

## START-UP AND OPERATION STEAM BOILERS

### WARNING:

IMPROPER SERVICING AND START-UP OF THIS EQUIPMENT MAY CREATE A POTENTIAL HAZARD TO EQUIPMENT AND TO OPERATORS OR PERSONS IN THE BUILDING.

SERVICING AND START-UP MUST BE DONE ONLY BY FULLY TRAINED AND QUALIFIED PERSONNEL.

### CAUTION:

BEFORE DISCONNECTING OR OPENING ANY FUEL LINE, OR BEFORE CLEANING OR REPLACING PARTS OF ANY KIND, TAKE THE FOLLOWING PRECAUTIONS:

Turn OFF the main fuel shutoff valves, including the pilot gas cock if applicable. If the burner is a multiple fuel type, shut OFF all fuel supplies.

Turn OFF all electrical disconnects to the burner, boiler and any other equipment or systems electrically interlocked with the burner or boiler.

All cover plates, enclosures, and guards must be in place at all times except during maintenance and servicing.

### 2.1 FIRING RATE ADJUSTMENT - ATMOSPHERIC GAS UNITS

2.1.1 The following procedures must be followed carefully before putting the boiler in operation. Failure to do so will present severe hazards to equipment, operating personnel and building occupants.

#### 2.1.2 ADJUST PILOT BURNER

Carefully follow the Lighting Instructions in the boiler manual for the proper adjustment of the pilot burner. This is absolutely essential before attempting to adjust the main burner.

#### 2.1.3 ADJUST BOILER INPUT(S)

The boiler input must be adjusted for both maximum and minimum input values which are listed on the boiler nameplate. First adjust the maximum input rating using the method described in Lighting Instructions in the Boiler Manual. Refer to the following information for the adjustment of the minimum input. To determine the adjustment

which firing rate system is used, see the boiler Equipment List and Wiring Diagram.

#### 2.1.4 ADJUST BOILER MINIMUM INPUT

After setting the correct Maximum input as described in the Lighting Instructions, proceed to adjust the minimum input as outlined below. This applies only to those boilers which are designed and equipped for two-stage (High/Low/Off) firing or Modulation. On those boilers which are equipped for ON/OFF firing only, no minimum input adjustment is required. NOTE: the low firing rate input is adjustable only on boilers equipped with two-stage or modulating motorized gas valves (V4055, V9055, or AH4 actuators) or with motor-operated modulating butterfly gas valves. The other two-stage firing systems (VR850 or VR852 combination valves or dual diaphragm valve type bypass systems) have a non-adjustable minimum input rate.

## NOTE

THE LOW FIRE ADJUSTMENT SHOULD RESULT IN A GAS PRESSURE ON THE BURNER MANIFOLD EQUAL TO 1" WATER COLUMN FOR NATURAL GAS AND 3" FOR PROPANE GAS.

### 2.1.5 MINIMUM INPUT ADJUSTMENT - COMBINATION GAS VALVES (VR850 OR VR852)

The minimum input on these gas valves is NOT adjustable. The maximum input must be properly set as outlined in Lighting Instructions. See the manufacturer's instructions on the VR850 or VR852 included in the Boiler Manual for further information.

### 2.1.6 MINIMUM INPUT ADJUSTMENT - DUAL DIAPHRAGM GAS VALVE HIGH/LOW BY-PASS SYSTEM

The minimum input on this control system is NOT adjustable. The maximum input must be properly set as outlined in Lighting Instructions. This system consists of two V48A (120 volt coil) or two V88A (24 volts coil) diaphragm gas valves which are piped in parallel. The minimum input is controlled by an orifice plug installed in a coupling in the by-pass piping (low fire valve piping), sized for approximately 1" w.c. manifold pressure at low fire natural gas (2" w.c. if propane gas). When the high fire gas valve is not activated, gas flows only through the bypass piping. When the high fire gas valve is activated, gas will flow through both valves achieving full input.

## 2.2 FIRING RATE ADJUSTMENT - GAS METER READINGS

### 2.2.1 CHECKING BURNER INPUT

The burner input rate can be checked by taking readings from the gas meter. Please note checking the rate with a meter is the only way to be sure of input. Manifold readings are only an approximate value and may vary from unit to unit.

In order to obtain accurate data, there must be no other appliances using gas from the same meter while the burner input rate is being checked. The test hand on the meter should be timed for several revolutions. The input rate in cubic feet per hour is

calculated from this timing. The method is described in Lighting Instructions. If the meter is not calibrated for gas temperature and pressure, correction factors must be applied to determine correct rate in SCFH (standard cubic feet per hour). Consult the National Fuel Gas Code (ANSI Z223.1, NFPA 54) or the local gas utility for further information. Refer to Table 2.2A for correction factors for the gas pressure at the meter. Refer to Table 2.2B for the gas temperature correction factors.

