

therefrom. These sources include the heat supplied by persons, lights, motors and machinery, and should also be ascertained in the case of theaters, assembly halls and industrial plants. (See Chapter 7). In many cases these heat sources should not be allowed to affect the size of the installation of heating equipment, although they may have a marked effect upon the fuel consumption. In residences this factor usually may be neglected.

DEGREE-DAY METHOD

A very useful unit for estimating fuel consumption, particularly for residences, is the degree-day. (See definition in Chapter 42). Degree-days for various cities in the United States and Canada are given in Table 1. The term degree-day originated in the gas industry and was later standardized by the *American Gas Association*³.

The base of 65 F is used for an inside temperature of 70 F. This base was chosen because it was demonstrated, by means of data collected from numerous installations, that heat is seldom supplied to a residence when the outdoor temperature is greater than 65 F⁴. It was also found that the fuel consumed varied almost directly with the difference between 65 F and the outside temperature.

If the inside temperature were maintained at 70 F throughout the 24 hours of the day, then the base of 65 F would probably be in error. It must be borne in mind, however, that although the temperature head is the difference between the inside temperature of say 70 F, and the outside temperature, a lower temperature than 70 F will usually be maintained at night and the base of 65 F will therefore allow for this condition. As already indicated, a temperature of 50 F from midnight to 6 a.m. will reduce the 24-hour average from 70 to 65 F. It is important to note that the degree-day applies specifically to an inside temperature of 70 F, which is the usual temperature for residences, and it should also be noted that allowance is automatically made for the lower night-time temperature, although this allowance is constant for any given locality.

In Equation 1, the quantity $(t - t_a) \times N$ is equivalent to the number of degree-days (D) in a heating season multiplied by 24, when the average daily value of t is 65 F. Therefore

$$(t - t_a) \times N = 24 D \quad (2)$$

Substituting the value of $(t - t_a) \times N$ from Equation 2 in Equation 1, the following general formula for an average daily inside temperature of 65 F, which is approximately equivalent to an inside daytime temperature of 70 F for residences, is obtained:

$$F_d = \frac{24 HD}{(t - t_o) \times C \times E} \quad (3)$$

Example 2: The calculated hourly heat loss of a residence located in Chicago is 127,000 Btu, which includes 28,000 Btu for infiltration. The design temperatures are -8 F and 70 F. The normal heating season is assumed to be 210 days (5,040 hours) and the average temperature during this period is 36.4 F (see Table 2, Chapter 7). The

³See *Industrial Gas Series, House Heating* (third edition) published by the American Gas Association.

⁴See also Iso-degree-day map and charts developed by P. E. Fansler for coal, oil and gas.

building is to be heated with oil fuel having a calorific value of 141,000 Btu per gallon. The heating efficiency is assumed to be 70 per cent. Thermostatic control is to be used and a temperature of 55 F is to be maintained from 11 p.m. to 7 a.m. How many gallons of oil will be required during a normal heating season if the loss of heat through open windows is neglected?

Solution. The maximum hourly heat loss will be $127,000 - \frac{28,000}{2} = 113,000$ Btu
 $= H$. Substituting the proper values in Equation 1:

$$F = \frac{113,000 \times (70 - 36.4) \times 5040}{141,000 \times 0.70 \times [70 - (-8)]} = 2486 \text{ gal of oil.}$$

The average inside temperature will be $\frac{70 \times 16 + 55 \times 8}{24} = 65$ F

and the fuel saving due to this fact will be $\frac{70 - 65}{70 - 36.4} = 0.149$ or 14.9 per cent.

Hence, the net fuel consumption will be $2486 - 0.149 \times 2486 = 2116$ gal.

The normal number of degree-days for Chicago is 6315. Substituting in Equation 3 and solving by the degree-day method:

$$F = \frac{113,000 \times 6315 \times 24}{78 \times 141,000 \times 0.70} = 2225 \text{ gal of oil}$$

No allowance need be made for the average temperature of 65 F since this is taken care of by the selection of a base of 65 F for the degree-day, as already explained. It will be noted that the two methods check within 5 per cent in this case. If the average daily inside temperature in the first solution had been 66.4 F instead of 65 F, the two methods would have checked exactly.

INDUSTRIAL DEGREE-DAY

Since the standard degree-day is intended for an inside temperature of 70 F, it is particularly convenient for solving residence problems. Where the design temperature differs greatly from 70 F, the standard degree-day cannot be accurately applied. Consequently, the industrial degree-day⁵ has been developed and values have been derived for two bases, namely 55 F and 45 F, intended for inside temperatures of 60 F and 50 F, respectively.

There is a considerable spread, however, among these three bases, and consequently there would be an appreciable error if the actual basis to be used in a certain case would be approximately midway between any two of the three bases for which degree-day values are at present available. Since the correction cannot be made on a proportionate basis, it would be more accurate in the majority of cases involving inside temperatures other than 70 F, 60 F or 50 F, to apply Equation 1.

APPROXIMATING FUEL REQUIREMENTS

It is sometimes desirable to obtain a rough approximation of the annual fuel consumption. Such approximations may be obtained by using unit factors based on the fuel requirements per square foot (or per 100 sq ft) of radiation or per 1000 cu ft of space.

Fig. 1 may be used for rough approximations of coal and oil require-

⁵See *Heating and Ventilating Degree-Day Handbook*.