



# PRECISION BOILERS

## *Installation and Operating Instructions*

**MODEL HVJ**

**ELECTRODE BOILER**

(Revision: April 30, 2014)



# PRECISION BOILERS

## *Installation and Operating Instructions*

### **MODEL HVJ**

### **ELECTRODE BOILER**

This manual supplies information on the application, installation and operation of Model HVJ Electrode Boilers. Review all application and installation procedures completely before proceeding with the installation. Consult the Precision Local Factory Representative with any problems or questions regarding this equipment. Experience has shown that improper installation causes most operation problems.

**RETAIN THESE INSTRUCTIONS NEAR THE EQUIPMENT FOR READY REFERENCE**

#### **WARNING**

Improper installation, adjustment, alteration, service or maintenance can cause injury or property damage. **Read this manual thoroughly and follow the instructions herein.** The HVJ Boilers shall be installed according to the procedures detailed in this manual, or the Precision Boilers Limited Warranty may be voided. The installation must conform to the requirements of the local jurisdiction having authority. Any modifications to the boiler or its controls may void the warranty. If field installation requires modifications, consult either the local HVJ Electrode Boilers' Representative or the Factory.

## TABLE OF CONTENTS

I Title page .....	1	4.1.1 Boiler .....	22
II Introduction .....	2	4.1.2 Condensate Feedwater System .....	28
III Table of Contents .....	3	4.1.3 Feedwater Pumps .....	28
<b>1.0 INSTALLATION GUIDELINES</b> .....	<b>4</b>	4.1.4 Blowdown Tank.....	29
<b>1.1 Introduction</b> .....	<b>4</b>	4.1.5 Electrolyte Feed System.....	29
<b>1.1.1 General</b> .....	<b>4</b>	4.1.6 Chemical Feed System .....	29
<b>1.1.2 Civil</b> .....	<b>4</b>	<b>4.2 Start-up Procedure</b> .....	<b>29</b>
<b>1.1.3 Mechanical</b> .....	<b>4</b>	<b>4.2.1 Boiler</b> .....	<b>29</b>
<b>1.1.4 Electrical</b> .....	<b>4</b>	<b>4.2.2 Feedwater Pumps</b> .....	<b>32</b>
<b>1.2 Description of Boiler Operation</b> .....	<b>4</b>	<b>4.2.3 Blowdown Tank</b> .....	<b>33</b>
<b>2.0 HANDLING AND STORAGE</b> .....	<b>7</b>	<b>4.2.4 Electrolyte Feed System</b> .....	<b>33</b>
<b>2.1 Shipping</b> .....	<b>8</b>	<b>4.2.5 Chemical Feed System</b> .....	<b>34</b>
<b>2.1.1 Boiler</b> .....	<b>8</b>	<b>4.3 Shut-Down Procedure</b> .....	<b>34</b>
<b>2.1.2 Components</b> .....	<b>8</b>	<b>4.3.1 Normal Shut-Down</b> .....	<b>34</b>
<b>2.2 Storage</b> .....	<b>8</b>	<b>4.3.2 Emergency Shut-Down</b> .....	<b>34</b>
<b>2.3 Uncrating</b> .....	<b>8</b>	<b>4.3.3 Moth Ball Procedure</b> .....	<b>34</b>
<b>3.0 INSTALLATION AND ASSEMBLY</b> .....	<b>8</b>	<b>5.0 BOILER WATER</b> .....	<b>34</b>
<b>3.1 Boiler</b> .....	<b>8</b>	<b>5.1 Properties of Feedwater</b> .....	<b>34</b>
<b>3.1.1 Primary Boiler Assembly</b> .....	<b>8</b>	<b>5.2 Feedwater Treatment</b> .....	<b>35</b>
<b>3.1.2 Assembly of Internal Components</b> .....	<b>9</b>	<b>5.3 Water Conductivity</b> .....	<b>36</b>
<b>3.1.3 Assembly of External Components</b> .....	<b>13</b>	<b>5.3.1 Adjustments</b> .....	<b>36</b>
<b>3.1.4 Piping Assembly</b> .....	<b>15</b>	<b>5.3.2 Conductivity Range</b> .....	<b>36</b>
<b>3.1.5 Electrode Assembly</b> .....	<b>19</b>	<b>5.3.3 Low-Output Operation</b> .....	<b>36</b>
<b>3.1.6 Pneumatic Assembly</b> .....	<b>20</b>	<b>5.4 Electrolyte Feed</b> .....	<b>37</b>
<b>3.2 Feedwater Pumps</b> .....	<b>20</b>	<b>5.5 Blowoff</b> .....	<b>37</b>
<b>3.3 Blowdown Tank</b> .....	<b>21</b>	<b>5.5.1 Automatic Blowoff</b> .....	<b>37</b>
<b>3.3.1 Erection</b> .....	<b>21</b>	<b>5.5.2 Response Adjustment</b> .....	<b>37</b>
<b>3.3.2 Assembly of External Components</b> .....	<b>21</b>	<b>6.0 ROUTINE MAINTENANCE</b> .....	<b>37</b>
<b>3.4 Electrolyte Feed System</b> .....	<b>21</b>	<b>6.1 Boiler</b> .....	<b>37</b>
<b>3.4.1 Erection</b> .....	<b>21</b>	<b>6.2 Condensate Feedwater System</b> .....	<b>39</b>
<b>3.4.2 Assembly of External Components</b> .....	<b>21</b>	<b>6.3 Circulating Pump</b> .....	<b>39</b>
<b>3.4.3 Piping Assembly</b> .....	<b>21</b>	<b>6.4 Feedwater Pumps</b> .....	<b>39</b>
<b>3.4.4 Electrical Connection</b> .....	<b>21</b>	<b>6.5 Chemical Feed Pumps</b> .....	<b>39</b>
<b>3.5 Chemical Feed System</b> .....	<b>22</b>	<b>7.0 PARTS &amp; LIMITED WARRANTY</b> .....	<b>39</b>
<b>3.5.1 Erection</b> .....	<b>22</b>		
<b>3.5.2 Assembly of External Components</b> .....	<b>22</b>		
<b>3.5.3 Piping Assembly</b> .....	<b>22</b>		
<b>3.5.4 Electrical Connection</b> .....	<b>22</b>		
<b>4.0 OPERATION</b> .....	<b>22</b>		
<b>4.1 Preliminary Checks and Adjustments</b> .....	<b>22</b>		

# 1.0 INSTALLATION GUIDELINES

## 1.1 Introduction

This Installation Manual is intended to supplement the experience and ability of qualified personnel in the installation, operation and maintenance of the boiler system.

### 1.1.1 General

All equipment supplied per this contract is intended for inside installation in a non-hostile environment. Complete installation shall be in compliance with all local codes and regulations.

### 1.1.2 Civil

Each piece of equipment shall be mounted in accordance with the respective dimensional drawing. Floor mounted equipment shall be adequately anchored to withstand that applicable Seismic requirements (6 degrees). Clearances for adequate service and maintenance shall be provided per shipment specifications / drawings. All equipment shall be adequately shimmed and grouted to assure the equipment to be level and / or plumb.

### 1.1.3 Mechanical

References to the system P&ID, in addition to detail piping drawings and the equipment dimensional drawings, should be made for the mechanical installation of each piece of equipment. Particular attention should be made in routing pipes both to allow for thermal expansion and to facilitate maintenance of equipment.

### 1.1.4 Electrical

The equipment should be wired per both the respective wiring diagrams and the overall system diagram. Care should be made to assure all conduits are routed to allow for equipment maintenance and away from both hot surfaces and areas of possible water or steam leakage. All analog instrument wiring should utilize shielded cable. High voltage cabling shall comply with the United States National Electrical Code (Part V of Article 490) and shall be routed to allow for sufficient ventilation.

## 1.2 Description of Boiler Operation

Refer to High Voltage Jet (HVJ) Electrode Steam Boiler, Figure 1. In the high voltage jet (HVJ) electrode boiler, water from the lower part of the boiler shell is pumped by the circulating pump(s) by the circulating pump(s) to the nozzle header and flows through the jets to strike an electrode, thus creating a path for the electric current. Primary voltage connections are made directly to the electrode terminals. As the unevaporated portion of the water, which is approximately 98% of total flow, flows from an electrode to a counter electrode, a second path for current is created.

Regulation of the boiler output is accomplished by a variable speed circulation pump, which varies the amount circulation pump, which varies the amount pump speed is set by the boiler pressure control system to hold the steam pressure constant.

**NOTE:** All size 1 boilers have standard ANSI pumps mounted external to the vessel. Size 2 and larger boilers have external circulation pumps. Size 338 and larger and have multiple internal pumps.

The conductivity of the water is important to boiler operation. In almost all instances, the conductivity of the boiler water tends to increase because make-up water adds salts to the boiler water (unless the make-up water is completely demineralized) which remain in the boiler since carryover of salt in the steam is negligible. To negate this trend of increasing conductivity, an automatic conductivity control senses water conductivity and, if too high, signals an automatic valve to allow a small amount of highly conductive water to be blown out of the boiler. This water is then replaced with less-conductive make-up water.

The boiler water level is controlled via a proportioning-type feedwater control. High and low water cutoffs are also provided as separate switches, and are connected into the boiler safety circuit. All boiler safety circuitry is connected directly to the circulation pump control and the boiler is effectively shut down.

A standby heater is provided to raise the boiler pressure to the minimum-operating limit (50 psi) on start-up or to maintain this or a higher pressure for short durations when the boiler is in the standby mode.

The high voltage power supply must be from a 'wye' system, as depicted in Figure 2, and must be installed in compliance with the *National Electrical Code (Part V of Article 490)*.

The high voltage power supply must be from a 'wye' system, as depicted in Figure 2, and must be installed in compliance with the *National Electrical Code (Part V of Article 490)*.

**Figure 1a: High Voltage Jet (HVJ) Electrode Steam Boiler**

**Legend**

- 3. Circulation Pump w/ VFD
- 12. Conductor Rod
- 18. Electrode / Strike Plate
- 19. Nozzle Header