Table 2.2A - Pressure Correction		Table 2.2B - Temperature Correction	
Gas Pressure at Meter	Correction Factor	Gas Temp. at Meter	Correction Factor
7" w.c.	1.017	40 °F	0.920
14" w.c.	1.034	50 °F	0.902
21" w.c.	1.051	60 °F	0.885
1 psig	1.061	70 °F	0.868
2 psig	1.136	80 °F	0.852
5 psig	1.340	90 °F	0.836

## 2.3 SAFETY SHUT-OFF DEVICES (FLAME SUPERVISION)

### 2.3.1 FLAME SUPERVISORY SYSTEM

The boiler is equipped with a flame supervisory system, either the Thermocouple type (such as a combination gas valve or a pilotstat) or electronic type (such as the RA890, or RM7895). The purpose of this device is to detect the main or pilot flame, depending on the type of device, and control the gas valves accordingly. The device must be checked for proper operation. See Lighting Instructions in the Boiler Manual for the correct procedure. The flame supervisory system must be tested to assure that it will shut off the main gas valves in case of a

flame loss. In addition to the information given in Lighting Instructions, operating sequence and troubleshooting information may be found in the manufacturer's instructions in the Boiler Manual.

### 2.3.2 AUTOMATIC (ELECTRIC) IGNITION SYSTEMS

On boilers equipped with automatic electrically ignited pilots, follow the procedures described in Lighting Instructions and test the controls for proper operation.

## 2.4 LIMIT CIRCUIT CUT-OUT TEST

### 2.4.1 PROTECTIVE DEVICES

All operating and limit controls and low water cutoffs must be tested for proper operation.

### 2.4.2 STEAM PRESSURE OPERATING CONTROL

The steam pressure in the boiler is regulated by the Boiler Operator. This is a pressure control which senses the steam pressure and turns the boiler on and off accordingly. This control must be operationally tested. Adjust the pressure setting on the control to a pressure less than the boiler pressure (as shown on the boiler pressure gauge). The control should turn the boiler off. Restore the control setting to normal. The boiler should cycle on.

### 2.4.3 HIGH LIMIT CONTROL

At least one additional pressure control is provided as the high limit control. It is set at a pressure above the operator to act as a back-up should the operator fail. The high limit control must be operationally tested. With the boiler operating, decrease the pressure setting of the limit control below the current pressure of the boiler. The boiler should cycle off. Restore the high limit control setting to normal (pushing reset button if it is a manual reset type). The boiler should now cycle on.

### 2.4.4 LOW WATER CUT-OFF(S)

Most boilers are supplied with a float-operated primary low water cut-off (and pump control or

water feeder combination) or electric probe type auxiliary control. These water level controls are intended to sense (and control) the level of the water in the boiler. They operate to shut off the boiler if the water level drops below their sensing level. The low water cut-off and water level controls must be operationally tested by manually lowering the boiler water level (by opening the boiler blowdown valve for probe controls, and by opening the control blowdown valve for float type controls). The boiler should cycle off when the water level drops below the control point of the low water cut-off. When the water level is restored, the boiler should cycle back on. Depress the manual reset button of devices which require manual reset in order to restore the boiler to operation. Carefully read the enclosed literature on the low water cut-off controls, particularly installing, operating and servicing.

### 2.4.5 COMBINATION LOW WATER CUT-OFF & FEEDER

The low water cut-off/feeder supplied with some boiler serves as a low water cut-off (see above) and also causes make-up water to be added to the boiler should the water level drop below its control point.

This type of control must be operationally tested as for low water cut-offs and also to assure that the make-up water is introduced as needed. Carefully read the enclosed literature on the Low

Water Cut-off controls, particularly installing, operating and servicing.

#### 2.4.6 OTHER CONTROLS

Additional controls as required for the particular installation may also be provided. Refer to the literature on these devices included in the Boiler Manual. All such devices must be operationally tested to assure reliable operation of the boiler and system.

#### 2.4.7 BOILER FEED SYSTEM

The boiler feed pump must be operationally tested to assure that it can provide boiler feedwater at the pressure and in the amount needed for safe and reliable boiler operation.

#### 2.4.8 CHEMICAL FEED SYSTEM & SOFTENER

Check the performance of the boiler water softener and chemical treatment system. Chemically test the feedwater to be certain it complies with the recommendations of the chemical treatment consultant.

## 2.5 RECOMMENDED DRAFT AND COMBUSTION READINGS

ATMOSPHERIC GAS-FIRED BOILERS					
BOILER SERIES	DRAFT AT BOILER OUTLET (i.w.c.)	CO <sub>2</sub> @ HIGH FIRE	O <sub>2</sub> @ HIGH FIRE	CO (ppm)	SMOKE NO.
F	-0.01 TO -0.04	7.5 TO 8.5 %	5.0 TO 7.5 %	< 400	0
CL	-0.02 TO -0.04	7.5 TO 9.0 %	4.8 TO 7.5 %	< 400	0
K	-0.02 TO -0.06	8.0 TO 9.5 %	4.0 TO 6.7 %	< 400	0

FORCED DRAFT GAS FIRED BOILERS					
BOILER SERIES	DRAFT AT BOILER OUTLET (i.w.c.)	CO <sub>2</sub> @ HIGH FIRE	O <sub>2</sub> @ HIGH FIRE	CO (ppm)	SMOKE NO.
D	-0.01 TO -0.04	7.5 TO 9.5 %	4.0 TO 7.5 %	< 400	0
HED	-0.01 TO -0.04	7.5 TO 9.5 %	4.0 TO 7.5 %	< 400	0
CL	0.0 TO -0.04	8.5 TO 10.0 %	3.2 TO 5.0 %	< 400	0
HECL	0.0 TO -0.06	8.5 TO 10.0 %	3.2 TO 5.0 %	< 400	0
RV & RW	+0.50 TO -0.10	9.0 TO 10.0 %	3.2 TO 5.0 %	< 400	0
AB	+0.25 TO -0.06	9.0 TO 10.0 %	3.2 TO 5.0 %	< 400	0

