

combustible material and 200 F for furnaces that may be installed in an enclosure using combustible materials. The limit control usually has a fixed stop at its maximum permissible setting and a differential of 25 deg or more to permit resumption of operation of the burner when the temperature has dropped to a safe value.

A fan control starts the blower when the temperature of the air in the furnace cabinet reaches a predetermined level and keeps it running until the heat in the furnace cabinet has been dissipated. This control is independent of burner controls. It usually has a Fan On temperature setting and may also have a fixed differential for turning off the fan or may also incorporate a Fan Off setting.

The fan and limit controls are often incorporated in the same housing and sometimes are operated by the same thermostatic element, through separate switches. The actuating elements of the controls may be located in the warm air plenum or duct or within the furnace cabinet at some point in the circulating air stream where the temperature is the same as the outlet air temperature.

Air Filters

Filters are described in Chapter 24. The usual filters supplied with warm air furnaces are of the throw away type. These filters are usually composed of fibrous material enclosed in a frame and coated with a viscous liquid. The velocity of air through these filters should be no greater than 300 fpm.

Permanent filters that may be washed and reinstalled are also used. The velocity of air through these filters should be in accordance with manufacturer's recommendations. Some permanent filters are of the electrostatic type in which a slight charge of static electricity is created by the friction of the air, thus attracting and holding dust particles.

Electronic filters are also coming into use in cleaning the circulating air for a forced air furnace. These air cleaning devices create an electrical field of high-voltage direct current in which dust particles are given a charge and consequently collect on a plate having an opposite charge. The attracted material may be washed out in some types, while other types use disposable pads.

Air filters are always located in the cool air ahead of the blower and heat exchanger.

Humidifiers

The humidifiers used with warm air furnaces usually consist of a pan in the warm air discharge with water level maintained by a float control. The rate of evaporation may be increased by placing porous plates in the water. These plates act like wicks to increase the wetted surface in the circulating air and increase the evaporation rate. More elaborate humidifiers are equipped with electric heat or may atomize the water mechanically to increase the rate of evaporation.

With the present trend toward better insulation, vapor barriers, and tight storm windows in homes, and also the use of more moisture producing equipment in the home such as automatic dish washers and laundry driers, humidifiers are not always needed in residences. One of the advantages of a warm air heating system is that it affords the opportunity to add humidification or to decrease the humidity by the introduction of outdoor air into the air circulating system.

GRAVITY FURNACES

Gravity furnaces are those which depend on the gravity thermal head in the system to circulate the air through both

the furnace and the heating system. Some gravity furnaces, however, may be equipped with an integral fan to overcome the resistance of the furnace only and others may have a booster fan to aid circulation of air but so designed that the fan, when stopped, offers only small resistance to gravity circulation of air.

Since the gravity head is relatively low, the furnace must have low internal resistance to the flow of air, and relatively large areas must be available for free circulation within the furnace casing. It is common practice to provide approximately 50 percent free-air area through gravity furnaces.

Furnaces for gravity systems are available in designs suitable for central heating, pipeless furnace, or unit floor-furnace installations.

Interest in the gravity furnace has decreased because it was large in size, required many large ducts which occupied much cellar space, it could not be equipped with air filters, and uniform distribution of heat to all rooms was difficult to achieve.

The simplest form of gravity furnace is the pipeless furnace which is almost always a coal furnace located in the basement. This furnace supplies the warm air through a single duct or outlet directly over the top of the furnace casing through the central portion of a grille above. This furnace has a second outer casing enclosing the inner casing which is not brought down to the floor but usually stops at about the grate level of the furnace. The space between the inner casing and the outer casing forms the return air passage-way for the air dropping through the outer portion of the grille.

The floor furnace is a variation of the pipeless furnace but is used when gas or oil is the fuel. It is a completely self-contained unit furnace suspended from the floor of the space being heated, taking air for combustion from outside this space, and having means for observing flames and lighting the appliance from such space.

It is called a gravity type whether operated without a booster fan or with a fan that aids circulation but does not materially restrict free circulation of air by gravity flow when stopped.

