SELECTING YOUR FUEL AND BURNER

Before you purchase any home heating equipment, it is important to decide on what fuel you want to use. The highest heating efficiency is obtained from fuel-burning equipment designed especially for a particular fuel. The decision as to fuel should be made while the house is being designed because storage requirements for a fuel may affect the plan.

Fuels

Factors which will influence your choice of fuel include:

- **Convenience offered by the fuel.**
- **Availability of the fuel.** Not all fuels can be obtained in all areas. Consult fuel dealers and utility companies in your locality.
- **Storage space required.** Solid fuels generally require storage space within the house at a point convenient to the driveway and the heating plant. Oil is stored in tanks either in the basement or outside the house area, preferably underground; liquefied petroleum gas, in tanks outside the house. Natural or manufactured gas does not require storage.
- **Cost of fuel.** To determine the true cost of a fuel, the heating value of the fuel and the efficiency of the heating plant must be related to the sale price of the fuel per unit—ton, gallon, therm,* cubic foot. (See page 8) Heating values are usually expressed in Btu's (British thermal units* per pound, per gallon, or per cubic foot.)
- **Cost of the heating plant.** As in other equipment, maintenance costs must be considered as well as initial cost.

All the different fuels contain the same three combustible elements. These, in the order of their importance, are carbon, hydrogen and sulphur. The heating values in Btu per pound for these elements are carbon, 14,540; hydrogen, 62,000; and sulphur, 4,050. Solid fuels contain the greatest proportion of carbon, and natural gas, the smallest proportion. While the sulphur contributes to the heating value of a fuel, its presence is undesirable because the sulphur dioxide formed by its combustion is irritating to humans, detrimental to vegetation, corrosive to exposed metals, and harmful to the strength of mortar in unlined brick chimneys.

Burners

Burners have been designed for the various types of fuels—coal, oil, gas, liquefied petroleum gas. These burners can be installed in furnaces (for warm-air heating systems) or in boilers (for hot-water or steam heating systems).

To help you in selecting a burner, safety and efficiency standards for equipment have been set up by several fuel associations and technical societies. Seals of approval are frequently placed on the equipment to show that these standards have been met.

To give the most efficient service, a fuel burner should be:

- **Purchased in the correct size.** For a house under construction, the heat loss should be estimated by a competent person before the burner is selected. In replacing a burner in an existing house, the performance of the old burner can be used as a guide to size. If its performance has been satisfactory, buy a new one having the same capacity.
- **Competently installed.** No equipment can perform efficiently unless it is correctly installed.
- **Properly maintained.** The life of mechanical equipment depends largely on careful maintenance. Equipment should be inspected and cleaned annually. Do not tamper with the equipment or controls—call a service man when something goes wrong.

*A British thermal unit is the heat required to raise the temperature of one pound of water one degree Fahrenheit. A therm is equivalent to 100,000 Btu.
Fuel oil is commercially available in five grades, numbered 1, 2, 4, 5, and 6. (No. 3 oil has been discontinued as a separate grade.) No. 1 oil is a transparent fluid similar to kerosene. It is more expensive and has a lower heating value per gallon than the other grades. As the classification number increases, the oil becomes darker and less fluid, and the heating value per gallon increases—from 136,000 Btu for No. 1 oil to 152,000 Btu for No. 6 oil. Oils numbered 4, 5, and 6 are used only in industrial burners.

Oil tanks should be installed in accordance with recommendations of the National Board of Fire Underwriters and local ordinances. Tanks are commonly located in the basement above the level of the burner. These tanks should not exceed 275-gallon capacity and should be 7 feet or more from any flame. They should be vented to the outside and should have an outside fill-pipe connection. Two 275-gallon tanks are the maximum storage allowed in the basement. For larger installations, tanks must be outside the area of the house, preferably buried in the ground.

**BURNERS**

Two types of oil burners are manufactured—the pressure-type, and the vaporizing type.

The burner you buy should carry the seal of approval of the National Board of Fire Underwriters showing that it has met safety standards. Use oil of the grade shown on that label.

All burners should be installed by an experienced service person in accordance with the manufacturer’s instructions. He should also inspect and clean the burner annually, and should be called on to make any adjustment of the rate of oil-feed or air supply which is necessary to provide a non-smoky flame free from soot and odors.

All oil burners (particularly the vaporizing type) require a small but steady draft. This should be controlled by an automatic draft regulator installed in the vent pipe.

