

to 12 in. water. A portion of the air or primary air required for combustion is entrained from the atmosphere by the stream of gas issuing from an orifice, and the air-gas mixture is delivered through a venturi mixing tube to the burner head and parts. About 40 to 60 percent of the air required for combustion is in the form of primary air and the remainder, known as secondary air, is supplied from the air surrounding the flame.

Each system embodies characteristics essential for certain applications. It is important that proper and qualified engineering authorities be consulted prior to the purchase, installation, or operation of industrial gas equipment.

FUEL BURNING RATES

The burning rate for automatic fuel-burning devices is determined by the gross heat output required of the boiler, or furnace, to carry the net heating load, plus allowances for system losses and pickup. General values for these allowances have been given in preceding text. Detailed information for piping and pickup allowances for steam and hot water systems, is given in Chapter 35, and for warm air systems, in Chapter 18.

When the gross output, operating efficiency, and heat value of the fuel are known, the required rate of burning can be determined by means of Figs. 17, 18, and 19 for the several fuels. As the rate of fuel-burning is directly proportional to the load for a given efficiency, these charts can be extended by moving the decimal points the same number of digits in both vertical and horizontal scales.

The correct fuel-burning rate can be determined directly from the several charts for oil or gas burning installations, as these customarily operate on a strictly intermittent basis. These fuel burning devices usually introduce the fuel at a single fixed rate during the on periods, and this rate should be sufficient to carry the gross load. In the case of coal stokers, which are usually capable of variable rates of firing, it is desirable to operate at as low a rate as weather conditions will permit, but the maximum firing rate of the stoker should be sufficient to carry the gross load. This rate may be determined by the same method as used for oil or gas.

CONTROLS FOR AUTOMATIC FUEL-BURNING EQUIPMENT

Controls for the automatic fuel-burning equipment described in this chapter are outlined here. The basic requirements for oil burners, gas burners and coal burners (stokers) are included and the term *burner* refers to all three types of fuel-burning equipment. Controls for these burners can be classified as *operating controls*, *limit controls* and *primary controls*. The schematic diagrams shown in Fig. 20 indicate the relationships of the basic components. The power supply may be line voltage for each type of burner. In control systems for domestic burners the line voltage may be reduced by means of a transformer for those portions of the circuits indicated by dotted lines. Such transformers are usually built into the stoker and oil burner *primary controls*. Control systems for domestic gas burners frequently contain a separate transformer as shown. Some domestic gas burner control systems obtain their electrical power supply from the conversion of heat to low-voltage electrical energy, in which case no transformer would be required. As the burner sizes increase, the tendency is to use line voltage controls.

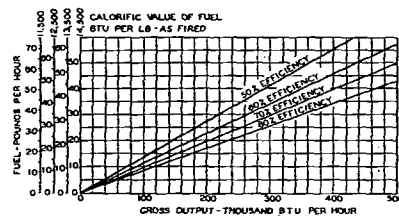
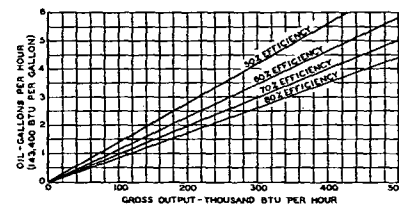


Fig. 17 Coal Fuel-Burning Rate Chart



* This chart is based upon No. 2 oil having a heat content of 145,000 Btu per gallon. If other grades of oil are used multiply the value obtained from this chart by the following factors: No. 1 oil (128,000 Btu per gallon) 1.022; No. 4 oil (144,500 Btu per gallon) 0.992; No. 5 oil (146,000 Btu per gallon) 0.985; and No. 6 oil (150,000 Btu per gallon) 0.954.

Fig. 18 Oil Fuel-Burning Rate Chart*

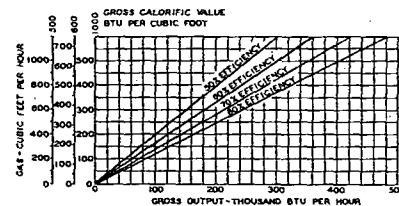
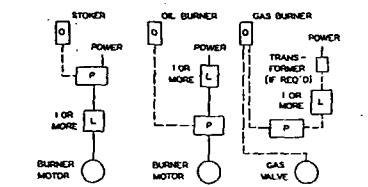


Fig. 19 Gas Fuel-Burning Rate Chart



(O = Operating Control; P = Primary Control; L = Limit Control)
Fig. 20 Schematic Diagrams of Some Typical Burner Control Systems

Operating Controls

Operating controls initiate the starting and stopping of the burner. For residential and small commercial heating plants with fuel inputs up to approximately 500,000 Btu/h, the operating controller is usually some form of room thermostat which automatically starts and stops the burner through the primary control as the limit controls permit. On larger installations the operating controller for the burner becomes an insertion thermostat (for furnaces), immersion thermostat (for hot water boilers), or pressure controller (for steam boilers). On some installations, outdoor compensated controllers may find application. Most large burners, over 2,000,000 Btu/h, are equipped to vary the rate of fuel and air input in response to the varying load demands.