FORCED DRAFT OIL FIRED BOILERS					
BOILER SERIES	DRAFT AT BOILER OUTLET (i.w.c.)	CO <sub>2</sub> @ HIGH FIRE	O <sub>2</sub> @ HIGH FIRE	CO (ppm)	SMOKE NO.
D	-0.01 TO -0.04	10.0 TO 12.0 %	4.0 TO 7.2 %	< 400	0
CL	0.0 TO -0.04	10.0 TO 12.0 %	4.0 TO 7.2 %	< 400	0
RV & RW	+0.50 TO -0.10	11.5 TO 12.5 %	3.7 TO 5.0 %	< 400	0
AB	+0.25 TO -0.06	11.5 TO 12.5 %	3.7 TO 5.0 %	< 400	0

NOTE: THE VALUES FOR CO<sub>2</sub> AND O<sub>2</sub> ARE SHOWN FOR HIGH FIRE ONLY. THE VALUES FOR LOW FIRE OR MID RANGE WILL GENERALLY BE LOWER, PARTICULARLY FOR ATMOSPHERIC GAS-FIRED BOILERS. DRAFT SHOULD BE MEASURED APPROXIMATELY 24" FROM TOP OF BOILER, BEFORE ANY DRAFT CONTROL.

#### 2.5.1 DRAFT ADJUSTMENT - ATMOSPHERIC GAS BOILERS

Refer to Section 1.8.6 for the adjustment method for barometric dampers. Adjust the damper so as to yield a draft which results in values of CO<sub>2</sub> and CO within the allowable limits listed above in the appropriate table.

Draft adjustments are generally not required for boilers equipped with draft diverters. The diverter must be installed without modification. Combustion readings are required, however, to assure that the boiler operation is both safe and efficient.

Draft measurement should preferably be made with an inclined tube manometer. If a draft gauge is not available, check to be sure the flue gases are being carried up the venting system by passing a lighted taper or match around the edge of the draft hood relief opening (or barometric). If the venting system is operating correctly, the match flame will be drawn toward the draft hood relief opening. Otherwise the products of combustion will tend to push the flame and extinguish it.

#### **CAUTION**

IF THE PRODUCTS OF COMBUSTION ARE BEING EMITTED INTO THE ROOM (VENTING SYSTEM NOT OPERATING CORRECTLY), THE BOILER MUST NOT BE OPERATED UNTIL PROPER ADJUSTMENTS OR REPAIRS

ARE MADE TO ASSURE ADEQUATE DRAFT THROUGH THE VENTING SYSTEM.

#### 2.5.2 DRAFT ADJUSTMENT -FORCED DRAFT BOILERS

Draft adjustments are generally not necessary on forced draft boilers. The draft must be measured as part of the start-up procedure. The measured draft at the boiler flue should fall within the recommended range specified in the appropriate table.

On some installations the draft may be excessive due to a high chimney. In these cases, the draft should be adjusted within the recommended range specified in the above appropriate table.

This may be done using a barometric damper, a restrictor, or a locking quadrant damper. Such devices must be installed and adjusted by a qualified technician.

#### 2.5.3 COMBUSTION ADJUSTMENTS - FORCED DRAFT

Refer to the separate burner manual for the procedures for burner adjustments. The burner must be adjusted for smooth lightoff. Combustion parameters should be within the range specified in the above appropriate table. In no case should the level of CO be allowed to exceed the limit given, and the smoke spot reading must also not exceed the value shown.

## **2.6 OPERATING INSTRUCTIONS**

### 2.6.1 FAMILIARIZATION WITH MANUAL(S)

The user of the boiler must familiarize himself with this manual and the burner manual for forced draft boilers to be sure he is prepared to operate and maintain the boiler properly.

The operating instructions should be kept in the pocket in the boiler for F Series boilers, or adjacent to the boiler for all others.

**READ THE MANUAL BEFORE ATTEMPTING A START UP.**

## **2.7 MAINTENANCE SCHEDULE**

### 2.7.1 POSTING SCHEDULE

Post a maintenance schedule in accordance with the recommendations in this manual. A copy of a typical schedule is included in this manual.  
Section 3

## **CARE AND MAINTENANCE STEAM BOILERS**

### **CAUTION:**

- The boiler area should be kept free of combustible materials, gasoline and other flammable liquids.
- The boiler and venting system must be kept free of obstructions of the air louvers and draft hood relief openings.
- The following procedures must be conducted as outlined to assure safe operation of the boiler.
- All cover plates, enclosures, and guards must be in place at all times except during maintenance and servicing.

### **3.1 REQUIRED PRECAUTIONS DURING TEMPORARY USE**

#### GENERAL

A boiler is often utilized in new construction to assist in curing of building components or to provide temporary heat for the construction crew or for other purposes during the time the building is under construction. If precautions are not taken during this time to protect the boiler, a great deal of damage can occur before the ultimate owner takes over the building.