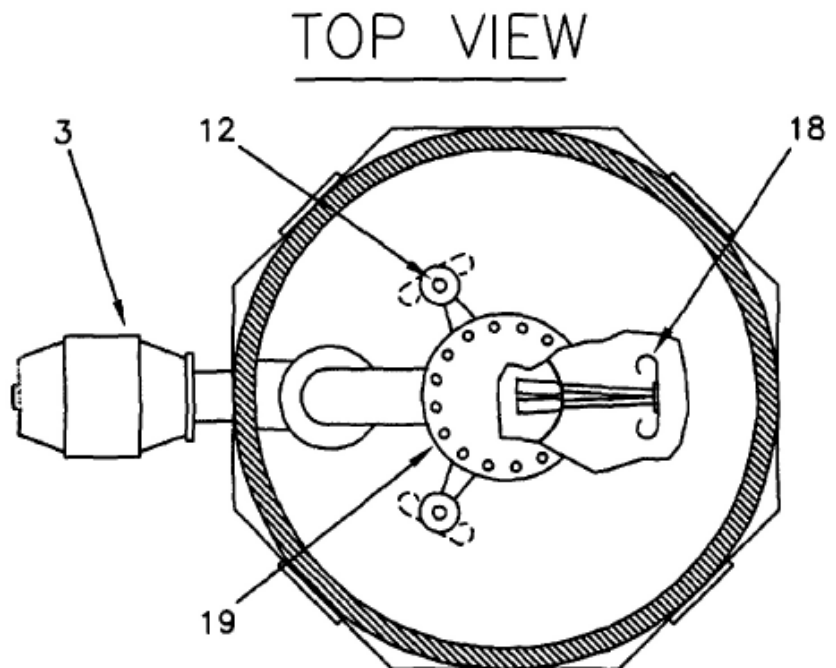
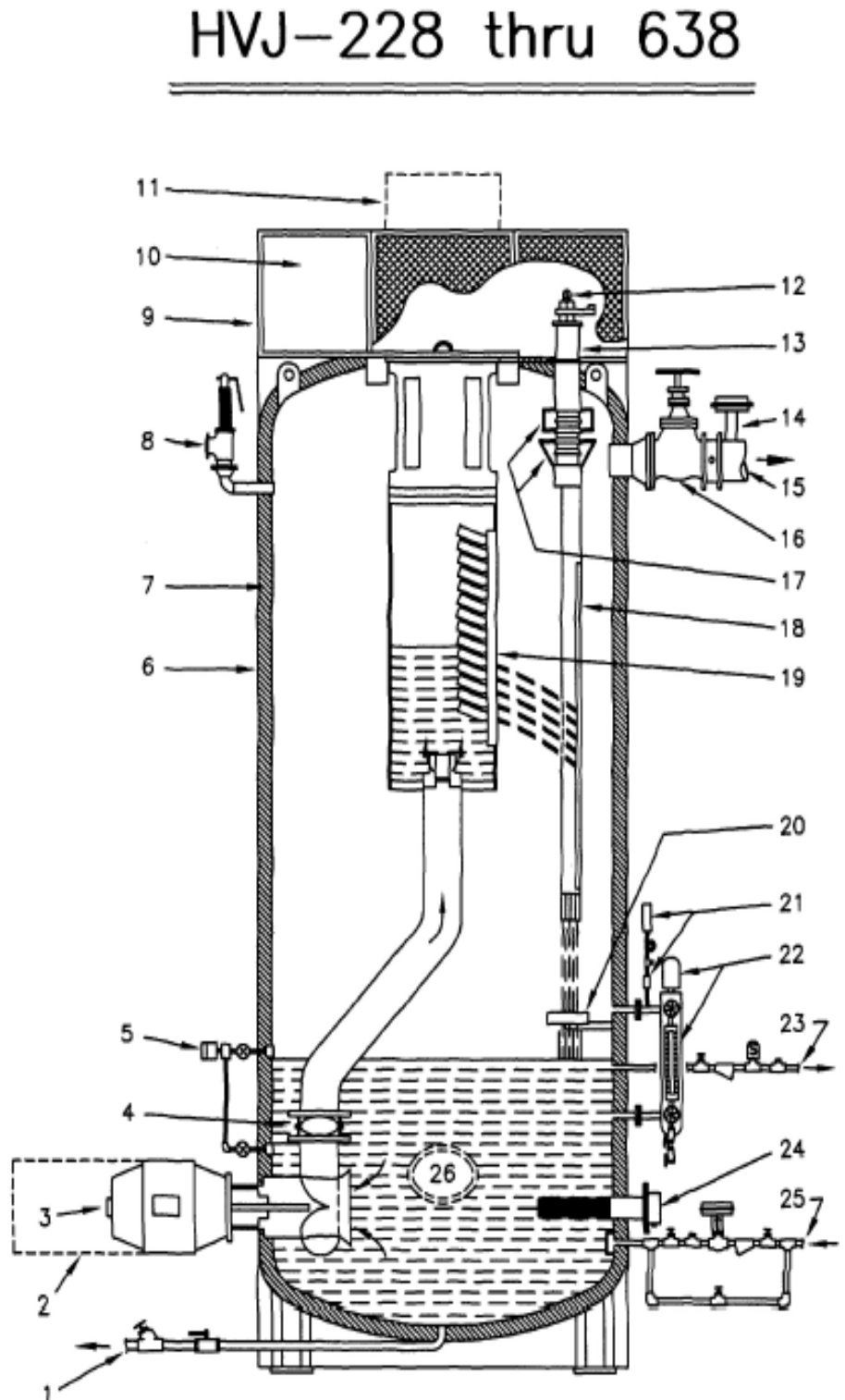


Figure 1b: High Voltage Jet (HVJ) Electrode

Steam Boiler

Figure 1 – Legend

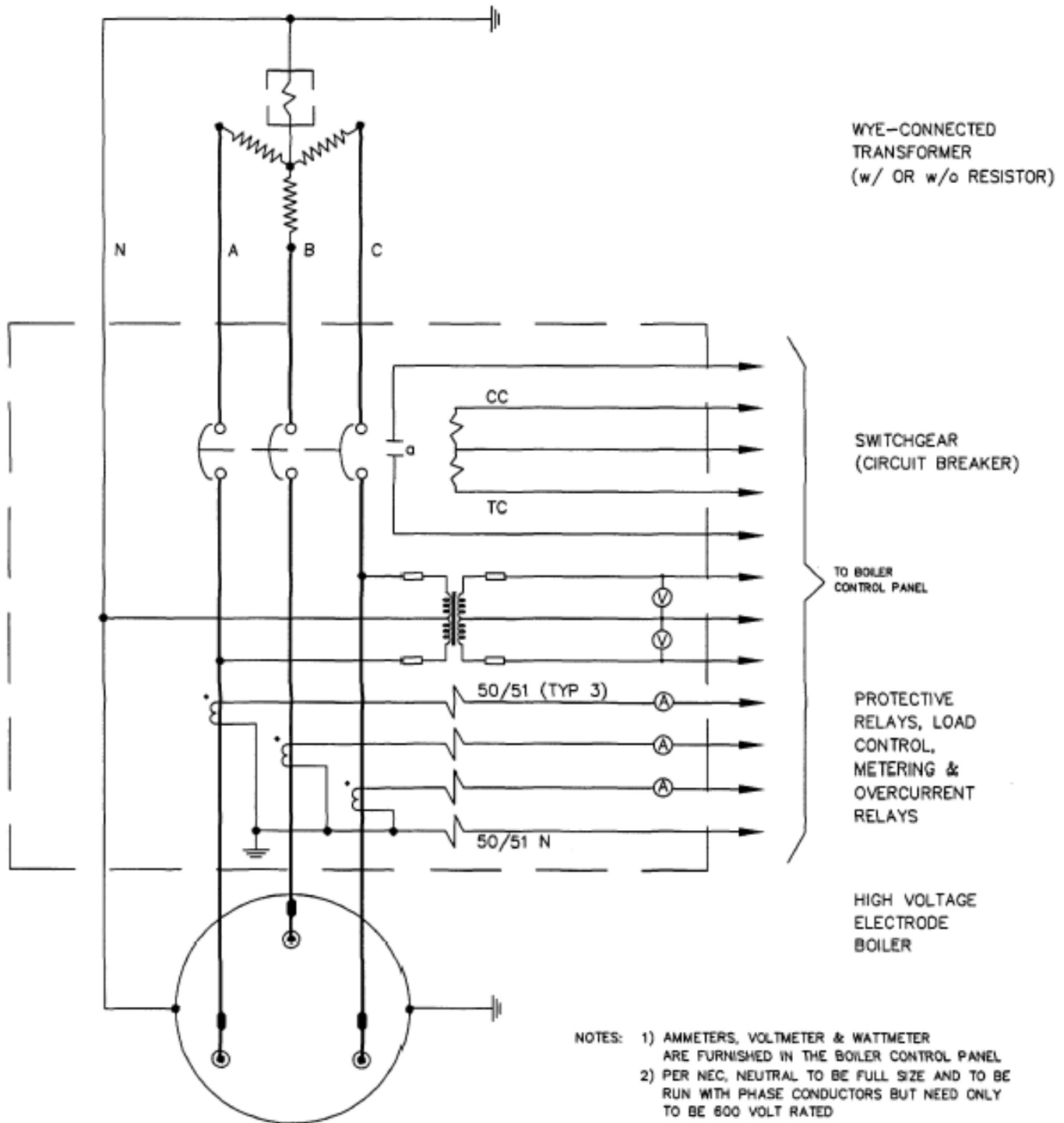
1. Blowdown Valves
2. Pump Removal Clearance
3. Circulation Pump w/ VFD
4. Check valve
5. Conductivity Cell
6. Sheet Metal Enclosure
7. Insulation
8. Safety Valves (2)
9. Electrode Terminal Enclosure
10. Conduit Entrance Panel
11. Header Removal Clearance
12. Conductor Rod
13. High Voltage Insulators
14. Back Pressure Regulator
15. Steam Outlet- 16. Non-Return Valve
- 17. Insulator Shields
- 18. Electrode / Strike Plate
- 19. Nozzle Header
- 20. Counter Electrode
- 21. Pressure Manifold & Gage
- 22. Water Column & Gage
- 23. Surface Blowoff
- 24. Standby Heater
- 25. Feedwater Valve w/ Bypass
- 26. Manhole



**Figure 2: Typical Wiring Schematic**

TYPICAL WIRING SCHEMATIC FOR MODEL 'HVJ' HIGH VOLTAGE ELECTRODE BOILER

## 2.0 HANDLING AND STORAGE



## 2.1 Shipping

### 2.1.1 Boiler

Boiler vessel will be shipped lying on its back supported by temporary shipping support beams. Lifting lugs located on the upper exposed side and top provide pickup points for removal from the container, and for later righting the boilers above their foundation pads.

### 2.1.2 Components

All loose components and trim, and the control enclosure will be shipped in crates and should be handled by a fork truck for removal from the containers.

## 2.2 Storage

Electrical equipment can be damaged if exposed to adverse weather. **The boiler and all accessories should be stored inside with temperatures held at 70°F + 20°F and humidity held to 60% + 20%.** The electrical panel and controls must be covered with plastic throughout all construction to avoid accumulation of dust and moisture on the controls and load components. Relays, contactors and switches can be damaged by dust in the mechanism.

## 2.3 Uncrating

Care must be given not to damage controls or to deform the boiler sheet metal during removal from the container. If using pry bars or forklifts, be certain to support the boiler weight on the temporary shipping skids.

## 3.0 INSTALLATION AND ASSEMBLY

### 3.1 Boiler

#### 3.1.1 Primary Boiler Assembly

##### 3.1.1.1 Setting the Boiler

**3.1.1.1.1** Position boiler in proper location and then shim boiler bearing plates to assure that boiler is plumb using boiler top cover flange as reference.

**3.1.1.1.2** Attach the boiler bearing plates to the floor using the appropriate anchor bolts. The anchor bolt holes are oversized to allow for thermal growth when the boiler is put in operation.

**3.1.1.1.3** Grout the bearing plates to assure boiler remains plumb.

**CAUTION:** Grout beneath bearing plates only to allow some lateral movement per Section 3.1.1.1.2.

##### 3.1.1.2 Top Platform\*

**3.1.1.2.1** Place the two pieces of painted grating within the angle iron supports on top of the boiler.



**3.1.1.2.2** Bolt grating in place temporarily using the appropriate cap screws and flat washers (these bolts will be removed later when mounting the electrode terminal enclosure).

### **3.1.2 Assembly of Internal Components**

#### **3.1.2.1 Bottom Platform\***

**3.1.2.1.1** Place the three remaining pieces of grating upon the support studs on the inside bottom of the boiler. Position so that the pieces are joined together over the support studs.

**3.1.2.1.2** Bolt grating to studs using the appropriate machine bolts and flat washers.

#### **3.1.2.2 Counter Electrodes**

Attach the counter electrodes to the support brackets using the appropriate machine bolts and nuts. Position electrodes with the angle iron brackets facing up.

#### **3.1.2.3 Conductor Rod Assemblies**

Refer to **Figure 3** and to the *Electrode Assembly Drawing Appendix B*.

**3.1.2.3.1** Install upper insulator shields\* into the plates welded to the bushings extended through the top of the tank.

**NOTE:** Upper insulator shields may be lowered later to assure proper location of upper inner insulator gasket.

**3.1.2.3.2** Install (3 each) shorting springs\* (outer) onto the outside face of the (3) bushings extending through the top of the tank using the appropriate machine screws.

**3.1.2.3.3** Assemble (2) shorting springs\* (inner) to each conductor rod using the appropriate machine screws.

**3.1.2.3.4** Screw the conductor rods\* into the coupling nuts and tighten securely.

**NOTE:** It is important that this joint be as tight as possible.

**3.1.2.3.5** Assemble the lower insulator shields\* to the coupling nuts using the appropriate machine screws. Do not tighten at this time.

**NOTE:** From past experience, it has been found to be easier to complete the electrode assembly inside the boiler. Pass the components of the conductor rod assemblies into the boiler through the manhole.

**IMPORTANT:** Avoid touching the silver oxide coating of the thru insulator. It is very important that this surface remains clean.

**3.1.2.3.6** Slip (1 each) 1-3/4" x 3" thru gasket over each conductor rod (DO NOT USE GASKET CEMENT)

**3.1.2.3.7** Slip (1 each) thru insulator over each conductor rod being careful not to disrupt short springs.

**NOTE:** Handle Insulators carefully. Insulators must be free of all grease and oil. To clean insulators, use hot soapy water and a soft brush. Chipped ends are only a concern on the inner steam side (ribbed) insulator. **Do not touch the silver oxide coating on the thru insulator.**

**3.1.2.3.8** Slip (1 each) 4" x 5-5/8" conductive inner gasket over each conductor rod – do not use gasket cement. Make sure groove in coupling nut is free of dirt. Position gasket within the rabbit on the coupling nut.

