Boiler Systems

An Online Continuing Education Course for Engineers

Course Number: HV-3006

Credit: 3 Hours / 3 PDH / 3 CPD

Boiler Systems

Introduction

The boiler is a closed vessel used to generate steam and hot water for heat or power. Within this vessel, water is contained and steam is produced and collected or hot water is produced. Heat is needed to change the water to the required medium. The most commonly used fuel sources for producing large volumes of steam or hot water are fuel oil, coal, or gas. Boilers come in many types and varieties. The following sections will describe in brief these various types of boilers, and the components they are composed of.

Boiler Types

Steam Boilers

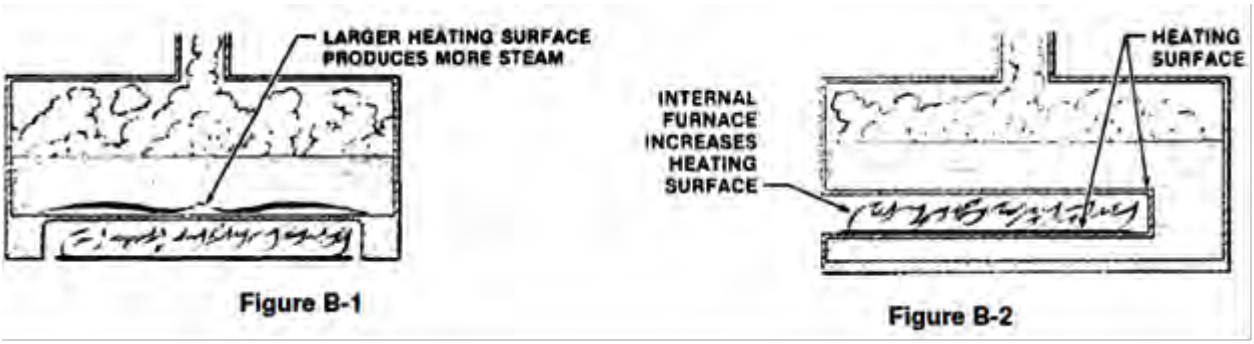
A high-pressure steam boiler operates at pressures greater than 15 psig. One advantage of the high-pressure boiler is the reduced size of the boiler and steam piping. A low-pressure steam boiler operates at pressures less than 15 psig. An advantage of the low-pressure boiler is the simpler design and operation; no pressure reducing valves are required, and the water chemical treatment is less costly and complex.

Hot Water Boilers

A high-temperature hot water (HTHW) boiler furnishes water at a temperature greater than 250 °F or at a pressure higher than 160 psig. HTHW systems can carry greater heat to end locations than the lower temperature systems. A low- temperature hot water boiler furnishes water at a temperature less than 250°F and a pressure less than 160 psig.

Hot water boilers usually require pumps to circulate the hot water and require power for pumping. Steam boilers do not require the pumps, but they do need larger piping. High-pressure steam systems will also require pressure reducing valves.

The efficiency of a boiler increases as the heating surface of the boiler increases. Figures 1 and 2 show that, with a larger heating surface, more heat is transferred to the water, and the amount of steam produced increases while using the same amount of fuel.



Source: Steingrass 1986. Used with permission of American Technical Publishers, Inc.

Boilers are classified based on their physical arrangement of the working fluid, the combustion gases, and the type of working fluid or heat carrier used.

Firetube Boilers

The largest percentage of small to medium-sized industrial boilers are firetube boilers (Figure 3). The name comes from the tubes through which the flue gases flow. As the flue gases flow through the tubes, heat from the flue gases transfers to the water surrounding the tubes. Steam or hot water is generated in the process.

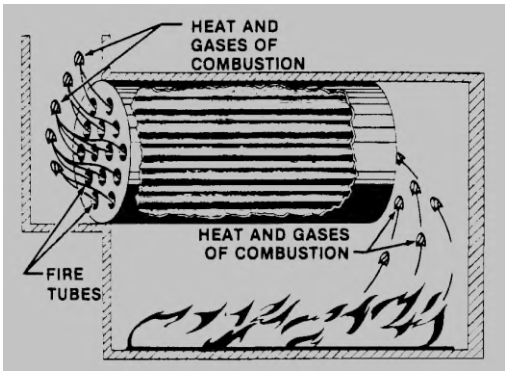


Figure 3. Firetube Boiler.

Source: Steingrass 1986. Used with permission of American Technical Publishers, Inc.

The most common firetube boilers used today are the Wetback and Dryback boilers. Both are variations of the Scotch boiler. Their names refer to the design of the rear of the combustion chamber, which is water-lined (Wetback) or lined with a high-temperature insulating material (Dryback).

The Wetback boiler (Figure 4) has more heating surface, but is more difficult to service because of limited access.

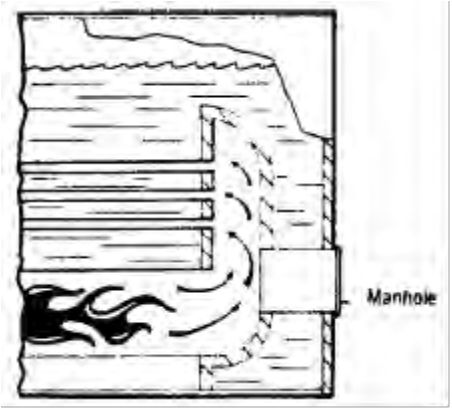


Figure 4. Wetback Boiler.
Source: Dukelow 1983. Used with permission of Kansas State University, Manhattan.