It is the mutual responsibility of the installing contractor and the boiler owner to consider the effect of temporary usage on the boiler warranty. The following should be observed so as to assure the longevity of the boiler.

#### OPERATOR SKILLS/RESPONSIBILITIES

During the temporary use period, a single individual must be assigned responsibility for the care and operation of the boiler. This person's responsibility must include, but not be limited to, the following:

1. Knowledge of burner/boiler operation.
2. Possession and understanding of boiler/burner operating instruction manual.
3. Assurance that the boiler is fed with only treated water at all times and that chemical treatment and blowdown procedures are always followed.
4. Notification to the manufacturer (or manufacturer's agent) to provide start-up services if the boiler was purchased with start-up by a factory representative.
5. Adherence to all of the start-up procedures noted in the boiler/burner manual.
6. Considerations of warranty should the boiler be used for temporary heat without adherence to the recommended start-up and operating procedures outlined in the instruction manuals.

### **3.2 CLEANING THE BOILER AND SYSTEM - NEW SYSTEMS**

#### BOIL OUT PROCEDURE

The internal surfaces of a newly installed boiler will have oil, grease or other protective coatings used in manufacturing. Such coatings must be removed since these coatings lower the heat transfer rate and could lead to overheating of a tube and reduce operating efficiency. Before boiling out procedures may begin, the burner must be ready for firing. The operator must be familiar with the procedure outlined in the boiler/burner operating instruction manuals.

In combination with system contamination, bacteria may cause objectionable odors, sometimes resembling natural gas. It is important to keep these fumes from air intakes which would distribute them throughout the building. On steam humidification systems this is especially critical. Consult your local water treatment chemist for further information.

## CAUTION

The boil out procedure outlined must be performed by, or under the direct supervision of, a qualified technician. The chemicals used present a hazard of burns and physical injury if mishandled. Always use suitable face mask, goggles, protective gloves and garments when handling caustic chemicals. Do not permit the chemical to come into contact with skin or clothing. Always follow the safety precautions on the container's label. Add chemicals slowly and in small amounts to prevent excessive heat and agitation. Do not add water to acid. Do not add water to dry chemical. This will cause splattering and/or explosion and severe risk of personal injury.

Boiling out under pressure is not recommended. If boil out under pressure is required, competent assistance must be provided.

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Your water consultant or water treatment company will be able to recommend a cleaning or boil out procedure. In the event that such service is unavailable or as yet not selected, the following may be used.

1. The boil out of the boiler and system is neither difficult nor expensive. The chemicals needed for cleaning are readily available. Trisodium phosphate, and sodium hydroxide (lye) are the most commonly used chemicals. Use only one type of solution in the system. The amount of chemical required will vary according to conditions, but an amount of one pound of chemical per fifty gallons of water is suggested.

2. Before introducing the solution into the boiler, an overflow pipe should be attached to the top of the boiler and routed to a safe point of discharge.

3. Remove all safety valves to ensure that none of the solution will come into contact with the valve seats. Use care in removing and reinstalling valves.

4. All valves in the piping to and from the system must be closed to prevent the chemical solution from getting into the system.

5. Gauge glasses must be protected from contact with the boil out chemicals.

6. Fill the boiler with clean softened water until the water level reaches the upper header. Then add the cleaning solution into the upper header. Add more clean water until the boiler is completely filled. The water used for this initial fill should be at room temperature, and must be softened as noted.

7. After filling, fire the boiler intermittently (at low fire) at a frequency as necessary to hold the boiler solution at boiling point temperature. **DO NOT PRODUCE STEAM PRESSURE.** Boil the water, supervised at all times, for at least five hours.

8. After the five hour boil out, begin to add a small amount of fresh softened water so as to create a slight overflow of the overflow pipe. This will carry out impurities which have accumulated at the water surface. Continue to apply heat and overflow until the water emitted from the overflow pipe clears. Then shut off burner.

9. Let the boiler cool to 120°F or less. Then drain the boiler. Use caution that the water is discharged with safety.

10. Remove the inspection/cleanout openings in the boiler upper and lower headers and wash the waterside surfaces thoroughly using high pressure water stream.

11. Inspect the boiler's internal (waterside) surfaces thoroughly after the procedure. If the surfaces are not clean, repeat the boil out.

12. After boil out, close all openings. Install relief valves, gauge glasses and other components as necessary. Completely fill the boiler with fresh, softened, ambient temperature water. Fire the boiler at low fire until water temperature of at least 180°F is reached. This will drive off dissolved gases.

13. The boiler is now ready to operate.

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## IMPORTANT

If boiler is not to be operated within 24 hours, a lay-up procedure is required. Refer to instruction for lay-up.

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### 3.3 SYSTEM CLEAN OUT

Many boilers have been ruined with system contaminants such as pipe dope, cutting oil, metal shavings or chips and other debris which are left in the piping. If these contaminants are not removed, they will end up in the boiler.

