



TECH TIP #1

Which Boiler is Right For Me?

WHICH BOILER?

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Boiler Selection

A boiler is a relatively simple object...it is a closed vessel containing water which is heated to produce steam or hot water.



Although the boiler is a single unit, four separate but interrelated systems are necessary for operation. When considering a boiler or the resulting efficiency of any system, all of these elements must be taken into consideration. The systems are:

- Feedwater System - supplies water to the boiler
- Fuel System - supplies fuel for making heat
- Draft System - provides air for combustion
- Distribution System - collects and controls the steam or hot water that is produced.

A SHORT HISTORY

Boilers were first used for warming water and are of Roman and Greek origin. Early boilers were recovered from the ruins of Pompeii. In 1698, Thomas Savery developed a steam-driven water pump. As the steam condensed, a vacuum was created causing water to be drawn into the cylinder. The boiler continued to be refined and developed for increased industrial use.

Today boilers are either firetube, cast iron or watertube in design. In addition, boilers can be package boilers and special-purpose boilers.

The following data does not show all boilers or all features of each type of boiler. This data is intended to give an overview of the major features of common boiler types regardless of manufacturer.

The first type of boiler is the Firetube Boiler. In firetube design boilers, combustion gases run through tubes surrounded by water. Firetube boilers are used in applications that require moderate pressures and moderate demands for quantities of steam per hour.

Firetube boilers generally have 2" diameter or larger tubes. They are usually straight and relatively short so the hot gasses experience a low pressure drop while passing through them.

The water space surrounding the tubes is unusually contained by a large cylindrical or flat surface vessel. For this reason, firetube boilers are rarely designed for more than 300 PSI as the required wall thickness would be excessive.

Firetube boilers have a fairly large amount of contained water so that there is a considerable amount of stored heat energy in the boiler. This also allows for load swings where large amounts of steam or water are required in a relatively short period of time.

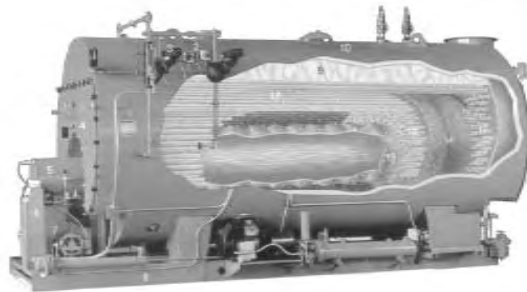
Firetube boilers can take a great deal of abuse and inattention and still function at competent levels. To maintain the entire firetube boiler system is operating at high efficiency

levels, accessory equipment is recommended especially for closed loop systems.

Packaged firetube boilers are assembled at the factory, shipped and installed as a unit. Packaged boilers are self-contained units and require minimal installation work in the field. They usually only need electrical, water, fuel and chimney connections. Most packaged boilers are test fired before shipment. Efficiency reports are supplied to the buyer.

These accessory equipment units consist of equipment designed to treat and maintain the quality of system water. Recommended pieces of equipment often include: water softeners, chemical feeders, feedwater systems, deaerators and blow-down equipment. Use of this equipment can not only increase the longevity of your firetube boiler but can also payback handsomely in increased daily operating efficiencies.

There are two major types of firetube boilers: scotch marine and firebox boilers.



SCOTCH MARINE

Scotch marine boilers derive their name from the Scottish shipyards that built boilers for marine vessels for the British Navy. Old brick set boilers used to burn through the bottom of ships. The "Scotch Marine" design featured a cylindrical vessel and enclosed furnace so they couldn't overheat the bottom of these ships.

The idea for these "packaged boilers" caught on in the 1930's as an alternative to brickset boilers. These self-contained packaged units today represent the growth portion of the firetube industry.

Scotch marine boilers are equipped with an internal furnace. The furnace is surrounded by water which increases the boiler heating surface and in turn boiler efficiency. Today all boilers feature the same five square foot per horsepower heating surfaces unless indicated otherwise. With the advent of NEPA '92, all boilers are also mandated to the same demonstratable efficiency standards of 80% for gas and 83% for oil.

♦ **Prime Duty** - hydronic heating, steam heating, high and low pressure process systems.

♦ **Sizes Available** -

A) ASME 150# High Pressure Code 670 MBH output (20 HP) to 33475 MBH output (1000 HP).



TECH TIP #1 (Cont.)

B) ASME Low Pressure Code 15# SWP or 30# WWP 2009 MBH output (60 HP) to 25706 MBH output (750 HP).

