Boilers

Combustion boilers are designed to use the chemical energy in fuel to raise the energy content of water so that it can be used for heating and power applications. Many fossil and nonfossil fuels are fired in boilers, but the most common types of fuel include coal, oil, and natural gas. During the combustion process, oxygen reacts with carbon, hydrogen, and other elements in the fuel to produce a flame and hot combustion gases. As these gases are drawn through the boiler, they cool as heat is transferred to water. Eventually the gases flow through a stack and into the atmosphere. As long as fuel and air are both available to continue the combustion process, heat will be generated.

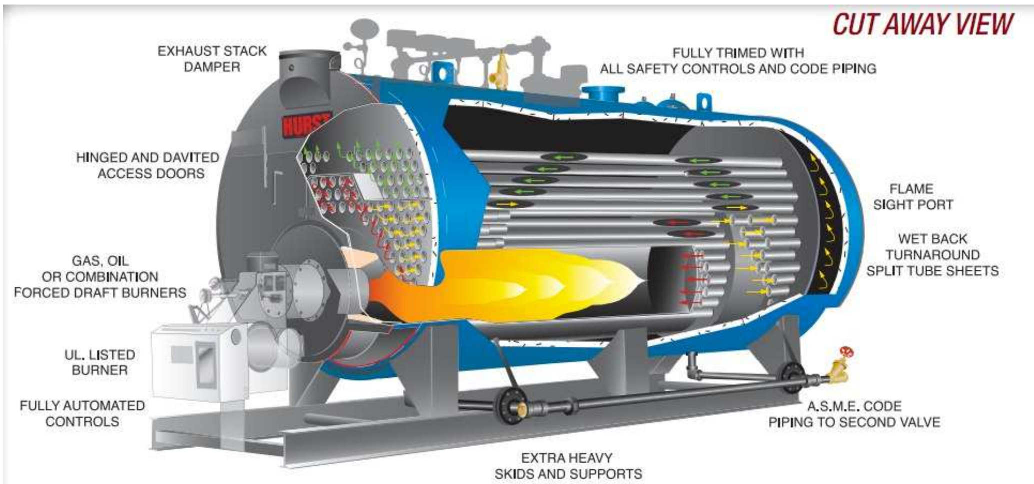
Classification

Boilers are manufactured in many different sizes and configurations depending on the characteristics of the fuel, the specified heating output, and the required emissions controls. Some boilers are only capable of producing hot water, while others are designed to produce steam. Steam generating boilers can be classified under various categories. The main purpose of steam boilers is to generate steam, and so the way in which the steam is generated and consumed forms the major category. The major two groups of boiler application are **Industrial steam generators** and **power generation boilers**. Boilers are also classified as **fire tube** and **water tube boilers**.

Some types of **fire tube boilers** have almost become extinct; however this can be classified as

- Locomotive boilers, which ruled rail transportation before diesel and electric engine came.
- Industrial boilers, mainly used for green projects where initial steam is required
- Domestic use boilers

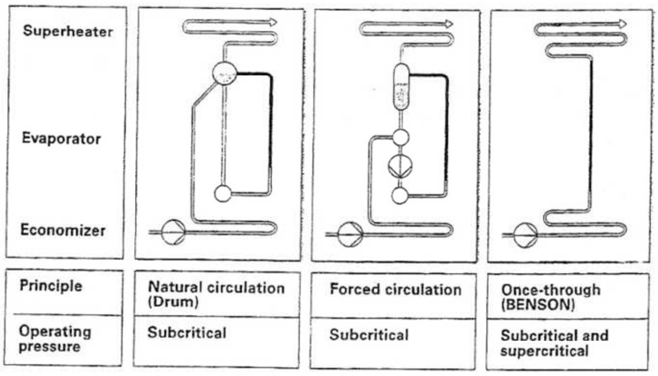
Fire tube boilers are used in the more typical industrial and commercial boilers, which generally require lower steam generation or have limited space. In this case the fire, or the hot combustion gases, are contained inside tubes within the boiler and the water is circulated around these tubes.



Water tube boilers took over when size and capacity increased. They consist of a large number of closely spaced water tubes creating boiler walls and heating surfaces located in flue gas flow.

