Electric Boilers

Learning Outcome

When you complete this module you will be able to:

Describe electric boilers with regard to their use and general design.

Learning Objectives

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

1. List the advantages and disadvantages of electric boilers compared to fuel fired boilers.

2. Describe the construction and operating principle of electrode type electric boilers.

3. Describe the construction and operating principle of immersion type electric boilers.

INTRODUCTION

The boilers described in other modules, namely the firetube and the watertube types, obtained the heat necessary for converting water to steam from the burning of fuel within the boiler furnace. The electric boiler uses electricity instead of burning fuel to heat the water and to convert it to steam.

Electric boilers are not usually used in large heating systems but are sometimes found in smaller heating systems. They are often used in hospitals, schools, hotels, etc., to provide steam for heating, sterilizing, laundry equipment, and kitchen equipment. Another application is in a system where electricity, produced by a gas turbine driving a generator, is used in an electric boiler to produce steam which supplements steam produced in a waste heat boiler. The waste heat boiler uses the gas turbine exhaust as a heat source.

Advantages of Electric Boilers

1. Electric boilers are very compact as they do not require furnace space for combustion, and therefore do not require ductwork or a chimney.

2. No fuel storage space is required as in the case of oil-fired or coal-fired boilers.

3. Electric boilers are quickly and easily installed due to the fact that ductwork, chimneys, and fuel lines are not required.

4. A high percentage (98%) of the energy delivered by the electricity is absorbed as heat in the boiler.

5. Electric boilers produce no pollution such as smoke, dust, ashes, etc. It is true, however, that the generating plant which originally produces the electrical power will no doubt produce some of the pollutants mentioned unless it is a hydroelectric plant.

6. Electric boilers are silent in operation and are safe because there is no possibility of furnace explosion.

The main disadvantage of the electric boiler is the usually high comparative cost of the electricity required. Also, most designs are limited in pressure to about 2100 kPa due to the effect of high temperature on the electrodes or elements.

ELECTRIC BOILER DESIGN

There are two general designs of electric boilers: the electrode type and the immersion heater type.

Electrode Type

The sketch in Fig. 1 shows the general arrangement of an electrode boiler.

