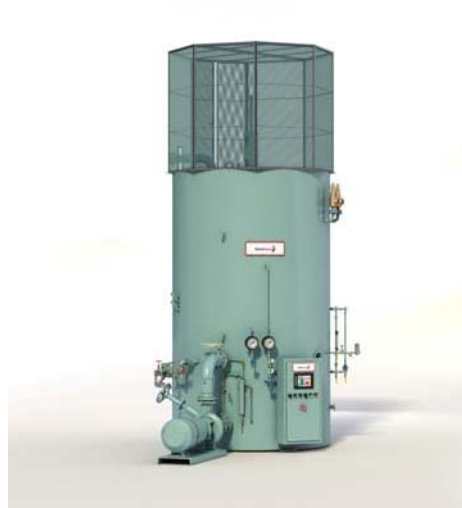


# Electrode Boilers

## Model CEJS Steam



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This section contains information on the complete line of Cleaver-Brooks electrode boilers with megawatt output ratings from 2 to 56 MW.

## FEATURES AND BENEFITS

	In applications where electric power is more economically available than fossil fuels, or where fossil fuel combustion and the handling of combustion by-products are unacceptable, electrode boilers offer a viable alternative.
<b>Economical Installation</b>	Fuel lines, storage and handling equipment, economizers, stacks, and emission control equipment are not required, saving on capital expenditures.
<b>Lower Operating Cost</b>	Simple to operate and maintain - automatic controls reduce personnel requirements. No complex pollution or combustion control equipment to operate or maintain. No heating surfaces.
<b>Emissions</b>	Because there is no combustion, electrode boilers are 100% emission free. This is beneficial in meeting total emissions of the project site or in areas where fuel combustion emissions are not tolerated.
<b>Quiet Operation</b>	Elimination of combustion noise and minimal moving parts result in extremely quiet operation (very beneficial in applications such as hospitals, nursing homes, and schools).
<b>High Efficiency</b>	With minimum radiation losses and without the losses associated with combustion equipment the electric boiler will provide nearly 100% efficiency at all operating points.
<b>Ease of Maintenance</b>	The absence of high maintenance combustion equipment and the use of solid state control devices reduce the complexity and number of moving parts. The absence of fuel residue greatly simplifies boiler cleaning. Pressure vessel components are not subjected to thermal stresses induced by high temperature differentials or cycling encountered with fossil fuel combustion.
<b>Quality Construction</b>	All CEJS boilers are designed to ASME Boiler and Pressure Vessel Code and are certified and registered pressure vessels.
<b>Design Features</b>	The CEJS electrodes are vertically mounted around the inside of the pressure vessel, enabling the boiler to produce maximum amounts of steam in a minimum amount of floor space.  The CEJS operates at voltages from 4.16 to 25 kV with up to 99.9% efficiency. Models are available to produce steam in capacities to 188,000 pounds per hour. Operating pressure ratings range from 100 psig to 450 psig, with design pressure up to 500.

## PRODUCT OFFERING

Cleaver-Brooks electrode boilers are available in sizes ranging from 2 to 56 MW with operating pressures from 100 psig to 450 psig. Input power is by direct connection to a 4.16 to 25 kV supply.

Dimensions, ratings, and product information may change to meet current market requirements and product improvements. Therefore, use this information only as a guide.

Refer to Table 1 as a quick reference guide to the boiler models and sizes provided.