**Pressure-Type Burner**

The pressure-type burner consists of 1) a pump and a nozzle which spray the oil into a fine mist, and 2) a fan which provides a stream of air which mixes with the oil before it enters the firepot. This mixture of oil and air is ignited by an electric spark when the burner is turned on. The burner is not operated continuously but is turned on or off in accordance with the demands of a room thermostat.

This type of burner usually projects outside of the furnace or boiler, making it readily accessible for servicing. Oil as heavy as grade No. 2 may be used.

**Vaporizing Burner**

The vaporizing or pot-type burner consists of a pot containing a pool of oil and a control which regulates the oil flow. Heat from the burning process vaporizes the oil. The air necessary for burning is drawn into the vapor above the oil pool by natural draft or is forced in by a very small fan. There are few moving parts, and the burner operates quietly. The fire is started manually with oily waste, after which a low pilot flame remains lighted. When heat is needed, more oil is fed into the pool and a hot flame results. Careful adjustment of both fuel and air is necessary in order to avoid a smoky, sooty flame. The initial cost of this burner is lower than for other types.
GAS AND GAS BURNERS

When gas is used as fuel, gas pressure is maintained by a central gas plant, and no storage facilities are necessary on the customer's premises. The cost to the homeowner of installing gas pipe from the street mains to the burner depends upon local utility practice, and on the distance between the main and the burner. Consult your utility company for an estimate of these piping costs.

Natural Gas

Natural gas has a heating value ranging from 960 to 1,550 Btu per cubic foot, depending on the location of the wells from which it is obtained.

In some areas, bills for natural gas are rendered in terms of therms (100,000 Btu). The number of therms of gas is obtained by multiplying the number of cubic feet consumed by the accepted heating value per cubic foot and then dividing this product by 100,000.

BURNERS

There are two types of gas burners used in residences—atmospheric and forced-draft. In the atmospheric burner, there are no moving parts. These burners are quiet in operation and relatively long in service life. Gas fuel is supplied at low pressure into the burner, where it is mixed with the air required for burning. The combustion forms hot gases which pass through the furnace or boiler and give up heat to the air or water to be circulated in the heating system. The gases then pass into the vent pipe and the chimney.

The design of burner head varies. Some are made up of multiple rows of straight pipe with slots or with holes (ports) spaced at regular intervals. Others are ring-type with either ports or slots.

The rate at which gas is supplied to the burner head is controlled by an automatic gas valve and an orifice (a small opening in the plug at the end of the supply pipe). The gas valve operates in accordance with the heat demands of the room thermostat.

The pressure of the gas is controlled by an automatic pressure regulator which reduces the gas pressure from the main supply lines to the exact amount needed in the burner.

In most models, a pilot burner is lighted at the beginning of the heating season and this flame is maintained continuously. When a demand for heat occurs, a large gas flow is introduced automatically to the main burner through the gas-control valve and a large fire is obtained. If the pilot flame is extinguished, an automatic cutoff shuts off the flow of gas.

A draft hood is required in the vent pipe to prevent excessive draft and also to prevent air currents from coming down the chimney and blowing out the pilot flame. The hood also helps to keep moisture from condensing in the chimney or in the vent pipe by introducing air which dilutes the water vapor formed during the combustion of the gas.

The forced-draft operates in a similar manner except that the air required for combustion is furnished by an electrically driven fan. Conversion gas burners can be installed in existing boilers and furnaces. These installations should be made by a competent installer in strict accordance with instructions of the burner manufacturer. Furnaces and boilers designed especially for the use of gas are usually more satisfactory than conversion installations. The initial cost of a furnace or boiler designed for use with gas is relatively low.

Gas-burning equipment should bear the American Gas Association's seal of approval. The final adjustment of the various valves and controls should be either made or checked by a service man from the gas company. Warning: If the distinctive odor of natural gas is smelled in the house, call the gas utility company immediately. This odor is added by the gas utility to aid in leak detection.

University of Illinois SHC-BRC
LIQUEFIED PETROLEUM GASES—BUTANE AND PROPANE

Fuels of the butane and propane types are transported, sold, and stored under pressure in the liquid state, but they are burned as a gas. They bring the convenience offered by gas to homes not served by pipe lines.

Two types of service are available to customers using this fuel.

In one type, two small tanks are installed. Gas is drawn from one tank until it is empty. The connection to the burners is then switched, either manually or automatically, to the other tank. (In the latter case, a signal indicates the switch. The customer notifies the dealer when a switch has been made, and the empty tank is replaced without any interruption of the service. The fuel supplied this way is sold by weight.

