

If the degree-days occurring each day are totaled for a reasonably long period, the fuel consumption during that period as compared with another period will be in direct proportion to the number of degree-days in the two periods. Consequently, for a given installation, the fuel consumption can be calculated in terms of fuel used per degree-day for any sufficiently long period and compared with similar ratios for other periods to determine the relative operating efficiencies with the outside temperature variable eliminated.

Studies made by the *National District Heating Association*⁵ of the metered steam consumption of 163 buildings located in 22 different cities and served with steam from a district heating company substantiate the fact that the 65 F base originally chosen by the gas industry is approximately correct.

Formula for Degree-Day Method

The general equation for calculating the probable fuel consumption by the degree-day method is:

$$F = U \times N \times D \quad (4)$$

where

F = fuel consumption for the estimate period.

U = unit fuel consumption, or quantity of fuel used per degree-day per building load unit.

N = number of building load units (when available use calculated heat loss instead of actual amount of radiation installed).

D = number of degree-days for the estimate period.

Values of N depend on the particular building for which the estimate is being prepared and must be found by surveying plans, by observation, or by measurement of the building. Values of U for use in this equation are the unit fuel consumptions per degree-day and are obtained as a result of the collection of operating information. Certain of this information is presented later but before referring to these data attention is directed to the nature of the unit.

Unit Fuel Consumptions per Degree-Day

The quantity of fuel used per degree-day in a given heating plant can be reduced to a unit basis in terms of quantity of fuel or steam per degree-day per square foot of radiation, per cubic foot of heated building space, or per thousand Btu hourly heat loss at design conditions. A less frequently used basis is quantity of fuel per degree-day per square foot of floor area. In fact any convenient unit can be used to relate the consumption to the degree-day and to the building.

The choice of these units requires explanation and some discrimination and judgment. The use of heated space in preference to the gross building cubage is obviously more accurate for this purpose. The gross cubage includes the outer walls and certain percentages of attic and basement space which are usually unheated. The net heated space is usually about 80 per cent of the gross volume and can be calculated from the latter if it cannot be measured. The cubical content is not considered accurate as a basis of comparison due to differences in types of construction, exposure, and ratio of exposed area to cubical contents.

The calculated heat loss or its equivalent square foot of calculated radiator surface may be used as the unit. The use of the unit equivalent direct radiation is of questionable value when referring to heat transfer

⁵Report of Commercial Relations Committee, *Proceedings, National District Heating Association*, 1932.

surfaces as applied to warm air furnace or central air conditioning systems. In view of all these considerations it is believed that the unit based on *thousands of Btu of hourly calculated heat loss for the design hour* is probably the most desirable although the one most widely used seems to be *units of fuel per degree-day per square foot of equivalent direct radiator surface*. The equivalent heating load for the hot water supply is not included in the latter unit, but it generally includes the piping load.

Since this unit is the one most widely used at present the unit fuel consumptions given in succeeding paragraphs of this chapter make use of this unit to a considerable extent, although it should be understood that most of these units of consumption can be transposed as desired.

Estimating Gas Consumption

Values of the Unit Fuel Consumption Constant (U) for gas are given in Table 3 for various gas heating values, and different types and sizes of heating plants. They are based on an inside design temperature of 70 F and an outside design temperature of 0 F and apply only to these conditions. For other design conditions corrections must be made as given in Table 6.

The factors in Table 3, as corrected if necessary, are satisfactory for regions having 3500 to 6500 degree-days per heating season. In regions with less than 3500 degree-days the unit gas consumption is higher than given; where over 6500, the unit is less than given. Ten per cent addition or deduction in these cases is recommended by A.G.A. publications. Estimates for industrial buildings where low inside temperatures are maintained cannot be made from this table.

For gas heating values other than those given in Table 3, simply interpolate or extrapolate. It will also be noted that Table 3 applies only to small installations. In general the larger the installation the smaller the unit gas consumption becomes and the values in the table should be used with care, if at all, in large gas-burning installations.

Example 5. Estimate the gas required to heat a building located in Chicago, Ill., which has 6287 degree-days and a gas heating value of 800 Btu per cubic foot. The calculated heating surface requirements are 1000 sq ft of hot water radiation based on design temperature of -10 F and 70 F.

Solution. From Table 3, the fuel consumption for a design temperature of 0 F with 800 Btu gas is found to be 0.085 cu ft of gas per degree-day per square foot of hot water radiation. From Table 6, the correction factor is 0.875 for -10 F outside design temperature, hence $0.875 \times 0.085 = 0.07438$. By Equation 4,

$$F = 0.07438 \times 1000 \times 6287 = 467,000 \text{ cu ft.}$$

Estimating Oil Consumption

Unit fuel consumption factors for oil, similar to those for gas in Table 3 are given in Table 4. The factors in Table 4 apply only to an inside design temperature of 70 F and an outside design temperature of 0 F. For other outside design temperatures, the constants in Table 4 must be multiplied by the values in Table 6 as explained under Estimating Gas Consumption.

Values given in Table 4 assume the use of oil with a heating value of 140,000 Btu per gallon. For other heating values, multiply the values in Table 4 by the ratio of 140,000 divided by the heating value per gallon of fuel being used.

Example 6. Estimate the seasonal oil consumption of an oil-fired boiler in a building located in Minneapolis having a calculated heat loss of 192,000 Btu per hour, burning