Table 1. Model CEJS Product Offering

Model No.		4.16 kV	6.9 kV	11 kV	13.2 kV	20 kV	25 kV
<b>CEJS 400</b>	lbs/hr @125 PSI	3,350	6,700	11,100	13,500	16,800	17,800
	lbs/hr @250 PSI	3,200	6,400	10,500	12,800	16,000	16,900
	Max Megawatts	1.0	2.0	3.3	4.0	5.0	5.3
	Vessel OD (in.)	72	72	72	72	96	108
	# of Electrodes	3	3	3	3	3	3
<b>CEJS 600</b>	lbs/hr @125 PSI	5,050	10,100	16,800	20,200	25,200	26,900
	lbs/hr @250 PSI	4,800	9,600	16,000	19,200	23,900	25,600
	Max Megawatts	1.5	3.0	5.0	6.0	7.5	8.0
	Vessel OD (in.)	72	72	72	72	96	108
	# of Electrodes	3	3	3	3	3	3
<b>CEJS 900</b>	lbs/hr @125 PSI	7,550	15,100	25,200	30,300	37,800	40,300
	lbs/hr @250 PSI	7,200	14,300	23,900	28,800	35,900	38,300
	Max Megawatts	2.25	4.5	7.5	9.0	11.25	12.0
	Vessel OD (in.)	72	72	72	72	96	108
	# of Electrodes	3	3	3	3	3	3
<b>CEJS 1200</b>	lbs/hr @125 PSI	10,100	20,200	33,600	40,400	50,400	53,800
	lbs/hr @250 PSI	9,600	19,200	31,900	38,400	47,900	51,100
	Max Megawatts	3.0	6.0	10.0	12.0	15.0	16.0
	Vessel OD (in.)	72	84	72	72	96	108
	# of Electrodes	3	6	3	3	3	3
<b>CEJS 1800</b>	lbs/hr @125 PSI	15,100	30,200	50,400	60,600	75,600	80,600
	lbs/hr @250 PSI	14,300	28,700	47,900	57,600	71,800	76,600
	Max Megawatts	4.5	9.0	15.0	18.0	22.5	24.0
	Vessel OD (in.)	84	84	84	96	108	120
	# of Electrodes	6	6	6	6	6	6
<b>CEJS 2400</b>	lbs/hr @125 PSI	20,150	40,300	67,200	80,800	100,800	107,500
	lbs/hr @250 PSI	19,200	38,300	63,800	76,800	95,800	102,100
	Max Megawatts	6.0	12.0	20.0	24.0	30.0	32.0
	Vessel OD (in.)	96	96	84	96	108	120
	# of Electrodes	6	6	6	9	6	6
<b>CEJS 3000</b>	lbs/hr @125 PSI	25,200	50,400	84,000	101,000	126,000	134,400
	lbs/hr @250 PSI	23,900	47,900	79,800	96,000	119,700	127,700
	Max Megawatts	7.5	15.0	25.0	30.0	37.5	40.0
	Vessel OD (in.)	96	96	96	108	120	120
	# of Electrodes	6	6	9	9	9	9
<b>CEJS 3600</b>	lbs/hr @125 PSI	30,200	60,500	100,800	121,200	151,200	161,300
	lbs/hr @250 PSI	28,700	57,500	95,800	115,100	143,600	153,200
	Max Megawatts	9.0	18.0	30.0	36.0	45.0	48.0
	Vessel OD (in.)	108	108	108	108	120	120
	# of Electrodes	9	9	9	9	9	9
<b>CEJS 4200</b>	lbs/hr @125 PSI	35,300	70,600	117,600	141,400	176,400	188,200
	lbs/hr @250 PSI	33,500	67,100	111,700	134,300	167,600	178,800
	Max Megawatts	10.5	21.0	35.0	42.0	52.5	56.0
	Vessel OD (in.)	108	108	108	108	120	120
	# of Electrodes	9	9	9	9	9	9
<b>CEJS 5000</b>	lbs/hr @125 PSI	N/A	N/A	140,100	168,300	N/A	N/A
	lbs/hr @250 PSI			133,100	159,900		
	Max Megawatts			41.7	50.0		
	Vessel OD (in.)			108	"120		"
	# of Electrodes			9	9		

