M2-2: Boilers

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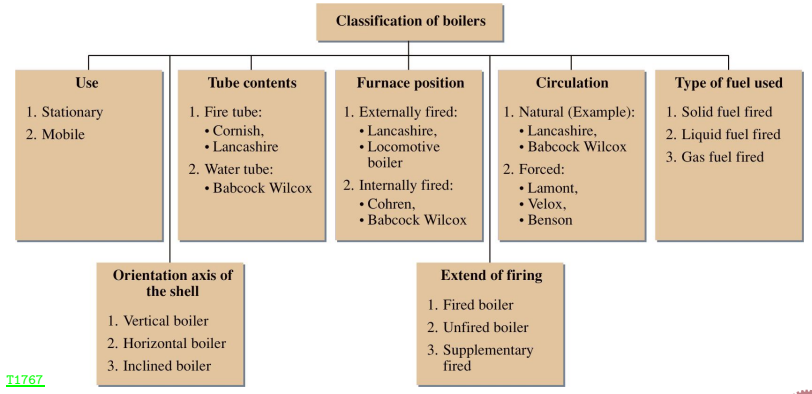
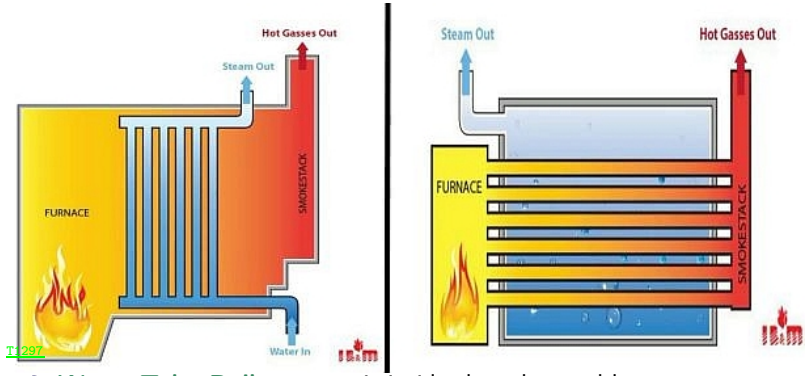
Capacity Development Training Program on
Energy Auditing and Energy Management

Boiler Classifications



T1767

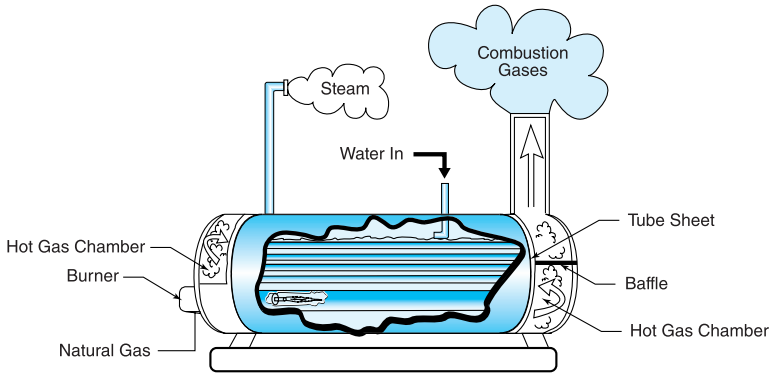
Water Tube & Fire Tube Boilers



T1297

1. **Water Tube Boiler**: water is inside the tubes and hot gases surround the tubes.
2. **Fire Tube Boiler**: hot gases are inside the tube and water surrounds the tubes.

