

to operating temperature, and heating up cold radiation and piping. The factors to be used for determining the allowance to be made should be selected from Table 3.

Other items to be considered in boiler selection are:

- Efficiency with hard or soft coal, gas, or oil firing, as the case may be.
- Grate area with hand-fired coal, or fuel burning rate with stokers, oil, or gas.
- Combustion space in the furnace.
- Type of heat liberation, whether continuous or intermittent, or a combination of both.
- Convenience in firing and cleaning.
- Adaptability to changes in fuel and kind of attention.
- Height of water line.
- Miscellaneous items such as draft available, possibility of future extension, possibility of break-down, and head room in the boiler room.
- The most economical size of boiler is usually one that is just the right size for the load. Either larger or smaller boilers may be less economical.

Selection of Cast-Iron Boilers

Net load ratings of cast-iron boilers are usually available from manufacturers' catalogs. They may also be obtained conveniently from published tables of $I=B=R$ ratings⁶, or from recommendations of the *Heating, Piping and Air Conditioning Contractors National Association*⁷ and can be used in selection of boilers, unless the heating system contains an unusual amount of bare pipe, or the nature of the connected load is such that the normal allowances for pipe loss and pick-up do not apply. In such a case, the selection must be based on the gross output.

Selection of Steel Heating Boilers

SBI catalog ratings in accordance with the previously mentioned *Steel Boiler Institute, Inc.* code are intended to correspond with the estimated *design load*. When the heat emission of the piping is not known, the net load to be considered for the boiler may be determined from Tables 1 and 2. The difference between design load and net load represents an amount which is considered normal for piping loss of the ordinary heating system.

Boilers with less than 177 sq ft of heating surface and having *SBI* net ratings (steam) of not more than 3,000 sq ft if mechanically fired and

TABLE 3. WARMING-UP ALLOWANCES FOR HAND-FIRED LOW-PRESSURE STEAM AND HOT WATER HEATING BOILERS^{a,b,c}

DESIGN LOAD (REPRESENTING SUMMATION OF ITEMS 1, 2, AND 3)		PERCENTAGE CAPACITY TO ADD FOR WARMING-UP
Btu per Hour	Equivalent Square Feet of Radiation	
Up to 100,000	Up to 420	65
100,000 to 200,000	420 to 840	60
200,000 to 600,000	840 to 2500	55
600,000 to 1,200,000	2500 to 5000	50
1,200,000 to 1,800,000	5000 to 7500	45
Above 1,800,000	Above 7500	40

^aThis table is taken from the A.S.H.V.E. Code of Minimum Requirements for the Heating and Ventilation of Buildings, except that the second column has been added for convenience in interpreting the design load in terms of equivalent square feet of radiation.

^bSee also Time Analysis in Starting Heating Apparatus, by Ralph C. Taggart (A.S.H.V.E. TRANSACTIONS, Vol. 19, 1913, p. 292); Report of A.S.H.V.E. Continuing Committee on Codes for Testing and Rating Steam Heating Solid Fuel Boilers (A.S.H.V.E. TRANSACTIONS, Vol. 36, 1930, p. 35); Selecting the Right Size Heating Boiler, by Sabin Crocker (Heating, Piping and Air Conditioning, March, 1932).

^cThis table refers to hand-fired, solid fuel boilers. A factor of 20 per cent over design load is adequate when automatically-fired fuels are used.

⁴240 Btu per square foot.

2,480 sq ft if hand fired, are classified as residence size. An insulated residence boiler for oil, gas or stoker firing 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 has been tested in accordance with the *SBI* Code for Testing Oil-Fired Steel Boilers at output rates of 125, 150 and 175 per cent of the *SBI* Net Rating. The *SBI* Net Rating (square feet steam) for hand-fired residence boilers is not greater than 14 times the heating surface. 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*.

Selection Based on Heating Surface and Grate Area

Where neither the *net load* nor *gross output* ratings based upon performance tests are 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. 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. *SBI* ratings for hand firing are based on 10 sq ft of heating surface per boiler horsepower.

Due to the wide variation which may be 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:

$$G = \frac{H}{C \times F \times E} \quad (1)$$

where

G = grate area, square feet.

H = required *gross output* of the boiler, Btu per hour (see Selection of Boilers).

C = desirable combustion rate for fuel selected, pounds of dry coal per square foot of grate per hour (see Table 4).

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 *gross 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 Equation 1. 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 Gas-Fired Boilers

After determining the *net load* for the installation, gas designed boilers can usually be selected from manufacturers' tables of *net load ratings* which are based on piping and pickup allowances varying from 56 per cent for boilers of 200 sq ft and less to 35 per cent for boilers of 4000 sq ft and larger. If the piping and pickup load or other factors create an unusual load, a boiler should be selected which has an *A.G.A.*