked at regular intervals by a qualified person, and the protective and operating devices should be tested at sufficiently frequent intervals to determine that they are in good operating condition. These checks should then be recorded on the log sheet.

Major maintenance jobs, testing, and adjustment of controls and safety valves, and instructions for operators, are commonly recorded in a log book.

This module contains two examples of log sheets. One sheet was developed by the Hartford Insurance Company for use with small capacity boilers of a large building complex; these boilers are checked daily. Boiler operators can develop similar log sheets and include all data relevant to their boiler plant. A partial leaf of a boiler room logbook is also included. It shows some of the information that should be recorded.

COMPANY _____

BUILDING _____ LOCATION _____

BOILER MAKE: _____ BOILER NO. _____

WEEK _____ 19 _____

	TIME	SUNDAY		MONDAY		TUESDAY		WEDNESDAY		THURSDAY		FRIDAY		SATURDAY	
		AM	PM	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM
CHECK AND RECORD	Steam Pressure														
	Water Level														
	Feed Pump Pressure														
	Feed Water Pressure														
	Flue Gas Temperature														
	Oil Pressure														
TEST	Low Water Cut-Off														
	Feed Pump Control														
	Gage Glass + Column														
CHECK	Feed Water Pump														
	Cond. Tank Level														
	Burner Operation														
	Fuel Supply														
TEST EACH SHIFT	Dissolved Solids														
	Alkalinity														
	Phosphate														
	Sulphite														
	pH														
	Blow-Off (Seconds)														
	Make-Up Water														
	Water Softener														
TEST OR CLEAN AT LEAST ONCE WEEKLY	Safety Valves														
	Water Filter														
	Oil Filter														
	Oil Burner														
	Ignition														
MINOR REMARKS ONLY	AM Remarks														
USE LOG BOOK FOR EXTENSIVE DETAILS	PM Remarks														
	Operators Initials														

Figure 1
Low-Pressure Heating Boiler Log

LOW-PRESSURE HEATING BOILER LOG

(WEEKLY READINGS)

RECORD TESTS EACH WEEK BY CHECKING SPACES
INSTRUCTIONS ARE PRINTED BELOW

BOILER NO._____

YEAR _____

	SAFETY VALVE TESTED	WATER COLUMN GAGE GLASS DRAINED	LOW-WATER FUEL CUT-OFF TESTED	PUMP AND RETURN SYSTEM CHECKED	BURNER OPERATION CHECKED
	WEEK 1 2 3 4 5	WEEK 1 2 3 4 5	WEEK 1 2 3 4 5	WEEK 1 2 3 4 5	WEEK 1 2 3 4 5
JAN.					
FEB.					
MAR.					
APR.					
MAY					
JUNE					
JULY					
AUG.					
SEPT.					
OCT.					
NOV.					
DEC.					

TO TEST:

SAFETY OR RELIEF VALVE—pull try-lever to full open position with pressure on boiler. Release lever to allow valve to snap closed.

WATER COLUMN OR GAGE GLASS—open drain quickly to void small quantity of water. Water level should return quickly when valve is closed.

LOW WATER FUEL CUT-OFF—drain float chamber while burner is running. This should interrupt the circuit and stop burner.

PUMP AND RETURN SYSTEM—check pump for proper operation, leaky packing. Examine traps, check valves, makeup float valves, and condition of condensate tank.

BURNER OPERATION—if flame is dirty, or burner starts with a puff, phone your service man at once!

SERVICING:

LOW WATER FUEL CUT-OFF—The low water fuel cut-off should be dismantled for a complete overhaul by a competent serviceman at least annually. The internal and external mechanism, including linkage, contacts, mercury bulbs, floats, and wiring should be carefully checked for defects. See manufacturer's instructions.

OIL OR GAS BURNER AND CONTROLS—The oil or gas burner and all operating and protective controls should be thoroughly checked at least once every three months by a competent service organization. See manufacturer's instructions. *Record service dates.*

Unusual conditions should be reported to the Company's branch office or inspector.

FOR IMMEDIATE REFERENCE ENTER
NAME OF YOUR SERVICE MAN

NAME.....

ADDRESS.....

PHONE.....

SERVICE DATES

THE HARTFORD STEAM BOILER INSPECTION AND INSURANCE COMPANY
HARTFORD, CONNECTICUT

1466

Figure 2
Daily Reading Sheet
(Courtesy Hartford Insurance Company)

DATE	REPORTS OF TESTS, INSPECTIONS, REPAIRS, ETC.
Mar 23	Replaced gage glass on #2 expansion tank J.C.
Mar 25	Tested flame scanners on #1 and #2 boilers P.J.
Mar. 26	Fuel oil tank filled, 1800L. Clean oil filters S.P.
Mar 29	Shut #1 boiler down for internal cleaning and inspection
	Valves in supply and return lines closed, fuel valves closed,
	burner removed. Power off. P.J.
Mar 30	Drained #1 boiler, opened man-and hand
	holes. Washed out boiler. Opened doors, cleaned
	firetubes. furnace and reversing chambers. P.J.

Figure 3
Sample Boiler Log Book Entries