is of importance in the original installation of the boiler and also in making repairs to or replacing a damaged boiler at a later date.

Cast-iron boilers may be designed to burn efficiently one kind of fuel only or various kinds of fuel. Practical combustion rates for coal-fired boilers are given in Table 1. Many recent designs of oil burning boilers have been designed exclusively for oil fuel and in some cases for both oil and gas. The present trend in the design of boilers for hand firing is, however, to design them so they will be suitable for ready conversion to and efficient operation with oil and stoker firing even after the boiler has been installed and has been operating for a period of time on one type of fuel.

TABLE 1. PRACTICAL COMBUSTION RATES FOR COAL-FIRED HEATING BOILERS OPERATING AT MAXIMUM LOAD ON NATURAL DRAFT OF FROM ⅛ IN. TO ½ IN. WATER[a]

KIND OF COAL	SQ FT GRATE	LB OF COAL PER SQ FT GRATE PER HOUR
No. 1 Buckwheat Anthracite	Up to 4	3
	5 to 9	3½
	10 to 14	4
	15 to 19	4½
	20 to 25	5
Anthracite Pea	Up to 9	5
	10 to 19	5½
	20 to 25	6
Anthracite Nut and Larger	Up to 4	8
	5 to 9	9
	10 to 14	10
	15 to 19	11
	20 to 25	13
Bituminous	Up to 4	9.5
	5 to 14	12
	15 and above	15.5

[a]Steel boilers usually have higher combustion rates for grate areas exceeding 15 sq ft than those indicated in this table.

Capacities of cast-iron boilers range from that required for small residences up to about 18,000 sq ft of radiation. For larger loads boilers must be installed in multiple. The maximum allowable working pressure for cast-iron boilers is limited by the *A.S.M.E.* Code to 15 lb per square inch for steam boilers. Hot water boilers are usually limited to 30 lb per square inch maximum working pressure but may be designed for higher pressures where required for heating purposes or for hot water supply where the boiler must withstand high local water pressures.

STEEL BOILERS

Steel heating boilers may be classified according to (a) position of combustion gas with respect to tube surface, (b) arrangement and construction of furnaces, and (c) type of fuel and method of firing.

Fire tube boilers are those in which the gases of combustion pass through the tubes and the boiler water circulates around them. In water

tube boilers, the gases circulate around the tubes and the water passes through them.

Steel heating boilers may be furnished with integral water jacketed furnaces or arranged for refractory lined brick or refractory lined jacketed furnaces. Those with integral water jacketed furnaces are called *portable firebox boilers* and are the most commonly used type. They may be either fire tube or water tube and are furnished for any fuel and method of firing used in heating boiler practice. They are usually shipped from the factory in one piece, ready for piping. Bridge-walls and smokeless furnace parts are shipped in place when furnished. Boilers with refractory lined furnaces may be either fire tube or water tube. They also may be arranged for any fuel or method of firing. Refractory furnaces are usually installed in such boilers after they are set.

SPECIAL HEATING BOILERS

A special type of boiler, known as the *magazine feed boiler*, has been developed for the burning of small sizes of anthracite and coke. These are built of both cast-iron and steel, and have a large fuel carrying capacity which results in longer firing periods than would be the case with the standard types using buckwheat sizes of coal. Special attention must be given to insure adequate draft and proper chimney sizes and connections.

Oil-burner boiler units, in which a special boiler has been designed with a furnace shaped to meet the general requirements of oil burners, or are specially adapted to one particular burner, have been developed by a number of manufacturers. These usually are compact units with the burner and all controls enclosed within an insulated steel jacket. Ample furnace volume is provided for efficient combustion, and the heating surfaces are proportioned for effective heat transfer. Consequently, higher efficiencies are obtainable than with the ordinary coal-fired boiler designed primarily for hand firing and converted to oil firing.

GAS-FIRED BOILERS

Gas boilers have assumed a well-defined individuality. The usual boiler is sectional in construction with a number of independent burners placed beneath the sections. In most boilers each section has its own burner. In all cases the sections are placed quite closely together, much closer than would be possible when burning a soot-forming fuel. The effort of the designer is always to break the hot gas up into thin streams, so that all particles of the heat-carrying gases can come as close as possible to the heat-absorbing surfaces. Because there is no fuel bed resistance and because the gas company supplies the motive power to draw in the air necessary for combustion (in the form of the initial gas pressure), draft losses through gas boilers are low. (See Chapter 11.)

Most gas-fired boilers carry the approval of the *American Gas Association*. In order to obtain this approval the boilers must be submitted to the *American Gas Association Testing Laboratory* and meet the Approval Requirements for Central Heating Gas Appliances issued by the *American Gas Association*. The boiler ratings must be such that they meet the limitations as set forth in these Approval Requirements.