C) ASME Low Pressure Code 100# WWP at 250 PSI Maximum 2009 MBH output (60 HP) to 25760 MBH output (750 HP).

◆ **Firing Modes** - Forced draft gas, oil, gas/oil.

A) On/Off firing. High/Low firing and Modulation available, costly for advantages.

B) High/Low firing with low fire start is standard on 2009 MBH (60 HP) to 2678 MBH (80 HP) output. Modulation is available.

C) Modulation firing with low fire start is standard on units 3348 MBH output (100 HP) and larger.

◆ **Approvals** -

A) ASME low and high pressure code.

B) U.L. "B" label on factory packaged boiler/burner units.

C) U.L., FM and IRI burners and gas trains available.

◆ **Comments** -

A) These units are true forced draft fired.

B) Good longevity with a good cost per horsepower can be expected from this type of boiler. These boilers can take a lot of abuse with a minimum amount of care and is easily repaired.

C) All boiler manufacturers are required to maintain combustion efficiencies in line with NEPA '92 legislation - 80% gas fired and 83% oil fired.

D) All boilers in this type have five square feet of heating surface per boiler horsepower. Three-pass type boilers are designed with greater primary heating surface and require fewer tubes. Four-pass type boilers have lower primary heating surface and require more tubes.



FIREBOX

The firebox boilers carry with them the tradition of the basic boiler design proven over the last one hundred years.

A second cousin to the brickset boilers and locomotives steam engine designs of the past, these boilers feature a simple durable construction and proven low maintenance reliable operation year after year.

◆ **Prime Duty** - Hot water and low pressure steam heating of office buildings, schools, churches and small to medium steam process application requiring moderate amounts of make-up.

Also suitable for solid and exotic fuel applications.

◆ **Sizes Available** -

A) 450 MBH output (10 HP) to 5050 MBH output (150 HP) 30# WWP or 15# SWP. Some available for 60# WWI, however, never over 250 PSI operating pressures. In this size range there is often a cost advantage per horsepower over Scotch boilers.

B) Units over 5050 MBH (150 HP) are available, but often cost more per horsepower than Firetube Scotch boilers for the same duty.

◆ **Firing Modes** - Forced draft gas, oil, gas/oil, solid and exotic fuels.

A) On/Off firing 450 MBH output (10 HP) to 1750 MBH output (40 HP). High/Low firing and Modulation is available; costly for slight advantages gained.

B) High/Low firing with low fire start is standard on 2050 MBH output (45 HP) to 2650 MBH output (60 HP) units. Modulation is available.

C) Modulation firing with low fire start is standard on units 3350 MBH output (70 HP) or larger.

◆ **Approvals** -

A) ASME low pressure code.

B) U.L. "B" label is also available on boiler/burner units shipped from the factory as a packaged unit.

C) If unit is shipped less burner and burner is mounted by local shop and/or on the jobsite, the U.L. label applies to burner only. No U.L. approval is available on field assembled boiler/burner units.

D) Many sizes of firebox design boilers will fit through a standard 36" door for retrofit installations.

◆ **Comments** -

A) These units are true forced draft and can be fired with high combustion chamber pressures and usually require smaller stacks than atmospheric or pressure fired units.

B) Good longevity with a moderate cost per horsepower. Simple operation, easy maintenance and many sizes that fit through a standard door make firebox a good choice for schools, churches and retrofit installations.

C) All boiler manufacturers are required to maintain combustion efficiencies in line with NEPA '92 legislation - 80% gas fired and 83% oil fired.

D) Boilers in this type are offered in four square feet, four and one half square feet and five square feet of heating surface per boiler horsepower models.

The second type of boilers are of CAST IRON design.

In the original boiler rooms, the building was built around or on the boiler room. When it came time for replacement of the boiler, there was no way to get a new boiler in without knocking out a wall. The cast iron sectional boiler solved this problem.

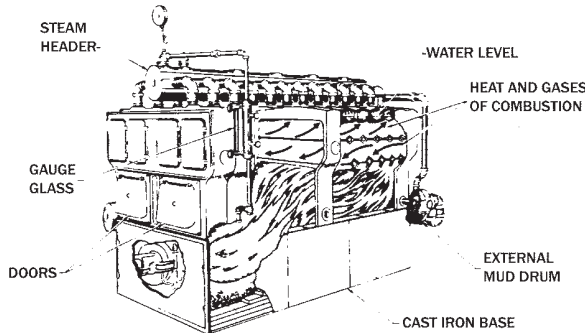
The cast iron sections are taken individually into the boiler room and field assembled at the jobsite. While the initial cost is low, much field labor is required to make the boiler operational. If a section becomes cracked, the entire boiler must be disassembled. These boilers have small



TECH TIP #1 (Cont.)

steaming areas so they are very sensitive to changes in demand or water levels.

