

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 $\frac{1}{2}$ hp size and larger motors are 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 57.

Manufacturers usually include blower performance data and motor requirements along with the furnace performance specifications giving the cubic feet of air delivered per minute against a range of duct system static pressures. Information will be given concerning required motor or drive changes to handle different conditions.

Controls

Controls on warm air furnaces usually consist of a low voltage room thermostat which starts and stops the burner in response to room temperature changes or opens and closes the draft on hand-fired coal furnaces, combustion controls as described in Chapter 51 and thermostatic controls which respond to the temperature of the discharge air to prevent overheating and to start and stop the furnace blower. The first of these is called the limit control.

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 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.

The limit control performs only a safety function to prevent overheating in the event of a reduction in the proper air flow through the furnace which can occur with a clogged filter, restrictions at the inlet or outlet, grilles of the duct system, broken blower drive belts or a defective blower motor.

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 either have a fixed differential for turning off the fan or may also incorporate a Fan Off setting.

The fan control settings and the speed or air delivery of this blower must be carefully adjusted to give as continuous air circulation as possible. Publications of the National Warm Air Heating and Air Conditioning Association and Chapter 7 of 1964 GUIDE AND DATA BOOK give details of setting blower speeds and fan controls.

The fan and limit controls are often incorporated in the same housing and are sometimes 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 36. 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; 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, having its 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.

Such humidifiers are not controlled but depend upon an increase in running time of the furnace during colder weather to increase the amount of moisture evaporated, this approximates the change in requirements or humidity. There are also other types of humidifiers available, some of which evaporate water electrically, mechanically atomize, motor drive a revolving wick or otherwise introduce moisture into the circulating air. These humidifiers are often controlled by a humidistat located in the space being heated.

With the present trend toward better insulation, vapor barriers, and tight storm windows in homes, as well as 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.

Humidifiers are usually sold as accessory equipment and are not included as a part of the furnace package. For further information on humidifiers, see Chapter 33.

Fuel Considerations

Chapter 18 gives information on fuels and combustion and Chapter 51 discusses fuel-burning equipment. Chapter 16 of the 1964 GUIDE AND DATA BOOK presents the economic factors in making fuel selection.

The American Standard Approval Requirements for Gas Fired Warm Air Furnaces (ASA 221), as sponsored by the American Gas Association, gives the minimum construction, safety and performance requirements for gas furnaces. The American Gas Association maintains laboratories to examine and test furnaces and a field inspection service. Furnaces submitted and found to be in compliance are listed in the American Gas Association Directory and also bear the Blue Star Seal of Approval.

Gas furnaces normally are approved for clearances from combustible materials of at least 6 in., although furnaces may be approved for lesser clearances and are so listed. Horizontal furnaces are normally approved for installation on combustible floors and may also be approved for attic installation

and so marked, in which case they may be installed with point or line contact between the jacket and combustible constructions. Gas furnaces may be listed to burn natural, mixed, manufactured, propane, liquefied petroleum or liquefied petroleum-air gases. The furnace must be ordered from the manufacturer for the specific gas to be used since they often require different burners for the different gases and different controls in addition to orifice changes. Most gas furnaces, however, may be converted in the field at a later date for other gases for which they were originally approved; change-over kits are available from the manufacturer.

In addition to American Gas Association approval, some municipalities and utilities have special requirements or require special testing for permission to sell in the territory under their jurisdiction.

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.

Ratings for Oil-Fired Furnaces

Oil furnaces are available as complete packages including the burner and control equipment. Pressure-type or rotary burners included as a part of the package should bear the Underwriters' Laboratories label showing compliance with U.L. 296, which is basically a safety standard and Commercial Standard label C.S. 75, which is a performance standard. In addition, the complete furnace should bear the U.L. 727 label and be so listed. It may also be certified by the manufacturer as complying with Commercial Standard 195. Vaporizing burner furnaces should also be listed under U.L. 727 and C.S. 104.

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 80 percent for forced air furnaces and 75 percent for gravity 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 Coal-Fired Furnaces

Coal-fired furnaces, both stoker and hand-fired, are rated from empirical formulas developed by the National Warm Air Heating and Air Conditioning Association.

ELECTRICAL HEATING

Warm air heating is also accomplished by means of a refrigeration cycle usually driven by an electric motor. Such equipment is known as the heat pump and is described in detail in Chapter 66, although it is applied similarly to fuel-burning warm air furnaces. Chapter 6 of the 1964 GUIDE AND DATA BOOK gives information on the sizing and selection of heat pump equipment and Chapter 66 of this volume discusses their design.

Electric resistance furnaces are made in various styles as are fuel-burning furnaces, although because of the absence of fuel-burning equipment, a singular furnace is often universal in its positioning. Electric furnaces are usually made up of one or more resistance elements of a maximum capacity

of 5 or 6 kw each. The low-voltage room thermostat brings on the heating elements through relays in stages arranged with delays so that all of the load will not be put on the line at once. Some controls, known as sequencers, use a reversing clock motor which operates cams to open or close the switches for the heating elements. When the room thermostat is closed the clock motor runs to bring in additional heating elements at timed intervals and when open, the motor reverses and drops out the heaters in sequence. With this operation, the furnace blower is usually started along with the first heating element and is kept in operation until it cuts off. This system of control gives very desirable capacity modulation and virtually continuous blower operation. A high limit control(s) is also used as on fuel-burning furnaces. Underwriters' Laboratories Standard 573 gives requirements for the listing and labelling of such equipment. Chapter 15 of the 1964 GUIDE AND DATA BOOK gives additional information on warm air furnaces using electricity as the source of heat.

COMMERCIAL AND INDUSTRIAL EQUIPMENT

Furnaces intended for commercial and industrial uses are also known as heavy duty heaters, heavy duty fan furnaces, non-residential warm air heaters and by a variety of other terms.

This equipment is shipped as factory-assembled packages or for site erection. There are two primary ways in which this equipment is used, (1) as large space heaters, and (2) with a duct distribution system. When used as space heaters, they may be free-standing units or suspended over head with discharge nozzles which may be adjusted to give the desired velocity, direction, and deflection of air flow. These furnaces are available with a selection of pulleys, belts, and motors to give the blower speed necessary to handle the required amount of air against the system resistance.

This equipment is available in the same variety of styles as residential warm air furnaces. They are often designed so that with minor alterations, either at the factory or in the field, the same unit may be used in a horizontal, upflow or counterflow position.

Roof-mounted units is a term applied to equipment designed to be installed on the roof to supply the floor below. They are weatherproofed and incorporate the means of disposing of products of combustion. Return air and discharge air is often handled in a single concentric duct extending vertically through the roof to a single ceiling diffuser, or it may be handled conventionally in a duct distribution system. A number of these may be used in a store or factory. They are often constructed with a complete refrigeration cycle for air conditioning built into the same cabinet.

In the largest sizes, these furnaces are often engineered for the specific installation and assembled on the site. This permits selection of the air-handling equipment to meet the ventilation and air-conditioning requirements of the building as well as the static resistance of special air-cleaning equipment in addition to providing circulation and distribution of heated air.

Heat Exchangers

Examination of the Catalog Data section of the GUIDE AND DATA BOOK will show some of the variety of heat exchanger designs that can be used. Alloy or coated steels are commonly used to permit operation at higher metal temperatures with higher heat release rates than in smaller furnaces.

Combustion Equipment

Although some large capacity furnaces use atmospheric gas burners, power burners for both oil and gas are more common. Many gas utilities have interruptive contracts with their