**Standard Equipment** Equipment described below is for the standard steam electrode boilers offering:

- A. Model CEJS Boiler
  1. Each boiler is designed and constructed in accordance with the ASME Code and is mounted on an integral steel frame.
  2. Trim and Controls:
    - a. Water column with 4-20mA transmitter and gauge glass; transmitter signal opens and closes the feedwater valve according to boiler water level.
    - b. High Water and High High Water limit probes.
    - c. Air vent.
    - d. Bottom and water column blowdown valves.
    - e. Automatic surface blowdown.
    - f. Three-valve bypass feedwater piping with regulating valve, check valve, and gate valve.
    - g. ASME pressure relief valves.
    - h. Boiler steam pressure gauge & transmitter.
    - i. System steam pressure gauge & transmitter.
    - j. Conductivity control system with sample cooler.
    - k. Standby heater.
    - l. Steam stop valve.
    - m. Back pressure regulating valve.
    - n. Steam injection.
  3. Pre-assembled centrifugal circulation pump with water-cooled mechanical seal.
  4. Electric Equipment
    - a. High voltage supply - customer connected three-phase, four-wire, 'Y' connected configuration.
    - b. Medium voltage supply - powers the control panel, circulating pump, hydraulic pump, and (optional) chemical feed pump.
    - c. PLC with 10" color touch screen HMI oversees automatic functioning of the following:
      - High pressure limit circuit
      - High and high-high water limit circuits
      - Alarm circuits
      - High voltage feedback
      - Conductivity controller
      - Load and pressure control
      - Standby control
      - Circulating pump
      - Hydraulic system

- d. Electrodes (three, six, or nine depending on boiler size) - comprising upper and lower electrode assemblies installed through lower manway on vessel and connected to electrode box and target plates; used to establish a current path to nozzle stock and to counter electrodes.
  - e. Attached pre-wired control panel.
5. Hydraulics:
    - a. Positioning of the control sleeve is accomplished by a hydraulic system consisting of hydraulic pump, lift tower, and hydraulic cylinder.
  6. Boiler Control System
    - a. PLC-based control system with touchscreen HMI.
    - b. PID controls for steam pressure and water level.
    - c. Real-time trending and bar graph display of process variable, setpoint, and control output.
    - d. Automatic or manual operation.
    - e. On-screen fault annunciation with diagnostics and alarm history

**Optional Equipment** For option details, contact the local authorized Cleaver-Brooks representative. Below are some options that can be provided with the boiler:

- Chemical feed pump.

## *PERFORMANCE DATA*

**Efficiency** Whereas fuel-fired equipment is susceptible to efficiency losses such as stack loss, combustion loss, excess air loss, etc., electrode boilers by contrast are nearly 100% efficient at all operating levels.

**Emissions** Electrode boilers do not use fuel combustion, and so produce no emissions. Therefore, electrode boilers are well suited for installations that must meet stringent emissions requirements.

**Noise Level** The electrode boiler is nearly noiseless and thus is well suited for installations sensitive to noise emissions from mechanical equipment. Installations such as hospitals, nursing homes, schools, research laboratories, and the like are ideal for an electrode boiler application.

## *ENGINEERING DATA*

**Water Treatment** Proper blowdown is a required maintenance procedure. Any water lost in the procedure must be made up. Make-up water should be properly treated prior to introduction into the boiler via water softener, chemical feed, etc. Proper water chemistry in a steam boiler is mandatory for effective operation and longevity.

See Table 2 for Model CEJS water quality requirements.

**Table 2. Electrode Boilers Required Water Quality Parameters**

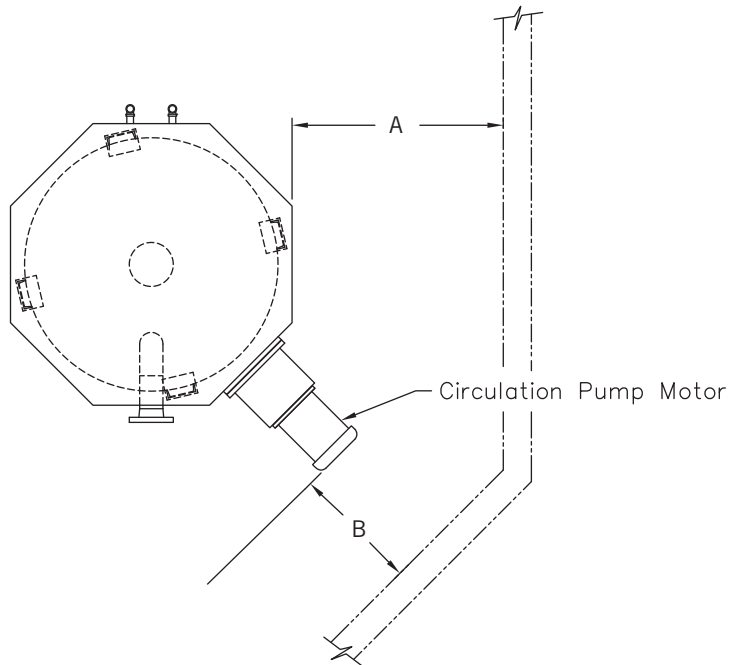
Parameter	Boiler Water Limit
pH	8.5 - 9.5
Iron	≤2.0 ppm
Alkalinity	0 - 750 ppm
Oxygen	0.005 ppm
Conductivity	3500 μmho/cm
Hardness	Makeup water 0 - 0.5 ppm (preferably 0); Boiler water 0 ppm