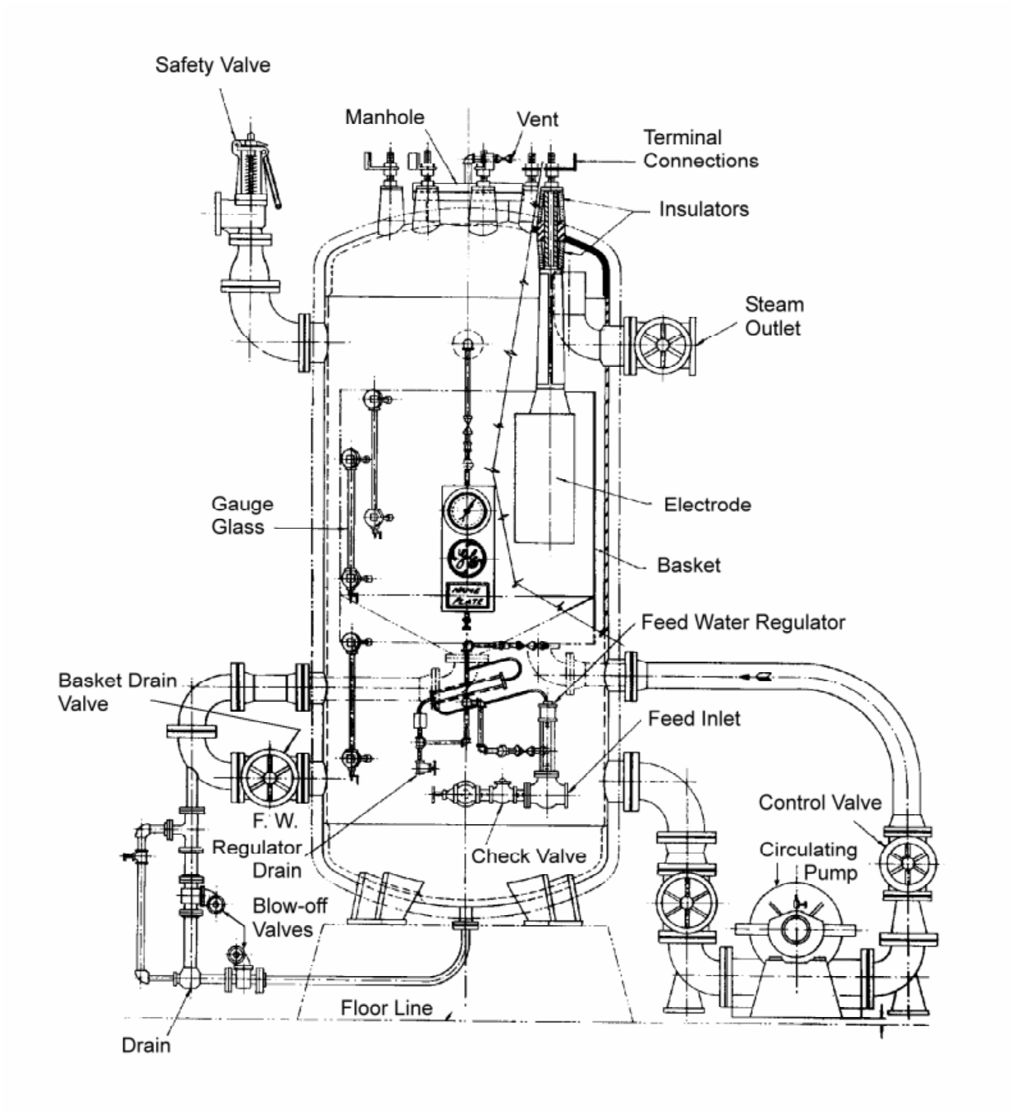

Figure 1
Electrode Type Electric Boiler
(Courtesy of General Electric)

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Referring to Fig. 1, the shell of the boiler contains a separate section called the basket into which the electrodes extend. The water level in the basket is varied by means of the circulating pump. It draws water from the bottom of the shell and pumps it into the basket through a control valve. The water then drains back into the lower portion of the shell. The water acts as a conductor and the depth of water surrounding the electrodes in the basket determines the amount of electric current flowing between the electrodes. This current flowing through the water heats the water and converts it to steam.

If too much steam is being produced, then the control valve at the pump discharge will be partially closed, thus lowering the level of water in the basket and reducing the amount of current flow. If not enough steam is being produced, then the control valve will open further and the water level in the basket will rise, allowing more current to flow.

The boiler type shown in Fig. 1 operates at voltages up to 16 000 volts and at power ratings up to 30 000 kilowatts.

The sketch in Fig. 2 shows the general arrangement of another electrode type boiler. The electrodes are located in a central generating chamber. Power is supplied to the terminals which are connected to the electrode adapters. The electrode adapters pass through insulators to the outside of the shell.

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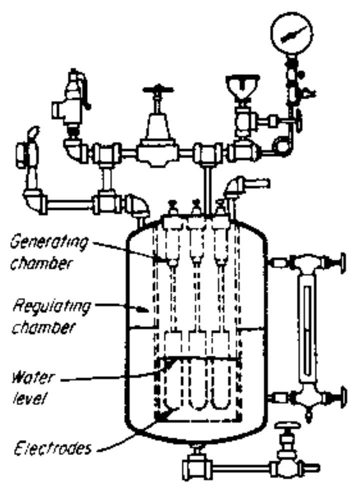


Figure 2
Electrode Type Boiler

Pure water does not conduct electricity, but when the water contains a salt it becomes a conductor through which current can pass. The boiler water is given the proper salinity by the addition of salt. When power is switched on, the current will flow through the water between the conductors. This current heats the water and converts it to steam. The amount of current passing through the water is directly proportional to the length of the electrodes submerged in the water.