Cast iron boilers also require much care in the treatment of their feedwater. They are sensitive to scale and require care in blowing down and maintaining the right internal water conditions.



CAST IRON SECTIONAL

◆ **Prime Duty -**

- A) Hydronic heating and process applications.
- B) Low pressure 35# Maximum S.W.P. for heating and process applications with low makeup water requirements.

◆ **Sizes Available -**

- A) 30# water 67 MBH input (1.5 HP) to 8,400 MBH input (190 HP) (208 BHP output). NOTE: Some models are available 85# W.W.P. but not over 250°F.
- B) 15# low pressure steam - 75 MBH input (1.5 HP) to 8,400 input (190 HP) (208 BHP output)

◆ **Firing Modes -**

- A) Atmospheric gas. 67 MBH input (1.5 HP) to 2860 MBH output (65 HP).
- B) Factory packaged induced draft gas with economizer - 67 MBH input (1.5 HP) to 167 MBH output (4 HP).
- C) Forced draft gas, oil, or gas/oil. 350 MBH input (8 HP) to 8,400 MBH input (190 HP) (208 BHP output).

◆ **Approvals -**

- A) ASME low pressure code on all vessels.
- B) A.G.A. approval on all atmospheric units.
- C) U.L. approval on all oil and force draft burners.
- D) FM and IRI burners available on all forced draft units.
- E) Standard gas trains U.L. approved. FM and IRI gas trains available.

◆ **Comments -**

- A) Good longevity when properly applied. However, subject to problems in high water make-up situations.
- B) Moderate cost per BTU output.
- C) Well suited to tight boiler replacement situations.
- D) However, if a customer wants another firetube boiler, "Job-Built" or field erected firetube boilers are available if the customer has access to code welders in the field.

The third type of major boiler design is the **WATERTUBE boiler**. In watertube design boilers, water runs

through tubes surrounded by combustion gases.

Water tube boilers are characterized by smaller diameter tubes, which are longer, often bent, curves or straight. Many of these boilers today have serpentine or tubes configured in a spiral. These tubes are often headered in parallel to make up a complete wall or panel of heat-absorbing watertubes. For this reason, the heat absorption rate per unit of furnace volume or furnace wall area is relatively high as compared to firetube boilers.

All high pressure boilers above 300# are usually of the watertube design, due to the fact that tubing of a given diameter and wall thickness will withstand a much higher internal pressure than external pressure. In the case of the firetube boiler, the tubes have to withstand the water pressure from the outside of the tube.

Most of the failures in watertube boilers come from split or burned tubes, which can result in a collapsing of the watertube walls.

As most watertube boilers have a small steaming area or water content, they are very sensitive to changes in demand and water level. They require close attendance, more sophisticated control systems, good consistent maintenance and water treatment procedures.

There are several different types of watertube boilers from those suited to small domestic hot water situations to large industrial based boilers of this design. These boilers come in four basic variations:

- Copper Watertube
- Steel Watertube
- Steel Bent Dry Base Watertube
- Steel Bent Wet Base Watertube

COPPER WATERTUBE

◆ **Prime Duty -**

Domestic hot water, pool heater, hospitals, health clubs, motels, small industrial plants, laundries, restaurant and car washes.

◆ **Sizes, Firing Modes and Approvals Available -**

Sizes 276 MBH input (6 HP) to 3060 MBH input (70 HP) at sea level. Pressures up to 160# WWP. Atmospheric gas fired only with AA or U.L. and ASME approval.

◆ **Comments -**

- A) Quick recovery and response to load demands.
- B) Caution, consult manufacturers data regarding minimum water circulation rates and pressure drops.
- C) Low cost.
- D) Low longevity.

STEEL WATERTUBE

◆ **Prime Duty -**

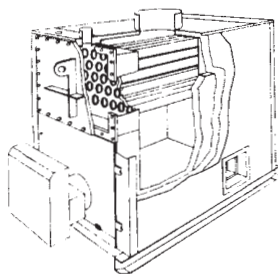
Hydronic heating systems, apartments, office buildings church, small commercial and industrial buildings.