#### SYSTEM CLEANING PROCEDURE

For steam systems, the boiler will need to be connected to the header utilizing steam to purge the piping and thus push the debris out of the system. However, at this time all condensate must be wasted until it runs clear and water analysis of the condensate indicates that it is free of contaminants. Steam trap strainers must be periodically opened and cleaned of any debris which accumulates.

During this system clean out, the boiler make-up water must be properly softened and treated. At the conclusion of the system clean out, the condensate must be reconnected.

For old or existing steam systems, the installation process may have jarred debris loose. Following the boil out of the new boiler, the condensate should be wasted until it is within proper guidelines. Check all steam trap strainers to assure their cleanliness. Refer to the succeeding section on replacement boiler installations.

### 3.4 REPLACEMENT BOILER INSTALLATIONS: PROTECTION AGAINST CORROSION & SEDIMENT

#### BOILER MUST CONTROL FEED WATER

The water feed to the boiler must be controlled by the boiler-mounted water level control. It is unacceptable to use gravity return or to let the water feed be controlled by a condensate/receiver/ condensate pump system. The water feed to the boiler must be controlled:

- ☐ by a feed pump control which is mounted on the boiler. This control is to activate the feed pump on a boiler feed system. It will be necessary to supply such a system if not already installed. - OR -
- ☐ by an automatic water feeder mounted on the boiler. This is used only on systems requiring 100% make-up, such as humidification, steam process, etc.

#### **NOTE**

It is not recommended to provide the make-up for a closed steam heating system to the boiler by means of a water feeder. It is preferred that system make-up be connected to the condensate return tank of a boiler feed system.

A boiler feed system may be used in conjunction with an existing condensate receiver system by allowing the receiver system to pump condensate into the boiler feed system tank.

#### CLEAN OR REPLACE ALL SYSTEM PIPING AND HEATING UNITS

Arrange for chemical and mechanical cleaning of

the entire system. A chemical treatment company should be consulted for the proper means of this chemical cleaning.

Replace any piping considered to be deteriorated beyond safe or cleanable condition. Flush the system clean, being certain to isolate the boiler.

#### **DO NOT FLUSH THE SYSTEM THROUGH THE BOILER**

NOTE: For some old systems, there is a reluctance to clean the piping because of the possibility of leaks occurring in badly corroded lines. Should the customer refuse cleaning, it is necessary to install filtration equipment. Install either a fibrous filter or a centrifugal filter in the boiler return piping. This will collect and remove sediment from the system. A booster pump may have to be installed as well to overcome the additional pressure drop introduced in the line by the filter. When filling the system, provide chemical treatment as outlined in Section 3.5.

#### **CAUTION**

Failure to properly clean the system or to install mechanical sediment removal equipment can result in tube blockage and severe corrosion plus damage to pumps, controls, and air removal device.

### 3.5 BOILER WATER TREATMENT

#### PURPOSE OF WATER TREATMENT

Water treatment is required for satisfactory operation of the boiler. It must be devised to prevent depositing of scale and to prevent corrosion from acids, oxygen and other such harmful elements that may be in the water supply. A qualified water treatment chemist should be consulted and the water systematically treated.

#### OBJECTIVES

The basic objectives of water treatment are:

1. Prevent the accumulation of scale and deposits in the boiler.
2. Remove dissolved gases from the water.
3. Protect the boiler against corrosion.
4. Maintain the highest possible boiler fuel efficiency.
5. Decrease the amount of boiler down time from cleaning.

#### WATER SOFTENER

It is highly recommended that a zeolite water softener be used for all make-up to the boiler. It is intended that this be used in addition to the chemical treatment of the boiler. Water softening removes calcium and magnesium, the primary causes of hard boiler scale.

#### CONTINUOUS MONITORING REQUIRED

Water treatment should be checked and maintained whenever the boiler is operating. The boiler operator should be sure that the boiler is not operating for long periods without proper water treatment. Water treatment may vary from season to season or over a period of time. Therefore, the water treatment procedure should be checked not less than four times a year, and possibly more frequently as the local water conditions may indicate.

### 3.6 EXTERNAL "FIRE-SIDE" CLEANING

#### PURPOSE

Carbon (soot) is an insulator and is corrosive. The heating surface of a boiler must be kept free from soot accumulation to keep the boiler operating at its highest efficiency and to avoid damage from corrosion.

#### SOOT REMOVAL

If the yearly inspection of the boiler tube surfaces reveals a build-up of either soot or rust (usually due to condensation), the tubes should be thoroughly brushed. (Tube cleaning brushes are available from Bryan Steam) To inspect and, if necessary, clean the tube surfaces and flue collector, first remove the tube access panels. Examine the exterior of the tubes for evidence of soot or rust. Using a flashlight, carefully look between the tubes. There should be an unobstructed opening between all tubes, and the top surfaces of the tube must be free from soot accumulation. Also inspect the interior of the flue collector. Brush or vacuum the soot from all surfaces. Be sure to cover atmospheric burners with a protective cover during cleaning to prevent soot from falling into them.

If the buildup of soot is appreciable, the flue gas venting system must be thoroughly inspected internally as well, and cleaned as necessary.

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### IMPORTANT

If either soot or condensation is apparent, a boiler service technician should be consulted. The presence of soot indicates poor combustion and possibly hazardous boiler operation. Failure to do so may result in fire, explosion potential, or asphyxiation. A combustion test and burner adjustments should be undertaken at once.

