

Higher efficiencies for hand-fired bituminous coal may be obtained by careful firing of a regular or a smokeless boiler. Boiler efficiencies are useful primarily to determine the required firing rate for a particular capacity. The efficiencies such as those in the table above are obtained under conditions of steady state operation and, therefore, are higher than the seasonal efficiency actually obtained in service. The ratio between the steady state test efficiency and the actual year round seasonal efficiency varies widely with operating conditions and, therefore, the test efficiency is not a reliable index for comparing probable fuel consumption with different types of fuels. Various factors, including stand-by loss during light load or idle periods and recovery rate of the boiler, have a material effect on the overall fuel economy.

RATING OF BOILERS

When referring to boiler rating, one must know the basis on which the rating has been established in order to understand the exact meaning of the term. The following example will illustrate the meaning of three ratings which might be established for the same boiler.

Assume that an installation has the following loads determined in accordance with the section Selection of Boilers:

Net Load.....	1000 sq ft of steam radiation
Piping Tax.....	200 sq ft of steam radiation
Design Load.....	1200 sq ft of steam radiation
Pickup Allowance.....	240 sq ft of steam radiation

Maximum or Gross Load..... 1440 sq ft of steam radiation

A boiler that is just large enough to carry this system might be said to have a *net load* rating of 1000 sq ft, a *design load* rating of 1200 sq ft, or a *gross load* rating of 1440 sq ft, depending on the basis on which the boiler is rated.

On a *net load* basis the boiler would be rated 1000 sq ft of steam radiation and would have sufficient excess capacity to supply the *normal piping and pickup load*. Net I=B=R Ratings, SBI Net Ratings, and Net Load Ratings of the Mechanical Contractors Association of America are established on this basis.

On a *design load* basis the boiler would be rated 1200 sq ft of steam radiation and would have sufficient excess capacity to supply the *pickup load*. It would be of adequate size for a system in which the sum of the *net load* and the *piping heat* load did not exceed 1200 sq ft of steam radiation. The SBI Ratings shown in columns 1, 2, 3, 11, 12, and 13 of Table 1 (not to be confused with SBI Net Rating) are established on a *design load* basis.

On a *gross output* basis of rating, the boiler would be rated 1440 sq ft of steam radiation and would be of adequate size for a system in which the sum of the *net load*, *piping load*, and *pickup load* did not exceed 1440 sq ft of steam radiation. SBI Gross Output, Gross I=B=R Output, A.G.A. Ratings and ABAI Ratings are established on a *gross output* basis.

In the determination of boiler ratings, the *Gross Output* is the quantity of heat available at the boiler nozzle, with the boiler normally insulated and operating under limitations stipulated in the code or method by which the boiler is rated. The boiler may be capable of producing a greater nozzle output, but in doing so would exceed some of these limitations.

SELECTION OF BOILERS

General Factors

The *Maximum Load* or *Gross Load* on the boiler is the sum of the four following items.

The *Design Load* is the sum of items 1, 2, and 3.

The *Net Load* is the sum of items 1 and 2.

1. *Radiation Load*. The estimated heat emission in Btu per hour of the connected radiation (direct, indirect, or forced convection coils) to be installed.

The connected radiation is determined by calculating the heat losses for each room in accordance with data given in Chapters 24, 25, and 28. The sum of the calculated heat losses for all the rooms represents the total required heat emission of the connected radiation, expressed in Btu per hour. As practically all boilers are now rated on a Btu basis, it is unnecessary to convert the radiation load to square feet of equivalent direct radiation.

2. *Hot Water Supply Load*. The estimated maximum heat in Btu per hour required to heat water for domestic use.

I=B=R recommends that allowance for hot water supply load be made only for bathrooms in excess of two, as follows: Instantaneous Coil, 12,000 Btu per hour, and for Storage Tank installation, 120 Btu per (hour) (gallon of tank capacity). For instantaneous coil installations, the boiler capacity should not be less than required to heat 2 to 3 gal of water, 100 deg per min. See also Chapter 82 of the 1964 GUIDE AND DATA BOOK.

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 22. In average house heating systems, it is common practice to consider the piping tax to be equal to 20 percent of the Net Load. In determining Net I=B=R rating from gross I=B=R output, the piping and pickup factor allowed varies from 1.333 to 1.288 for automatically fired steam and hot water boilers, and from 2.380 to 1.40 for hand-fired steam and hot water boilers.

4. *Warming-Up or Pickup 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 radiators and piping.

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 breakdown, 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.

