called portable firebox boilers, and are the most commonly used type. They are usually shipped in one piece, ready for piping connections.

A *packaged* steam boiler (also called steam generator or hot water generator) is a modified boiler unit having all components, including burner, boiler, controls, and auxiliary equipment, assembled as a unit. Larger packaged boilers or generators are usually of a modified Scotch type. Smaller units are usually of the fire box type.

Capacities of steel boilers range from those required for small residences up to about 17,500 MBh.

Boilers for Special Applications

Boilers for *hot water supply* are classified as direct, if the water heated passes through the boiler, and as indirect, if the water heated does not come in contact with the water or steam in the boiler.

Direct heaters are built to operate at the pressures found in city supply mains, and are tested at pressures from 200 to 300 psig. The life of direct heaters depends almost entirely on the scale-forming properties of the water supplied and the temperatures maintained. If low water temperatures are maintained, the life of the heater will be much longer due to decreased scale formation and minimized corrosion. Direct water heaters in some cases are designed to burn refuse and garbage.

Indirect heaters generally consist of steam boilers in connection with heat exchangers of the coil or tube types which transmit the heat from the steam to the water. This type of installation has the following advantages:

1. The boiler operates at low pressure.
2. The boiler is protected from scale and corrosion.
3. The scale is formed in the heat exchanger in which the parts to which the scale is attached can be cleaned or replaced. The accumulation of scale does not affect efficiency, although it will affect the capacity of the heat exchanger.
4. Discoloration of water may be prevented if the water supply comes in contact with only nonferrous metal.

Where a steam or a forced circulation hot water heating system is installed, the domestic hot water may be heated by an indirect heater attached to the boiler. For most satisfactory performance in the steam system, this heater is placed just below the water line of the boiler. In a forced circulation hot water system, it should be located as high as practicable with respect to the boiler.

BOILER DESIGN CONSIDERATIONS

Furnace Design

Good efficiency and proper boiler performance are dependent on correct furnace design. There must be sufficient volume for burning the particular fuel which is used, and there must be means to obtain a thorough mixing of air and gases at a high temperature and at a velocity low enough to permit complete combustion of all the volatiles. For hand-fired boilers, the furnace volume should be large enough to hold sufficient fuel for reasonably long firing periods. (See Chapters 18 and 51).

Heating Surface

Boiler heating surface is that portion of the surface of the heat transfer apparatus in contact with the fluid being heated on one side and the gas or refractory being cooled on the other side. Heating surface on which the fire shines is known as *direct* or radiant surface, and that in contact with hot gases only, as *indirect* or convection surface. The amount of heating surface, its distribution, and the temperatures on either side thereof, influence the capacity of any boiler.

Direct heating surface has higher heat transfer rate per unit of area because it is generally subjected to higher temperature differences and because, with solid fuel and certain other fuels which burn with radiant flames, the direct heating surface absorbs an appreciable amount of radiant energy.

The effectiveness of the heating surface depends upon its cleanliness, its location in the boiler, and the size and shape of the gas passages. Where fans or blowers are used to create draft, high gas velocity may be employed to increase heat transfer in secondary heating surfaces. This may be accomplished by baffles or by using small or narrow flue passages. Heat transfer from flue gases in the turbulent flow range increases with velocity. Where high pressure fans are used for draft, the noise level must be considered. Where natural draft is employed, the area of the gas passages must not be so small as to cause excessive resistance to flow.

Heat Transfer Rate

Average overall heat transfer rates, expressed in BTU per sq ft per hr, will range from about 3300 for atmospheric vented hand-fired boilers, to over 8000 for power vented high draft loss boilers. The practical firing rate for any particular boiler depends upon its design and, to a certain extent, upon the method of firing. Some boiler rating codes take into account minimum heating surface, thereby establishing maximum heat transfer rates; other rating codes take into account actual performance determined by test.

RATING AND TESTING CODES

Heating boilers are usually rated according to codes developed by the Steel Boiler Institute, the Institute of Boiler and Radiator Manufacturers, the American Gas Association, the Mechanical Contractors Association of America, and the Packaged Firetube Branch of the American Boiler and Affiliated Industries. These test codes have been prepared specifically for the purpose of obtaining information required for establishing acceptable ratings. The various current rating and testing codes will be discussed in following paragraphs in which limitations, methods of application, and resulting ratings will be described.

The Steel Boiler Institute has adopted a rating code for boilers designated *Table 1 Steel Boilers*, *Table 2 Steel Boilers*, and *Table 3 Steel Boilers*, and a testing code for *Oil-fired Table 2* and *Table 3 Steel Boilers* (*SBI Rating Code*, Eighth Edition, February 1958). Tables 1, 2, and 3 of this chapter show the SBI Gross Outputs and Net Ratings of these three classes of boilers.

The *Table 1* boilers (defined as those having 129 to 3571 sq ft of heating surface and formerly designated as *Commercial* boilers) are rated in square feet EDR design load (steam) on the basis of heating surface with limitations set for grate area, furnace volume, and furnace height. The *Table 2* boilers (defined as those having not more than 294 sq ft of heating surface and formerly designated as *Residential* boilers) are rated on the basis of heating surface with ratings confirmed by test. The *Table 3* boilers (defined as having no limits of minimum heating surface or furnace volume, and having Gross Outputs and Net Ratings listed in Table 3) are rated on the basis of performance under the provisions of Section III, Part 2, of the *SBI Rating Code*.