**Clearances**

See below for Model CEJS minimum clearances.

**Table 3. CEJS Minimum Clearances**

Model Number	Minimum Clearances	
	A	B
CEJS-200	60"	30"
CEJS-400	60"	36"
CEJS-600	60"	36"
CEJS-900	60"	48"
CEJS-1200	60"	48"
CEJS-1800	60"	48"
CEJS-2400	60"	48"
CEJS-3000	60"	55"
CEJS-3600	60"	55"
CEJS-4200	60"	70"
CEJS-5000	60"	70"



## SAMPLE SPECIFICATIONS

### ELECTRODE STEAM BOILER MODEL CEJS

#### SPECIFICATION

Provide High Voltage Electrode Steam Boiler for operation on \_\_\_\_KV PH, 4 wire, \_\_\_\_HZ. Boiler rating shall be \_\_\_\_ PSI and shall be designed for operation at \_\_\_\_ PSI steam pressure, \_\_\_\_MW capacity.

#### 1.0 Design

The boiler design shall consist of a pressure vessel having a central column from which water, under pressure, is forced through nozzles toward the several electrodes which surround the column. Steam is generated from the surface of the several streams of water by heat generated as the electrical current flows from the electrode to the central column and through the stream of excess water as it falls from the electrode to a grounded "counter electrode" on its way back to the bottom of the boiler.

All streams of water originating in the central column shall be identical in shape based on pressure maintained in the central column therefore avoiding steam and interference droop causing splashing and potential electrical short leading to shut-down.

There shall be an upper level man-way(s) allowing a visual initial adjustment of stream shape by varying the speed of the boiler pump (see 2.1.4) to establish suitable pressure in the central column for internal distance based on voltage spacing.

Regulation of the boiler output shall be accomplished by a movable load regulating shield which prevents part or all of the nozzle streams from coming into contact with the boiler electrodes. The position of the load regulating shield will be regulated by the boiler controls to maintain the desired steam pressure or to prevent the boiler from drawing more than the desired kilowatts when the steam requirements exceed the boiler capacity. The boiler electrodes shall be located entirely in the boiler steam space so that stopping of the boiler pump will cause the boiler to shut down. Regulation of the boiler capacity shall be from 100% to 0% without the necessity of interrupting the high voltage supply.

#### 2.0 The Boiler Component Parts

##### 2.0.1 Boiler Shell

The boiler shall be a single shell, vertical type. The shell shall be constructed and stamped in accordance with the ASME Boiler & Pressure Vessel Code, and shall carry a National Board Pressure Vessel Registration Nameplate.

The shell design (and stamped) pressure rating shall be \_\_\_\_ PSI for operation at \_\_\_\_ PSI.

A man-way 355mm x 457mm (14" x 18") shall be provided for access to the boiler interior for internal inspection and repair/replacement of internal parts. A second man-way

305mm x 380mm (12" x 16") shall be provided at the upper level for inspection of the jets. No other access is required for inspection or service. All boiler connections over 50mm (2") pipe size shall be flanged.

### 2.0.2 The Central Column and Nozzle Stock Plates

The central column and nozzle stock, through which water is conducted to the stream nozzles, is fabricated from mild steel and supported from the top of the boiler.

