must be given to the overall efficiency of the boiler or firing device. This factor is largely dependent upon good judgment and is a measure of the degree of efficiency to be expected from a particular installation.

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 or maximum design 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.

In the case of warm air heating installations the heat loss of the building expressed in Btu per hour can be determined by use of the Standard Codes[6] of the *National Warm Air Heating and Air Conditioning Association*. If the design heat loss of the building is divided by the proper factor, the required gross output may be obtained from the proper charts shown in Figs. 4, 5 and 6.

Example 3. The estimated net load (including domestic hot water supply) as calculated for a residence is 1500 sq ft of hot water radiation. Determine the firing rates for various fuels assuming an overall efficiency of 70 per cent; using coal with a calorific value of 12,500 Btu per pound; No. 3 fuel oil and natural gas having a gross heating value of 1000 Btu per cubic foot.

Solution. Referring to Fig. 3, Chapter 13, a piping and pick-up factor for a net load of 1500 sq ft is found to be 43 per cent or the gross output is equivalent to 1500 × 1.43 = 2145 sq ft hot water radiation.

Using the chart in Figs. 4, 5 and 6 project vertically from the gross output value on the proper horizontal scale to the intersection of the 70 per cent efficiency line. From the intersection of this line proceed horizontally to the proper vertical scale where a direct value of the required fuel burning rate is given. These values are rates of burning while firing device is in operation and are not indicative of hourly fuel consumption.

By use of the respective charts the firing rates for the various fuels will be found to be: coal 36.8 lb per hour, oil 3.2 gal per hour, and gas 460 cu ft per hour.

TABLE 4. BUILDING LOAD FACTORS AND DEMANDS OF SOME DETROIT BUILDINGS[a]

BUILDING CLASSIFICATION	LOAD FACTOR	LB OF DEMAND PER HR PER SQ FT OF EQUIVALENT INSTALLED RADIATOR SURFACE
Clubs and Lodges	0.318	0.184
Hotels	0.316	0.207
Printing	0.287	0.217
Offices	0.263	0.209
Apartments	0.255	0.225
Retail Stores	0.238	0.182
Auto Sales and Service	0.223	0.248
Banks	0.203	0.158
Churches	0.158	0.152
Department Stores	0.138	0.145
Theatres	0.126	0.151

[a]Loc. Cit. Note 5.

[6]Standard Code Regulating the Installation of Gravity Warm Air Heating Systems in Residences (9th edition) and the Technical Code for the Design and Installation of Mechanical Warm Air Heating Systems, may be obtained from the *National Warm Air Heating and Air Conditioning Association*, 50 W. Broad St., Columbus, Ohio.

MAXIMUM DEMANDS AND LOAD FACTORS

In one form of district heating rates, a portion of the charge is based upon the maximum demand of the building. The maximum demand may be measured in several different ways. It may be taken as the instantaneous peak or as the rate of use during any specified interval. One method is to take the average of the three highest hours during the winter. These figures are available for a number of buildings in Detroit, as shown in Table 4.

These maximum demands were measured by an attachment on the condensation meter and therefore represent the amounts of condensation passed through the meter in the highest hours, rather than the true rate at which steam is supplied. There might be slight differences in these two quantities due to time lag and to storage of condensate in the system, but wherever this has been investigated it has been found to be negligible.

The load factor of a building is the ratio of the average load to the maximum load and is an index of the utilization habits. Thus, in Table 4, the theatres, operating for short hours, have a load factor of 0.126 as compared with the figure of 0.318 for clubs and lodges.

PROBLEMS IN PRACTICE

1 ● What will be the cost per year of heating a building with gas, assuming that the calculated hourly heat loss is 92,000 Btu based on 0 F, which includes 26,000 Btu for infiltration? The design temperatures are 0 F and 72 F. The normal heating season is 210 days, and the average outside temperature during the heating season is 36.4 F. The heating efficiency will be 75 per cent. The heating plant will be thermostatically controlled, and a temperature of 55 F will be maintained from 11 p.m. to 7 a.m. Assume that the price of gas is 7 cents per 100,000 Btu of fuel consumption, and disregard the loss of heat through open windows and doors.

The average hourly temperature is

$$t_a = \frac{(72 \times 16) + (55 \times 8)}{24} = 66.3 \text{ F.}$$

The maximum hourly heat loss will be

$$H = 92{,}000 - \frac{26{,}000}{2} = 79{,}000 \text{ Btu.}$$

$$M = \frac{79{,}000\ (66.3 - 36.4) \times 24 \times 210}{100{,}000 \times 0.75 \times (72 - 0)} = 2204.6 \text{ hundred thousand Btu.}$$

$$2204.6 \times 0.07 = \$154.34 = \text{cost per year of heating the building.}$$

2 ● What factors should be taken into consideration when determining the efficiency at which a fuel will be burned?

Manufacturers' catalogs usually give equipment efficiencies obtained under test conditions. These values do not allow for poor attendance, defects in installation, or poor draft. Such efficiencies do not consider heat radiated from the outside of the equipment, but in many cases this heat is utilized.