opening of windows, abnormal heating of the building, poor design of heating system, sun effect, and other variations. The Degree-Day Method is the more practical since it is based, in part, on actual consumption data. The presentation of the two illustrative estimating methods will be preceded by a discussion of *seasonal efficiency*.

SEASONAL EFFICIENCY

The seasonal efficiency differs from the measured efficiency of the fuel-fired heating unit because it is affected by the many minor sources of extraneous heat gain and heat loss. Throughout a season, useful heat is supplied to a building not only by the heating unit, but also by the external surfaces of the heating unit, the flue pipe, and the chimney. In addition, heat is gained from lights, occupants, cooking and other appliances, and from the sun. Indeterminable amounts of heat are lost through radiation directly to basement or utility-room walls and floors, from the heating unit, the distribution system, and the flue pipe, from stand-by operation of the unit, from opening of doors and windows, and from faulty adjustment and operation of the combustion unit. Fortunately, data which are available permit the making of reasonable estimates of seasonal efficiency for residences.

The average fuel consumption of various types of approved gas-fired equipment has been obtained from a large number of heating systems.[1] Corresponding seasonal efficiencies can be calculated from these data. They show a variation from approximately 72 to 88 percent, depending upon the type and size of system. Laboratory tests on a gas conversion burner in a heating boiler operated with *on* and *off* cycles gave about 72 percent efficiency.[2] Other tests on coal-fired room heaters indicate seasonal efficiencies of 65 to 75 percent, when the heat from the flue pipe was included.[3] A survey of 30 residences in one locality showed a variation of 45 to 75 percent in utilization efficiency, depending upon the condition of the equipment and the fuel used.[4] A summary[5, 6] of many tests in two research residences at the *University of Illinois*, using many fuels and systems, gave values of 67 to 90 percent for overall house efficiency (the ratio of the heat loss from the structure to the heat input to the unit for an average test day).

These data were used by the *Small Homes Council*[7] of the *University of Illinois* in a tabulation of the comparative costs of heating the *same* building with various fuels.

The approximate seasonal efficiencies shown in Table 1 are suggested as a guide.

TABLE 1. APPROXIMATE SEASONAL EFFICIENCY

Type of Fuel-Burning Unit	Approximate Seasonal Efficiency, Percent	Type of Fuel-Burning Unit	Approximate Seasonal Efficiency, Percent
Gas, designed unit	75–80	Anthracite, hand-fired with controls	60–80
Gas, conversion unit	60–80	Anthracite, hand-fired without controls	50–65
Oil, designed unit	65–80	Anthracite, stoker-fired	60–80
Oil, conversion unit	60–80	Coke, hand-fired with controls	60–80
Bituminous coal, hand fired with controls	50–65	Coke, hand-fired without controls	50–65
Bituminous coal, hand fired without controls	40–60	Direct electric heating	100
Bituminous coal, stoker-fired	50–70		

CALCULATED HEAT LOSS METHOD

In the Calculated Heat-Loss Method a constant average outdoor temperature is assumed throughout the heating season. This average temperature is considerably above the design temperature given in Chapter 12. The method becomes unreliable whenever data on the seasonal average temperature are not available for the particular locality. If the length of time is shown over which the degree-day data apply in the particular locality, it is possible to calculate the average temperature from the definition of the degree-day (see Chapter 1). When this is done, the two methods described in this chapter become identical. The average temperature for the period October to April inclusive, is listed in Table 1, Chapter 12, for U. S. and Canadian cities.

Computation and Application

In order to apply the Calculated Heat-Loss Method, the hourly heat loss from the building under maximum load, or design condition, is computed following the principles discussed in Chapters 9, 11, and 12. The fuel requirement is then computed by the equation

$$F = \frac{H(t - t_a)N}{E(t_d - t_o)C} \tag{1}$$

where

F = quantity of fuel or energy required (in the units in which C is expressed).

H = calculated heat loss including infiltration loss, Btu per hour, during the design hour, based on t_o and t_d.

t = average inside temperature maintained during heating period, Fahrenheit.

t_a = average outside temperature through estimate period, Fahrenheit (for cities with an Oct. 1–May 1 heating season—see Table 1, Chapter 12).

t_d = inside design temperature, Fahrenheit (usually 70 F).

t_o = outside design temperature, Fahrenheit (see Table 1 in Chapter 12).

N = number of heating hours in estimate period (for an Oct. 1–May 1 heating season, 212 days × 24 hr = 5088).

E = efficiency of utilization of the fuel over the period, expressed as a decimal; not the efficiency at peak or rated load condition.

C = heating value of one unit of fuel or energy.

Although the assumption of an Oct. 1–May 1 heating season is reasonably accurate in the well-populated New York-Chicago zone, it is not valid as far north as Minneapolis nor farther south than Washington, D. C. and St. Louis. Consequently, it is suggested that allowance be made for this variation, especially in the far north or southern cities.

Example 1: A residence building is to be heated to 70 F from 6 a.m. to 10 p.m. and 65 F from 10 p.m. to 6 a.m. The calculated hourly heat loss is 120,000 Btu per hour based on 70 F inside at −10 F outside. If the building is to be heated by metered steam, how many pounds would be required during an average heating season?

Solution: The heating value of steam may be taken as 1000 Btu per lb, and since it is purchased steam, the efficiency can be assumed as 100 percent. Assume average outside temperature as 36.4 F. The average inside temperature is:

$$\frac{(16 \times 70) + (8 \times 65)}{24} = 68.3\text{ F.}$$