Solution. Substituting in Equation 1: $F = \frac{120{,}000\ (65 - 36.4)\ 5088}{0.55\ [70 - (-10)]\ 11{,}000} = 36{,}079$ lb = 18 tons, which, at $8 per ton, costs $144.

Several time-saving procedures have been devised for quickly estimating the heat consumption of one and two-story residences in order that fuel estimates can be predicted more quickly from Equation 1. A graphical method of calculating heat losses has been developed[1] which makes possible a quick solution if the gross wall, ceiling, or floor areas and respective transmission coefficients are known.

The Federal Housing Administration has originated a short-cut formula for residential heat loss determinations which makes use of the floor area and three selected transmission coefficients. Equation 2 is for a one-story residence and Equation 3 is intended for two-story structures.

$$H_1 = A\ (0.45 + U_w + U_c + U_f)\ (t_d - t_o) \quad (2)$$

$$H_2 = A\ (0.45 + 1.2\ U_w + 0.5\ U_c + 0.5\ U_f)\ (t_d - t_o) \quad (3)$$

where

H_1 = heat loss from one-story residence, Btu per hour.
H_2 = heat loss from two-story residence, Btu per hour.
A = floor area, square feet.
U_w = coefficient of transmission for outside wall.
U_c = coefficient transmission for ceiling from air in rooms to air in attic space (for ventilated attics).
U_f = coefficient of transmission for floor from air in rooms to air in basement.
t_d = inside design temperature, degrees Fahrenheit.
t_o = outside design temperature, degrees Fahrenheit.

Both the graphical method and short-cut formula have been found to give accurate and consistent results for the average residence, but if precise estimates are required, the procedure outlined in Chapter 6 should be used.

Example 3. What will be the estimated fuel 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 seasonal 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.

Solution. 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 × $0.07 = $154.32 = estimated fuel cost per year of heating building.

In the case of gravity warm air heating installations, the load is usually expressed in square inches of leader pipe. This can be converted into hourly heat loss by multiplying by the factors in Table 1.

[1]Graphical Method of Calculating Heat Losses, by Paul D. Close (A.S.H.V.E. TRANSACTIONS, Vol. 49, 1943, p. 345).

TABLE 1. HEAT CARRYING CAPACITY OF GRAVITY WARM AIR FURNACE ROUND LEADER PIPES

175 F Register Temperature

LEADER PIPE	BTU PER HOUR AT DESIGN CONDITIONS PER SQ IN. OF LEADER PIPE
First floor	111
Second floor	167
Third floor	200

Example 4. What would be the total gas consumption over a full heating season of a gas-fired gravity warm air furnace designed according to the Code[2], and with four 12 in. and two 8 in. round leaders to the first floor and six 10 in. leaders to the second floor, if the gas has a heating value of 500 Btu per cubic foot, the plant operates at a 70 per cent seasonal efficiency and is designed to maintain an average inside temperature of 65 F when it is 10 F outside in a city where the average outside temperature is 45 F and the heating season is 5088 hr long?

Solution. The area of the round leaders is: 12 in., 113 sq in.; 10 in., 79 sq in.; and 8 in., 50 sq in. From Table 1 the total Btu transmitted is:

First Floor: [(4 × 113) + (2 × 50)] × 111 = 61,272 Btu per hour.
Second Floor: (6 × 79) × 167 = 79,158 Btu per hour.
Total 140,430 Btu per hour.

Substituting this total heat loss value as H in Equation 1 gives:

$$F = \frac{140{,}430\ (65 - 45)\ 5088}{0.70\ (70 - 10)\ 500} = 680{,}483 \text{ cu ft gas.}$$

DEGREE-DAY METHOD

This method is based on consumption data which have been taken from buildings in operation, and the results computed on a degree-day basis. While this method may not be as theoretically correct as the Calculated Heat Loss Method, it is considered by many to be of more value for practical use.

The amount of heat required by a building depends upon the outdoor temperature, if other variables are eliminated. Theoretically it is proportional to the difference between the outdoor and indoor temperatures. Some years ago the *American Gas Association*[3] determined from experiment in the heating of residences that the gas consumption varied directly as the difference between 65 F and the outside temperature. In other words, on a day when the temperature was 20 deg below 65 F, twice as much gas was consumed as on a day when the temperature was 10 deg below 65 F. For any one day there exists as many degree-days as there are degrees Fahrenheit difference in temperature between the mean temperature for the day and 65 F when the mean temperature is less than 65 F.

The normal or average number of degree-days which have occurred over a long period of years, and such averages, by months, on a 65 F basis are given for various United States and Canadian cities in Table 2. The United States values were computed from daily mean temperatures

[2]Standard Gravity Code for the Design and Installation of Gravity Warm Air Heating Systems (11th 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*, 145 Public Square, Cleveland, Ohio.

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