Fire Tube Boiler

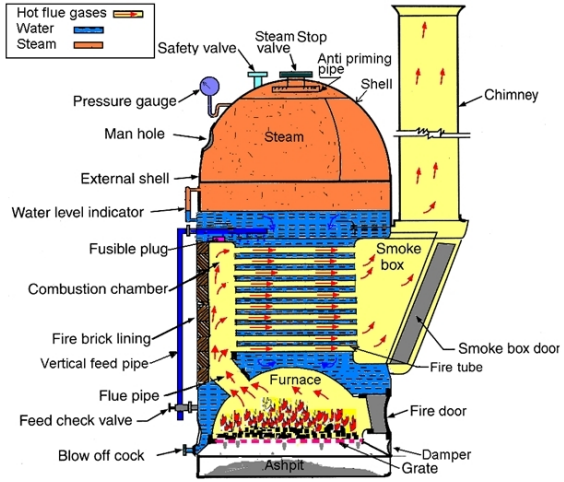


T1129

(Heated Tubes Submerged in Water)

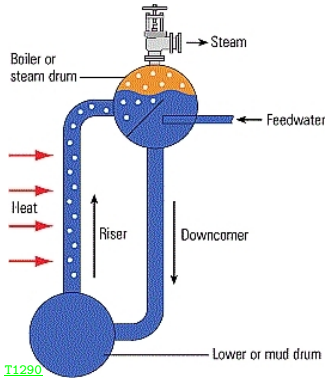
In fire tube boiler, the hot gases passes inside the tubes and boiler feed water in the shell side is converted into steam.

Fire Tube Boiler: Cochran Boiler



T1287

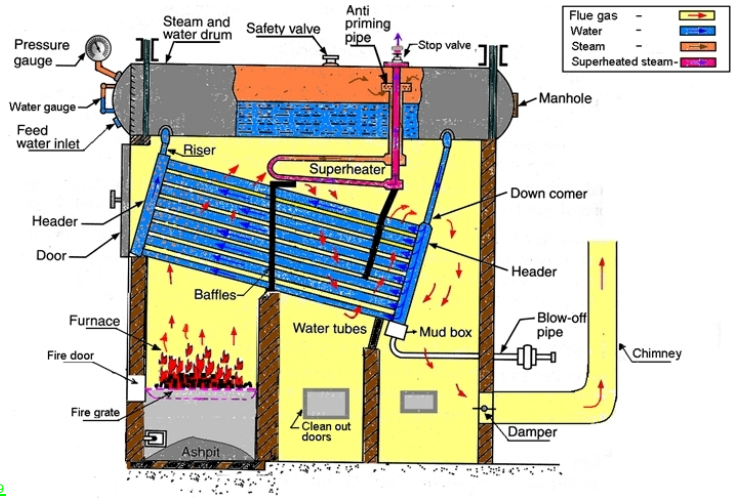
Water Tube Boiler



T1290

- In a water tube boiler, water is heated inside the tubes and the hot gases surround the tubes.
- Larger heating surface can be achieved by using more numbers of tubes.
- Due to convectional flow, movement of water is much faster than that of fire tube boiler, hence rate of heat transfer is high which results into higher efficiency.
- Very high pressure in order of 140 atm can be obtained smoothly.

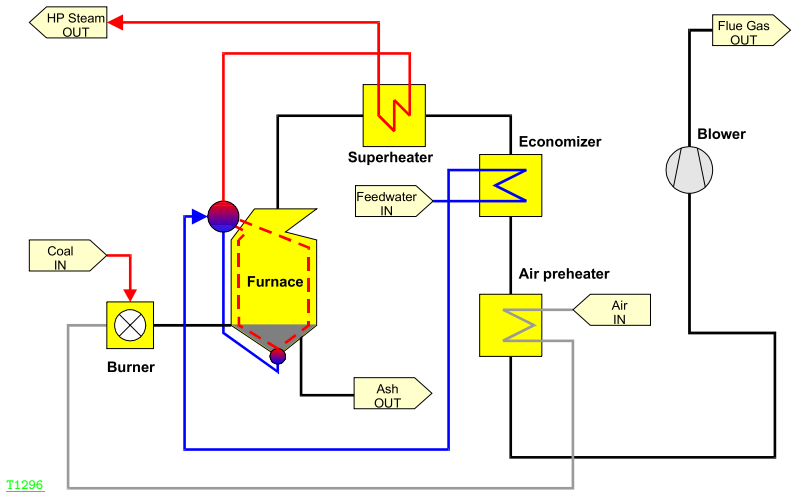
Water Tube Boiler: Babcock & Wilcox Boiler