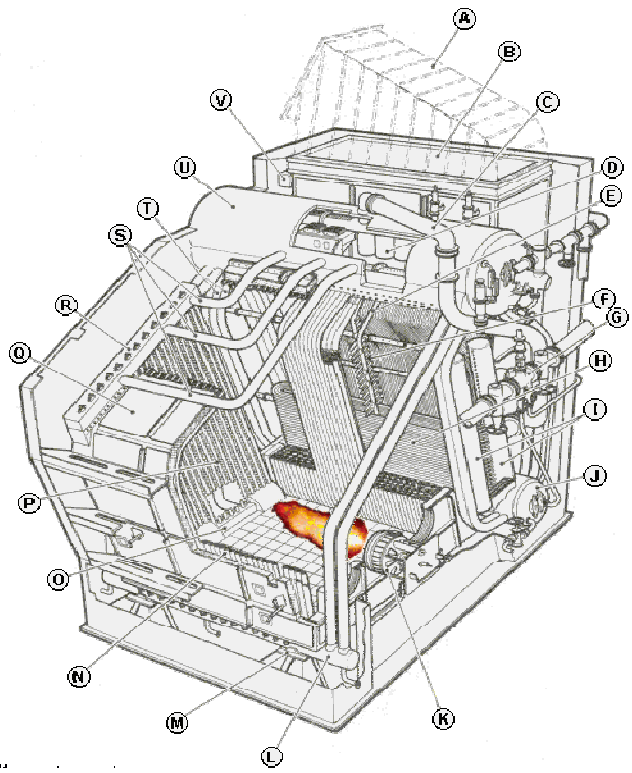
This can be classified depending on type of circulation used to generate steam as

- Natural circulation boilers
- Forced circulation boilers
- Once-through design (zero circulation) boilers



In circulation boilers the evaporator tubes are connected to one or more drums, which act as water pockets and steam separators, giving rapid water circulation and quick steaming.

Water tube boilers are usually used in large industrial and power generation situations where extremely high heat transfer rates are required to produce large quantities of steam. The water is heated in tubes and the fire (combustion process) is contained in the space around the tubes.



A. **Smoke uptake**

B. **Economizer**
A heat exchanger that transfers heat from Boiler Flue Gases to Boiler Feedwater.

C. **Steam Outlet**
Saturated steam from the Steam Drum to the Superheater

D. **Cyclone**
A device inside the drum that is used to prevent water and solids from passing over with the steamoutlet.

E. **Stay tube**
for superheater

F. **Stays**
for superheater tubes

G. **Superheated steam outlet**

H. **Superheater**
A bank of tubes, in the exhaust gas duct after the boiler, used to heat the steam above the saturation temperature.

I. **Superheater Headers**
Distribution and collecting boxes for the superheater tubes.

J. **Water Drum**

K. **Burner**

L. **Waterwall Header**
Distribution box for Waterwall and downcomers.

M. **Footing**

N. **Waterwall**
Tubes welded together to form a wall.

O. **Waterwall Header**
Distribution box for Waterwall and downcomers.

P. **Back side Waterwall**

Q. **Boiler hood**

R. **Waterwall Header**
Collecting box for Waterwall and risers.

S. **Riser**
The water-steam emulsion rises in these tubes toward the steamdrum.

T. **Downcomer**
A tube through which water flows downward. These tubes are normally not heated, and the boiler water flows through them to supply the generating tubes.

U. **Steam Drum**
Separates the steam from the water.

V. **Economizer Header**
Distribution box for the economizer tubes.

Depending on **type of firing** adopted in boilers they can be classified as

- Stoker fired
- Pulverized coal fired
- Fluidized bed boilers
- Cyclone fired
- Heat recovery boilers
- Incinerators

Of these the stokers which were predominantly used in early days of high pressure high capacity boilers are being replaced by pulverized coal fired boilers and fluidized bed boilers. Stoker boilers are still designed and used in few applications like biomass combustion and incinerators. Fluidized boilers are also going through fast development and can be now sub classified as

- Bubbling fluidized bed boilers
- Circulating fluidized bed boilers.

The higher capacity boilers are mainly circulating fluidized bed boilers due inherent limitations in bubbling bed boilers.

Boilers can be classified based on the type of fuel used as

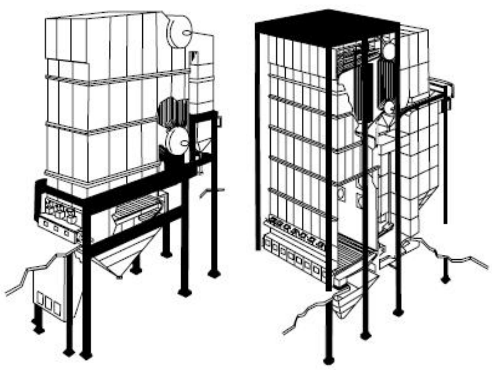
- Coal fired boilers
- Oil fired boilers
- Gas fired boilers
- Multi-fuel fired
- Municipal and industrial waste fired boilers
- Biomass fired boilers

Depending on steam pressure boilers can be classified at:

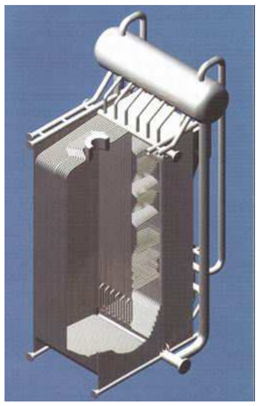
- low pressure (0.7–1.4 MPa) to supply heat to heating coils etc., or by direct injection into fluid.
- high pressure (> 4.2 MPa) to drive turbines or reciprocating engines
- subcritical pressure (< 22.14 MPa) for standard power plants
- supercritical pressure (> 22.14 MPa) for modern power plants with high capacity