Rust on the tubes indicates that boiler-operating temperatures are too low. The set point of the boiler operating control must be no less than 130°F for natural gas or propane firing, and 170°F for oil fired boilers. Boilers equipped with outdoor reset control must also follow these limits.

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### 3.7 SUGGESTED MAINTENANCE SCHEDULE

#### DAILY

1. Make visual inspection of gauges, monitors, and indicators and record readings in boiler log.
2. Make visual check of instrument and equipment settings against factory recommended specifications.
3. Check operation of float type low water cutoffs to ensure control is functioning. The lower piping connections of float type level controls should have a suitable blowdown valve piped into a proper drain. This valve should be opened periodically to allow any sludge accumulated in the control to be flushed out. On closed loop water heating systems this should not be often required. Consult manufacturer's instructions.

#### WEEKLY

1. On units equipped with firing rate control, verify that it is functioning correctly by adjusting control and observing if input changes accordingly.
2. Make visual inspection of igniter and pilot flame. For an atmospheric unit, confirm pilot flame is as shown in this manual (Section 1.9) and that the main burners light off correctly (smoothly) and that the flame is clean and normal. For units with a power burner, check pilot flame signal strength as specified in burner manual.
3. Check pilot and main fuel valves for correct operation. Open limit switch - make audible and visual check - check valve position indicators and check fuel meters, if supplied.
4. Confirm boiler area is free of combustible materials and that there is nothing obstructing air openings, draft hood relief openings, etc.
5. Check combustion safety controls for flame failure and flame signal strength as specified in manufacturer's instructions located at the back of this manual for atmospheric units or in the burner manual for units equipped with a power burner.
6. Check all limit controls as specified in manufacturer's manual.
7. Check float low water cutoff as described above.

#### MONTHLY

1. Make visual inspection of linkage and proper operation of flue, vent, stack, or outlet dampers. Check draft as specified in Section 2 of this manual.
2. Check float low water cutoff as described above.
3. For those units equipped with a power burner, check low draft, fan, air pressure and damper position interlocks as specified in burner manual.
4. Check high and low gas pressure interlocks. Refer to manufacturers instructions for correct procedure.
5. Check high and low oil pressure interlocks. Refer to manufacturers instructions for correct procedure.

#### ANNUALLY

1. Perform leakage tests on pilot and main gas or main oil fuel valves as specified in manufacturers instructions.
2. Check operating control, high limit, low fire start control, and low water cutoff as specified in manufacturers instructions.
3. For units equipped with power burners, check air atomizing interlock, fuel valve interlock switch, purge switch, burner position interlock, and fuel changeover control, as specified in burner manual.
4. The boiler should be checked at least yearly by the local gas utility company. Particular attention should be paid to the pilot burner safety devices. The pilot burner should be checked to ensure that prompt ignition of all burners occurs as the gas valve opens. Refer to Section 1.9.
5. The flue gas passages and the exterior surfaces of the boiler tubes should be inspected at least annually. Any accumulation of soot or debris should be thoroughly cleaned out.
6. If the yearly inspection of the boiler tube surfaces reveals a build-up of soot (carbon) or rust, the tubes surfaces should be thoroughly brushed. Failure to do so may result in fire or asphyxiation hazards.
7. The boiler pressure vessel and piping should be checked annually.
8. Check combustion safety control for pilot turndown and refractory hold-in as specified in manufacturer's instructions.

### 3.8 FLOAT-ACTUATED WATER LEVEL CONTROLS

Inspect float type water level controls for proper operation. Visually inspect sight glasses for evidence of scale forming residues. Refer to section 3.9 for gauge glass maintenance.

On closed steam heating systems, the float low water cutoff should be blown down by means of opening a blowdown valve on the lower connection of the cutoff once per day.

On humidification or process systems, the blowdown schedule should be based on recommendation from a water treatment and maintenance program specifically designed for the boiler.

At the annual inspection, all float type level controls should be disassembled, cleaned and inspected thoroughly. When re-installed these controls must be given an operational test.

### 3.9 WATER GAUGE GLASSES

#### INSTALLATION

Check with the maintenance supervisor and engineering for the proper glass to be used. Compare the box and the glass label or marking to ascertain that the gauge glass ratings or temperature and pressure are suitable for use on the boiler. Use new gaskets when replacing glass. The gaskets used should be the same type as those originally supplied with the boiler. Make certain that the gauge glass valves are properly aligned.

All bolts and nuts must be free running and well lubricated, preferably with a graphite type lubricant. Washers under nuts and bolt heads are desirable. DO NOT tighten while equipment is in operation.

#### MAINTENANCE

Inspect the gauge glass regularly for any signs of clouding or scratching. In new processes, the gauge glass should be inspected daily until the need for replacement becomes apparent. This will help establish the routine inspection cycle.

The gauge glass should be blown down daily so as to remove accumulated sediment from the valves.

#### INSPECTION

To examine for scratches, shine a bright concentrated light at about a 45° angle. Anything that glistens brightly should be inspected closely. Any scratch which glistens and will catch a fingernail, or crescent-shaped or star-shaped mark is cause for replacement. This is because scratches, corrosion, chips and surface damage weaken the glass. If inner surface appears cloudy or roughened, and will not respond to cleaning procedures, this is evidence of chemical attack. If severe, this is cause for replacement.