In the other type of service, a much larger tank is installed, and the liquid-fuel level is indicated by a float-operated gage. When the gage shows that the level is low, the customer notifies the dealer and the tank is refilled by pumping liquid fuel into it from a special tank truck. When liquefied petroleum gas is so supplied, the fuel is usually sold by the gallon, and the amount supplied is measured by a meter on the tank truck.

The heating value of these liquefied gases ranges from 21,000 to 22,000 Btu per pound and from 90,000 to 105,000 Btu per gallon.

BURNERS

Burners for liquefied petroleum gases are similar to those used for burning natural gas, the principal differences being:

• The pipe bringing the fuel to the burner is attached to a storage tank instead of to a gas main.
• The pressure regulator is usually required to operate against a much higher pressure in the pipe line than is the case with natural gas.
• The orifice, which feeds the fuel into the air-mixing chamber of the burner, must be a smaller size. (See page 4.)

The gas is delivered to the burner from the bottleshaped metal tank located outside the house.

Gas pressure in the upper part of the tank is maintained by evaporation of liquid in the lower part. When gas is drawn from the top of the tank for use in heating (or cooking appliances), the pressure is momentarily reduced, but some of the liquid then evaporates and the original pressure is restored. When all of the liquid has evaporated, the tank must either be refilled or replaced. If an installation is correctly made, the available pressure is always more than is needed as long as any liquid fuel remains in the tank. A pressure regulator installed between the tank and the burner maintains a constant pressure at the burner orifice.

Warning: Liquefied petroleum gases are heavier than air and are not easily vented from basements in case of a leak. If the pilot flame should go out, it should be relit only by a competent service man who should determine with instruments whether the air is free enough from gas to permit relighting without an explosion.

ELECTRICITY FOR HOME HEATING

Heating with electricity is not new, but it is only within recent years that it has become popular in the residential field. Electricity may be thought of as “fuel” much the same as coal, oil, or gas. If it is used to “fire” a furnace or boiler, then heating with electricity is basically the same as with any other fuel except there is no chimney loss.

Electric heating also may be found in the form of baseboards, similar to the units used with hot water systems; ceiling cable, with heating wires embedded in plaster or sandwiched between two layers of drywall; high-temperature panels mounted on the ceiling; units that have a small fan to circulate the heated air; and resistance units inserted in the branch supply ducts of a central air duct system. In addition, there is the electric heat pump, which is effectively a reversible refrigeration unit. A more complete discussion of electric heating systems may be found in Circular G3.1, Heating the Home.
Anthracite Coal

Anthracite coal (hard coal) produces little or no smoke in burning. It is well adapted for use in automatically-fired furnaces and boilers, and also in hand-fired heaters which are equipped with self-feeding supply chambers (magazines), because it does not soften and fuse together in the burning process. As a result, the coal flows readily by gravity action. Automatic ash removal is possible with anthracite coal because, in burning, large hard clinkers are not formed. However, it is not available in many areas of the country.

Anthracite coal produces an even heat. Its heating value is usually between 12,000 and 13,000 Btu per pound.

Bituminous Coal

Bituminous coal (soft coal) is sold in a wide variety of types, preparations and qualities. It is found in more areas of the country than anthracite and hence is less expensive in most regions because of lower transportation costs.

Some of the bituminous coals are nearly as hard as anthracite when handled or stored at outdoor or room temperatures, but they all soften and the lumps fuse together to a varying extent when heated in a fuel bed. They are, therefore, not well adapted for use in hand-fired furnaces or boilers having a magazine to feed the fuel to the fire by gravity. Most burn well in underfeed stokers.

Stokers for bituminous coal employ the underfeed principle of burning. They burn bituminous coal smokelessly when properly adjusted. This is possible because the fresh coal is fed into the burning zone at a controlled rate; the gases released are mixed with air from the openings in the retort; and the mixture is passed through the hot coke at the top of the fuel bed where ignition is assured. The fire is started with kindling and is maintained by a hold-fire control. This control automatically keeps the fire alive in mild weather when the thermostat makes infrequent demands for heat. The hot fire fuses the ashes into clinkers, which can be removed with tongs.

Installation and Care of Stokers

Stokers require reasonable care:

- Use a size and type of coal recommended by the stoker manufacturer. Coal should be one inch in diameter or smaller. Coal larger than one inch is apt to make a crunching noise in the coal screw.