The Dryback boiler (Figure 5) is easier to service, but its insulation may deteriorate over a period of time, and its efficiency may be reduced if the insulation is not properly maintained.

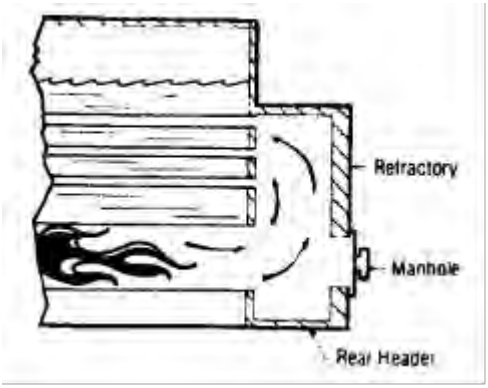


Figure 5. Dryback Boiler.
Source: Dukelow 1983. Used with permission of Kansas State University, Manhattan.

The number of boiler passes for a firetube boiler refers to the number of horizontal runs the flue gases take between the furnace and the flue gas outlet. The combustion chamber or furnace is considered the first pass; each separate set of firetubes provides additional passes as shown in Figure 6.

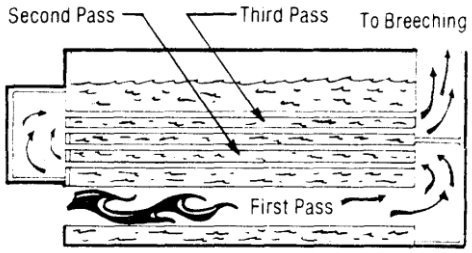


Figure 6. Boiler Passes.
Source: Dukelow 1983. Used with permission of Kansas State University, Manhattan.

Note that the number of passes does not determine the efficiency of a firetube boiler. Generally, increased passes increase consumption of air blower power due to increased resistance to flow.

Watertube Boilers

The watertube boiler gets its name from the circulation of water through the boiler tubes. The tubes generally connect two cylindrical drums. The higher drum—the steam drum—is half filled with water. The lower drum—the mud drum—is filled completely with water. The lower drum collects any sludge that may develop. The heating of the riser tubes causes a release of steam in the steam drum. A packaged watertube boiler is shown in Figure 7. Hot water can be generated using the same principle.

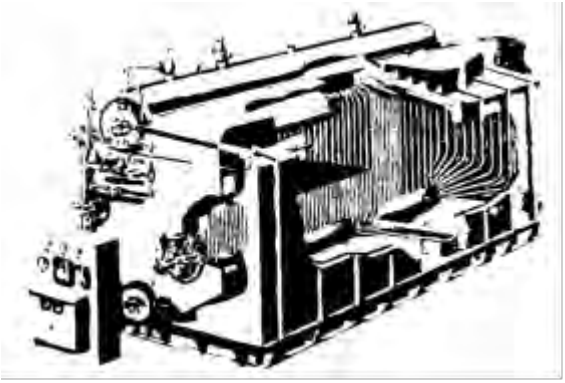
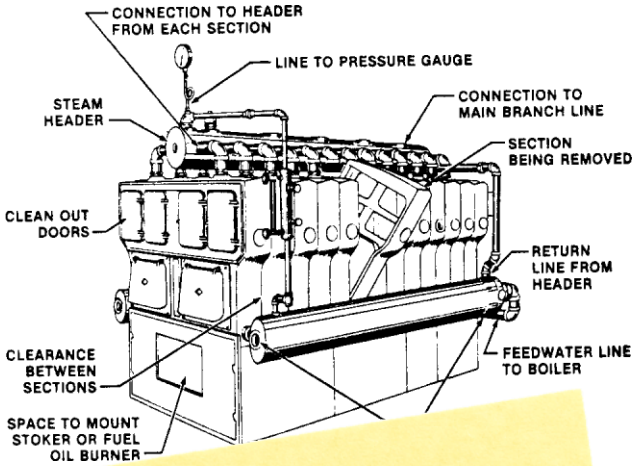


Figure 7. Watertube Boiler.
Source: Dukelow 1983. Used with permission of Kansas State University, Manhattan.

Watertube boilers are applicable for a wide range of sizes and pressures. Pressures range from 50 to 5,000 psig. Sizes range from 20,000 to 1,000,000 lb/h of steam for industrial watertube boilers. Watertube boilers using solid fuels require greater spacing between the boiler tubes than boilers using liquid and gaseous fuels. This requirement is due to the buildup of ash residue and other particulates on pipes, which reduces air circulation around the pipes. This makes converting a gas or oil-fired boiler to a coal-firing boiler difficult. Conversion from a coal boiler to a gas or oil boiler is more easily accomplished.

Cast Iron Sectional Boilers

Cast iron sectional boilers are also called watertube cast iron boilers, even though there are no tubes in them. These boilers can be expanded by adding sections. As shown in Figure 8, the combustion gases flow around the sections that contain water.



Source: Steing *nical Publishers, Inc.*

Forced Draft Boile

A forced draft boiler pushed through the burner wind box.

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Natural Draft Boilers

The draft in the natural draft boiler is caused by the difference in weight of the column of flue gases within the stack, and a corresponding column of equal dimensions outside. The intensity of the draft is negative and is expressed in inches of water.

Induced Draft Boilers

A fan is used to pull the air and combustion products through the boiler. The fan is located in an area of the boiler that will allow it to suck particles through the boiler, not permitting ash, etc., to settle and clog the air passage. If this is not done, the boiler will become dirty inside and inefficient.