A furnace equipped with a fan providing primary means for circulation is called a Fan Type Floor Furnace.

FURNACE RATING

Rating Equations for Gravity Warm Air Furnaces*

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:

1. *Hand-fired furnaces converted to Stoker, Gas, or Oil Firing.*

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

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

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

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

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

where S = heating surface, in square feet.

G = actual grate area, in square feet.

Heating Boilers, Furnaces, Space Heaters

The National Warm Air Heating and Air Conditioning Association recommends the following empirical equations for use in rating solid fuel forced air furnaces:

1. *Hand-fired furnaces converted to Stoker, Gas, or Oil Firing.*

$$\text{Bonnet Capacity in Btu per hour} = 2265 \times S \times 1.177 \quad (5)$$

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

$$\text{Bonnet Capacity in Btu per hour} = 2265 \times S \times 1.177 \quad (6)$$

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

$$\text{Bonnet Capacity in Btu per hour} = 2265 \times 25 \times G \times 1.177 \quad (7)$$

These rating formulas are based on 55 percent efficiency for gravity furnaces and 65 percent efficiency for forced air furnaces.

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:

1. Extended heating surface may consist of fins, ribs, webs, lugs, or other projections from the prime heating surface. Projections less than 1/4 in. thick at the base, and extending more than 1 in. from the prime surface are classified as fins.

2. 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 in.	2nd in.	3rd in.	Over 3 in.
Ratio of effective area to total area.....	0.40	0.30	0.20	None

3. 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 in.	2nd in.	3rd in.	Over 3 in.
Ratio of effective area to total area.....	0.30	0.20	0.15	None

4. In the case of ribs, webs, or lugs more than 1/4 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.

5. In the case of ribs, webs, or lugs more than 1/4 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:

1. 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.

2. 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 Oil-fired Furnaces

Oil-fired furnaces equipped with pressure-atomizing or rotary burners should be rated in accordance with Commercial Standard 195 test methods. This requires a minimum efficiency of 70 percent for forced air furnaces.

Furnaces equipped with pot-type oil burners should be rated in accordance with Commercial Standard 104 tests. This requires a minimum efficiency of 70 percent.

Oil-burning floor furnaces should be rated from tests described in Commercial Standard 113.

Ratings for Gas-fired Furnaces

The American Standard Approval Requirements for Central Heating Gas Appliances, Vol. II, Gravity and Forced Air Central Furnaces (ASA 221.13.2) is universally used in testing and rating. All gravity gas furnaces approved by the American Gas Association under these requirements are assigned a rating based on 75 percent efficiency and forced air furnaces are assigned a rating based on 80 percent efficiency.

Vol. III Gravity and Fan-type Floor Furnaces (221.13.3) is used in testing and rating floor furnaces.

Ratings for Heavy Duty Furnaces

Heavy Duty Furnaces should be rated in accordance with the ASHRAE Code for Testing and Rating Heavy Duty Furnaces and Direct-Fired Unit Heaters. This standard applies to forced warm air furnaces having output ratings in excess of 250,000 Btu per hour. It includes performance standards and efficiency determination.

SPACE HEATERS

Space heaters may be classified in several ways, such as:

1. By the type of fuel used as coal, wood, gas, and fuel oil.

2. According to the method of heat distribution as circulators or radiant types. A radiant heater is one in which the heat exchanger surface is exposed directly to the room atmosphere, and the generated heat is dissipated primarily by radiation. A circulating heater is essentially a jacketed radiant heater from which circulation of room air is promoted by the chimney effect caused by the movement of air passing upward between the jacket and heat exchanger surface.

3. According to method of design for particular fuel types, such as: (a) surface-fired and magazine-fed for solid fuels, (b) vaporizing pot-type and blue-flame heater for oil, and (c) vented and unvented heaters for gas. (The type of gas burner design, such as injection, yellow flame, power, and pressure, may also be mentioned.)

SOLID FUEL-FIRED HEATERS

Surface-fired heaters normally have a front firing door and are operated with relatively shallow fuel beds. A magazine-feed heater includes a deep reservoir of fuel to lengthen