**3.1.2.3.9** Slip (1 each) inner (ribbed) insulator over each conductor rod.

**IMPORTANT:** Clean coupling nut and bushing in top of boiler prior to assembling insulators.

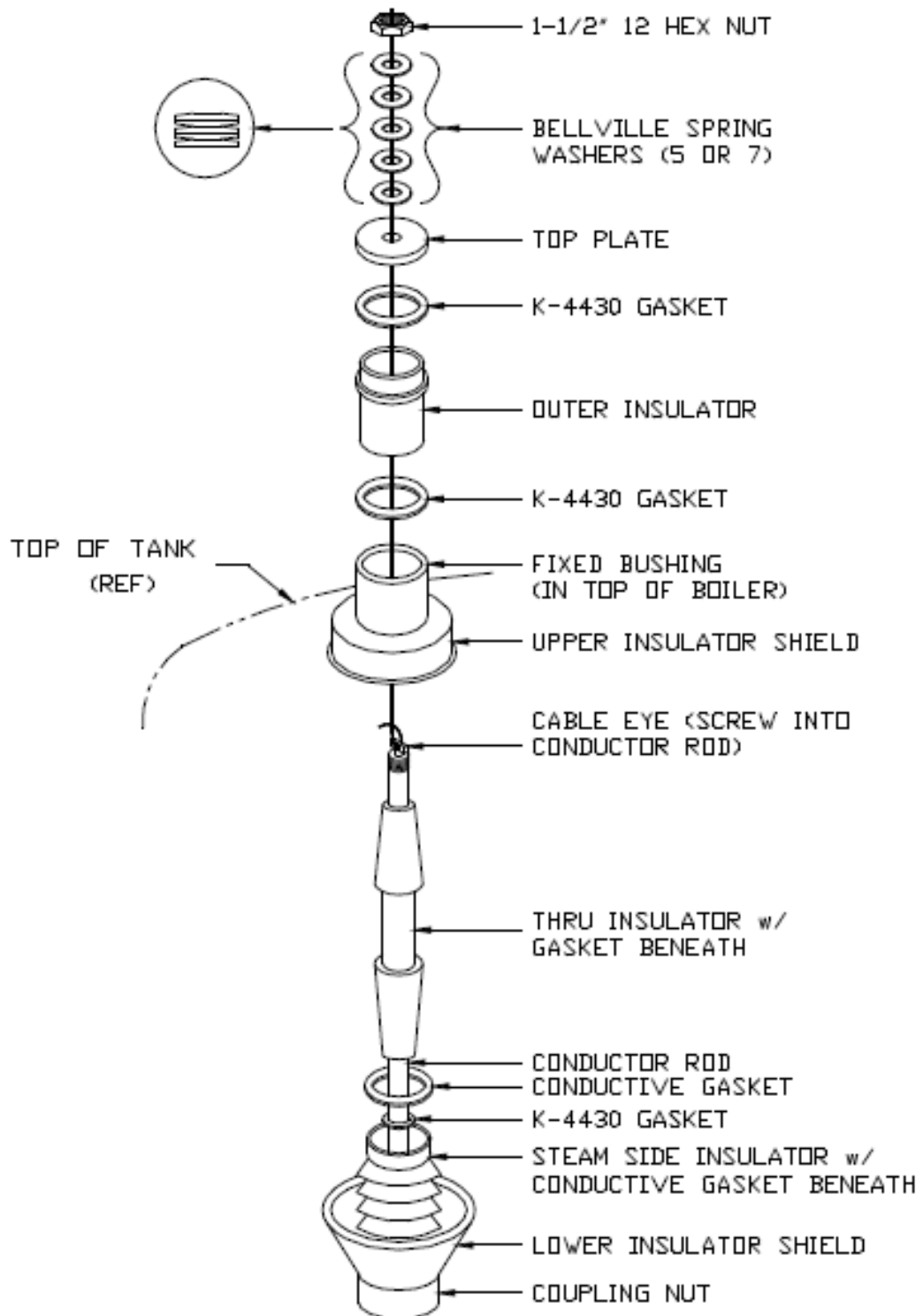
**3.1.2.3.10** While on top of the boiler, thread the 3/16" lifting cable (supplied" through the following items (in order): Refer to *Assembly Installation, Figure 3.*

- 1-1/2 – 12 hex nuts
- (5) Belleville spring washers – first (2) pairs to be opposed as shown on **Figure 3.**
- Top plate
- 4" x 5-5/8" outer gasket
- Outer insulator
- 4" x 5-5/8" outer gasket
- Fixed bushing in top of boiler

**3.1.2.3.11** Screw the lifting hook, attached to the lifting cable, into the end of the conductor rod assembly and hoist assembly up through the tank bushing..

**IMPORTANT:** Exercise care to assure both the safety of the thru insulator and the proper function of the outer shorting springs. Thumb pressure may be required on the shorting springs to guide them during their compression along the insulator surface.

**FIGURE 3 – CONDUCTOR ROD ASSEMBLY INSTALLATION**



**3.1.2.3.12** Screw the 1-1/2 – 12 hex nut onto the conductor rod until it is just snug. Orient the assembly so that the bolt hole in the bottom of the electrode coupling nut closest to the center of the nut faces radially inward.

**3.1.2.3.13** After assuring the proper alignment of all gaskets and insulators, tighten the tie-nut approximately one full turn after hand tight (final tightening instructions to follow).

**3.1.2.3.14** Repeat steps Paragraph 3.1.2.4.11 – 3.1.2.4.14 for the remaining conductor rod assemblies.

**3.1.2.3.15** Adjust the lower insulator shields to that there is 1-3/4" + 1/8" gap between the rings of the upper and lower insulator shields. Tighten securely.

**3.1.2.3.16** Pass the electrodes into the boiler through the manhole. Attached to the coupling nut using the appropriate machine screws and a triangular 3-hole electrode clamp plate.

**3.1.2.3.17** Test the insulating resistance of each bushing with a meggar; each must be at least 1.5 megohms. If a meggar is not available, hi-pot each conductor rod at the phase-to-neutral voltage + 100% for AC, +200% for DC.

#### **3.1.2.4 Nozzle header\***

**3.1.2.4.1** Apply a thin film of non-hardening gasket cement on the inside shoulder of the tank cover flange and then place the appropriate 1/8" top flange gasket on this surface.

**3.1.2.4.2** Hoist the lower part of the nozzle header assembly up and onto the top flange opening. Lower the assembly into the boiler and support assembly on top flange using the rod extending through the header support pipe.

**3.1.2.4.3** Hoist the upper part of the nozzle header assembly up and onto the lower part and orient so that the locating pin in the lower assembly fits into the locating hole in the upper assembly.

**3.1.2.4.4** Join together the two nozzle header assemblies using the appropriate machine bolts as required. Tighten securely.

**NOTE:** If adequate over-head space is available, this assembly may be fitted together at floor level and then hoisted fully assembled to the top of boiler for installation.

**3.1.2.4.5** Using the inside lifting eye, first raise the whole assembly enough to remove the support rod, then lower the assembly into the boiler; orient so that the locating pin in the top plate lines up with the slot in the boiler flange.

**NOTE:** During this step, one needs to be inside the boiler to ensure that the circulation pipe properly slips into the nozzle header.

**3.1.2.4.6** At this time, snug up the bolts fastening the riser pipe to the pump discharge flange.

#### **3.1.2.5 Dimensional Checks**

Before leaving the inside of the boiler, make sure that the critical dimensions comply with those tabulated in *Assembly Dimensions, Figure 4*. A threaded 'T-rod' has been supplied to facilitate

checking the alignment of the electrodes and the distance 'a'. This rod should be screwed into the threaded hole at the bottom of each nozzle plate. The bolts of the electrode fastenings have adequate play (+ 3/4" circumferentially) to correct small deviations in the electrode locations. The electrodes must also be square to the T-rod and plumb to the axis of the nozzle header.

**NOTE:** If the distance 'a' cannot be exactly attained on all electrodes, then the objective is to obtain a distance that is most uniform for all of the electrodes within the tolerance limits per *Assembly Dimensions, Figure 4*.

### **3.1.2.6 Final Tightening**

Being careful not to turn the conductor rod assemblies by using the flats on the top of the conductor rods to prevent rotation, tighten the 1-1/2 – 12 tie rod nuts an additional turn or more to result in a 3/64" (approximately the thickness of a US dime) gap between the edges of the Belleville washers.

### **3.1.3 Assembly of External Components**

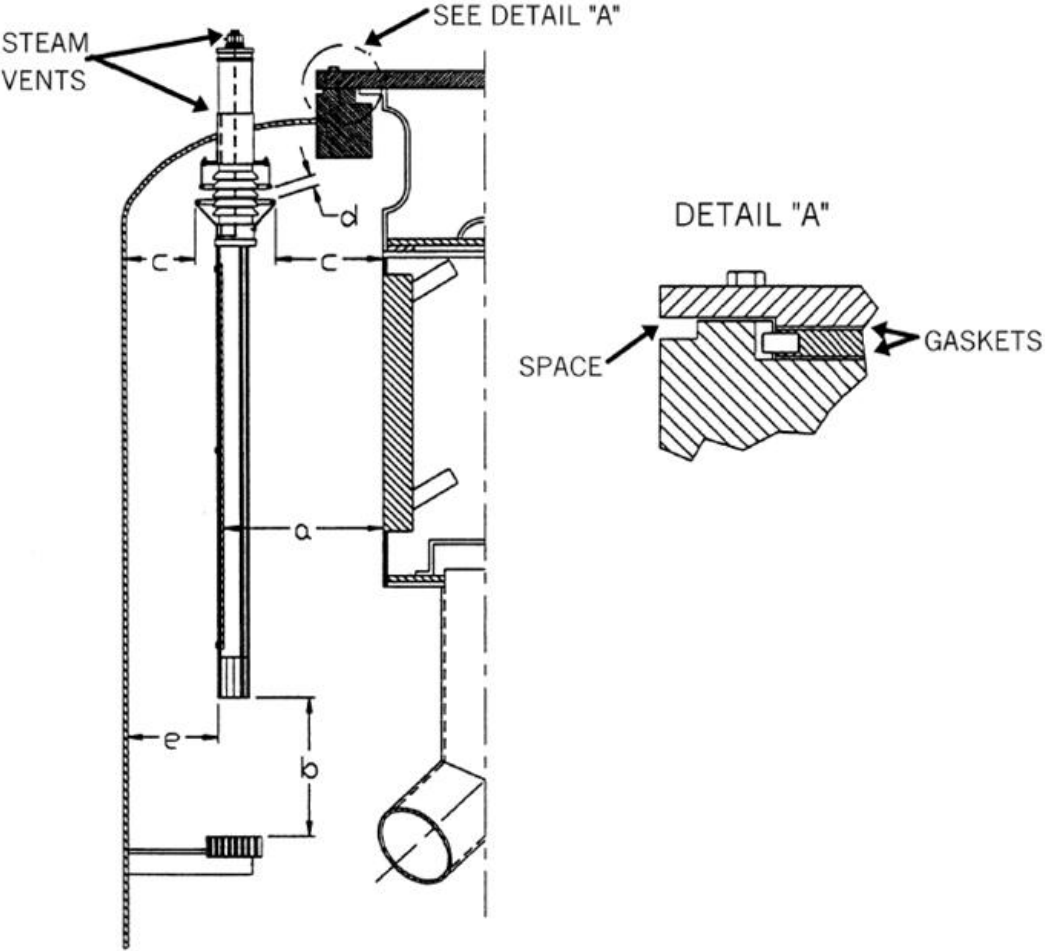
#### **3.1.3.1 Standby Heater\***

**3.1.3.1.1** Locate the standard flange gasket and attach it to the standby heater flange using gasket cement.

**3.1.3.1.2** Apply gasket cement to the standby heater flange and insert the heater into the boiler. Fasten securely using the appropriate machine bolt and hex nuts as required.

**NOTE:** For electric heaters, orient heater so that conduit connection either faces the right or left, depending on the accessibility to the electrical connection.

**FIGURE 4: Assembly Dimensions**



### **3.1.3.2 Circulating Pump(s) (boilers with internal pump(s) only)**

**NOTE:** Exercise caution when handling the circulation pump to prevent damaging the exposed impeller.

**3.1.3.2.1** Screw into the pump flange the (12) 1-8 x 5 – 1/2 mounting studs and tighten securely.

**3.1.3.2.2** Locate the outer pump gasket (18" OD) and fit it to the outer pump flange.

**3.1.3.2.3** Prior to pump installation; ascertain proper rotation per *Lawrence Pumps Operations & Maintenance Manual, Vendor Supplied Material, Appendix E*.

(Note: Impeller unscrews clockwise).

**3.1.3.2.4** Hoist pump assembly using lifting eye on motor and insert into side of tank through flange and fasten securely using the appropriate nuts; make sure pump turns freely and check for uniform impeller clearance from inside the boiler. Torque nuts to 250 ft-lbs.

#### **3.1.3.3 Electrode Terminal Enclosure**

**3.1.3.3.1** Hoist the electrode terminal enclosure onto the angle-iron from the top of the boiler. Orient enclosure so that the solid panel is in the direction from which the high voltage power supply will come

**3.1.3.3.2** At the (4) corners of the octagon under which plates with threaded holes are welded to the T-iron frame, thread the appropriate cap screws into the most accessible holes.

