automatically controlled, their sequence of control is similar to that described for horizontal rotary-cup burners.

3. *Gas Burners.* Some of the more common *primary controls* for gas burners are as follows.

a. Domestic gas burners of the atmospheric type require a *primary control*, to insure safe starting and operating conditions, which will (1) prevent opening of the gas valve unless the pilot is operating properly, and (2) stop the flow of gas through the burner if safe ignition conditions do not prevail at all times.

b. Commercial and industrial gas burners of the atmospheric type require a *primary control* whose function is similar to that for domestic sizes of these burners except in the rate of response to a pilot flame failure. The pilot flame burns constantly and, in general, the primary control system will (1) ensure operation only when ignition of the main burner will be safe; (2) start and stop the main burner when required to do so by either the *operating controller* or a *limit control*; and (3) close the *safety shut-off* valve in the gas supply line to the burner upon a flame failure or an electrical power failure.

c. Commercial and industrial gas burners of the power type equipped with electric ignition require a *primary control* whose most important operations include: (1) starting the burner motor upon a call for heat by the *operating control*; (2) providing a prepurge period before activating the gas-electric ignition; (3) proving the presence of proper ignition before allowing gas to flow to the main burner or shutting off the electric ignitor; (4) closing the safety shut-off valve in the event of a flame failure (it is usually required that the flow of gas be stopped within four seconds following a flame failure); (5) stopping the burner when either an *operating controller* or a *limit control* requires it; and (6) locking out on a flame failure shut-down (the programming control then must be manually reset prior to a restart).

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[3] Code for determination of rated capacities of anthracite underfeed stokers, adopted June 1, 1944, and Code for determination of rated capacities of bituminous underfeed stokers, adopted May 3, 1944 (*Stoker Manufacturers Association Manual*, Stoker Manufacturers Association).

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CHAPTER 35

HEATING BOILERS, FURNACES, SPACE HEATERS

BOILERS: Construction, Types, Design Considerations, Rating and Testing Codes, Efficiency, Rating, Selection, Space Limitations, Connections and Fittings, Erection, Operation and Maintenance. FURNACES: Types, Materials and Construction, Ratings, Testing and Rating Codes, Efficiency, Design Considerations, Humidification Equipment. SPACE HEATERS: Types: Solid Fuel, Oil, Gas; Materials and Construction, Testing and Rating, Design Considerations, Installation

IN presenting the subject of Boilers, Furnaces, and Space Heaters this chapter is divided into three parts; the first dealing with boilers, the second treating warm air furnaces, and the third covering space heaters.

HEATING BOILERS

Steam and hot water boilers for low-pressure heating are built of steel or cast iron in a wide variety of types and sizes, many of which are illustrated in the Catalog Data Section.

The nationally recognized code governing the construction of low-pressure steel and cast-iron heating boilers is the *ASME Boiler Construction Code for Low Pressure Heating Boilers*. Some states and municipalities have their own codes which apply locally, but these are usually patterned after the ASME Code.

The maximum allowable working pressures are limited by the *ASME Code for Low Pressure Heating Boilers* to 15 psi for steam and 160 psi for hot water heating boilers, with a maximum temperature limitation of 250 F. Hot water boilers are generally designed for a working pressure of 30 psi and may be supplied for higher working pressures, for either heating purposes or for hot water supply, only when designed, tested, and stamped for the higher pressure.

TYPES OF HEATING BOILERS

Heating boilers are classified in a number of different ways, such as:

1. According to materials of construction. These are steel and cast iron. Very few nonferrous boilers are made.

2. According to the fuels for which the boilers are designed. These are coal, hand-fired or stoker-fired; oil; gas; or wood. Some boilers are designed specifically for one fuel, but many boilers are designed for more than one fuel.

3. According to the specific purpose or application for which the boiler is used, such as space heating or domestic hot water supply.

4. According to the design or construction of the boiler such as sectional, round, fire-tube, water-tube, magazine-feed, Scotch, etc.

Cast-Iron Boilers

Cast-iron boilers are generally classified as:

1. Square or rectangular boilers with vertical sections and rectangular grates, commonly known as sectional boilers.

2. Round boilers with horizontal pancake sections and circular grates.

Cast-iron boilers are usually shipped in sections, and assembled at the place of installation. However, some small boilers are shipped factory assembled. In the majority of boilers the sections are assembled with push nipples and tie rods but external headers and screw nipples are also used successfully. Many sectional boilers are provided with large push nipples at top to permit the circulation of water between adjacent sections at both the water line and bottom of the boiler, which is necessary to enable the use of an indirect water heater with the boiler for summer-winter hot water supply. Round and sectional boilers may be increased in size by the addition of sections and corresponding plate work.

Small sectional type boilers are available with *wet-base* construction, wherein the ashpit or combustion chamber sides and bottom are surrounded by extensions of the water legs of the boiler sections, and thus no separate base is required. This type of construction permits the boiler to be set directly on a wood or composition floor without danger of fire. The *wet-base* also provides some additional heating surface.

Capacities of cast-iron boilers range generally from capacities required for small residences up to about 12,000 sq ft of steam radiation but boilers are made with capacities up to approximately 32,000 sq ft EDR (steam).

Steel Boilers

Steel boilers may be of the fire-tube type, in which the gases of combustion pass through the tubes and the boiler water circulates around them, or of the water-tube type, in which the gases circulate around the tubes and the water passes through them. Either the fire-tube or water-tube type may be designed 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 are usually shipped in one piece, ready for piping connections. Refractory furnaces are usually installed in refractory lined furnace boilers after they are set in place.

Capacities of steel boilers range from those required for small residences up to about 50,000 sq ft EDR (steam).

Boilers for Special Applications

One of these is known as the *magazine-feed boiler* developed for the burning of small sizes of anthracite and coke, and has a large fuel carrying capacity, which results in longer firing periods than would be the case with the standard types burning coal of buckwheat size. Special attention must be given to proper chimney sizes and connections in order to insure adequate draft.

Boilers for *hot water supply* are classified as direct, if the water heated passes through the boiler, and as indirect, if