

**2. Liquid and Gaseous Fuels:** The combined efficiency of boiler, furnace and burner is the ratio of the heat absorbed by the water and steam in the boiler per pound or cubic foot of fuel to the calorific value of 1 lb or cubic foot of fuel respectively.

The following efficiencies apply to current designs of boilers operated under favorable conditions at their gross output ratings. Some older boilers designed primarily for hand firing may have lower efficiencies when automatically fired.

|                                  |                   |
|----------------------------------|-------------------|
| Anthracite, hand fired.....      | 60 to 75 per cent |
| Bituminous Coal, hand fired..... | 50 to 65 per cent |
| Stoker fired.....                | 60 to 75 per cent |
| Oil and Gas fired.....           | 70 to 80 per cent |

Higher efficiencies for hand fired bituminous coal may be obtained by careful firing of either a regular or a smokeless boiler.

### RATING OF BOILERS

In referring to boiler rating it is necessary to 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 *Heating, Piping and Air Conditioning Contractors National Association* 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 loss* did not exceed 1200 sq ft of steam radiation. The SBI Ratings shown in columns 1, 2, 3, 10, 11 and 12 of Table 2 (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. Gross  $I = B = R$  Output and A.G.A. 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 when 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 Chapter 6, 8, and 14. 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 equivalent square feet of equivalent radiation.

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

When the hot water supply is heated by the building heating boiler, this load must be taken into consideration in sizing the boiler. A common practice is to add 240 Btu per hour to the radiation load for each gallon of storage tank capacity. For more specific information see Chapter 50.

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 28. 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 4.

TABLE 4. WARMING-UP ALLOWANCES FOR HAND-FIRED LOW-PRESSURE STEAM AND HOT WATER HEATING BOILERS<sup>a, b, c</sup>

| DESIGN LOAD (REPRESENTING SUMMATION OF ITEMS 1, 2, AND 3) |                                     | PERCENTAGE CAPACITY TO ADD FOR WARMING-UP <sup>d</sup> |
|-----------------------------------------------------------|-------------------------------------|--------------------------------------------------------|
| 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                                                     |

<sup>a</sup> This 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.

<sup>b</sup> See 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. 35, 1930, p. 35); Selecting the Right Size Heating Boiler, by Sabin Crocker (Heating, Piping and Air Conditioning, March, 1932).

<sup>c</sup> This 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.

<sup>d</sup> 240 Btu per square foot.