**3.1.3.3.3** Attach the solid panel of the enclosure securely to the T-iron from by drilling holes\* and then bolting the panel to the frame using the appropriate cap screws, washers and hex nuts.

#### **3.1.4 Piping Assembly**

Refer to Boiler *Dimensional Drawing (DD - \_\_\_\_\_)* and P & ID, **Appendix A**.

##### **3.1.4.1 Blowdown\***

**3.1.4.1.1** Per the dimensional drawing, install and connect the bottom blowdown fittings and piping per installation and local code requirements, and pipe to the blowdown tank or separator.

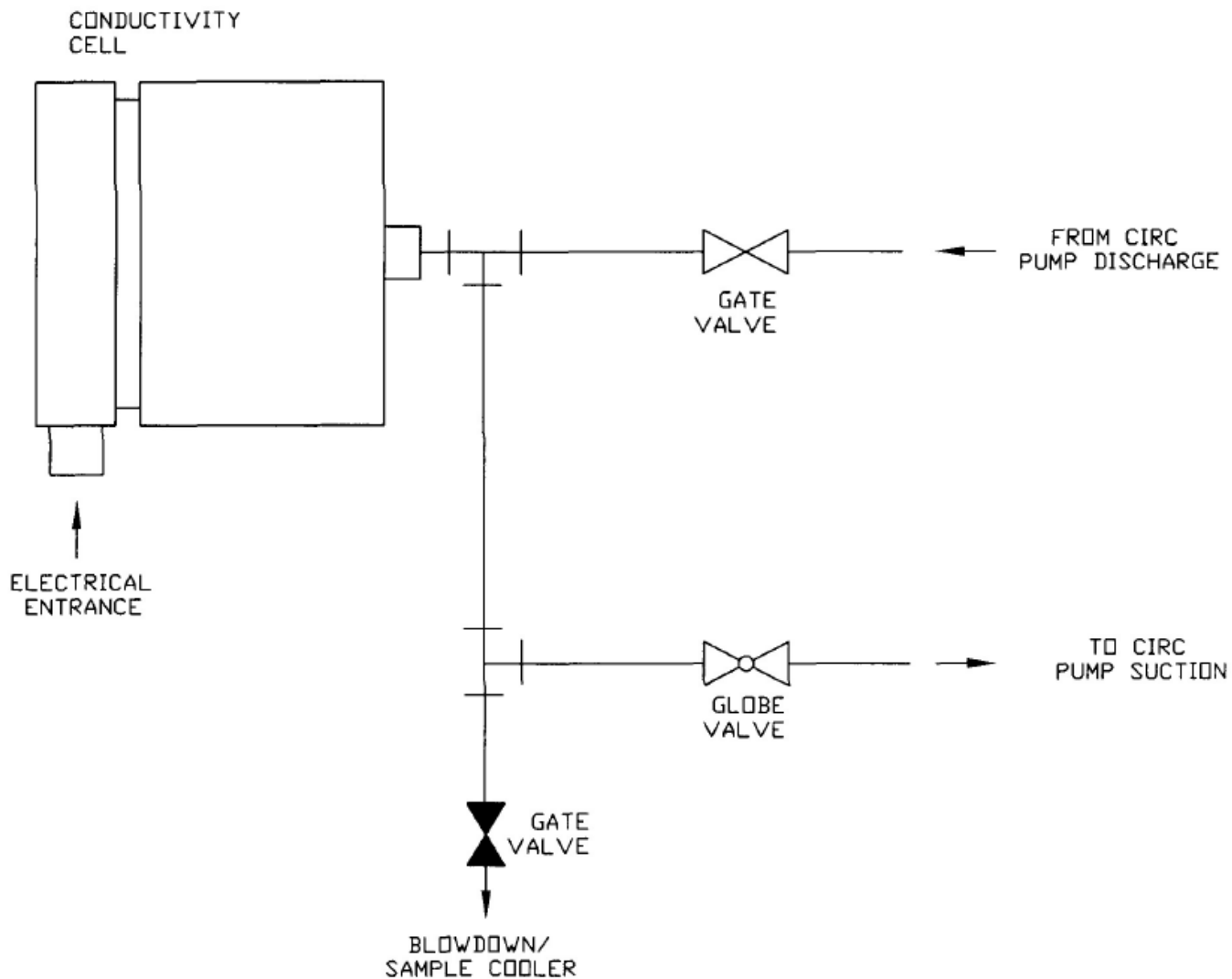
**3.1.4.1.2** Install the surface blowdown fittings (stop valve, strainer, solenoid valve and check valve) per the installation drawing and pipe to the blowdown tank or separator.

**NOTE:** The solenoid valve should be in a horizontal section of pipe with the solenoid oriented vertically up.

##### **3.1.4.2 Conductivity Cell and Sample Cooler\***

Refer to *Conductivity Piping, Figure 5*

**Figure 5: Conductivity Piping**



- 3.1.4.2.1** Using the fittings supplied, attach the pre-piped conductivity cell assembly to the boiler as shown.
- 3.1.4.2.2** Attach the sample cooler to the boiler skin near the conductivity cell.
- 3.1.4.2.3** Pipe the process inlet of the sample cooler to the valve on the conductivity cell drain piping.
- 3.1.4.2.4** Connect cooling water supply to the bottom shell connection of the sample cooler.
- 3.1.4.2.5** Pipe the cooling water discharge to the drain manifold with visible flow provision.



**NOTE:** For boilers operating above 250 psi, the sample water to the conductivity cell must be cooled per the following:

For 250 psi Operating Pressure, 400°F Max Cell Temperature

For 275 psi Operating Pressure, 370°F Max Cell Temperature

For 300 psi Operating Pressure, 340°F Max Cell Temperature

The sample cooler can be used for this purpose with the process discharge used as the supply to the conductivity cell.

### **3.1.4.3 Feedwater**

Refer to *Feedwater Piping, Figure 6*.

**3.1.4.3.1** The feedwater system should be sized to allow for a 10 – 15 psi pressure drop across the modulating feedwater control valve. The pipe size may be 1 or 2 sizes larger than the control valve body size.

**3.1.4.3.2** Pipe the feedwater to the boiler as shown in *Figure 6*. A 3 – valve bypass is recommended as shown. The chemical fill inlet (quill) should be located as close to the boiler as possible.

**3.1.4.3.3** If a feedwater pressure gauge is provided, install it in the feedwater line upstream of the control valve.

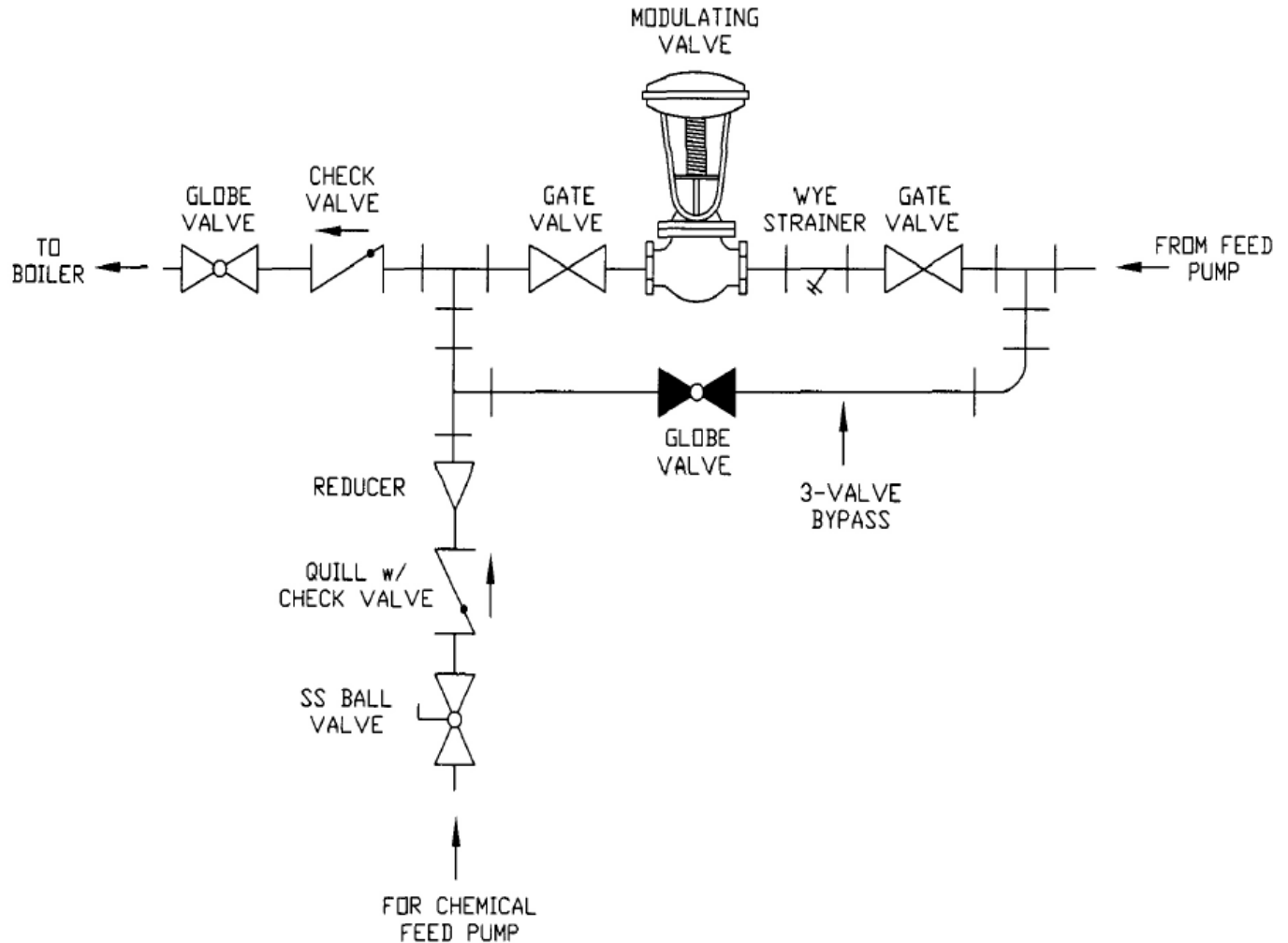
### **3.1.4.4 Water Column and Pressure Sensing Manifold\***

**3.1.4.4.1** Locate the pre-piped pressure sensing manifold and mount it to the top outlet of the water column assembly. Alternately, this assembly may be factory-mounted on a sub-panel to be attached to the boiler sheet metal. In this case, piping must be installed to connect the sensing manifold to the upper water column connection.

**3.1.4.4.2** Mount the water column assembly to the 1" flanges on the boiler using gaskets and the appropriate machine bolts.

**3.1.4.4.3** Screw the drain valve\* into the drain outlet and pipe it to the floor drain.

**FIGURE 6: Feedwater Piping**



**NOTE:** At this time make sure that balancing pendulums (if provided) in both pressure limits indicate that they are level. Make plumbing adjustments if necessary to assure their levelness.

**3.1.4.5 Air Release\***

Install the air release globe valve on the nipple extending from the boiler approx 5' above the floor (this actually runs from the top of the boiler behind the lagging) and pipe to approximately 1" above a drain receiver and in sight of the air release valve.

**3.1.4.6 Circulation Pump Connection\***

Refer to the pump drawing, *Vendor Supplied Material*, **Appendix C**.

**3.1.4.6.1** Using a 1/2" minimum pipe, pipe cooling water to the 1/2" connection for the pump oil and seal cooling. Include the 1/2" flow switch and check ball valves provided in this line. (The flow switch must mount in a horizontal pipe.)

**NOTE:** For ease of pump removal / disassembly, the final connections to the pump should be made with stainless steel tubing.

**3.1.4.6.2** Using 1/2" pipe, pipe the cooling water discharge (upper connection) to the open drain manifold. Include the 1/2" needle valve provided in this line.

**NOTE:** For prolonged seal performance, the cooling water should be both softened and filtered.

### **3.1.4.7 Safety Valves\***

**3.1.4.7.1** Using the pipe fittings required / provided, install the safety valves to the (2) vessel connections per the dimensional drawing.

**3.1.4.7.2** Pipe the safety valve discharges to atmosphere using drip pan elbows per code requirements. The discharge pipe cross-sectional area shall be the total area of the valves discharging thereunto, shall be as short and straight as possible, and shall be carried from running boards and platforms.

### **3.1.4.8 Steam Stop and Check Valves**

Install the stop and check valves on the steam outlet flange per installation requirements.

### **3.1.4.9 Back Pressure Regulator**

Install the backpressure regulator (to be set at slightly below normal operating pressure) in the steam outlet valve train per installation requirements.