T1289

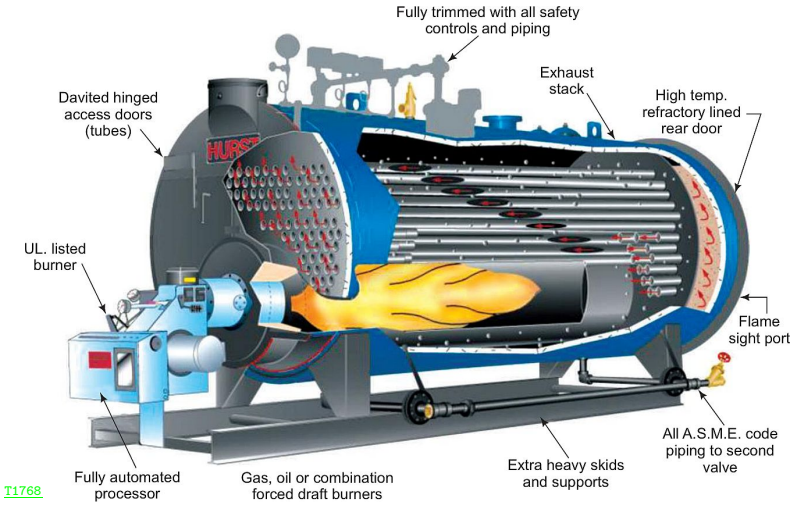
Boiler Accessories

- **Air-Preheater**: air supplied to the boiler is heated using the hot flue gases in the chimney.
  - Some waste heat is recovered, so system efficiency improves.
  - Better combustion and low-grade fuels can be burnt.
- **Economiser**: feed-water is heated using the hot flue gases.
  - Recovers energy leaving with flue gases, so system efficiency improves.
  - Hot feed water is supplied to the boiler drum, so thermal shock is minimized.
- **Super-heater**: steam is superheated to increase system efficiency.



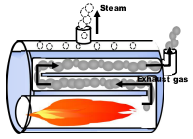
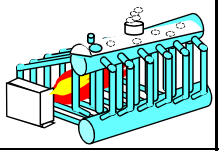
T1296

Typical steam and gas circuit showing the locations of some boiler accessories



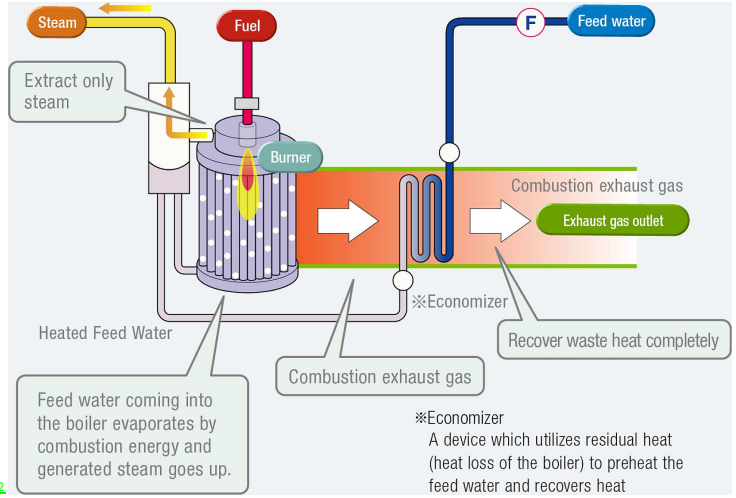
T1768

Packaged boiler

	Once-through boiler	Fire tube boiler	Water tube boiler
Outline drawing			
Design efficiency	98%	88 - 92%	85 - 92%
Load following capability	Multiple installation with MI control enables the boilers to follow the load.	The boiler has a large water content. Because of its self-evaporation, it responses well to load changes and has a good stability.	The boiler has a large water content. Because of its self-evaporation, it responses well to load changes and has a good stability.
Qualified person (In Japan)	None	Required (Boiler engineer)	Required (Boiler engineer)
Operation Monitoring (In Japan)	Continuous monitoring is not required.	Continuous monitoring is required, by a qualified person in principle.	Continuous monitoring is required, by a qualified person in principle.
Performance check (In Japan)	None	Required	Required