- Have a competent service man make any necessary adjustments of the coal feed and air supply, as well as of the control settings. In a properly-adjusted stoker, the thickness of the fuel bed will be about equal to the diameter of the retort. If the type of coal is changed, readjustments may have to be made by the service man.

- If the stoker is of the clinkering type, use a bar to loosen clinkers from the fuel bed. They can then be removed by means of clinker tongs.

- Do not disturb the fuel bed any more than necessary. Remove only large-sized clinkers. In mild weather, these may take several days to form. If clinkers are not formed and difficulty is experienced in cleaning the fire, reduce the temperature setting of the room thermostat at night. This will prolong the stoker operation in the morning when the thermostat is returned to daytime setting and will produce the hot fire needed to form clinkers.

- At the end of the heating season, all coal, ash, and clinkers should be removed. The coal screw, the retort, and the inside surfaces of the hopper should be coated with oil to prevent rust.

An automatic draft regulator in the smoke pipe is required for stokers.
HEATING EFFICIENCIES

The amount of fuel you need to keep your house at a desired temperature depends on the house construction, the weather (outdoor temperature, wind velocity, clear or cloudy sky), and heating efficiencies. Reference is frequently made to two types of efficiencies:

- **The efficiency of the heating plant by itself** as tested in the laboratory. In other words, how much of the heat given off by a fuel is transferred to the heating medium (air or water circulating in the heating system)?

  Much heat never reaches the heating medium because it escapes through the front of the furnace or boiler, through the smoke pipe, and up the chimney. There is also a heat loss when fuel is unburned since the heat in the fuel is never released.

- **The over-all efficiency.** How much of the heat in the fuel is used to warm the house?

  Over-all efficiency considers not only the heat transferred to the air or water but also that part of the escaped heat which is actually within the house and is eventually used in heating the house. (This includes the heat which escapes through the front of the furnace or boiler, and through the smoke pipe. Heat which goes to the outdoors through the chimney is not included, nor is the heat lost due to unburned fuel.) The over-all efficiency, therefore, indicates how well the heating plant and the house utilize the heat in the fuel.

  Heating plant and over-all efficiencies are affected by the type of fuel used. Comparative values of over-all efficiency with different fuels can be obtained by testing in the same house all of those fuels to be considered. Each fuel should be tested for a period which includes all of the different climatic conditions of a typical heating season.

  The table below presents assumed values of over-all efficiency as determined at the University of Illinois. These are based on an analysis of data taken in research homes over a period of many years. These research houses had furnaces and boilers located in full basements, and in crawl spaces of split-level houses. While the actual efficiencies would be different for other houses, the ratio of the over-all efficiency with one fuel to that with another fuel would probably be about the same for any house.

<table>
<thead>
<tr>
<th>Type of Fuel</th>
<th>Method of Burning</th>
<th>Assumed Over-all Efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bituminous coal</td>
<td>Stoker-fired</td>
<td>65%</td>
</tr>
<tr>
<td></td>
<td>Units designed for oil burning with exception of vaporizing type without fan.</td>
<td>80%</td>
</tr>
<tr>
<td>Oil</td>
<td>Vaporizing-type units without fan, and units converted to oil burning.</td>
<td>70%</td>
</tr>
<tr>
<td>Oil</td>
<td>Any properly designed burner</td>
<td>80%</td>
</tr>
<tr>
<td>Gas (all types)</td>
<td>Ceiling cable, baseboards</td>
<td>100%</td>
</tr>
<tr>
<td>Electric (in room)*</td>
<td>Ducted furnace, boiler</td>
<td>90%</td>
</tr>
</tbody>
</table>

*While electrical current is not a fuel, it is sometimes used to supply heat and for this reason is included in the table for comparison purposes.

ADJUSTING BURNERS FOR MAXIMUM EFFICIENCY

Too little or too much air entering the combustion chamber will reduce the efficiency of any fuel-burning unit. The higher efficiencies which are usually assumed in the case of automatic fuel-burning may not be achieved if the burners are not properly adjusted.

The amount of carbon dioxide in flue gas samples indicates whether a satisfactory air-fuel ratio is being maintained. Such analysis requires the help of a heating engineer.
HOW TO COMPARE FUEL COSTS

Estimating the seasonal cost of fuel for residential heating is a very complicated procedure, since it is dependent not only upon the heat loss of the house, but also upon the occupancy of the house, solar orientation, the amount of cooking, and the amount of lights and electrical appliances used. These sources of energy within the house can affect seasonal cost of operation by as much as 25-30%.