### **3.1.4.10 Manual Vent Valve**

If other boilers discharge into a common header, then both a header gate valve and 1" vent valve, located between the gate valve and the non-return or stop valve, are normally required (check local code requirements).

### **3.1.4.10 Auto Vent Valve**

Assemble the automatic vent valve assembly to the 1/2" NPT tapping in the top cover plate.

## **3.1.5 Electrode Assembly**

Refer to Boiler *Electrical Wiring Diagram (WD-\_\_\_\_\_)*, Appendix A.

### **3.1.5.1 High Voltage Wiring**

**3.1.5.1.1** Make the high voltage conduit connection through the solid panel (removable) on the electrode terminal enclosure.

**3.1.5.1.2** Using the appropriate cop screw and star type lock washer, attach an equipment ground lug (minimum size per electrical schematic) to the NEMA ground pad on the base of the boiler (2 provided).

**3.1.5.1.3** Using the appropriate cap screw a star-type lock washer, attach a neutral lug to one of the tapped holes in the boiler cover plate. This will be used later for the grounded conductor (neutral).

**3.1.5.1.4** Attach one bus bar to each electrode terminal.

**CAUTION:** When tightening the jam nuts, do not allow the conductor rod assembly to turn. Hold conductor rod via flatted sides at top.

**3.1.5.1.5** Attach phase conductors to each electrode terminal per installation requirements. Route the wires to facilitate later installation requirements. Route the wires to facilitate later

installation or removal of the boiler cover plate, and so that they do not come in contact with hot boiler surfaces.

**NOTE:** If complete assembly is to be meggered, refer to Paragraph 3.1.2.4.18.

### **3.1.5.2 Control Wiring**

**3.1.5.2.1** Anchor the control cabinet to the floor per installation requirements.

**3.1.5.2.2** Run the 480 VAC branch circuit to the boiler control cabinet per the electrical schematic.

**3.1.5.2.3** Attach an equipment ground (minimum size per the wiring schematic) to the grounding lug in the control enclosure.

**3.1.5.2.4** Make the field wiring connections between the control cabinet and the external electrical components per the wiring drawing. Use AWG #14 wire minimum (except for 480 Volt circuitry) and shielded control cables. For shielded wire cables, use the AWG #20 multi-conductor cable as provided. The shields should be terminated at one end only.

### **3.1.5.3 Grounding**

After completing the above electrical connections, be certain that the following components are solidly grounded:

- Boiler enclosure
- Circulation pump motor casing
- Control cabinet

### **3.1.6 Pneumatic Assembly**

Refer to Boiler Loop Diagram (\_\_\_\_ - **LOOP**), Appendix B.

#### **3.1.6.1 Feedwater Control Valve\***

Install the assembled air loader, filter, and gauge assembly to control air supply (1/4" NPT / 35 psi min) and tube (3/8" OD copper tubing min. – typical for all tubing) to the 'Supply' port of the feedwater valve positioner.

## **3.2 Feedwater Pumps**

Install the feedwater pumps per the *P & ID* and the respective Operation & Maintenance Manual located in *Vendor Supplied Material, Appendix C*.

**NOTE:** Most boiler feed pumps require a relief valve or orifice with a bypass loop back to the feedwater receiver. Check the requirements of the specified feed pump being used.

**NOTE:** Make certain that the continuous recirc / vent connection is made at the top of the pump stack. This will eliminate the accumulation of air at the top of the pump.

**NOTE:** Schedule 80 pipe should be used for the pump discharge piping (check with local code requirements).

### **3.3 Blowdown Tank**

#### **3.3.1 Erection**

**3.3.1.1** Position the blowdown tank in its proper position and then shim the bearing plates to assure the tank is plumb using the vessel sides as reference.

**3.3.1.2** Attach bearing plates to the floor using the appropriate anchor bolts.

**3.3.1.3** Grout the bearing plates to assure the tank remains plumb.

#### **3.3.2 Assembly of External Components**

Refer to Blowdown *Dimensional Drawing (DD-)*, Appendix A.

##### **3.3.2.1 Gauges\***

Install the temperature, pressure and sight gauges in their proper location.

##### **Valves\***

Install the cold-water quench and drain valves in their proper location.

### **3.4 Electrolyte Feed System**

#### **3.4.1 Erection**

**3.4.1.1** Position the electrolyte feed system in its proper location and then shim the bearing plates to assure the tank is plumb using the vessel sides as reference.

**3.4.1.2** Attach the bearing plates to the floor using the appropriate anchor bolts.

**3.4.1.3...**Grout the bearing plates to assure the system remains plumb.

#### **3.4.2 Assembly of External Components**

Refer to *Electrolyte Feed Dimensional Drawing (DD-\_\_\_)*, Appendix A.

##### **3.4.2.1 Make-Up Valve\***

Install the make-up valve to the open fitting on the upper part of the tank.

##### **3.4.2.2 Agitator\***

Clamp the agitator to the C-channel extension.

#### **3.4.3 Piping Assembly**

##### **3.4.3.1 Make-up Water**

Pipe make-up water to the make-up globe valve previously installed.

##### **3.4.3.2 Discharge**

Pipe the pump discharge to the boiler quill assembly per the Piping Layout Drawing using stainless steel pipe or tubing.

##### **3.4.3.3 Drain**

Run a drain line from the tank drain valve to a suitable floor drain.

#### **3.4.4 Electrical Connection**

Refer to *Electrolyte Feed Wiring Diagram (WD-\_\_\_)*, Appendix A.

Wire the electrolyte feed system to the boiler control cabinet per the referenced wiring diagram.

### **3.5 Chemical Feed System**

#### **3.5.1 Erection**

**3.5.1.1** Position the chemical feed system in its proper location and then shim the bearing plates to assure the tank is plumb using the vessel sides as reference.

**3.5.1.2** Attach the bearing plates to the floor using the appropriate anchor bolts. Grout the bearing plates to assure the system remains plumb.

#### **3.5.2 Assembly of External Components**

Refer to *Chemical Feed Dimensional Diagram (DD-\_\_\_\_)*, **Appendix A**.

##### **3.5.2.1 Make-Up Valve\***

Install the make-up valve to the open fitting on the upper part of the tank.

##### **3.5.2.2 Agitator\***

Clamp the agitator to the C-channel extension.

#### **3.5.3 Piping Assembly**

##### **3.5.3.1 Make-Up Water**

Pipe make-up water to the make-up globe valve previously installed.

##### **3.5.3.2 Discharge**

Pipe the pump discharge to the boiler quill assembly per the Piping Layout Drawing using stainless steel pipe or tubing.

##### **3.5.3.3 Drain**

Run a drain line from the tank drain valve to a suitable floor drain.

#### **3.5.4 Electrical Connection**

Refer to *Chemical Feed Wiring Diagram (WD-\_\_\_\_)*, **Appendix A**.

Wire the chemical feed system to the boiler control cabinet per the referenced wiring diagram.

## **4.0 OPERATION**

### **4.1 Preliminary Checks and Adjustments**

#### **4.1.1 Boiler**

##### **4.1.1.1 Pressure Check**

**4.1.1.1.1** Place the top cover on the boiler using a thin film of non-hardening gasket cement on both sides of the appropriate gasket (this cover will be removed later to permit observation of the water flow pattern).

**4.1.1.1.2** Fasten the cover down using the appropriate high stress hex nuts.

**4.1.1.1.3** Install the manhole cover.

**4.1.1.1.4** Install gags on the safety valves or, alternatively, blanking plates (pans) in the safety valve connections.

**4.1.1.1.5** Tightly close valves farthest from the boiler on all valve trains intended to be pressurized.

**4.1.1.1.6** Perform a hydrostatic test on the entire system. Use the pipe plug on the boiler top cover as a vent and, if the steam outlet train is included in the test, use the 1" vent valve to vent the steam outlet train.

**4.1.1.1.7** Drain water from boiler and remove safety valve gags or pans.

**4.1.1.1.8** Refill boiler to proper water level (+1").

**4.1.1.2 Electrical Checks**

**4.1.1.2.1** Switch on the 480VAC power to the control console.

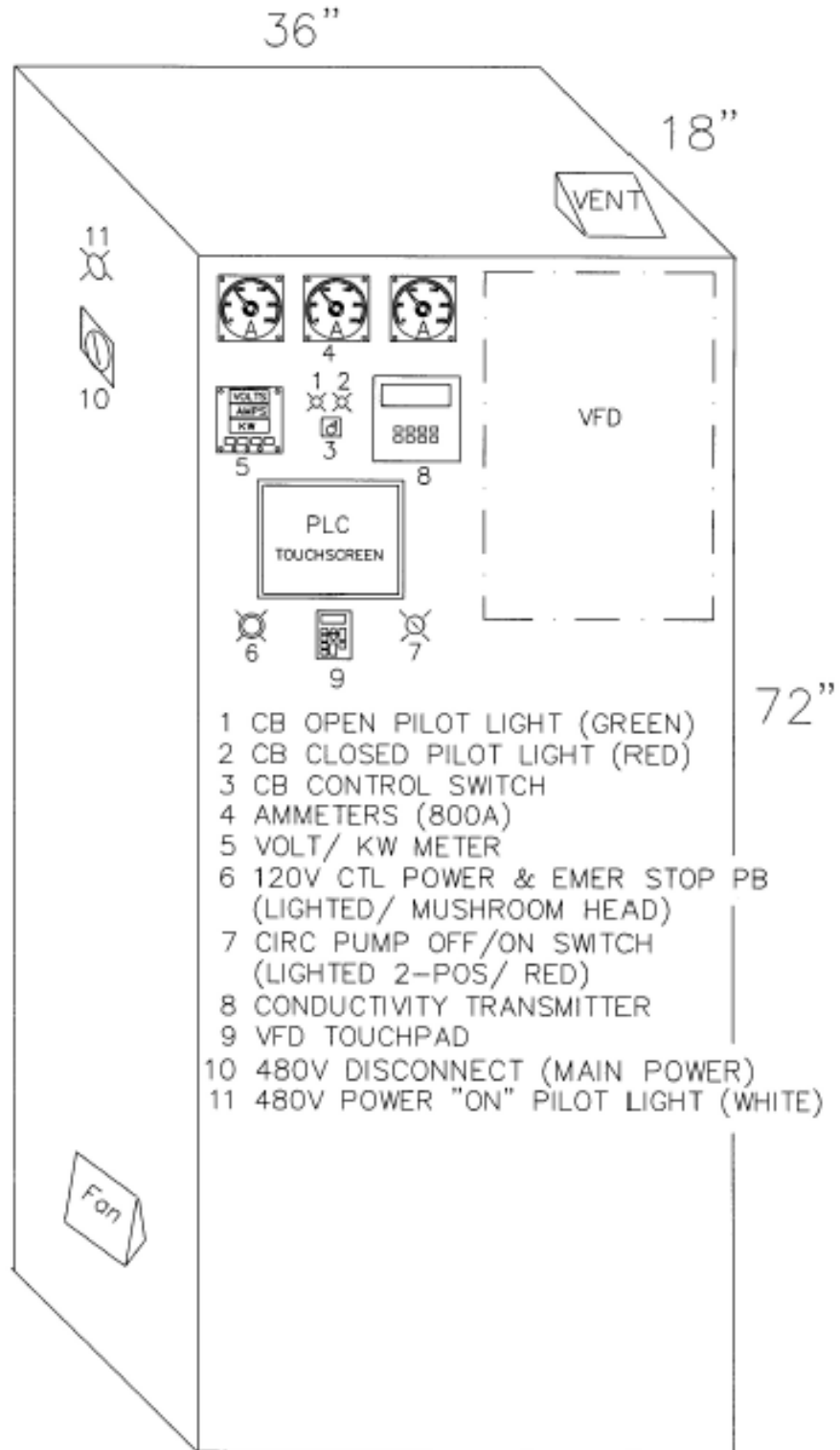
**4.1.1.2.2** Switch on the 480VAC 'CONTROL POWER' at the control panel. The '480VAC On' (amber) light should illuminate.

**4.1.1.2.3** Switch on the '120VAC' power at the control panel. The audible alarm (if provided) should sound and the following should light:

(Refer to *Control Panel, Figure 7.*)

- 120VAC 'CONTROL POWER' Lighted Switch
- High Voltage Switchgear 'Open' Pilot Light
- Touch screen Panel (HMI)
- Conductivity Control

**Figure 7 CONTROL PANEL**





- 4.1.1.2.4** Silence the audible alarm by pushing the 'alarm silence' button. (HMI)
- 4.1.1.2.5** Attempt to reset the alarms by depressing the 'reset' button on the HMI. All alarm points should reset except low water.
- 4.1.1.2.6** Circulation Pump
- 4.1.1.2.6.1** Check that the pump turns freely by hand and that the gland cooling water is turned sufficiently on (approx 1.5 gpm).

