

3. **Piping Tax.** The estimated heat emission in Btu per hour of the piping connecting the radiation and other apparatus to the boiler.

As the heating industry as a whole is not entirely agreed upon piping tax allowances for different sizes of installations it is better to compute the heat emission from both bare and covered pipe surface in accordance with data in Chapter 17. In average house heating systems, it is common practice to consider the piping tax to be equal to 25 per cent of the Net Load. In determining Net $I=B=R$ Ratings from Gross $I=B=R$ Output, the piping factor allowed varies from 30 per cent for small boilers to 12 per cent for larger boilers.

4. **Warming-Up or Pick-Up Allowance.** The estimated increase in the normal load in Btu per hour caused by the heating up of the cold system.

The warming-up allowance represents the load due to heating the boiler and contents 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 2.

TABLE 2. 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-UPS
Btu per Hour	Equivalent Square Feet of Radiation ^d	
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.

^d240 Btu per square foot.

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 $I=B=R$ ratings^a, or from recommendations of the Heating, Piping and Air Conditioning Contractors National Association.¹

^a $I=B=R$ Ratings for Cast-Iron Boilers (Institute of Boiler and Radiator Manufacturers).

¹Engineering Standards, Part II, Net Square Feet Radiation Loads in 70 Deg Fahr., Recommended for Low Pressure Heating Boilers, 1943 (Heating, Piping and Air Conditioning Contractors National Association.)

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

Catalog ratings in accordance with the previously mentioned Steel Heating Boiler Institute 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 Table 1. 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 128 sq ft of heating surface are classified as residence size. An insulated residence boiler for oil or gas, not convertible, 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 it to be capable of operating at a maximum output of not less than 150 per cent of net load rating with over-all 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.

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. S.H.B.I. 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 3).

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.

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