Any horizontal line in the table represents the same seasonal fuel bill for a given house operated under the same conditions, regardless of fuel used. If you have an exceptionally efficient gas- or oil-fired heating system, the prices in the table for that system can be increased by as much as 10%. For this comparison to be valid, the proper fuel price must be used. If the fuel price varies with the quantity used, an average price per unit should be based upon the total cost for the quantity to be used rather than using the price per unit for the lowest step on the rate scale.

### TABLE OF EQUIVALENT FUEL COSTS

<table>
<thead>
<tr>
<th>Electricity (units in room)</th>
<th>Electricity (central system)</th>
<th>LP gas (propane)*</th>
<th>Natural gas</th>
<th>No. 2 Oil</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>c/kwh</td>
<td>c/gal</td>
<td>c/therm</td>
<td>c/gal</td>
</tr>
<tr>
<td>0.2</td>
<td>0.22</td>
<td>4.0</td>
<td>4.1</td>
<td>5.7</td>
</tr>
<tr>
<td>0.3</td>
<td>0.33</td>
<td>5.7</td>
<td>6.2</td>
<td>8.6</td>
</tr>
<tr>
<td>0.4</td>
<td>0.44</td>
<td>7.5</td>
<td>8.2</td>
<td>11.5</td>
</tr>
<tr>
<td>0.5</td>
<td>0.55</td>
<td>9.9</td>
<td>10.2</td>
<td>14.3</td>
</tr>
<tr>
<td>0.6</td>
<td>0.67</td>
<td>11.9</td>
<td>12.3</td>
<td>17.2</td>
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<tr>
<td>0.7</td>
<td>0.78</td>
<td>13.2</td>
<td>14.3</td>
<td>20.1</td>
</tr>
<tr>
<td>0.8</td>
<td>0.87</td>
<td>15.1</td>
<td>16.4</td>
<td>23.0</td>
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<tr>
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<td>1.11</td>
<td>18.9</td>
<td>20.5</td>
<td>28.7</td>
</tr>
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<td>20.7</td>
<td>22.5</td>
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<td>1.33</td>
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</tr>
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<td>1.44</td>
<td>24.5</td>
<td>26.6</td>
<td>37.3</td>
</tr>
<tr>
<td>1.4</td>
<td>1.55</td>
<td>26.4</td>
<td>28.7</td>
<td>40.2</td>
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<td>1.67</td>
<td>28.3</td>
<td>30.7</td>
<td>43.1</td>
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<td>1.78</td>
<td>30.2</td>
<td>32.8</td>
<td>45.9</td>
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<tr>
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<td>2.11</td>
<td>37.7</td>
<td>38.9</td>
<td>54.5</td>
</tr>
<tr>
<td>2.0</td>
<td>2.22</td>
<td>39.6</td>
<td>41.0</td>
<td>57.4</td>
</tr>
</tbody>
</table>

*If LP gas sold in your area is butane, use the price of natural gas per therm as the price of butane per gallon.

Heat Pump

If an air-to-air heat pump is used, the coefficient of utilization or effective efficiency varies with the outside temperature. The power used in operating the compressor is converted to heat, and, in addition, heat is extracted from the outside air. If the outside air is warm, the coefficient of utilization may be as high as 3.5. As outside air temperature approaches 10°F., the coefficient approaches 1.0. To use the table above to compare heat pump operating costs with other fuels, the price of electrical energy for central systems should be divided by 1.5 if your location has an 8000 degree-day heating season, by 2.0 if a 6000 degree-day season, and 2.5 where the heating season is only 4000 degree-days.

**Example:** To compare the operating cost during the heating season of a gas-fired warm air system with a ducted air-to-air heat pump system, in an area with a 4000 degree-day heating season, an electric heating rate of 1.1¢/kwh and a natural gas rate of 82¢ per 1000 cubic feet, the fuel prices first must be converted to fit the table. The price of gas at 82¢ per 1000 cubic feet is equal to 8.2¢ per therm or 100 cubic feet. The price of electricity should be divided by the utilization factor of 2.5 for a heat pump in a 4000 degree-day area, which is 1.1/2.5 + 0.44¢/kwh. Since the natural gas rate of 8.2¢ and the electrical central system rate of 0.44¢ appear in the same horizontal line, the annual operating cost for heating will be approximately the same with either system.