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 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 33 and 34.)

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 is more valuable than indirect per square foot because it is subjected to a higher temperature and also, in the case of solid fuel, because it is in position to receive the full radiant energy of the fuel bed.

The effectiveness of the heating surface depends on its cleanliness, its location in the boiler, and the shape of the gas passages. The area of the gas passages must not be so small as to cause excessive resistance to the flow of gases, where natural draft is employed. Inserting baffles so that the heating surface is arranged in series with respect to the gas flow, increases boiler efficiency and reduces stack temperature, but increases the draft loss through the boiler.

Heat-Transfer Rate

Practical average overall heat transfer rates, expressed in Btu absorbed per square foot of surface per hour, will average about 3300 for hand-fired boilers, and 4000 for mechanically-fired boilers when operating at *design load*. When mechanically-fired boilers are operating at *maximum load*, as defined in this chapter under heading Selection of Boilers, these values will run between 5000 and 6000. Boilers operating under favorable conditions at these heat transfer rates, will give exit gas temperatures that are considered consistent with good practice, although there are boilers which have high efficiencies and also operate at higher transmission rates.

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, and the Mechanical Contractors Association of America, whose 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 2* boilers are rated (SBI Net Rating) not greater than fourteen times the heating surface.

The Institute of Boiler and Radiator Manufacturers has adopted a code[1] for rating cast-iron heating boilers, based upon performance obtained under controlled test conditions. This code applies to all sectional cast-iron heating boilers except those of magazine-feed type.

The *Gross I = B = R Output* is obtained by test, and is subject to certain limiting factors. For hand-fired boilers, the number of boilers of a series to be tested, the minimum overall efficiency, the minimum time limit (the time an *Available Fuel Charge* will last when burned at a rate which will produce the *Gross I = B = R Output*), the chimney area and

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

Mechanically-Fired										Minimum Heating Surface Sq Ft	Hand-Fired					(e) Tappings	
SBI Rating		SBI Net Rating			SBI Gross Output MBh	(c) Minimum Furnace Volume Cu Ft	(b) Minimum Furnace Height In.				SBI Rating		SBI Net Rating		(d) Minimum Grate Area Sq Ft		
Sq Ft Steam	Sq Ft Water	MBh	Sq Ft Steam	Sq Ft Water	MBh						Sq Ft Steam	Sq Ft Water	Sq Ft Steam	Sq Ft Water	MBh	Steam Outlet IPS In.	Steam Return IPS In.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)		(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)
2,190	3,500	528	1,800	2,880	432	648	16.7	28		129	1,800	2,880	432	1,500	2,400	360	7.9	6	3*
2,680	4,280	643	2,200	3,520	528	792	19.2	28		158	2,200	3,520	528	1,830	2,930	439	8.9	6	3*
3,160	5,050	758	2,600	4,160	624	936	22.6	28		186	2,600	4,160	624	2,170	3,470	521	9.7	6	3*
3,650	5,840	876	3,000	4,800	720	1,080	26.1	29½		215	3,000	4,800	720	2,500	4,000	600	10.5	6	4*
4,250	6,800	1,020	3,500	5,600	840	1,260	30.4	30		250	3,500	5,600	840	2,920	4,670	700	11.4	6	4*
4,860	7,770	1,166	4,000	6,400	960	1,440	34.8	30½		286	4,000	6,400	960	3,330	5,330	800	12.2	6	4*
5,470	8,760	1,313	4,500	7,200	1,080	1,620	39.1	31½		322	4,500	7,200	1,080	3,750	6,000	900	13.4	6	4*
6,080	9,720	1,459	5,000	8,000	1,200	1,800	43.5	31¾		358	5,000	8,000	1,200	4,170	6,670	1,000	14.5	6	4*
7,290	11,660	1,750	6,000	9,600	1,440	2,160	52.1	32¾		429	6,000	9,600	1,440	5,000	8,000	1,200	16.4	8	4*
8,500	13,600	2,040	7,000	11,200	1,680	2,520	60.8	34		500	7,000	11,200	1,680	5,830	9,330	1,400	18.1	8	4*
10,330	16,250	2,479	8,500	13,600	2,040	3,060	73.8	35½		608	8,500	13,600	2,040	7,080	11,330	1,700	20.5	8	4
12,150	19,440	2,916	10,000	16,000	2,400	3,600	86.8	37½		715	10,000	16,000	2,400	8,330	13,330	2,000	22.5	8	4
15,180	24,280	3,463	12,500	20,000	3,000	4,500	108.5	40¾		893	12,500	20,000	3,000	10,420	16,700	2,500	25.6	8	4
18,220	29,150	4,373	15,000	24,000	3,600	5,400	130.2	43		1,072	15,000	24,000	3,600	12,500	20,000	3,000	28.4	8	4
21,250	34,000	5,100	17,500	28,000	4,200	6,300	151.8	46		1,250	17,500	28,000	4,200	14,580	23,330	3,500	30.9	8	4
24,290	38,860	5,830	20,000	32,000	4,800	7,200	173.5	48¾		1,429	20,000	32,000	4,800	16,670	26,670	4,000	33.2	8	4
30,360	48,760	7,286	25,000	40,000	6,000	9,000	216.9	54½		1,786	25,000	40,000	6,000	20,830	33,330	5,000	37.4	10	6
36,430	58,280	8,743	30,000	48,000	7,200	10,800	260.3	60½		2,143	30,000	48,000	7,200	25,000	40,000	6,000	41.2	10	6
42,500	68,000	10,200	35,000	56,000	8,400	12,600	303.6	66		2,500	35,000	56,000	8,400	29,170	46,670	7,000	44.7	10	6
48,570	77,710	11,657	40,000	64,000	9,600	14,400	346.9	71½		2,857	40,000	64,000	9,600	33,330	53,300	8,000	48.0	12	6
54,640	87,420	13,114	45,000	72,000	10,800	16,200	390.3	77½		3,214	45,000	72,000	10,800	37,500	60,000	9,000	51.0	12	6
60,710	97,140	14,570	50,000	80,000	12,000	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 600 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 99 sq ft minimum heating surface with 11.9 cu ft minimum furnace volume.