◆ **Sizes, Firing Modes and Approvals Available -**

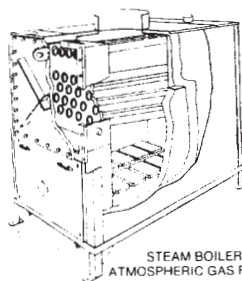
100 MBH (2 HP) to 9,500 MBH (215 HP) sea level input. Pressures 50# WWP to 150# WWP at maximum 250° F. Atmospheric gas firing. Some gas, gas/oil units. ASME on all shells, AA or U.L. atmospheric fired shell 100 MBH to



TECH TIP #1 (Cont.)



WATER BOILER WITH POWER BURNER



STEAM BOILER ATMOSPHERIC GAS FIRED

9,500 MBH.

◆ **Comments -**

- A) Economical where high hydrostatic pressures over 30# WWP are required.
- B) Boiler not affected by thermal shock by nature of its construction, however, is subject to flue gas condensation caused by low inlet and/or operating temperatures.
- C) This boiler is generally atmospheric fired. Pressure fired units are not true forced draft. Large refractory surfaces that are not water-backed make it difficult to reduce hot spots. Units must be heavily insulated to maintain low jacket temperatures.
- D) This boiler is not used as a process steam boiler due to low water content. Scaling is a problem with high to medium make-up water. Small disengaging area and steam space.
- E) Low to medium cost and longevity.

STEEL BENT WATERTUBE - DRY BASE

◆ **Prime Duty -**

Domestic Hot water and hydronic heating for apartments, office buildings small commercial and industrial buildings.

◆ **Sizes, Firing Modes and Approvals Available -**

Atmospheric firing 150 MBH (3 HP) to 15,000 MBH (300 HP) sea level input. Forced draft gas and gas/oil 251 MBH (5 HP) to 14,845 MBH (300 HP) sea level input. 30# WWP to 125# WWP 15# SWP to 150# SWP. ASME on all shells, AGA or U.L. atmospheric fired units 100 MBH to 9,500 MBH.

◆ **Comments -**

- A) Economical where high hydrostatic pressures over 30# WWP are required.
- B) Boiler not affected by thermal shock by nature of its construction, however, is subject to flue gas condensation caused by low inlet and/or operating temperatures.
- C) This boiler is generally atmospheric fired. Pressure fired units are not true forced draft. Large refractory surfaces that are not water-backed make it difficult to reduce hot spots. Units must be heavily insulated to maintain low jacket temperatures.
- D) This boiler is not used as a process steam boiler due to low water content. Scaling is a problem with high to medium make-up water. Small disengaging area and steam space.
- E) Medium cost and longevity.

STEEL BENT WATERTUBE - WET BASE

◆ **Prime Duty -**

Hydronic heating 30# to 160 # WWP. For schools, hospital commercial and industrial buildings and process. Separate domestic heat exchanger may be installed in separate drum.

◆ **Sizes Available -**

850 MBH (20 HP) to 30,000 MBH (666 HP) input. 30# WWP to 160# WWP 15#, SWP to 205 # SWP.

◆ **Firing Modes -**

Forced draft firing only.

- A) On/Off firing. 850 MBH (20 HP) input to 1500 MBH (35 HP).
- B) High/Low firing with low fire start. 2000 MBH (40 HP) to 30,000 MBH (666 HP) input.
- C) Modulation with low fire start 850 MBH (20 HP) input to 30,000 MBH (666 HP) input.

◆ **Approvals -**

- A) ASME Section IV Low Pressure Code for up to 250° F maximum temperature.
- B) ASME Section I High Pressure Code for high pressure steam boilers up to 205 SWP standard.

◆ **Comments -**

- A) Economical boiler where high electrostatic pressures over 30# WWP are required.
- B) The entire combustion chamber and all flue gas passages are backed with tangential water tubes.
- C) The water-backed walls and floor are backed with high temperature ceramic wool and gas tight panels. This construction makes it possible to pressurize the boiler for true forced draft firing.
- D) This boiler is good for all hydronic applications, however, with its low water content, low disengaging area and steam volume, it is difficult to maintain steady water levels with fluctuating steam loads. For steam applications, a modulating boiler feed system is recommended.
- E) Good longevity, reasonable cost.

SPECIAL PURPOSE BOILERS

Special purpose boilers are designed for specific applications. These boilers use equipment that may require specialized training by manufacturers of the equipment. The method of generating steam varies among special-purpose boilers, but the end product is the same. These boilers include:

- Public Utility Boilers
- Electric Boilers
- High Temperature, High Pressure Hot Water Boilers
- Natural Circulation Boilers
- Industrial Waste Boilers

For more information concerning boilers and boiler applications, please contact a sales representative at Federal.