For optimum water stream shape, each nozzle has a conical collector cone leading to a round pipe with a cross insertion forming straightening vanes. This design produces a sharply defined water stream from each nozzle.

The stream nozzles are inserted into bolted, removable plates to allow replacement or cleaning without removal of the nozzle stock from the boiler. Nozzle rows shall be horizontally slanted for smooth progressive interception and capacity control.

The pump shall deliver its full output to the nozzle stock at all times and maintain a constant static head inside the nozzle stock to assure that at no time during boiler operation will any stream nozzle have less than 15' of liquid static head supply pressure.

### 2.0.3 Electrode Boxes and Target Plates

Electrode boxes have 3 closed sides terminating in rounded edges.

Target Plates are removable and reversible with round bars facing the jet streams for smooth contact and no splashing. Water then flows smoothly in the formed grooves to a collection at the bottom of the box.

The bottom of the box is solid steel with machined holes with cross insertion to form the steams of water toward the counter electrode.

### 2.0.4 Counter Electrodes

Counter electrodes shall be made of solid steel plate with machined holes matching the holes in the bottom of the electrode box for smooth flow in order to avoid splashing. Solid welded bracket for attaching to boiler shell.

### 2.0.5 Insulators and Power Rods

Each electrode box is supported by the high voltage power rod. Power rods insulating tubes shall be quartz - 25KV class.

Insulators shall be 25KV class high grade aluminum, 9 skirts for long tracking path, coated, for maximum protection and reliability.

The internal insulator shall be protected by stainless steel steam throttling shield and rated for 750PPM alkalinity.

The external insulator shall be identical 25KV class coated insulator in order to offer maximum protection against deposits on skirts due to air contaminants in boiler room atmosphere.

### 2.0.6 The Load Regulating Shield 0-100%

The load regulating shield shall be concentric with the central column and will be supported by a yoke and rod extending through the top of the boiler to the load regulating mechanisms. The upper rim of the load regulating shield shall incorporate a stainless steel "knife" edge to intercept the flow from the water nozzles in a manner which will minimize the disturbance to the nozzle streams which are above the shield. This sharp edge shall be able to split the capacity of a stream for maximum



accuracy in capacity control and without loss of quality or excessive splashing. A shield position Indicator shall be included in the control system. Boiler will be furnished with a hydraulic cylinder, pump and control system to control shield position according to demand between 0% and 100%.

### **2.0.7 Boiler Circulating Pump(s) on separate skid**

The boiler circulating pump(s) shall be a centrifugal type rated for continuous duty at the boiler operating pressure and temperature and shall be selected for low NPSH and to deliver the flow and head required for proper operation of the boiler. The pump shall be coupled to the boiler with suitable piping spools, flanges and a manually set butterfly valve.

The pump shall incorporate a single mechanical seal with water cooling. Pump motors shall be sized for maximum pump horsepower requirements and to be standard shaft, T.E.F.C., foot mounted, and readily available. The pump will be belt-driven or VSD driven, allowing for a simple initial adjustment to maintain a steady pressure in the central column and therefore of the shape of the parallel water jets.

### **2.0.8 Standby Heater**

The boiler will be supplied with an immersion type flanged heating element assembly rated at \_\_\_V, \_\_\_Ph, \_\_\_Hz for use in maintaining the boiler at desired pressure when the boiler is not being used to generate steam. The standby heater shall be controlled by two pressure set points and by the "Standby-Run".

### **2.0.9 Steam Water Preheater**

A steam injection preheater has been provided for quicker heating of the "cold" boiler water after a shut-down. It will bring the boiler to "stand-by" condition by using an outside source of steam to heat the water and generate steam in the isolated boiler. This procedure is manually controlled by a hand valve.

## **2.1 Boiler Control System**

### **2.1.1 Pressure and Load Controls and associated Control Panel**

The boiler control system shall incorporate processor pressure control and ampere load control in the primary control system in a manner which will permit the boiler to maintain the desired steam pressure so long as the steam demand does not exceed the desired maximum KW limit and at such times as the demand exceeds the rating, to regulate the boiler output to the desired maximum. The maximum allowable KW rating will be adjustable by the operator to ratings of 100% maximum to 5% minimum. The boiler will regulate the output from 0% to 100% as required by the pressure control. Boiler will utilize "split" streams to attain step-less control that is linear over entire output range of the boiler. Stable regulation shall be possible from 100% output down to zero load.

