insulated residence application with inputs of 40,000 Btu per hour or less, to capacities as large as 600,000 Btu per hour.

Cast-iron furnaces are usually constructed with a minimum sectional thickness of ¼ in. and effectively resist high temperatures and corrosion. They usually have a fairly large heat capacity because of their mass, which provides a distinct *fly wheel* or carry-over heating effect.

Steel Furnaces

Formed sheet steel construction is frequently used in furnace design. Welding, riveting or both, are used to join the formed metal. The use of steel castings, however, is rare, because of the cost, and because high stresses are not encountered in normal furnace construction. Types of design employed vary greatly, although perhaps the most common type consists of a drum and circumferential or rear radiator. Steel gas furnaces may also be sectional in design or may be combinations of common combustion chambers and sectional or tubular radiation surfaces connected to a flue gas collector.

Steel furnaces are made in capacities ranging from those for small insulated residence application with inputs of 40,000 Btu per hour to capacities as large as 600,000 Btu.

Steel furnaces have low heat capacities as a result of their relatively low mass and, therefore, deliver heat rapidly on demand.

RATING OF FURNACES—TESTING AND RATING CODES

Warm air furnaces are generally rated in Btu per hour output at the bonnet (point of heat generation) or at the register (point of heat delivery).

Rating Equations for Gravity Warm Air Furnaces[9]

Until a method of testing and rating gravity warm air furnaces has been developed, the following empirical rating equations are recommended by the *National Warm Air Heating and Air Conditioning Association.*

Gravity warm-air furnaces of conventional design, having ratios (of heating surface to grate area) of 15 to 1 or greater, and having a ratio of casing area to face area not less than 0.4, are rated by the following equations:

a. *Hand-fired furnaces Converted to Stoker, Gas, or Oil Firing.*

$$\text{Bonnet Capacity in Btu per hour} = 1785 \times S \times 1.333 \qquad (2)$$

b. *Hand-fired furnaces, with ratios of heating surface to grate area greater than 15 to 1 and less than 25 to 1.*

$$\text{Bonnet Capacity in Btu per hour} = 1785 \times S \times 1.333 \qquad (3)$$

c. *Hand-fired furnaces with ratios of heating surface to grate area in excess of 25 to 1.*

$$\text{Bonnet Capacity in Btu per hour} = 1785 \times 25 \times G \times 1.333 \qquad (4)$$

where

S = heating surface, in square feet.
G = actual grate area, in square feet.

The *Register Delivery Rating* is equal to 0.75 x (*Bonnet Capacity*). The *Leader Pipe Rating* in square inches, formerly used as a rating unit, may be found by dividing the *Register Delivery Rating* by 136.

Heating Surface of Furnace

Prime heating surface is defined as surface above the top of the grate having *hot gases or live fuel on one side and circulating air over the other*, and in all cases is measured on the exterior or air side. The areas of the outer casing, the inner liner, and any radiation shields shall not be considered as heating surface.

In determining the amount of heating surface, extended surfaces are considered to be prime heating surface subject to the following limitations:

a. Extended heating surface may consist of fins, ribs, webs, lugs, or other projections from the prime heating surface. Projections less than ¼ in. thick at the base and extending more than 1 in. from the prime surface are classified as fins.

b. Integral fins are continuously welded to, or cast as a part of, the prime heating surface. Both sides are included as heating surface, subject to the following allowances:

Distance from Prime Surface	1st inch	2nd inch	3rd inch	Over 3 in.
Ratio of Effective Area to Total Area	0.40	0.30	0.20	None

c. Non-integral fins are spot welded to, or otherwise held in line contact with the prime heating surface. Both sides are included as heating surface, subject to the following allowances:

Distance from Prime Surface	1st inch	2nd inch	3rd inch	Over 3 in.
Ratio of Effective Area to Total Area	0.30	0.20	0.15	None

d. In the case of ribs, webs, or lugs more than ¼ in. thick at the base and extending less than 1 in. from the prime surface, the entire surface in contact with circulating air is included as heating surface.

e. In the case of ribs, webs, or lugs more than ¼ in. thick at the base and extending more than 1 in. from the prime heating surface the areas of both sides of the first inch are included as prime heating surface. The portions projecting beyond 1 in. are treated as integral fins.

Grate Area

Grate area is defined and treated for purpose of rating as follows:

a. The *nominal grate area* is defined as the total cross-sectional area of the bottom of the firepot. In steel furnaces the nominal grate area is the cross-sectional area inside the firebrick lining.

b. The *actual grate area*, used for calculating the ratios of heating surface to grate area, is the nominal grate area minus certain areas that cannot be considered as part of the grate itself. The following rules govern these deductions: (1) If a solid, continuous ledge extends around the grate and inside the firepot, any area of this ledge extending inside of a circle, the diameter of which is 1 in. less than the diameter of the bottom of the firepot, shall be deducted. (2) If separate, solid projections extend from the firepot towards the grate, the areas of any portions of these projections extending inside of a circle, the diameter of which is 3 in. less than the diameter of the bottom of the firepot, shall be deducted. (3) In the case of grates which are inclined, or are conical, the projected area is the same as the nominal grate area. The latter should, therefore, be used after making any necessary deductions.

Ratings for Forced Air Furnaces

For solid fuel burning, forced air furnaces having bonnet capacities between 80,000 and 250,000 Btu per hour, no standard method of test has been accepted, although eventually such codes will be developed.