T1439

Once-Through Boilers



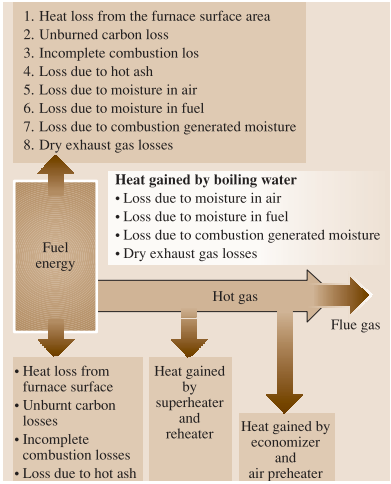
T1732

Energy Saving Potentials of Boilers

Technique/method	Energy saving potential*
Operation and maintenance of boilers	Up to 5%
Boiler and burner management systems, digital combustion controls and oxygen trim	Up to 5%
Economisers	Up to 5%
Blowdown heat recovery	Up to 4%
Combustion air preheating	Up to 2%
Water treatment and boiler water conditioning	Up to 2%
Total dissolved solids (TDS) control and boiler blowdown	Up to 2%
Flue-gas shut-off dampers	Up to 1%

T1134

Heat Losses in Boiler



T1133

Boiler Capacity & Performance Parameters

Boiler Efficiency:

$$\eta_{boiler} \equiv 100\frac{Heat\ absorbed\ by\ feed\ water}{Energy\ released\ by\ fuel} = 100\frac{\dot{m}_w(h_g - h_w)}{\dot{m}_f\ GCV}$$

Evaporation Ratio:

$$Evaporation\ ratio = \frac{Quantity\ of\ steam\ generation}{Quantity\ of\ fuel\ consumption} = \frac{m_w}{m_f}$$

- Quantity of steam generated per hour (m_w) in kg/hr.
- Quantity of fuel used per hour (m_f) in kg/hr.
- Gross calorific value of the fuel (GCV) in kcal/kg of fuel
- h_g - Enthalpy of saturated steam in kcal/kg of steam
- h_w - Enthalpy of feed water in kcal/kg of water

Find out the efficiency of the boiler by direct method with the data below:

- Type of boiler: Coal fired
- Quantity of steam (dry) generated: 8 TPH
- Steam pressure / temp: 10 kg/cm^2(g)/ 180 °C
- Quantity of coal consumed: 1.8 TPH
- Feed water temperature: 85 °C
- GCV of coal : 3200 kCal/kg
- Enthalpy of saturated steam at 10 kg/cm^2 pressure: 665 kCal/kg(saturated)
- Enthalpy of feed water: 85 kCal/kg

[80.6%]

Blow-down

- Lower pre-treatment costs
- Less make-up water consumption
- Reduced maintenance own time
- Increased boiler life
- Lower consumption of treatment chemicals

$$Blow\ down(\%) = \frac{TDS_{feed-water} \times (\%feed - water)}{TDS_{max} - TDS_{feed-water}}$$

$$Blow\ down\ rate = \frac{TDS_{feed-water} \times (steam - generation - rate)}{TDS_{max} - TDS_{feed-water}}$$

A 10 TPH boiler has feed-water TDS = 250 ppm, and estimate the blow-down rate is maximum TDS is 2500 ppm.

[1111 kg/hr]

Oil fired Boiler is generating 100 TPH of steam at 85% efficiency, operating 330 days in a year. Management has installed a water treatment plant at Bangladeshi Taka (BDT) 1.16 Crore investment for reducing the TDS in boiler feed from 450 ppm to 150 ppm. The maximum permissible limit of TDS in the boiler is 3000 ppm and make up water is 10%. Temperature of blow down water is 175 °Cand boiler feed water temperature is 45 °C. Calorific value of Fuel oil is 1200 kCal/kg. Calculate the payback period if the cost of fuel is 23150 BDT / Ton.

[0.4 yrs]