t_d = inside design temperature, Fahrenheit degrees.

t_o = outside design temperature, Fahrenheit degrees.

Notes for application of Equations 2 and 3.

1. The calculation of heat loss from heated spaces into adjacent spaces such as attics, basementless areas, and heated or unheated garages shall be based on the assumption that the temperature of such adjacent spaces is the same as the outside design temperature.

2. For all floors over basements or other warmed spaces assume $U_f = 0$.

3. For structures having concrete slab floors laid on the ground a modified application of the formula may be made. Assume $U_f = 0$ and calculate the heat loss in accordance with the check formula. Then add the slab loss determined in accordance with the procedure developed by the National Bureau of Standards and described in BMS Report 103.

4. No basement area is to be included in the formula calculation. If finished habitable rooms in the basement are to be heated, the additional heat loss should be calculated separately and added to the amount obtained by the formula.

Both the graphical method and short-cut formulas, when used within the limitations established, have been found to give reasonably accurate results for the average residence, but if precise estimates are required, the procedure outlined in Chapter 11 should be used.

In the case of gravity warm air heating installations, the load was formerly expressed in square inches of leader pipe which can be converted into Btu per hour by multiplying the square inches of leader area by 111, 167, and 200 for first, second, and third floors, respectively.

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 cu ft, 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. The total Btu transmitted is:

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

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. 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 mean outside temperature. In other words, on a day when the mean 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, when the mean temperature is less than 65 F, there are as many degree-days as there are degrees difference in temperature between the mean temperature for the day and 65 F. Degree-days may be calculated on other than the 65 F base but are seldom used and are of little value except where the inside temperature to be maintained as, for example, in warehouses, differs greatly from the usual inside temperature range of 68 F to 72 F.

Table 1 lists the average number of degree-days, which have occurred over a long period of years, by months and the yearly totals for various cities in the United States, Canada and Newfoundland. The values for United States cities were calculated by taking the difference between 65 F and the daily mean temperature computed as half the total of the daily maximum and the daily minimum temperatures. The monthly averages were obtained by adding daily degree-days for each month each year and dividing by the number of days in the month; then totaling the respective calendar monthly averages for the number of years indicated and dividing by the number of years. The total or long term yearly average degree-day value is the summation of the 12 monthly averages. Degree days for Canadian cities were supplied by the Canadian Meteorological Division of the Department of Transport and were computed from the mean temperature normals on record for the various stations.

Any attempt to apply the degree-day method of calculating fuel consumption for less than one month would be of very little value. It should be noted that this method of calculation is based on a long term average and cannot be expected to coincide with any single year in calculating fuel requirement. Individual yearly degree-day calculations will vary as much as 20 per cent above and below the long term average.

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*[4] 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:

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

where

F = fuel consumption for the estimate period.

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

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

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