Limit Controls

Limit controls guard against unsafe temperature, pressure or water level to assure that safe conditions prevail for the operation of the burner. Where the operating control is other than a thermostat, separate operating and high-limit controls should be used. It is not recommended and codes seldom permit the use of one and the same instrument as both an operating controller and a high limit control. The operating controller will be adjusted to control at the desired set point while the high limit control will be adjusted to stop the burner at some higher point in the event that the operating controller fails to stop the burner before the higher shut-off point is reached. For example, to maintain a constant water temperature in a hot water boiler, the operating controller may be set to stop the burner when the boiler water temperature reaches 180 F. The high limit control should then be set to stop the burner at a higher temperature, say 200 F.

Primary Controls

Primary controls provide for safe start and operation of the burner. They are somewhat different for each of the three types of fuel burners, and may also vary considerably between domestic and commercial-industrial burners.

Domestic Burners. Primary controls for domestic burners are discussed in the following paragraphs 1 to 3.

1. **Stokers.** Stokers are equipped with refueling, or hold-fire, controls. These primary controls cause the stoker to intermittently feed a predetermined amount of coal during the long off periods of the operating controller to maintain ignition and to reduce the possibility of having idle fuel beds damage stoker castings. In some cases the primary control system includes an out-fire feature which stops the feeding of coal into the firebox if the fire goes out.

2. **Oil Burners.** Primary controls required for domestic oil burners depend on the type of burner.

a. Domestic oil burners of the vaporizing type usually require a primary control that will (1) meter the correct amount of oil into the burner to maintain the pilot flame; (2) regulate the required amount of oil into the burner for its high flame operation; and (3) completely shut off the flow of oil in the event of a flame failure.

b. Domestic oil burners of the pressure-atomizing and vertical rotary types require a primary control that will (1) energize the burner motor and electric ignition; (2) test for the establishment of main burner flame and stop the burner and ignition if flame has not been established within a set time; (3) cut off the ignition after a safe burner flame has been established (does not apply to constant ignition type

burners); (4) monitor the flame continuously during burner operation and stop the burner in the event of flame failure (manual reset is necessary following a flame failure lock-out); and (5) stop the burner when either the operating controller or limit control requires it.

3. **Gas Burners.** Domestic gas burners of the atmospheric type require a primary control (to insure safe starting and operating conditions) that will (1) prevent opening of the gas valve unless the pilot is operating properly, and (2) stop the flow of gas through the burner if safe ignition conditions do not prevail at all times. For domestic power burners a relay is normally added to operate the blower motor as well as the gas valve which may be energized simultaneously with the blower motor or following a slight delay.

Commercial and Industrial Burners. The primary controls for commercial and industrial burners, often referred to as programming flame safeguard controls, may in some cases be similar in function to those used on domestic burners but involve two major differences: (1) the use of a means of flame sensing which shortens the speed of response to a flame failure to within four seconds, and (2) the more elaborate sequencing of the primary control. The entire control system also becomes more elaborate, requiring added controls to provide the additional sequences and safety interlocks. Primary controls for commercial and industrial burners are discussed in the following paragraphs 1 to 7.

1. Pressure-atomizing type burners for commercial and industrial applications use flame safeguard controls to provide similar functions to those outlined for domestic burners of the same type except for the speed of response to a flame failure. However, in addition, they may also involve pre-ignition purge, timed ignition (electric ignition, or, on the larger burners, spark-ignited gas pilots). In addition, the over-all control system, would also include safety oil shutoff valves, provision for low fire start and, on the larger burners, a means of modulating the firing rate.

2. Horizontal rotary type oil burners for commercial and industrial installations use still more elaborate flame safeguard controls. The sequencing included in the flame safeguard control may provide for (1) a pre-purge period before energizing the spark-ignited gas pilot; (2) proving the presence of proper ignition means before permitting the flow of oil to the main burner; (3) proving the presence of a stable main burner flame within a pre-determined timed trial for ignition; (4) shutting off the ignition means after a pre-determined length of time; (5) monitoring the main burner flame during its entire period and shutting off the main fuel supply within four seconds in the event of a flame failure; (6) stopping the flow of oil when the operating or limiting control requires it, but continuing the burner motor operation for a pre-determined purging period after the main fuel valve has been closed; and (7) locking out on flame failure shutdown (requiring a manual reset prior to a restart).

3. When steam, air, or mechanical atomizing burners are automatically controlled, the sequence of control is similar to that described for horizontal rotary-cup burners.

4. Commercial and industrial gas burners of the atmospheric type may be equipped with a constantly burning gas pilot or have provision for establishing a spark-ignited gas pilot on each cycle—the pilot continuing to burn during the entire burner operating cycle. This will require a flame safeguard control with the following sequence: (1) on a call for heat, provision is made to prove the presence of an existing pilot or to establish and prove an adequate spark-ignited