Controls shall be provided so electrodes are energized before water is supplied to electrodes. Boiler shall always start at zero load.

### **2.1.2 Standby-Run Control**

The boiler shall incorporate a Standby-Run control which, when in "Standby", will manually override the Pressure and Load controls to cause the Load Regulating

Shield to go to the “No Output” position and simultaneously energize the Standby Heater control circuit and de-energize the conductivity control and surface blow-down. When the Standby-Run Control is returned to “Run”, the boiler will resume normal operation starting at “0” load. This operation can also be remotely controlled.

### **2.1.3 Limit Controls**

The boiler shall be equipped with limit controls to shut down the boiler in event of occurrence of any of the following conditions: (1) excess pressure; (2) low water; (3) high water; (4) sudden pressure drop in system supply line. Limit controls (optional or supplied by others) such as supervisory relays for over-current, ground fault, or phase imbalance (supplied by others) may be connected into the limit control circuit.

### **2.1.4 Water Level Controls**

The boiler water level control will be a proportional type regulator which will adjust the position of a valve in the feed-water supply line to maintain the flow of feed-water to match the rate of steam generation. If a single dedicated suitable feed-water pump is used, the control valve could be replaced by a variable speed control on the feedwater pump motor.

### **2.1.5 Conductivity Control and Sample Cooler Assembly**

Conductivity of the water being circulated to the boiler electrodes will be controlled by an indicating type conductivity controller which will have separately adjustable high and low set points. On actuation of the “high” set point, automatic boiler bleed (surface blow-down) will begin and a light will indicate that bleed is in process.

“Low conductivity” closes a PLC contact and may be used to signal a chemical feed pump to start. Chemical feed pump is optional or supplied by others. It is not furnished as part of this boiler.

A Sample Cooler assembly shall be supplied, including the sample cooler, connections for the boiler water, connections for the cooling water, valves, conductivity measuring cell, and manual sampling valve.

## **2.2 Boiler Trim**

The boiler will be supplied with the following trim items:

### **2.2.1 Pressure Control Piping**

Pressure gauges will indicate steam pressure in the boiler shell and in the user's steam header. Gauge ranges shall be approximately 2 times the operating pressure. The Gauges and Pressure Controllers will be mounted on the boiler at eye level, pre-piped and pre-wired.

### **2.2.2 Water gauge glass**

Water gauge glass complete with drain valve will be provided.

### **2.2.3 Water Column**

A water column will be provided and will be suitable for mounting of the water gauge glass, gauge cocks, the water level controller and the high and low water cut-offs. A water column drain valve will be provided. A separate control is provided for

the “Low-Low” water level protection.

#### 2.2.4 Feed-water Valves

Boiler feed-water line will be equipped with shut off valve and check valve between the boiler and the feed-water regulating valve or pump

#### 2.2.5 Blow-down Valves

Boiler blow-off line will be fitted with one quick and one slow opening valve. Valves shall be “Y” pattern rated for boiler blow-off service.

#### 2.2.6 Steam Valve

Boiler steam outlet valves, such as a stop and check, are optional.

#### 2.2.7 Back Pressure Regulating Valve

A pneumatic back pressure regulating valve will be provided and will be adjusted to throttle or close when the boiler steam pressure drops below the operating pressure range. Valve and controller will be pneumatic type. This Valve will protect the boiler against a sudden drop in system pressure. Timing shall be adjusted for quick closing and slow opening.

#### 2.2.8 Safety Valves

The boiler will have a minimum of two safety valves which shall be ASME rated and stamped. Aggregate capacity of the safety valves at their set pressure will not be less than 110% of the boiler rating in kilograms of steam per hour. Boiler rated output will be taken as 3.5lbs of steam per KW. (1.59 kg of steam per KW).