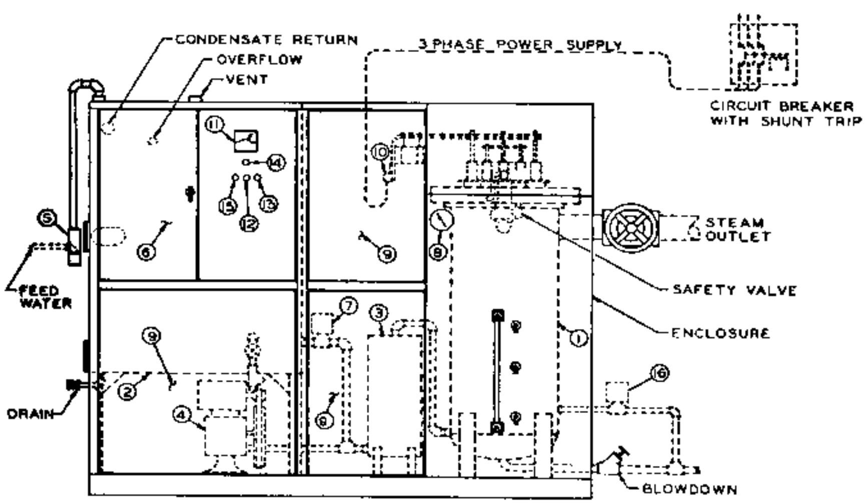
The water is supplied from the outside regulating chamber to the generating chamber. When the steam load drops, the pressure in the generating chamber will increase slightly and this extra pressure will force some of the water out of the generating chamber, thus lowering the level.

As a result of the lower level, the current flow is reduced since a shorter length of the electrodes is submerged, and thus less steam is produced.

An increased load will do the opposite. The pressure will drop slightly, the water level rises, current increases, and steam production increases to meet the larger demand. This boiler is thus completely self-regulating. At no-load, the pressure will increase enough to force the water out of the generating chamber and to stop the current flow completely so a high pressure limit switch is not required. The boiler does not need a low-water cutoff either since the current flow will stop when the level drops below the electrodes.

The water supply to the regulating chamber is controlled by a float valve which regulates the supply from the feedwater pump.

The electrode boiler is also manufactured as a packaged unit. Fig. 3 is a sketch showing the components within the cabinet. Note that in this type, the feed pump and condensate tank are included in the package as well as all controls.



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1. Electrode Steam Boiler
2. Condensate and Feed Water Tank
3. Cold Column Tank (optional)
4. Feed Pump
5. Feed Water Float Valve
6. Control Compartment
7. Load Control Solenoid Valve
8. Steam Pressure Gauge
9. Access Panels
10. Power Connection Terminals
11. Ammeter
12. Load Control Adjustment
13. Pump Starting Switch
14. Emergency Stop Switch
15. Control Switch
16. Bleed Solenoid Valve (optional)

Figure 3
Electrode Packaged Boiler Components
(Courtesy of Cam Industries Inc.)

Immersion Heater Type

Fig. 4 shows the outside view of an immersion heater steam boiler and Fig. 5 is a sketch depicting the various parts. The boiler type shown is manufactured in sizes up to 1500 kilowatts and for pressures up to 2100 kPa.

The immersion heater boiler differs from the electrode boiler in that no electric current travels through the water. Instead the electric current flows through a heating element or elements which are entirely submerged beneath the boiler water level. This is the same principle as is employed in the ordinary electric element tea kettle.