**NOTE:** The pump will not operate unless at least 0.5 gpm of cooling water is flowing. Cooling water discharge temperature should be approx. 110°F.

- 4.1.1.2.6.2** Select the 'HAND' mode at the VFD unit and decrease output (speed) to 0.
- 4.1.1.2.6.3** Switch the 'CIRCULATION PUMP' pilot switch to 'ON/AUTO' – the red 'PUMP ON' pilot light should not light (the high voltage switchgear must be closed for normal pump operation).
- 4.1.1.2.6.4** Enable the password protected 'SWITCHGEAR INTERLOCK OVERRIDE' by pressing the 'CIRCULATION PUMP' button (HMI) and pressing the 'SWITCHGEAR BYPASS' (HMI). Enter the code and press enter – the red 'PUMP ON' symbol should light on the touchscreen.
- 4.1.1.2.6.5** If not previously done, check proper rotation of the circulation pump. From the VFD unit, barely increase output (speed) to check for correct pump rotation.

**CAUTION:** Reverse rotation could cause impeller to unscrew and jam against the pump casing with possible motor damage resulting.

#### **4.1.1.3 Water Flow Check & VFD Characterization**

- 4.1.1.3.1** Remove boiler top cover.
- 4.1.1.3.2** Using the VFD hand / auto station and with the switchgear interlock in the 'BYPASS' position observe, from the top of the boiler, the water flow at various pump speeds through the 'windows' in the nozzle header extension. The water jets should be a solid stream with minimal spray, and should impinge the strike plates in the middle (+ 1/2"). If the jet streams are more than 1/2" off center, the electrode must be adjusted circumferentially at its attachment to the coupling nut.
- 4.1.1.3.3** Characterize the VFD's by establishing the no-flow speed for pump operation. The full flow operation is when water just reaches the top nozzle.

**NOTE:** Refer to the VFD Operation and Maintenance Manual, Vendor Supplied Material, Appendix C, on how to characterize.

- 4.1.1.3.4** Replace boiler top cover (with gasket) and tighten bolts.
- 4.1.1.4 Standby Heater**

**4.1.1.4.1** The standby heater pressure control (HMI) should be set at 50 psi with a differential setting of approximately 10 psi.

**4.1.1.4.2** Depress the standby heater 'ON' button (HMI). The standby heater symbol should light (red).

**NOTE:** The standby heater 'red' symbol will not light if either the boiler pressure is above the standby heater set point or the low water alarm is not reset.

#### **4.1.1.5 Pneumatic Checks**

**4.1.1.5.1** Check that operating air is available at the boiler feedwater control valve and adjust the air set to a pressure of 35 psi.

**4.1.1.5.2** Check that operating air is available at the boiler back-pressure control valve and adjust the operating air to 35 psi.

**NOTE:** Refer to the appropriate Operation and Maintenance Manual, Vendor Supplied Material, Appendix C, if the valve controls malfunction or require adjustment.

#### **4.1.1.6 Conductivity Control System**

The Conductivity control menu is accessed by pressing the Conductivity display button (HMI), then pressing the 'ON' button (HMI).

Refer to the Conductivity Analyzer Operation and Maintenance Manual, *Vendor Supplied Material, Appendix C, for information on the conductivity control used relative to adjustment and calibration procedures.*

**4.1.1.6.1** Check the alarm point settings by accessing the menus in the conductivity controller. The high alarm set point is factory set at 2000 umho. Above the high set point, the Blowdown solenoid valve should be energized. Below the low set point, the electrolyte feed circuit should be energized.

**4.1.1.6.2** Select the 'AUTO' mode for the 'SURFACE BLOWOFF' function (HMI). The red light (on the Surface Blowoff Valve symbol) should not illuminate since the conductivity is well below the factory preset limit.

**4.1.1.6.3** Select the 'HAND' mode for the 'SURFACE BLOWOFF' function (HMI). The red light (on the Surface Blowoff Valve symbol) should illuminate and the solenoid valve at the boiler should energize.

**4.1.1.6.4** Select the 'AUTO' mode for the 'ELECTROLYTE FEED PUMP' function (HMI). The red light (on the Electrolyte Feed Pump symbol) should illuminate and the pump will turn on if power is available to the electrolyte feed system, since conductivity is well below the preset level.

#### **4.1.1.7 Historic Data Acquisition**

From the HMI 'HOME' screen, touch the 'HISTORY' button. The history can be viewed for all listed parameters for the past several weeks by using the arrow keys to scroll.

#### **4.1.1.8 Water Level Switches**

**4.1.1.8.1** With the boiler empty, depress the 'HIGH WATER' 'RESET' button (HMI). The 'HIGH WATER' alarm should clear.

**4.1.1.8.2** Depress the 'LOW WATER' 'RESET' button (HMI). The 'LOW WATER' alarm should clear.

- 4.1.1.8.3** Manually fill the boiler to normal water level (center of the sight gauge).
- 4.1.1.8.4** Depress the 'LOW WATER' 'RESET' button (HMI). The 'LOW WATER' alarm should clear.
- 4.1.1.8.5** Manually fill the boiler above normal water level. The 'HIGH WATER' should alarm when the water level reaches the set limit.
- 4.1.1.8.6** Manually blow down the boiler below the normal water level – 'LOW WATER' should alarm when the water level reaches the set limit.

#### **4.1.1.9 Conductivity Cell**

Check that the (2) conductivity cell flow valves are open. The globe type flow valve on the discharge should be opened one turn only to maintain positive pressure on the cell to preclude the cell from becoming vapor-locked.

#### **4.1.1.10 Pressure Settings**

**4.1.1.10.1** Pressure Limit Cutout – Manual Reset (located on control manifold near the pressure gauge). This switch is normally set to trip the circuit breaker at a pressure 5% less than the lowest safety valve set pressure. This switch has a button located on the top of the switch.

**4.1.1.10.2** Pressure Limit – Auto Reset (located on the control manifold near the pressure gauge). Set the pressure limit at approximately 10% below the lowest safety valve set pressure.

#### **4.1.1.10.3 Standby Heater**

The standby heater is set via the HMI. Pressing the Standby Heater symbol will pop up a set point menu. This pressure is normally set at 50 psi (+ 5 psi).

#### **4.1.1.11 Kilowatt & Pressure Control**

The HMI touch screen accesses all set points, PID parameters, and automatic / manual functions. The back-pressure control valve is controlled by the lower output signal (low select) of the boiler pressure and kilowatt limit. The circulation pump is controlled by the boiler pressure.

#### **4.1.1.11.1 Back-pressure Control Valve**

Pressing the Back-pressure Control Valve (BCV) symbol on the HMI will pop up a screen that contains both the boiler pressure and MW limit set points. Pressing the set point display box will pop up a keypad or pressing the arrows will increase or decrease the set points incrementally. PID settings are password protected and can be changed by pressing the 'PID' button. Pressing the 'AUTO / MANUAL' button will cycle the control of each loop from AUTO to MANUAL. Pressing the 'OFF' BUTTON will stop all output.

#### **4.1.1.11.2 Circulation Pump Control**

Pressing the Circulation Pump symbol (CP) on the HMI will pop up a screen that allows the set point to be changed. Pressing the set point display box will pop up a keypad or pressing the up / down arrow keys will allow the set point to be changed. PID settings are password protected and can be changed by pressing the 'PID' button. Pressing the 'AUTO / MANUAL' button will cycle the control of each loop from AUTO to MANUAL. Pressing the 'OFF' button will stop all output.

#### **4.1.1.12 Cleaning Boiler Interior**

Prior to start-up, the boiler interior should be thoroughly cleaned to remove oil, mill scale and other construction and installation contaminants. A commercial boiler 'Boil Out' compound should be used, per their procedure, with the boiler completely flooded. In lieu of a

commercial boil out compound, the following mix of chemicals can be used for every 250 gallons of water:

- 30 lbs. tri-sodium phosphate ( $\text{Na}_3\text{PO}_4$ )
- 5 lbs. caustic soda ( $\text{NaOH}$ )
- 2 lbs. ordinary detergent

These chemicals should be dissolved in warm water prior to their addition to the boiler. The boil out can be accomplished per the following procedure:

- 1) Remove all tools, rags, etc. from the boiler. Remove boiler top cover.
- 2) Fill boiler to just below the manhole with feedwater.
- 3) Add the chemical solution.
- 4) Close manhole.
- 5) Fill boiler until water level is at the top of electrodes (IE: below coupling nut).
- 6) Operate standby heater to raise temperature.
- 7) Upon achieving 210°F water temperature, operate circulation pump in manual mode, with speed at approximately 600 rpm, for about 5 minutes.
- 8) Allow boiler to boil for 3 hours minimum, 24 hours maximum.
- 9) Repeat instructions number 8.
- 10) Drain boiler.
- 11) Open manhole.
- 12) Rinse all walls and surfaces thoroughly with a garden hose.

#### **4.1.2 Condensate Feedwater System**

N/A (Supplied by others)

#### **4.1.3 Feedwater Pumps**

Refer to the appropriate manufacturer's O & M Manual provided in **Appendix C**.

- 4.1.3.1** Make sure the pumps are flooded and that the orifice isolation valves are open.
- 4.1.3.2** Check that the pumps turn freely by hand and are properly aligned.
- 4.1.3.3** Make sure the pump control switches are in the 'OFF' position.
- 4.1.3.4** Close the 480v disconnect to the feedwater pump control panel.
- 4.1.3.5** 'Bump' the feedwater pumps individually by briefly switching their pilot switches to 'HAND' – the red 'PUMP ON' pilot lights should light momentarily.
- 4.1.3.6** Correct the pump rotation if reverse.

#### **4.1.4 Blowdown Tank**

Pressure Check

**4.1.4.1** Place blanking plates (pans) between the vent flanges and outlet (discharge) flanges.

**4.1.4.2** Close blowdown tank quench and drain valves, and boiler blowdown valves.

**4.1.4.3** Perform hydrostatic test at 75 psi on the entire system.

**NOTE:** Loosen the vent flange bolts to vent air from the tank.

**4.1.4.4** Drain water from the tank and remove flange blanking plates (pans).

#### **4.1.5 Electrolyte Feed System**

##### **4.1.5.1 Pressure Check**

**4.1.5.1.1** Close the ball valve upstream of the boiler quill.

**4.1.5.1.2** Remove the pump discharge relief valve and use this connection for hydrostatic test connection.

**4.1.5.1.3** Perform a hydrostatic test at 75 psi on the electrolyte feed discharge line. Use the ball valve at the boiler quill as a vent.

**4.1.5.1.4** Drain discharge line and re-install relief valve.

#### **4.1.6 Chemical Feed System**

##### **4.1.6.1 Pressure Check**

**4.1.6.1.1** Close the ball valve upstream of the boiler quill.

**4.1.6.1.2** Remove the pump discharge relief valve and use this connection for hydrostatic test connection.

**4.1.6.1.3** Perform a hydrostatic test at 75 psi on the chemical feed discharge line. Use the ball valve at the boiler quill as a vent.

**4.1.6.1.4** Drain discharge line and re-install relief valve.

##### **4.1.6.2 Electrical Checks**

**4.1.6.2.1** Make sure local control switches are in the 'OFF' position, and then switch 'ON' the 120VAC 'POWER SUPPLY' at the boiler control panel (HMI).

**4.1.6.2.2** Check that the 120VAC is available at the chemical feed control panel.

## **4.2 Start-Up Procedure**

### **4.2.1 Boiler**

**CAUTION:** The possibilities of 'arcs' in the boiler can be minimized if the following points are heeded:

- Avoid sudden pressure drops.
- Do not allow water conductivity to exceed the value required for maximum boiler output by more than 10%.
- Do not add any chemicals to a shutdown boiler since water conductivity is also a function of temperature.

- Be sure boiler is free of organic or other substances which could cause foaming inside the boiler
- Limit iron content in boiler water to less than the recommended maximum of 2.0 ppm.

#### **4.2.1.1 Start-Up From a Hot Condition (NORMAL START-UP)**

**4.2.1.1.1** Check that both the air release and stream valve are fully closed, and that the cooling water to the pump stuffing box is sufficiently open.

**4.2.1.1.2** To minimize the possibility of arcs, it is always best to start the boiler from the hot condition (50 psig or greater).

##### **4.2.1.1.2.1 Standby Heater**

It is best to start the boiler using the standby heater to bring the boiler up to 50 psi.

##### **4.2.1.1.2.2 Existing Steam Source**

It is possible to bring the boiler above 50 psi by bleeding steam in from another source while circulating the water with the high voltage switchgear open. This starting method, while being appreciably more rapid than the previous method, also requires more attention than when using the standby heater.