#### 2.2.9 Bleed Valves (for conductivity control)

The boiler bleed (surface blow-down) valve shall be a needle type valve with calibrated stem, optional adder for boiler. This valve shall be set to control the bleed rate. On-Off control of the bleed will be by means of a separate valve, air operated.

### 2.3 Insulation and Casing

The boiler will be insulated with 2” of glass fiber insulation secured to the boiler to prevent sagging. Insulation rings are provided on the boiler pressure vessel. Insulation is covered by 18GA Aluminum sheets.

### 2.4 Top Cage

The boiler high voltage terminals will be enclosed in a preferably full height heavy screen enclosure with Kirk key interlock on access opening to prevent entrance unless the boiler supply switch-gear is open. Kirk interlock shall be supplied by others. Switch-gear and Kirk key interlock provided by others

### 2.5 Control Panel

Power required to Control Panel is \_\_\_V, 3Ph, \_\_\_Hz, incorporating a \_\_\_A disconnect switch.

All electrical controls, relays, pump and shield drive starters and associated push buttons, lights, ammeters, and other components of the boiler control system will be attached to

the boiler before shipment and pre-wired with a 2 door NEMA 12 dust proof panel.

Power and Control sections are separate, each with front access.

The H.V. switch-gear (by others) should include CTs and PTs to be connected (by others) to the Control Panel. In addition to their use for the boiler control logic, the information on V, A, KW is available in the PLC. KW value can be sent to a building system if desired.

### 3.0 Boiler Assembly and installation

The boiler will be shipped in two containers or on a flat bed truck in main sections, and will require field erection and assembly and completion of electrical and piping connections. The boiler manufacturer's representative will supply labor for the assembly and start-up of the boiler. The representatives will reassemble under supervision the internal components of the boiler which were disassembled (Power Rods, Insulators and Boxes) before shipping in order to protect them in transit. Containers should be opened at the site. This is an opportunity to train local personnel. Boiler access is through the lower level manhole.

Insulated boiler is provided with lifting lugs for handling vertically or horizontally. Labor, material and equipment required for setting of the boiler and electrical and piping work is not included in this proposal.

### 4.0 Electrical Supply System

The boiler will require a 3 phase, 4 wire supply circuit derived from a distribution or a transformer with a wye-connected secondary and having the transformer neutral grounded at the transformer and extended by means of a full size insulated conductor to the boiler neutral lug. The boiler shell and casing must also be grounded to the building ground system. The motors specified for the boiler circulating pump and shield control and stand-by heater will be \_\_\_\_\_V, 3Ph, \_\_\_\_Hz., unless otherwise specified. The boiler control circuits will be 120V, 1 phase, \_\_\_\_Hz.

### 4.1 High Voltage Switchgear

High voltage switchgear for the boiler supply circuit is not included as a part of the boiler proposal. The boiler supply circuit switchgear shall be air or vacuum or SF6 circuit breaker rated for the boiler voltage and ampere load and should be equipped with protective relays as required to open the switchgear in event of phase unbalance or loss of a phase, over-current and under-voltage, and ground current.

The switchgear may also be such that it can be made to open by the boiler high pressure limit control for safety shutdown. Instrumentation should include an ammeter and an ammeter switch for monitoring of phase amperages. The breaker shall be equipped with a Kirk key interlock which shall be keyed to match the access door of the boiler high voltage terminal compartment described in par. 2.4.

It will be the Purchaser's responsibility to advise the supplier of the switchgear of the need to coordinate the keying system with Cleaver-Brooks. Provide CT's and PT's for connection to boiler control circuit in boiler panel (2.5). The switchgear shall incorporate a disconnect switch or equivalent means to provide a visible break in the power supply circuit to the boiler.

### 5.0 Feedwater Treatment

No feed-water treatment equipment is included in this proposal. The necessary feed- water treatment is not detailed in this typical specification.

The water hardness, required conductivity in the boiler shell, water pH, and alkalinity

ity play a key role in the proper functioning of the boiler. See Electrode Boilers Required Water Quality Parameters table.

Boiler will operate at up to 3500  $\mu\text{mho}$  conductivity for reduced blow-down and 750PPM alkalinity with superior insulators.