#### REPLACEMENT OF GLASS

Any glass that has been removed from its mounting in process boilers, regardless of the reason for removal, should be discarded and replaced with a new glass and gaskets. Used glasses may contain hidden damage and represent a safety hazard.

Be sure that the replacement glass is suitable for service conditions.

Protective shields to keep cold air, water, or falling objects from glass must be replaced.



## 4.0 IDLE BOILER CARE AND LAY-UP

### GENERAL

Corrosion damage to boilers is often the result of improper lay-up during non-operating periods. Substantial damage can occur in only a few days in proper precautions are not taken. This damage is irreversible and will reduce boiler reliability, increase maintenance costs and eventually shorten the useful life of the boiler tubes.

Idle boilers are vulnerable to attack when air contacts untreated wet metal surfaces. To prevent corrosion, the boiler metal must be protected by either keeping the surfaces completely dry or excluding air from the boiler. Air exclusion is accomplished either by keeping the boiler completely full of water (short term lay-up) or filling the boiler with nitrogen gas (long-term lay-up). The nitrogen gas prevents air infiltration and does not react with the metal.

In addition to the corrosion damage that occurs, the metal particles that are released will form an insulating scale on the tubes when the boiler is returned to service. These corrosion products will accumulate on critical heat transfer areas of the boiler, increasing the potential for localized corrosion and over heating.

### PRE-OPERATIONAL CLEANING AND LAY-UP

Proper lay-up techniques must be used on an idle boiler even if it has never been in operation. Before pre-operational lay-up, the boiler must be chemically cleaned as outlined in Section 3.2 of this manual. This is required, as noted in this section, to remove preservatives, oil and grease from the tube surfaces. Follow the short term or long term lay-up procedure as appropriate.

### TAKING BOILERS OFF LINE

In operation, boiler water contains suspended solids which are held in suspension due to water circulation and the action of treatment chemicals. Unless care is exercised when draining the boiler, these suspended solids settle on the tube surfaces and will air dry to an adherent deposit, sometimes requiring chemical cleaning to remove. In addition, these deposits may be misleading regarding the effectiveness of the chemical treatment program.

### PRE-SHUTDOWN PRECAUTIONS

For a period of three to seven days prior to shutdown, manual blowdown frequency should be increased. During this period, the lower conductivity limit should be below 3500 micro-mohs per centimeter. The feed of internal treatment must be increased to maintain a specific residual concentration. Continuous blowdown

(when used) should be kept to a minimum so the reduction of solids is achieved by the increased manual blowdown.

### WASHDOWN

As the boiler cannot be washed immediately, the heat in the boiler may cause baking of residual sludge. The boiler should not be drained until cooled enough to prevent this. However, never leave the boiler filled with water for any extended period of time without taking measures to prevent corrosion.

### LAY-UP CONSIDERATIONS

There are two basic methods of steam boiler lay-up: Wet lay up or Dry lay-up. The choice of which method should be used depends on:

- The possibility that the boiler may need to be placed in operation on short notice.
- Disposal of lay-up solutions
- Freezing potential

Wet Lay-up is recommended for relatively short outages, such as seasonal lay-up. This method has the advantage of allowing the boiler to be brought on line with short notice. But it can pose problems if there is any likelihood of freezing.

Dry Lay-up is recommended for longer periods of boiler shut-down or storage. But it is practical only if boiler can be drained hot (120°F to 170°F) or if external drying can be provided.

### WET LAY-UP OF STEAM BOILERS - SHORT TERM

In the wet lay-up procedure, the boiler is to be filled with chemically treated water and sealed to prevent air in-leakage. Nitrogen gas under slight pressure can also be used to displace air and protect the boiler surfaces from corrosion. The following steps should be taken for wet lay-up of a boiler:

#### 1a. Procedure for operational boiler:

At least thirty minutes before the boiler comes off line, add the following chemicals:

Sodium Sulfite - 0.5 lbs. per 100 gallons water

Polymeric Sludge Dispersant - 0.1 lbs. per 100 gallons water

Caustic Soda - 0.3 lbs. per 100 gallons water

#### 1b. Procedure for idle boiler:

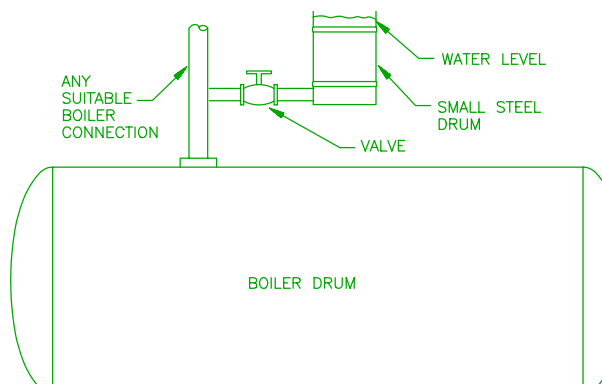
If the boiler has never been on line or has been out of service for cleaning - Select the highest quality water available to fill the boiler. Steam condensate, softened water, filtered fresh water, and boiler feedwater are generally acceptable for

lay-up. Raw city water is not recommended and should not be used.

