

9. Check the firing equipment and all operating and safety controls. Any required repair work should be taken care of immediately so that the heating plant will be in good working order at the start of the next heating season.

10. Bring the water level down to normal operating level before firing again.

WARM AIR FURNACES

A warm air furnace is a self-enclosed fuel-burning appliance for heating air by transfer of heat of combustion through metal to air, and designed to discharge the heated air from its outlet(s) directly to space being heated or through ducts to spaces remote from, or adjacent to, the appliance. A number of types and a wide range of sizes are listed and illustrated in the Catalog Data Section.

In describing or classifying furnaces reference is generally made to (1) method of air circulation, whether forced or gravity, (2) type of fuel, whether gas, oil, or solid and (3) metal used in the heat exchanger, whether cast-iron, steel, steel alloy, or coated steel. Sometimes the shape of the combustion chamber as round or square, and the construction of the secondary or flue surface as wrap-around, tubular, or sectional, are also included in the description.

Modern furnaces are usually designed for a specific fuel and consequently are designed with combustion space, flue passages, heating surfaces, combustion equipment, and controls to assure proper performance and intended heat output.

Warm air furnaces are available in outputs ranging from 40,000 Btuh to as much as 8,000,000 Btuh. Those having outputs up to 250,000 Btuh are usually considered as residential furnaces while those having outputs above 250,000 Btuh are designated heavy duty or sometimes industrial or commercial furnaces. A fine distinction cannot be drawn because larger furnaces can be used in residences, and smaller furnaces can be used to heat portions or all of commercial or industrial buildings as well as churches and schools.

FORCED AIR FURNACES

Forced Air furnaces are those equipped with a blower which circulates the air through the heating system as well as the furnace. Three types of these furnaces are in common use:

1. *Horizontal.* A furnace designed for low headroom installation, with air flow through the appliance essentially in a horizontal path.
2. *Upflow.* A furnace designed with an air flow essentially in a vertical path, discharging air at or near the top of the furnace.
3. *Downflow.* A furnace designed with air flow essentially in a vertical path, discharging air at or near the bottom of the furnace.

The horizontal furnace has a blower discharging air into one end of the casing. The heated air leaves the opposite end in a horizontal direction and is distributed through ducts to the space to be heated. This furnace is frequently installed in a crawl space under the house or in the attic but may be used in a variety of locations.

The upflow furnace usually consists of a blower and filter compartment and a heat exchanger compartment. If the former is placed at the side or back of the latter, the return air is generally brought into the top of the blower compartment. If the blower compartment is placed under the heat exchanger compartment it is common practice to refer to the unit as a hi-boy type. This hi-boy unit receives return air either through ducts connected to blower compartment side or bottom, or it may take return air into the blower compart-

ment from the space in which it is installed. It is often installed on the first floor of houses without basements.

The downflow furnace has the blower compartment located above the heat exchanger so that air is discharged vertically downward through the unit to the bottom outlet. The return air connection is at the top of the furnace and the warm air discharge is at the bottom. This type of furnace is used in conjunction with a perimeter heating system in a house without basement.

Heavy Duty Fan Furnaces. Fan furnaces for large commercial and industrial buildings, churches, schools, etc., are available in sizes ranging from 300,000 to 8,000,000 Btu per (hour) (unit). Heavy duty furnace heaters may be arranged in battery combinations of one or more units.

Most manufacturers of heavy duty furnaces rate their furnaces in Btu per hour. Limitations on temperature of flue gases, heat exchanger, and casing and also limitations on carbon monoxide, air temperature rise, and efficiency are factors in establishing ratings for these units. These limits are shown in the ASHRAE Code for Testing and Rating Heavy Duty Furnaces and Direct-fired Unit Heaters.

Control of temperature is secured through (1) controlling the quantity of heated air entering the room, (2) using mixing dampers, or (3) regulating the fuel supply.

The design of heavy duty fan furnace heating systems is in many respects similar to that of the central fan heating systems described in Chapter 19. Ducts are designed by the method outlined in Chapter 21.

Components of forced air furnaces include (1) heat exchanger; (2) combustion equipment including burner, grates, etc.; (3) casing or cabinet; (4) blower; (5) controls; (6) filters; and (7) humidifier. The last two components are not used in every furnace.

Heat Exchanger

The fuel being used has a definite influence on the design of the heat exchanger. In a coal furnace, the heat exchanger must include storage space for the burning fuel and ash in addition to combustion space. In gas or oil furnaces where the fuel is burned as rapidly as it enters the heat exchanger some space is required for burners or combustion chamber but less space is required for combustion. Sufficient combustion volume must be allowed for the requirements of the fuel being used. Most heat exchangers have a primary combustion volume and then have secondary flue-gas passageways in which the products of combustion are brought into close contact with the heat exchanger surfaces.

In a coal furnace, where the resistance of the fuel bed must be overcome by chimney draft, the total draft requirement of the appliance is greater than for oil burning, for which only a slight draft is required in the combustion space, or for gas burning for which the appliance requires no chimney draft except to remove the products of combustion from the furnace outlet.

Flue-gas passages must be readily accessible for cleaning, when coal or oil is burned, for the purpose of removing soot and scale. In gas furnaces they must be accessible for cleaning where (a) the products of combustion are drawn below the level of the burner; (b) the temperature of the combustion products is less than 250 F when the furnace is operated at normal test pressure with the gas rate within plus or minus 2 percent of the manufacturer's hourly Btu input rating; or (c) the width of any flue-gas passage is less than 1½ inches.