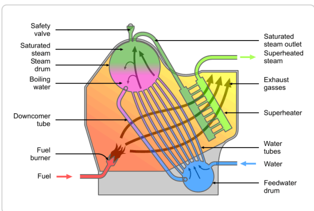
Various types of arrangement are used by designers in designing the boiler for meeting the end requirement. Hence boilers are classified based on the arrangement

- by support as
    - Bottom supported - is more economical if used in small scale like package boiler and solid fuel fired boiler which has capacity steam until 60 ton per hour. All of pressure parts are assumed as load and the load is supported from bottom
    - Top supported boilers - all of pressure parts assemblies of steam boiler are supported from top; they are suspended like a church bell. The weight of load and expansion are transferred to the ground. Top supported structure is usually more expensive than bottom supported.

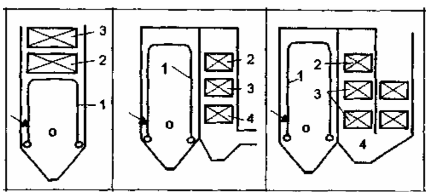


- by drum number
    - Single drum - used mainly for higher capacities and steam parameters. Single drum boilers are suitable and can adapt to both reheat and non-reheat type of boilers. They can be designed as bottom supported where the frame is not required and also they are designed as top supported where the whole boiler assembly needs an external frame and supported by top drum.
    - Bi drum - are commonly used for process steam generation as they can adapt to the high load fluctuation and respond to load changes.
    - Three drums, but these are presently out of use





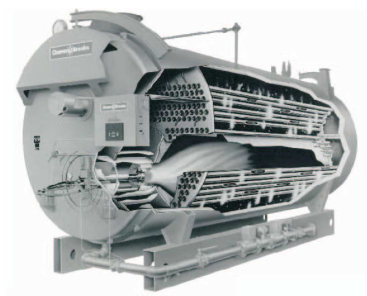
- by pass configuration
    - Package boilers
    - Tower type or single pass
    - Two pass boilers
    - Three pass boilers



1 – evaporator
2 – superheater
3 – economizer
4 – air preheater

Packaged Boiler

The packaged boiler is so called because it comes as a complete package. Once delivered to site, it requires only the steam, water pipe work, fuel supply and electrical connections to be made for it to become operational. Package boilers are generally of shell type with fire tube design so as to achieve high heat transfer rates by both radiation and convection.



The features of package boilers are:

- Small combustion space and high heat release rate resulting in faster evaporation.
- Large number of small diameter tubes leading to good convective heat

transfer.

- Forced or induced draft systems resulting in good combustion efficiency.
- Number of passes resulting in better overall heat transfer.

These boilers are classified based on the number of passes – the number of times the hot combustion gases pass through the boiler. The combustion chamber is taken, as the first pass after which there may be one, two or three sets of fire-tubes. The most common boiler of this class is a three-pass unit with two sets of fire-tubes and with the exhaust gases exiting through the rear of the boiler.

Boiler Specification

Maximum continuous rating

Steam boilers rated output is also usually defined as Maximum Continuous Rating (MCR). This is the capability of steam boiler to produce and provide the stated quantity of steam continually and easily with no all kinds of deficit or unwanted effects (for example overloading, slagging or overheating) upon the principal steam boiler and its components. MCR usually defines maximum evaporation rate that can be sustained for 24 hours and may be less than a shorter duration maximum rating.

New units are purchased with a guaranteed efficiency at MCR for a specific design fuel producing a specified quantity of steam or hot water at a specified temperature and pressure. Guaranteed parameters at MCR are

- Boiler efficiency
- Steam rating
- Final superheater/reheater temperature
- Final superheater/reheater pressure

These parameters are guaranteed on following conditions

- Feed water temperature and pressure
- Ambient air temperature at FDF inlet
- Ambient air relative humidity
- Barometric pressure.
- Fuel parameters
- Continuous blow down rate.

Any changes in these characteristics change the operating efficiency.

Boiler output

means the heat transferred to the water/steam between the feed inlet and the boiler water/steam outlet(s). This includes any heat transferred in economiser(s) and superheater(s).

Capacity

means the boiler output at maximum continuous rating specified by the boiler manufacturer.

Design pressure

means the pressure used by the designer for the purpose of calculating pressure parts of the boiler.

Pressure

means the pressure above the atmospheric pressure.

Example of steam boiler specification at MCR:

Steam rating	52.7 t/hour
Steam temperature	450°C
Steam pressure	62 bar
Feed water temperature	110°C
Feed water pressure	75 bar
Temperature of flue gas at boiler output	140 ±10°C
Fuel	wood waste
LCV	12.4 MJ/kg
Boiler efficiency	91%