Prepare the chemical solution described in (1a) in a separate tank. Adhere to the safety precautions described in Section 3.2 of this manual. Add the concentrated lay-up solution to the boiler during the time it is being filled.

After the boiler is filled and the lay-up solution has been added, the boiler is to be operated for thirty minutes at low fire to circulate and mix the chemicals.

2. After filling, the boiler must be closed or blanked tightly. The power supply to the boiler must be cut off. Vent all air from the top of the boiler to allow complete fill with the required solution. Nitrogen gas at 5 psig may be introduced through a suitable opening to prevent air in-leakage during the lay-up period. An alternative to the nitrogen gas (see safety precautions under dry lay-up) is to install a 55 gallon drum or auxiliary vessel as shown in Figure 3.11A. This is to be fitted with a cover and filled with properly treated water. This vessel or drum should be connected to an available opening in the top of the vessel. Its purpose is to create a hydrostatic head and to allow a ready visual check of water level loss or in-leakage during the lay-up period.



**Figure 3.11A: WET LAY-UP STATIC HEAD DRUM**

3. During lay-up, test the boiler weekly to assure the proper levels of sulfite and alkalinity. To do this, take a sample of the boiler water from the surface blowdown line or other high point. The test results should be:

- ☐ Sodium Sulfite 200 ppm minimum
- ☐ Phenolphthalein Alkalinity (as  $\text{CaCO}_3$ ) 400 ppm minimum

If the tests indicate chemical concentration has decreased, chemical may be introduced to the boiler by putting it in the drum shown in Fig. 3.11A. Then lower the boiler water level to introduce it into the boiler. Then operate the boiler at low fire to circulate the water and mix the

chemical. Then repeat Step. 2. Pay attention to the maintenance of the valves being used to isolate the boiler to prevent leakage and resultant dilution of the lay-up solution.

#### ALTERNATE METHOD

An alternate wet lay-up method is to pipe clean continuous blowdown water from a properly treated boiler into any convenient bottom connection on the idle boiler, allowing the water to flow through the boiler and out the top (through any convenient top opening) to the sewer. This method will insure a continuous, complete fill with warm, properly treated water. It also prevents in-leakage of air by keeping the boiler slightly pressurized. It may also provide enough heat to keep the fireside of the boiler dry and possibly produce adequate freeze protection.

#### DRY LAY-UP OF STEAM BOILERS - LONG TERM

The dry lay-up method recommended requires that the boiler be drained, dried as completely as is possible, all opening and valves closed. Nitrogen gas at 5 psig is introduced to the boiler to pressurize it and prevent air in-leakage. The success of the procedure depends on the thorough drying of the boiler metal surfaces after draining and the exclusion of air during the lay-up.

### **CAUTION**

The use of nitrogen for blanketing is recommended in both the wet and dry lay-up procedures. Even though nitrogen in dilute quantities is non-toxic, it will not support life. Precautions must be taken before entering equipment filled with nitrogen for inspections or any other purposes. These precautions shall be as follows:

- ☐ disconnection of nitrogen supply line
- ☐ complete purging and venting of the equipment with fresh air
- ☐ testing oxygen levels inside before any attempt to enter
- ☐ all confined entry guidelines applicable to site must be followed

Appropriate caution signs shall be posted around the equipment to alert personal that nitrogen blanketing is in use. A boiler laid up dry must be tagged with information that the unit is not to be operated until the boiler is properly refilled.

1. Drain the boiler before the steam pressure falls to zero. Then pressurize with 5 psig nitrogen gas through a suitable top opening during draining. The nitrogen pressure is to be maintained through draining and subsequent storage.

An alternate method is to completely dry a clean boiler (by blowing hot dry air through the boiler) and then purge the air from the boiler and pressurize with 5 psig nitrogen. Be aware that all metal surfaces which are not completely dry are vulnerable to corrosion, particularly if oxygen is present.

2. If a boiler has been down for repairs and is to be laid up, it should be operated to pressurize with steam and then drained and pressurized with nitrogen as in step 1.

3. All connections must be blanked or tightly closed.

Note: Operating boilers must be removed from service to minimize adherence of boiler water suspended solids on boiler metal surfaces. Refer to previous instructions for boiler washdown.

#### RETURNING IDLE BOILER TO SERVICE

##### After wet lay-up

To start an idle boiler after wet lay-up, use the following procedure:

1. If the boiler was pressurized with nitrogen, disconnect the nitrogen supply source and vent the boiler.

2. Using the blowdown valve, drain the boiler partially and make up with feedwater so as to dilute the chemical residuals to operating concentration levels.

3. After the boiler water concentrations and the water level are returned to proper operating conditions, the boiler can be started in the normal manner.

##### After Dry Lay-Up

To start an idle boiler after dry lay-up, use the following procedure:

1. Disconnect the nitrogen supply source and vent the boiler in a safe manner - external to the building and away from air intakes. Then thoroughly purge the boiler of nitrogen with dry air.

2. The boiler was to have been cleaned before the lay up procedure. So it is necessary only to fill the boiler with properly treated water. Then proceed with start-up.