Flue-gas passages in coal burning furnaces must be larger than for other fuels due to a greater volume of flue products

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as well as the tendency to collect soot (especially when burning soft coal).

The majority of the furnaces for coal, gas, or oil firing are now made of hot- or cold-rolled low carbon steel with welded seams. Some welded coal furnaces also have the joints riveted since they can be more subject to overheating than oil or gas furnaces in which the combustion rate is carefully controlled. Frequently, in heavy duty furnaces, alloy steels, containing chromium and nickel, may be used for higher temperature operation. Heat exchangers may also be protected against oxidation at somewhat higher temperatures by ceramic coating or by the use of aluminized steel in which the aluminum coating changes into aluminum iron and oxide which will withstand higher temperatures than the normal low carbon steel.

Publications of the American Gas Association and Underwriters' Laboratories give the maximum allowable temperature for the various materials commonly used.

Combustion Equipment and Performance

Gas. Gas-designed furnaces may burn natural, manufactured, mixed, liquefied petroleum, and liquefied petroleum-air gases. The American Gas Association approval requirements for central heating gas appliances set the minimum standards for the construction, performance and safety of gas furnaces. In addition, many municipalities and utilities have special requirements or require special testing for permission to sell in the territory under their jurisdiction.

Most residential gas furnaces are equipped with one of two heat exchanger types. Either a single combustion chamber is used, usually cylindrical in shape, with extended flue-gas passageways which may be adjacent to the combustion chamber or encircle it, or the heat exchanger may be made of a series of individual sections connected near the bottom and connected to a common flue-gas breeching at the top. The former design will usually be equipped with a burner of the single port design while the latter, known as a sectional furnace, will usually have individual burners under each of the flues, cross-connected to ignite from a single pilot burner ignition source.

Output ratings of gas furnaces that meet the A.G.A. approval requirements are established at 80 and 75 percent of the improved input for forced and gravity type furnaces respectively.

Oil. Oil furnaces consist of a single primary heat exchanger plus additional flue-gas passageways which provide secondary heating surface. In residential furnaces, the high-pressure, low-pressure and rotary burners are most frequently used.

With the first two burners, it is usually necessary to provide a combustion chamber that will keep the temperatures in the combustion zone high enough to promote rapid vaporization of the oil and at the same time protect the side walls of the heat exchanger from the flame temperature. Insulating-type refractory either in molded or felted form or high-temperature chrome-nickel steel may be used.

In heavy duty furnaces, it is often possible to burn the flame in suspension without the aid of an inner combustion chamber. In this case the heat exchanger itself will be made of chrome alloy steel in the combustion zone.

Most furnaces designed for oil are available as complete packages including the furnace and the oil burner. In the smaller sizes, they are completely assembled at the factory and are shipped ready for installation. In addition to bearing a label showing equipment with an Underwriters' Laboratories listed oil burner, the entire furnace may bear the

Underwriters' Laboratories label showing that it meets the requirement of Underwriters' Standard 737, Oil Fired Central Furnaces. Oil-Fired furnaces may also be certified by the manufacturer under Commercial Standard 104, Warm Air Furnaces Equipped with Vaporizing Type Oil Burners or 195, Warm-Air Furnaces Equipped with Pressure-Atomizing or Rotary-Type Oil Burners.

Casing or Cabinet

Forced air furnaces for both oil and gas are enclosed in cabinets that are usually rectangular in shape. The cabinet provides the passageway for the air over the heat exchanger and also usually encloses the blower, motor, filters, burners, controls, and draft hood.

The cabinet is insulated in the heat exchanger compartment with aluminum-faced mineral wool or asbestos or by a metal liner to assure cabinet surface temperatures that are not dangerous to touch and do not offer a fire hazard to adjacent combustible materials. Cabinets are usually finished in baked enamel. Flanged openings are usually provided for supply and return air duct connections. Removable access doors or panels are included for access to all parts.

Blowers and Motors

Centrifugal blowers with forward-curved blades of the double inlet type are almost exclusively used as the air circulation means in forced warm air furnaces. These blowers are selected to overcome the resistance of the furnace air passageways, the filters, and the duct work, as shown in Chapters 18 and 21. They may also be sized to provide the additional air requirement for cooling and to overcome additional static resistance through cooling coils.

The blower wheel may be mounted directly on the motor shaft to run at motor speed but usually it is belt driven by a V-belt in which case a fixed pulley is mounted on the blower shaft and a variable-pitch drive pulley is mounted on the motor shaft to permit adjustment for proper fan speed. Means are provided for shifting the motor position to obtain proper belt tension after pulley adjustment.

The electric motors used for driving furnace blowers are usually designed for that specific purpose. Since the blower does not pick up its full load until it is up to operating speed, it is not necessary to have a motor with a high starting torque. Motors with medium starting torque will overcome the bearing friction and bring the blower up to speed more smoothly. Direct-drive blowers may be of the shaded-pole or permanent-split-capacitor type. Speed variation may be obtained either by extra windings in the motor or by a reactor-type speed selector that operates on the principle of a transformer to reduce the voltage to the motor. Blower motors for belt drive are usually of the split-phase type up through the ½ hp size with larger motors being capacitor-start split-phase motors. Some of the larger motors may be repulsion-induction motors for single-phase and squirrel-cage motors for polyphase current. Motors are described in more detail in Chapter 45.

Controls

The controls for forced air furnaces include those described for the combustion equipment in Chapter 34 and in addition those which prevent overheating of the air or furnace or prevent delivery of air below desired temperature.

A limit control is used to shut off the burner if the temperature of the air leaving the furnace is excessive. This temperature is usually 250 F for furnaces not to be installed near