and return lines, but better practice, especially when there is much bare pipe, is to compute the emission from both bare and covered pipe surface in accordance with data in Chapter 36. With direct radiation served by bare supply and return piping the percentages may be higher than those stated, while in the case of unit heaters where the output is concentrated in a few locations, the piping tax may be 10 per cent or less.

Warming-Up Allowance

The warming-up allowance represents the load due to heating the boiler and contents to operating temperature and heating up cold radiation and piping. (See Item 4.) The factors to be used for determining the allowance to be made should be selected from Table 3 and should be applied to the estimated design load as determined by Items 1, 2 and 3.

Performance Curves for Boiler Selection

In the selection of a boiler to meet the estimated load, the A.S.H.V.E. Standard Code for Rating Steam Heating Solid Fuel Hand-Fired Boilers recommends the use of performance curves based on actual tests conducted in accordance with the A.S.H.V.E. Performance Test Code for Steam Heating Solid Fuel Boilers (Code No. 3), similar to the typical curves shown in Fig. 2. It should be understood that performance data apply to test conditions and that a reasonable allowance should be made for decreased output resulting from soot deposit, poor fuel or inefficient attention.

Selection Based on Heating Surface and Grate Area

Where performance curves are not available, a good general rule for conventionally-designed boilers is to provide 1 sq ft of boiler heating surface for each 14 sq ft of equivalent radiation (240 Btu per square foot) represented by the design load consisting of connected radiation, piping tax and domestic water heating load. As stated in the section on Boiler Output, this is equivalent to allowing 10 sq ft of boiler heating surface per boiler horsepower. In this case it is assumed that the maximum load including the warming-up allowance will be provided for by operating the boiler in excess of the design load, that is, in excess of the 100 per cent rating on a boiler-horsepower basis.

Due to the wide variation encountered in manufacturers' ratings for boilers of approximately the same capacity, it is advisable to check the grate area required for heating boilers burning solid fuel by means of the following formula:

$$G = \frac{H}{C \times F \times E} \qquad (4)$$

where

G = grate area, square feet.

H = required total heat output of the boiler, Btu per hour (see Selection of Boilers, p. 451).

C = combustion rate in pounds of dry coal per square foot of grate area per hour, depending on the kind of fuel and size of boiler as given in Table 1.

F = calorific value of fuel, Btu per pound.

E = efficiency of boiler, usually taken as 0.60.

Example 1. Determine the grate area for a required heat output of the boiler of

500,000 Btu per hour, a combustion rate of 6 lb per hour, a calorific value of 13,000 Btu per pound, and an efficiency of 60 per cent.

$$G = \frac{500{,}000}{6 \times 13{,}000 \times 0.60} = 10.7 \text{ sq ft}$$

The boiler selected should have a grate area not less than that determined by Formula 4. With small boilers where it is desired to provide sufficient coal capacity for approximately an eight-hour firing period plus a 20 per cent reserve for igniting a new charge, more grate area may be required depending upon the depth of the fuel pot.

Selection of Steel Heating Boilers

Boiler ratings previously described under the *Steel Heating Boiler Institute's* Boiler Rating Code are intended to correspond with the estimated design load based on the sum of items 1, 2 and 3 outlined on pages 451 to 453. Insulated residence type boilers for oil or gas may carry a net load expressed in square feet of steam radiation of not more than 17 times the square feet of heating surface in the boiler, provided the boiler manufacturer guarantees the boiler to be capable of operating at a

Table 4. Boiler Ratings Based on Net Load[a]

Hand Fired Ratings		Mechanically Fired Ratings	
Steam Radiation Sq Ft	Net Load[b] Steam Radiation Sq Ft	Steam Radiation Sq Ft	Net Load[b] Steam Radiation Sq Ft
1,800	1,389	2,190	1,695
2,200	1,702	2,680	2,089
2,600	2,020	3,160	2,461
3,000	2,335	3,650	2,853
3,500	2,732	4,250	3,335
4,000	3,135	4,860	3,830
4,500	3,540	5,470	4,330
5,000	3,945	6,080	4,834
6,000	4,770	7,290	5,850
7,000	5,608	8,500	6,885
8,500	6,885	10,330	8,490
10,000	8,197	12,150	10,125
12,500	10,417	15,180	12,650
15,000	12,500	18,220	15,183
17,500	14,584	21,250	17,708
20,000	16,667	24,290	20,242
25,000	20,834	30,360	25,300
30,000	25,000	36,430	30,359
35,000	29,167	42,500	35,417

[a]Adopted by the *Steel Heating Boiler Institute* in cooperation with the *Bureau of Standards, United States Department of Commerce Simplified Practice Recommendation R 167-35.*

[b]The net load is made up by the sum of the estimated design load, items 1 and 2 (pages 451 to 453). All net loads are expressed in 70 F. For hand fired boiler ratings less than 1800 sq ft of steam or 2880 sq ft of water and mechanically fired boiler ratings of 2190 sq ft of steam or 3500 sq ft of water, apply the factor 1.3 to the net load to determine the boiler size. For water boilers use the equivalent net load for steam boilers of similar physical size.

maximum output of not less than 150 per cent of net load rating with overall efficiency of not less than 75 per cent with at least two different makes of each type of standard commercial burner recommended by the boiler manufacturer. If the heat loss from the piping system exceeds 20 per cent of the installed radiation, the excess is to be considered as a part of the net load.