**4.2.1.1.3** Upon attaining 50 psi boiler pressure, carefully open the air release valve until all of the entrapped air is blown out. (IE: until steam is present).

**4.2.1.1.4** Set the kW limit (HMI) to the desired limit.

**4.2.1.1.5** Check that the 'SWITCHGEAR INTERLOCK OVERRIDE' switch is in the 'NORMAL' position (HMI), and that the circulation pump pilot switch is 'OFF'.

**4.2.1.1.6** Close the high voltage switchgear using the CB control switch.

**4.2.1.1.7** Select the 'manual' mode at the pressure control (HMI) and set the output to 0%.

**4.2.1.1.8** Switch the 'CIRCULATION PUMP' pilot switch 'ON' – the red 'POWER ON' should light and the pump should start.

**NOTE:** Pump cavitation is probable when there is rapid drop in the boiler pressure. For occurrence of cavitation from a rapid loss of boiler pressure, switch to "MANUAL" pressure control and decrease the output (pump speed) until flow (output) is re-established. Manually bring the boiler up to pressure and then switch to 'AUTO' operation.

**4.2.1.1.9** Through manual speed control (HMI), attempt to bring the boiler up to the appropriate operating pressure.

**NOTE:** The boiler output at this time is wholly dependant on the conductivity of the boiler feedwater and could realistically be immeasurable.

**NOTE:** As a rule of thumb, in bringing the boiler up to operating pressure, manually adjust the output so that its percentage numerically equals or is slightly less than the boiler pressure.

**4.2.1.1.10** If after 30 minutes, the boiler fails to reach normal operating pressure, switch 'ON' the power supply to the electrolyte feed pump (HMI) and allow chemicals ( $\text{NA}_3\text{PO}_4$  is recommended mixed at approximately 20 lbs. / 25 gal) to enter the boiler.

**NOTE:** If the chemical connection is in the feedwater line, manual blowdown may have to be effected to permit the entrance of feedwater into the boiler.

**IMPORTANT:** No foaming chemical may be added to the boiler for any reason! This includes Amines and 'anti-foam' chemicals.

**4.2.1.1.11** When the boiler reaches normal operating pressure, switch the pressure control to the 'AUTO' mode (HMI) and gradually open the steam outlet valve.

**NOTE:** It is preferred to slightly exceed the operating set pressure before switching to the 'AUTO' mode to permit a bumpless transfer.

**4.2.1.1.12** With the pump at maximum flow speed, full rated boiler output should be attained.

**NOTE:** The conductivity control is factory set at approximately the correct value for the rated boiler output. Although the control has automatic temperature compensation, the control may have to be calibrated to correct for actual water composition. A portable conductivity sensor should be used for a periodic 'bench test' to assure proper calibration of the conductivity control. Refer to HVJ Characteristic Curve, **Figure 8**, for the approximate pump characteristic curve to aid in properly setting the conductivity control for boiler operation at less than full output. Refer to the conductivity controller Operation and Maintenance Manual, Vendor Supplied Material, **Appendix C**, if the conductivity control requires further adjustment.

#### **4.2.1.2 Start-Up from a Cold Condition (EMERGENCY START-UP)**

**NOTE:** This procedure is not recommended except in an emergency requiring a quick start-up.

**4.2.1.2.1** Close all valves leading to and from the boiler.

**4.2.1.2.2** Check that the cooling water to the pump stuffing box is sufficiently open.

**4.2.1.2.3** Open the air release to assure no vacuum, and then re-close.

**4.2.1.2.4** If boiler is empty, fill the boiler to normal water level – this should raise the boiler pressure to 10 – 15 psig.

**4.2.1.2.5** Close the high voltage switchgear.

**4.2.1.2.6** Decrease the output to the VFD using the 'MANUAL' mode at the HMI.

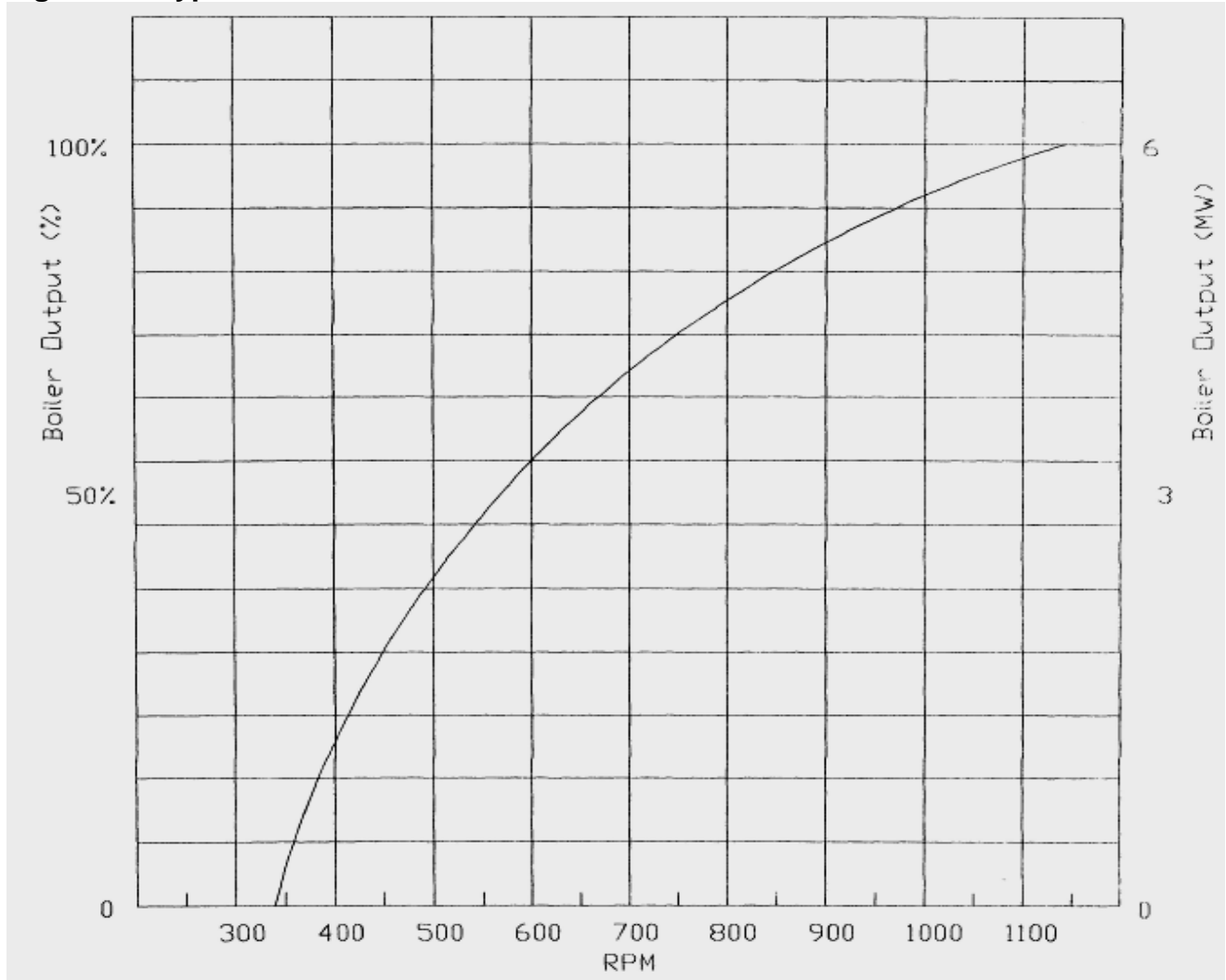
**4.2.1.2.7** Start the circulation pump (HMI).

**IMPORTANT:** In bringing the boiler up to pressure from a cold state, the pump speed should never exceed 20% of its no-flow speed until the boiler pressure is observed to increase and the air is released from the boiler.

**4.2.1.2.8** When the boiler has risen to approximately 50 psi, bleed the entrapped air off through the air release.

**4.2.1.2.9** Proceed per **Sections 4.2.1.1.4 – 4.2.1.1.12**.

**Figure 8: Typical HVJ Characteristic Curve for a 6 MW Rated Boiler**



**4.2.2 Feedwater Pumps (if installed with the system)**

**4.2.2.1** Before starting pumps, rotate several revolutions by hand to get oil on bearings.

**4.2.2.2** If not previously done, check pump rotation.

**4.2.2.3** Switch on each pump using the 'HAND' position of the 'FEEDPUMP #1' and 'FEEDPUMP #2' control switches (HMI). Observe that the pumps come up to speed smoothly and, with the bypass relief valve or orifice isolation valve closed, achieve no-flow discharge pressure. The no-flow discharge pressure should be noted to verify the pump performance curve.

**CAUTION:** Do not operate the pumps in no-flow condition for more than 2 minutes to avoid overheating.

**4.2.2.4** Open bypass isolation valves and observe pressure drops to a point on the curve providing the necessary minimum pump flow per the pump specifications. If relief valves are provided, adjust accordingly.



**NOTE:** Refer to the appropriate relief valve Operation and Maintenance Manual, *Vendor Supplied Material*, **Appendix D** for adjustment instructions.

### **4.2.3 Blowdown Tank**

**4.2.3.1** Using the quench valve, fill tank to point of overflow (level with bottom of discharge pipe).

#### **4.2.3.2 Small Automatic Discharges**

Normal drip trap discharges and boiler surface blowdowns do not require manual attention.

#### **4.2.3.3 Large Manual Discharges**

To accommodate boiler bottom blowdown operation, the quench valve on the blowdown tank must be opened prior to the blowdown operation, and then closed after the blowdown is complete. If the quench valve is automatic, make sure the stop valve is in the open position.

### **4.2.4 Electrolyte Feed System (IF supplied)**

**CAUTION:** Be sure pump gear box is properly filled with hydraulic fluid. Refer to the appropriate Operation and Maintenance Manual, *Vendor Supplied Material*, **Appendix C**.

**4.2.4.1** Using the glove valve on the water supply line, fill tank with water.

**4.2.4.2** Check manual operation of the agitator by placing the H-O-A switch (HMI) in the 'HAND' position. Return H-O-A switch to the 'OFF' position.

**4.2.4.3** Check timer operation of the agitator by turning the timer knob (local panel) clockwise. Return timer knob to the 'OFF' (CCW) position.

**4.2.4.4** Check automatic operation of the agitator by placing the H-O-A switch (HMI) in the 'AUTO' position and properly adjusting the interval timer.

**4.2.4.5** Open both ball valves on pump discharge and the valve on the pump suction.

**4.2.4.6** Make certain the pumping chamber is flooded by loosening the discharge valve cap approximately 2 to 3 turns, allowing solution to appear. Tighten discharge valve cap. This procedure will also allow air to vent from pumping chamber. The 'DIA-PUMP' will not function if air is trapped in the hydraulic fluid or liquid pump chambers.

**4.2.4.7** Set the capacity control knob to approximately 30 – 40% of maximum capacity.

**4.2.4.8** On initial start-ups: Switch the H-O-A switch (HMI) to 'HAND' and run the pump for 10-20 seconds, then stop for 20 – 30 seconds. Repeat a few times. During these short runs, listen for any abnormal motor or crank noises. If present, refer to the appropriate Operation and Maintenance Manual, *Vendor Supplied Material*, **Appendix C**.

**4.2.4.9** Run pump for 1/2 to 1–1/2 hours to warm up oil. Check discharge line for indication of flow.

**4.2.4.10** Once discharge flow is observed, proceed to next step. If no flow, repeat steps in Sections 4.2.4.8 – 4.2.4.9 until discharge flow is achieved.

**4.2.4.11** Increase capacity adjustment setting to 70% of maximum capacity and operate for 10 – 20 minutes.

**4.2.4.12** Reduce capacity adjustment setting to 30 – 40% of maximum capacity and operate for several minutes, then increase capacity adjustment back to 100% for approximately 10 minutes. Repeat several times to insure that the air is bled from both the hydraulic fluid and liquid sides.

**4.2.4.13** Drain the tank and refill with properly mixed water treatment solution.

**4.2.5 Chemical Feed System** Perform the same procedure as for the Electrolyte Feed System (Sections 4.2.4.1 – 4.2.4.13).

### **4.3 Shut-Down Procedure**

#### **4.3.1 Normal Shut-Down**

**4.3.1.1** Reduce the steam demand to 0, by gradually closing the steam outlet back-pressure control valve (HMI).

**4.3.1.2** Switch off the circulation pump.

**4.3.1.3** Open the high voltage switchgear.

**4.3.1.4** Close the feedwater stop valve.

**4.3.1.5** Switch off both the chemical and boiler feed pumps (HMI).

**4.3.1.6** If the boiler is to be down for several days or is to be drained, the standby heater power should also be switched off, as well as the control power (120VAC and 480VAC).