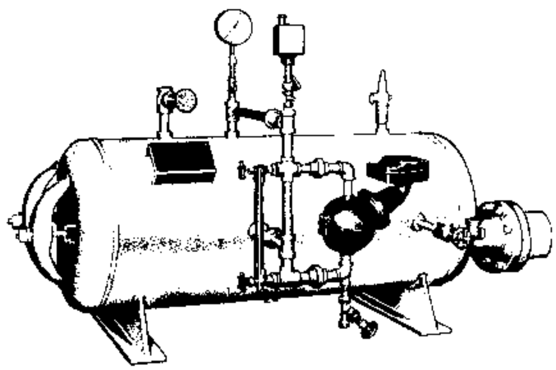

Figure 4
Immersion Heater Boiler

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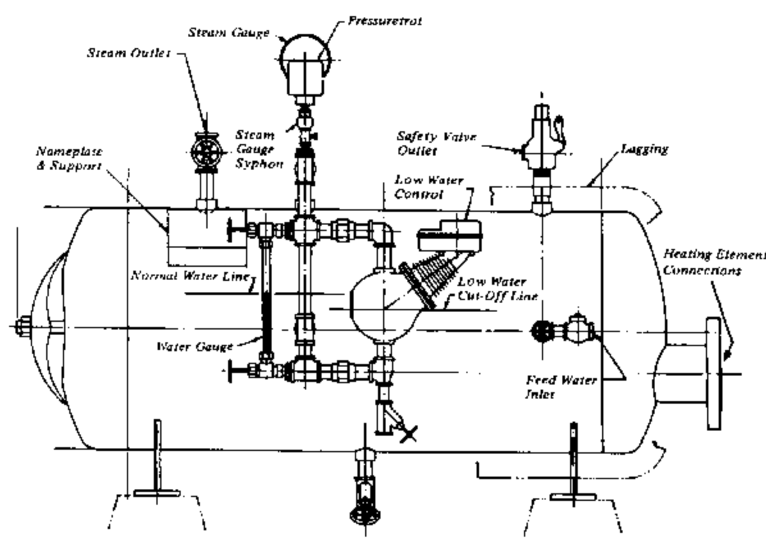

Figure 5
Immersion Heater Boiler Parts
(Fig.4&5, Courtesy of General Electric)

Control of the immersion heater boiler is accomplished by turning on and off the power supply to one or two or more elements as required.

The packaged boiler concept is also used for some immersion heater types. These packaged units may include controls, feed pumps, and condensate tank all within one cabinet.

The immersion heaters are arranged in the boiler so that they are easily accessible for maintenance or replacement. Fig. 6 shows the arrangement of a number of elements and also illustrates the general design of an element which has been removed from the boiler.

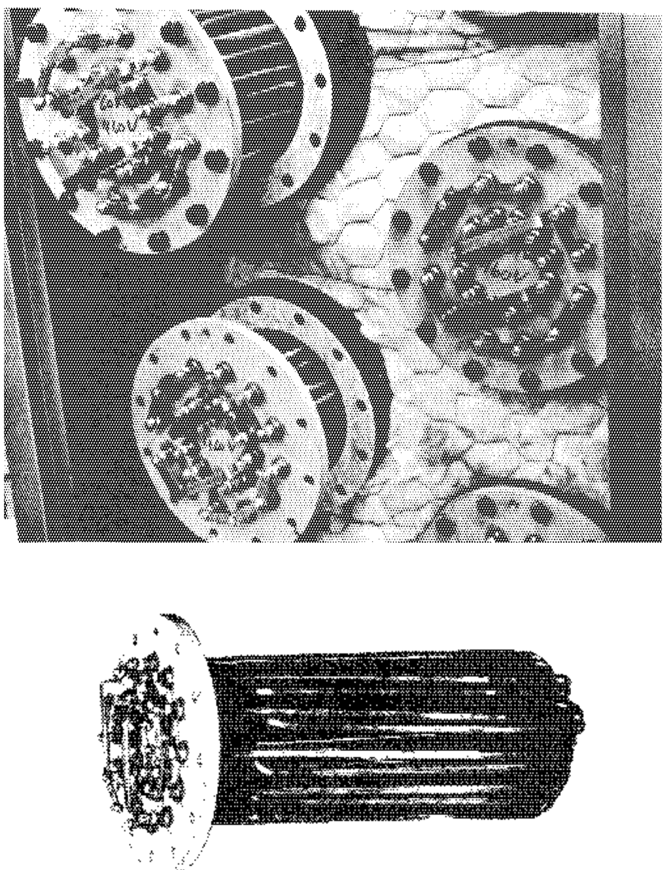

Figure 6
Immersion Heater Elements
(Courtesy of Cam Industries Inc.)

Connections to the heating elements can be rearranged to provide full load operation on various voltages (which may vary due to plant location).

Notes: