surrounding air temperatures are normal, and of air heaters when fully heated and in stable operating conditions, (*b*) The heat loss from piping when surrounding air temperatures are normal, (*c*) The heat required to raise temperature of metal in boiler and system to temperature of circulating medium, (*d*) The heat required to raise circulating medium from lowest expected temperature to normal circulating temperature, (*e*) The excess heat output of radiation, other heating units, air heaters and piping due to decreased temperature of surrounding air, (*f*) The heat requirement of attached water heaters and other devices which may require heat during pick-up period. When the system and air have reached normal temperature parts (*c*), (*d*) and (*e*) disappear.

2. The number of hours during which maximum hourly output would be required during heating-up period, which varies according to the use of the building in which the installation is made, usually from 1 to 4 hours, being shortest for residences and longest for buildings used only occasionally.

3. The maximum hourly continuous output for any 24-hour period, or the average output which the boiler would have to deliver during a period of continued low outside temperature.

4. The kind and amount of attention available. This is least skillful and least frequent for owner operated residence installations and generally increases in skill as well as frequency as size of boiler increases. Local fuels and types of firing service must be considered carefully in this connection.

5. The kind of fuel to be used, including size and characteristics.

6. Size and height of the available chimney.

With the information contained in items 1 to 6 at hand, definite test information could be used as a basis for selecting the right size of boiler.

OTHER FACTORS IN SELECTION OF BOILER

As it will usually be found that several boilers will meet the specifications, the final selection of the boiler will be effected by other considerations as follows:

(*a*) dimensions of boiler, (*b*) height of water line, (*c*) durability under service, (*d*) convenience in firing and cleaning, (*e*) type of controls, (*f*) adaptability to changes in fuel and kind of attention, (*g*) the output required during the greater part of the season.

In large installations the use of several small units instead of one larger one will obtain greater flexibility and economy by permitting the operation of a required number of units according to heat requirements at the best operating efficiency.

NUMERICAL VALUE OF MAXIMUM HOURLY OUTPUT

Experience with gas-fired boilers, which are rated on B.t.u. output and can only slightly exceed the rated output, but which require no chimney draft, has shown that a continuous output capacity of 25 per cent in excess of the normal heat loss of radiation plus piping is ample for all direct radiator installations. This would correspond to an output of 40 to 60 per cent in excess of the normal heat loss of the radiation depending upon the proportion of piping to radiation. Upon the basis of gas-fired boiler experience, a coal-fired or oil-fired boiler which could deliver a continuous average output of 25 per cent in excess of radiation and piping would be amply large for any job. This is true for an oil-fired boiler provided the known output of the combination of boiler, burner, and chimney is used. In the case of coal-fired boilers however, it is

generally necessary to make additional allowance for the following conditions which may obtain at the time when the maximum or pick-up load occurs. (*a*) insufficient draft, (*b*) poor quality of fuel, (*c*) fuel bed not in good condition, (*d*) inferior quality of attention, (*e*) necessity of firing a charge of fuel that will last for a long period.

The conditions (*a*) to (*e*) inclusive, reduce the output obtainable below that which could be obtained under good or normal conditions and necessitate an increase in normal output of boiler selected in order that when the normal output is decreased by effect of items (*a*) to (*e*) there will still be available a quantity of heat 25 per cent in excess of the radiation plus piping loss. Coal-fired boilers therefore are usually selected with a maximum continuous output 60 to 80 per cent in excess of heat output of radiation plus piping.

For large installations the boiler output required in excess of heat loss of radiation plus piping will be about as follows:

	Per Cent
School buildings without recirculation of air	50
School buildings with full recirculation of air	25
Buildings with periodical heating only	50
Other large buildings	25

For any boiler selected it is well to determine whether the rate of combustion (pounds of coal burned per square foot of grate per hour) likely to be required continuously for more than a few hours is obtainable and is low enough to prevent clinker trouble. With natural draft it is recommended that for *continuous* output (under favorable conditions) with a *minimum of attention* the following combustion rates be not exceeded:

TABLE 1. PRACTICAL COMBUSTION RATES FOR RELATIVELY SMALL COAL FIRED HEATING BOILERS OPERATING ON NATURAL DRAFT OF FROM ¼ IN. TO ½ IN. WATER

SQ. FT. GRATE	KIND OF COAL	LB. OF COAL PER SQ. FT. GRATE PER HOUR
Up to 4	No. 1 Buckwheat Anthracite	3
5 to 9	No. 1 Buckwheat Anthracite	3½
10 " 14	No. 1 Buckwheat Anthracite	4
15 " 19	No. 1 Buckwheat Anthracite	4½
20 " 25	No. 1 Buckwheat Anthracite	5
Up to 9	Anthracite Pea	5
10 to 19	Anthracite Pea	5½
20 " 25	Anthracite Pea	6
Up to 4	Anthracite Nut and Larger	5
5 to 9	Anthracite Nut and Larger	6
10 " 14	Anthracite Nut and Larger	7
15 " 19	Anthracite Nut and Larger	8
20 " 25	Anthracite Nut and Larger	9
Up to 4	Bituminous	4
5 to 14	Bituminous	7
15 and above	Bituminous	10

In the case of boilers having larger grates, better draft and more constant attention, rates of combustion may be greatly increased over those shown in Table 1. For further data on this see Chapter VI on Chimneys and Chapter VII on Mechanical Draft.