#### **4.3.2 Emergency Shut-Down**

**4.3.2.1** Trip the high voltage switchgear via either the switchgear control switch or the 'EMERGENCY STOP' pushbutton. This also de-energizes the circulation pump.

**4.3.2.1** Close the steam header stop valve.

**4.3.2.2** Proceed per *Sections 4.3.1.2 – 4.3.1.6 as required*.

#### **4.3.3 Moth Ball Procedure**

(When boiler is taken out of service for a lengthy period of time.)

**4.3.3.1** Close steam stop and header gate valves; open 1" header vent valve.

**4.3.3.2** Blowdown boiler under pressure to remove sludge.

**4.3.3.3** Drain boiler completely, including water column and conductivity cell.

**4.3.3.4** Remove manhole cover.

**4.3.3.5** Rinse boiler to further aid in sludge removal.

**4.3.3.6** Assure good ventilation of the boiler interior and that steam or condensate does not leak into the boiler. To insure that vessel interior remains dry, place a small heat source inside the boiler to slightly elevate the internal temperature.

RETORQUE FLANGE BOLTS – After the initial boiler start-up and with the boiler start-up and with the boiler including the top cover bolts, should be retorqued.

## **5.0 BOILER WATER**

### **5.1 Properties of Feedwater**

Municipal water used for feeding boilers is never pure. It contains various impurities detrimental to operation, and therefore, must be treated before being introduced to the boiler. By far the greatest proportion of these impurities consists of inorganic combinations in solutions: calcium, magnesium and sodium salts. Also present at times are organic impurities.

The salts form scale in the boiler; organic matter causes foaming which could short the electrodes.

Generally, hard water is classified as that which contains large quantities of calcium and magnesium salts in solution; soft water is that which contains none of these salts, but can contain sodium salts which are not detrimental to the boiler operation. However, if excessive amounts of sodium salts enter the boiler they will cause frequent blowdowns resulting in decreased boiler efficiency.

## 5.2 Feedwater Treatment

Refer to *Recommended Feedwater & Boiler Water Properties*, **Table 1**.

In most instances it is recommended that the makeup water be softened, using a zeolite softener. In this system, usually referred to as the 'sodium-cycle base exchange', the calcium, magnesium, and iron ions are exchanged for sodium ions, thus eliminating 99.9% of the hardness. In most instances, it is also recommended that a deaerator be used which will eliminate most of the oxygen and carbon dioxide and thus minimize system corrosion. If iron in the condensate becomes a problem, re-evaluate the water treatment program as this indicates system corrosion and is detrimental to the boiler operation. The addition of sodium sulfite directly to the boiler is recommended to eliminate any free oxygen from being in the boiler water. A sulfite residual of at least 20 ppm should be maintained in the boiler at all times.

**IMPORTANT:** We recommend that **only** the (3) following generic chemicals be added directly to the boiler as needed: **Caustic (NaOH); Sodium-Sulfite; Tri-Sodium- Phosphate**. Amines should be added to the steam header.

**Table 1: Recommended Feedwater & Boiler Water Properties**

<b>FEEDWATER</b>						
TYPE OF BOILER	Hardness (ppm)	pH	Alkalinity (ppm-total)	Fe + Cu* (ppm)	Oxygen (cc/l)	Conductivity (pmho)
RESISTANCE -						
Hot Water	0-10	7.5-9.5	25-400	0-5	4	0-600
Steam	0-5	7.5-9	1-50	0-1	0.03	0-500
ELECTRODE STEAM -						
High Voltage @ 6.9KV	0-2	7.5-9	1-50	0-1	0.005	0-300
High Voltage @ 13.2 KV	0-2	7.5-9	1-50	0-1	0.005	0-250
High Voltage @ 22.5 KV	0-2	7.5-9	1-50	0-1	0.005	0-200

<b>BOILER WATER</b>						
TYPE OF BOILER	Hardness (ppm)	pH	Alkalinity (ppm-total)	Fe + Cu* (ppm)	Oxygen (cc/l)	Conductivity (pmho)
RESISTANCE - Hot Water	0-10	7.5-9.5#	25-600	0-50	0	0-6000
Steam	0	7.5-9.5#	25-600	0-20	0 ##	0-4500
ELECTRODE STEAM - High Voltage @ 6.9KV	0	7.5-10.5	100-350	0-15	0 ##	500-2600
High Voltage @ 13.2KV	0	7.5-10.5	100-350	0-10	0 ##	500-2400
High Voltage @ 22.5 KV	0	7.5-10.5	100-350	0-7	0 ##	500-2000

\* Total Iron (ie,  $FE+FE_2O_3+FE_3O_4$ ) plus total Copper (ie,  $Cu+CuO$ )

# This limit should be reduced to 9 ½ max if copper elements are used

## If hydrazine is used to scavenge oxygen, the maximum hydrazine residual recommended is 0.2 ppm unless boiler is "bronze free"

Any additional concern in regard to the boiler feedwater is alkalinity control. Alkalinity control, or more specifically the amount of hydroxide present (usually indicated by the pH reading), is important because too little alkalinity concentration may result in corrosion or the formation of objectionable sludge or scale; whereas too high a level of alkalinity may result in foaming and deterioration of the insulators.

In a system with 100% makeup, a complete water analysis is definitely recommended to ensure that proper treatment of the boiler feedwater is administered. We suggest that a qualified water treatment firm be consulted for recommendations regarding your particular application. Such organizations as Bets, Calgon, Culligan, Dearborn, or Mogul can assist you in this matter. We do, however, caution against over-feeding chemicals and so not recommend the use of chelants. If hydrazine is used for oxygen scavenging, the residual level should be kept below 0.2 ppm to minimize corrosion to any bronze used in the boiler. This level can be raised to 1.0 ppm if the boiler is supplied 'bronze free". In all cases, magnetite ( $Fe_3O_4$ ) should be avoided since it will cause rapid erosion of nozzles and electrode strike plates.

## 5.3 Water Conductivity

### 5.3.1 Adjustments

The conductivity of the boiler water is the prime determinant of boiler output and is controlled by the conductivity control by either signaling for automatic blowdown or electrolyte feed. The conductivity control should be so adjusted that the rated boiler output is attained with the pump at full flow speed. Refer to the appropriate Operation and Maintenance Manual, *Vendor Supplied Material*, **Appendix C** for the method of adjustment.

### 5.3.2 Conductivity Range

The typical conductivity range is from 700 umho to 2200 umho. See Table 1 above for details

**CAUTION:** Do not exceed the rated maximum conductivity of 3000 umho at any time!

### **5.3.3 Low-Output Operation**

If the boiler is to be operated at partial load for any length of time, the water conductivity should be decreased so as to effect greater water flow to the electrodes and, thus, to provide for better load control and lower carryover. Operation at a lower conductivity will also lessen the erosion of both the jet nozzles and electrodes.

## **5.4 Electrolyte Feed**

Both a shot feeder and an automatic electrolyte feed system are supplied for increasing the water conductivity. The shot feeder is used for initial boiler startup to quickly increase the water conductivity. The automatic system is used for conductivity maintenance when the condensate return is greater 90%, or where the feedwater has a very low conductivity (less than 50 umho). For the electrolyte, a solution of tri-sodium phosphate ( $\text{Na}_3\text{PO}_4$ ) is recommended because it is basic, forms a soft sludge, and has a relatively stable conductivity throughout the operating temperature range of the boiler.

**NOTE:** Approximately 1/2 lb. of  $\text{Na}_3\text{PO}_4$  will raise the boiler water conductivity 1000 umho per 100 gallons.

For conductivity maintenance, a mixture of caustic, sodium sulfite, and tri-sodium phosphate is used depending on actual water conditions. In any event, it is recommended that a small amount of sodium sulfite be continually fed to the boiler to establish a sulfite residual of at least 20 ppm for oxygen scavenging.

## **5.5 Blowoff**

### **5.5.1 Automatic Blowoff**

All PRECISION Model HVJ Boilers are supplied with an automatic surface blowdown, in conjunction with the conductivity control, to limit the boiler conductivity to the desired maximum level.

### **5.5.2 Response Adjustment**

Overall response of the blowdown system is controlled by a cycle timer within the conductivity control by increasing or decreasing the 'in process' portion of the blowdown cycle.

## **6.0 ROUTINE MAINTENANCE**

### **6.1 Boiler**

#### **6.1.1 Manual Blowdown**

##### **6.1.1.1 Bottom Blowdown**

The boiler should be subjected to a periodic short manual bottom blowdown depending on system requirements. A daily blowdown is highly recommended to remove any sludge that may have formed.

##### **6.1.1.2 Surface Blowoff**

It is essential to skim off the water surface at least once a month because the jet-type boiler does not form steam beneath the water surface and thus does not have carryover from the water surface, and because foaming on the water surface could create arcing from the bottom

of the electrodes. With the circulating pump off and the feedwater stop valve closed, manually perform a surface blowoff until the water level is below the level of the surface blowoff tapping.

#### **6.1.2 Automatic Blowoff**

The strainer of the automatic blowoff should be periodically cleaned depending on system requirements. This cleaning should be carried out at least weekly.

#### **6.1.3 Water Column**

Both water column and sight gauge should undergo a brief daily blowdown.

#### **6.1.4 Conductivity Chamber**

The conductivity chamber should be blown down weekly. Turn off conductivity control. Shut off inlet flow valve to perform this blowdown to cause a 'back flush' of the conductivity cell.

#### **6.1.5 Conductivity Cell**

The conductivity cell should be removed and inspected at least bi-monthly (or as experience dictates). Refer to the appropriate Operation and Maintenance Manual, *Vendor Supplied Material – Appendix C*, for inspection procedures.

#### **6.1.6 Valve Actuators**

Bi-monthly visual checks should be made to assure proper stroking of the control valves.

#### **6.1.7 Feedwater Strainer**

The feedwater strainer should be cleaned periodically depending on feedwater contamination. This should be performed at least monthly.

#### **6.1.8 Conductor Rod Insulators / Gaskets**

Refer to the *Conductor Rod Assembly Installation, Figure 3*.

##### **6.1.8.1 Gasket Deterioration**

The sealing gaskets between the inner insulator and both the tank mounting bushing and the coupling nut deteriorate over a period of time. The PRECISION Electrode Boiler is provided with steam 'tell-tale' vents, which indicate when the gaskets need replacing. Leaking steam is channeled to these vents from collecting grooves located on the sealing surfaces.

##### **6.1.8.2 Gasket Replacement**

All steam vents should be checked daily for evidence of gasket deterioration. Upon noticing leaking steam, a boiler overhaul should be scheduled within a week to replace the sealing gaskets and to examine the insulators for deterioration.

**NOTE:** The sealing gaskets are made of a special conductive gasket material in order to obtain uniform voltage across the entire insulator face. Failure to replace these gaskets can allow steam leakage into the interior of the insulator and cause flashover, which will destroy the thru insulator. During gasket replacement, make sure that all steam leakage passages are clean and clear of obstruction.

### **6.1.8.3 Insulators**

Insulators returned to service should be free of scale and dirt. To clean insulators, use hot soapy water and a soft brush. The shorting springs are provided to eliminate static discharges and should be thoroughly cleaned.

### **6.1.9 Back Pressure Regulator**

The packing gland of the back-pressure regulator should be subjected to periodic inspection, tightening, and repacking. If the regulator is self-contained with a piston operator, the operator should also undergo periodic checks to assure it is free of dirt and operates smoothly.

### **6.1.10 Nozzles**

#### **6.1.10.1 Blockage**

The nozzles should be inspected annually or more often if it is found that the water conductivity has to be gradually increased over the months of service to attain full rated output. In this occurrence, the boiler will eventually have to be shut down for nozzle cleaning. A 1" reamer can be used to loosen hardened deposits on the nozzle ID. A stiff wire brush should be used to remove the remaining contamination from within the nozzles.

#### **6.1.10.2 Flow Check**

After each boiler overhaul, perform a water flow check per Section 4.1.1.3.

### **6.1.11 Safety Valves**

The safety valves should be periodically checked per local code requirements.

## **6.2 Condensate Feedwater System**

Refer to the appropriate Operation and Maintenance Manual, *Vendor Supplied Material*, **Appendix C**, for required pump maintenance, motor lubrication, and mechanical seal maintenance.

## **6.3 Circulating Pumps**

Refer to the appropriate Operation and Maintenance Manual, *Vendor Supplied Material*, **Appendix C**, for required pump maintenance, motor lubrication, and mechanical seal maintenance.

## **6.4 Feedwater Pumps**

Precision Boilers

## **6.5 Chemical Feed Pumps**

Refer to the appropriate Operation and Refer to the appropriate Operation and *Material*, **Appendix C**, for required pump maintenance.