

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 65 F usually is the maximum temperature at which fuel is burned to supply heat for a residence.² 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 3, Chapter 2). The 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:

$$F = \frac{113,000 \times (70 - 36.4) \times 5040}{141,000 \times 0.70 \times [70 - (-8)]} = 2490 \text{ gal of oil}$$

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

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

²See also Iso-degree-day map and charts developed by P. E. Fansler for coal, oil and gas.

Hence, the net fuel consumption will be $2490 - 0.149 \times 2490 = 2120$ gal.

The normal number of degree-days for Chicago is 6300. Substituting in Equation 3 and solving by the degree-day method:

$$F = \frac{113,000 \times 6300 \times 24}{78 \times 141,000 \times 0.70} = 2220 \text{ gal of oil}$$

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-day³ 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, between 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, 60 or 50, to apply Equation 1.

Rough Approximations of 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. Steam consumption factors for various types of buildings for New York City are given in Chapter 22 under the heading, Steam per Square Foot of Heating Surface.

Fig. 5 may also be used for rough approximations of coal and oil requirements. It should be noted that this figure is given in terms of the fuel consumption per 1000 degree-days per 100 sq ft of equivalent heating surface (steam) based on an emission of 240 Btu per square foot. Unless the radiation is calculated with reasonable accuracy, unit factors will be of little value even for rough approximations, since it is obvious that such radiation requirements must bear some relationship to the actual heating requirements of the building.

Example 3. Estimate the approximate coal consumption for a building located in New York City in which the calculated heating surface requirements (steam) are 1000 sq ft based on design temperatures of zero and 70 F.

Solution. From Fig. 5, the fuel consumption for a design temperature of zero is 0.53 ton per 1000 degree-days per 100 sq ft of heating surface. Since there are 5348 degree-days in New York City in a normal heating season, the fuel consumption will be approximately $0.53 \times 5.348 \times 100 = 284$ tons.

³See Heating and Ventilating Degree-Day Handbook.