The minimum stack area dimensions to be cataloged for *Table 3* boilers are shown in Table 4. Required stack heights are found in the catalogs of the manufacturers.

Stoker-fired and gas-fired *Table 2* boilers are rated (SBI Net Rating) not in excess of the oil-fired rating. Hand-fired

Table 1 . . . SBI Ratings for Table 1 Steel Boilers

Mechanically-Fired SBI Rating			SBI Net Rating			SBI Gross Output MBh	(c) Minimum Furnace Volume Cu Ft	(b) Minimum Furnace Height In.	Minimum Heating Surface Sq Ft	Hand-Fired SBI Rating			SBI Net Rating			(d) Minimum Grate Area Sq Ft	(a) Topping Steam Outlet IPS In.	(a) Steam Return IPS In.
Sq Ft Steam	Sq Ft Water	MBh	Sq Ft Steam	Sq Ft Water	MBh					Sq Ft Steam	Sq Ft Water	MBh	Sq Ft Steam	Sq Ft Water	MBh			
(1)	(2)	(3)	(4)	(5)	(6)		(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)
2,320	3,710	557	2,020	3,250	488	648	15.7	26	129	1,800	2,880	432	1,500	2,400	360	7.9	6	3"
2,840	4,540	682	2,480	3,980	597	792	19.2	28	158	2,200	3,520	528	1,830	2,930	439	8.9	6	3"
3,360	5,360	804	2,930	4,690	703	936	22.6	29½	186	2,600	4,100	624	2,170	3,470	521	9.7	6	3"
3,870	6,190	920	3,380	5,410	813	1,080	26.1	29½	215	3,000	4,800	720	2,500	4,000	600	10.5	6	4"
4,500	7,200	1,080	3,940	6,300	946	1,260	30.4	30	250	3,500	5,600	840	2,920	4,670	700	11.4	6	4"
5,150	8,240	1,230	4,500	7,200	1,081	1,440	34.8	30½	286	4,000	6,400	960	3,330	5,330	800	12.2	6	4"
5,800	9,280	1,392	5,090	8,110	1,217	1,620	39.1	31½	322	4,500	7,200	1,080	3,760	6,000	900	13.4	6	4"
6,440	10,300	1,546	5,620	9,020	1,353	1,800	43.5	31½	358	5,000	8,000	1,200	4,170	6,670	1,000	14.5	6	4"
7,720	12,350	1,853	6,760	10,820	1,622	2,160	52.1	32½	429	6,000	9,600	1,440	5,000	8,000	1,200	16.4	8	4"
9,000	14,400	2,160	7,880	12,610	1,890	2,520	60.8	34	500	7,000	11,200	1,680	5,830	9,330	1,400	18.1	8	4"
10,940	17,500	2,628	9,580	15,330	2,298	3,060	73.8	35½	608	8,500	13,600	2,040	7,080	11,330	1,700	20.5	8	4
12,870	20,590	3,089	11,260	18,020	2,703	3,600	86.8	37½	715	10,000	16,000	2,400	8,330	13,330	2,000	22.5	8	4
16,070	26,710	3,857	14,080	22,500	3,376	4,500	108.5	40¼	893	12,500	20,000	3,000	10,420	16,700	2,500	25.6	8	4
19,300	30,880	4,632	16,880	27,010	4,052	5,400	130.2	43	1,072	15,000	24,000	3,600	12,500	20,000	3,000	28.4	8	4
22,500	36,000	5,400	19,690	31,500	4,725	6,300	151.8	46	1,250	17,500	28,000	4,200	14,580	23,330	3,500	30.9	8	4
25,720	41,150	6,173	22,510	36,020	5,402	7,200	173.5	48½	1,429	20,000	32,000	4,800	16,670	26,670	4,000	33.2	8	4
32,150	51,440	7,716	28,150	45,010	6,751	9,000	216.0	54½	1,786	25,000	40,000	6,000	20,830	33,330	5,000	37.4	10	6
38,570	62,000	9,260	33,750	54,000	8,100	10,800	260.3	60½	2,143	30,000	48,000	7,200	25,000	40,000	6,000	41.2	10	6
45,000	72,000	10,800	39,370	62,990	9,450	12,600	303.6	66	2,500	35,000	56,000	8,400	29,170	46,670	7,000	44.7	10	6
51,430	82,290	12,340	45,000	72,000	10,800	14,400	346.9	71¾	2,857	40,000	64,000	9,600	33,330	53,300	8,000	48.0	12	6
57,860	92,560	13,880	50,620	80,990	12,150	16,200	390.3	77½	3,214	45,000	72,000	10,800	37,500	60,000	9,000	51.0	12	6
64,280	102,850	15,430	56,240	89,980	13,500	18,000	433.6	83½	3,571	50,000	80,000	12,000	41,670	66,700	10,000	54.0	12	6

(a) The return tapping sizes shown for boilers having 129 to 500 sq ft heating surface, inclusive, are adequate for forced hot water.

(b) Bituminous Stoker-Fired. Does not apply to Scotch-Type Boilers.

(c) Oil, gas or bituminous stoker-fired coal. Minimum furnace volumes for anthracite, stoker-fired, are not specified in this code.

(d) Does not apply to Scotch-Type Boilers.

(e) Does not apply to high-pressure boilers.

Note: Scotch-Type Boilers may be cataloged in sizes having 60 sq ft minimum heating surface with 7.2 cu ft minimum furnace volume, and 90 sq ft minimum heating surface with 11.0 cu ft minimum furnace volume.