Cast Iron Boilers

Net load ratings of cast iron boilers are usually available from manufacturers' catalogs. They may also be obtained from published tables of I=B=R ratings,¹ or from recommendations of the Mechanical Contractors' Association of America,² and can be used in the 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 pickup do not apply. In such a case, it is best to base the selection on the gross output.

Steel Heating Boilers

SBI catalog ratings, in accordance with the previously mentioned Steel 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 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 having 294 sq ft or less of heating surface and

Heating Boilers, Furnaces, Space Heaters

SBI net ratings (steam) of not more than 5620 sq ft is mechanically-fired, and 4120 sq ft if hand-fired, are classified as *Table 2 Steel Boilers*, formerly as Residential boilers. An insulated *Table 2* boiler for oil, gas, or stoker firing may carry a maximum *net load*, expressed in square feet of steam radiation, of 19.1 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 85, 100, and 115 percent of the SBI gross output. The SBI net rating for an automatically-fired water or steam boiler, expressed in Btu per hour, is 4590 times the boiler heating surface. SBI Net Ratings for water and steam boilers are based on a piping and pickup factor of 33 1/3 percent. The SBI net rating (sq ft steam) for hand-fired *Table 2* boilers is not greater than fourteen times the heating surface. If the heat loss from the piping system exceeds 20 percent of the installed radiation, the excess is to be considered as part of the *net load*.

Gross Output ratings for *Table 1* and *Table 2*, as well as for *Table 3 Steel Boilers*, are shown in the *SBI Rating Code* (1958).

Packaged Firetube Boiler ratings as published by the American Boiler and Affiliated Industries are Gross Output ratings. It is recommended that boilers of this type be selected with ratings equal to the Gross Load imposed on the boiler, which is the sum of the *Radiation Load*, *Hot Water Supply Load*, *Piping Tax*, and *Pickup Allowance*.

If the *Piping Tax* and *Pickup Allowance* cannot be determined, a maximum allowance of 25 percent is generally considered to be a safe maximum for the sum of both allowances added to *Radiation Load* and *Hot Water Supply Load*.

Heating Surface and Grate Area Basis

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 sq ft) (hr) 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 percent 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) (hour). (Table 6.)
- 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 percent.

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

The boiler selected should have a grate area not less than that determined by Equation 1. With small boilers, where it

Table 6.... Practical Combustion Rates for Coal-Fired Heating Boilers Operating at Maximum Load on Natural Draft of From 1/4 in. to 1/2 in. Water*

Kind of Coal	Sq Ft Grate	Lb of Coal per (Sq Ft Grate) (hr)
No. 1 Buckwheat Anthracite	Up to 4	3
	5 to 9	3 1/4
	10 to 14	4
	15 to 19	4 1/4
	20 to 25	5
Anthracite Pea	Up to 9	5
	10 to 19	5 1/4
	20 to 25	6
Anthracite Nut and Larger	Up to 4	8
	5 to 9	9
	10 to 14	10
	15 to 19	11
	20 to 25	13
Bituminous	Up to 4	9.5
	5 to 14	12
	15 and above	15.5

* Steel boilers usually have higher combustion rates for grate areas exceeding 15 sq ft than those indicated in this table.

is desired to provide sufficient coal capacity for approximately an eight-hour firing period plus a 20 percent reserve for igniting a new charge, more grate area may be required, depending upon the depth of the fuel pot.

Gas-Fired Boilers

After the net load for the installation has been determined, gas designed boilers can usually be selected from the manufacturer's catalogs, or the net ratings may be obtained from the published I=B=R or SBI Rating Tables by substitution of the A.G.A. gross output in lieu of the I=B=R or SBI output and by selection of the corresponding net rating. If the piping and pickup load or other factors create an unusual load, a boiler should be selected which has an A.G.A. gross output rating equal to the maximum output required.

SPACE LIMITATIONS

Boiler rooms should, if possible, be situated at a central point with respect to the building and should be designed for a maximum of natural light. The space in front of the boilers should be sufficient for firing, stoking, ash removal, and cleaning or renewal of the flue tubes, and should be at least 3 ft longer than the length of the tubes.

A space of at least 3 ft should be allowed on at least one side of every boiler for convenience of erection and for accessibility to the various dampers, cleanouts, and trimmings. The space at the rear of the boiler should be ample for the chimney connection and for cleanouts. With large boilers the rear clearance should be at least 3 ft in width.

The boiler room height should be sufficient for the location of boiler accessories and for the proper installation of piping. In general, the ceiling height for small steam boilers should be at least 3 ft above the normal boiler water line. With vapor heating, especially, the height above the boiler water line is of vital importance.

CONNECTIONS AND FITTINGS

Steam outlet connections should be the full size of the manufacturer's tapings, in order to keep the velocity of flow