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:

$$H = 92{,}000 - \frac{26{,}000}{2} = 79{,}000 \text{ Btu.}$$

$$M = \frac{79{,}000\ (66.3 - 36.4) \times 24 \times 210}{100{,}000 \times 0.75 \times (72 - 0)} = 2204.6 \text{ hundred thousand Btu.}$$

$2204.6 \times \$0.07 = \$154.32$ = 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.

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

180 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[1], 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: $[(4 \times 113) + (2 \times 50)] \times 111 = 61{,}272$ Btu per hour.
Second Floor: $(6 \times 79) \times 167 = 79{,}158$ 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

[1]Standard Code Regulating the Installation of Gravity Warm Air Heating Systems in Residences (9th 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.

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*[2] 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.

TABLE 2. BASE TEMPERATURE FOR THE DEGREE-DAY[a]

TYPE OF BUILDING	NO. OF BUILDINGS ANALYZED	TEMPERATURE F CORRESPONDS TO ZERO STEAM CONSUMPTION
Office	60	66.2
Office and Bank	4	65.8
Bank	3	66.2
Office and Telephone Exchange	2	65.5
Office and Stores	6	67.4
Stores	11	64.0
Department Stores	12	64.3
Hotels	7	66.5
Apartments	14	68.8
Residences	8	66.9
Clubs	4	65.5
Lodges	5	64.9
Theaters	3	67.6
Churches	2	65.8
Garages	2	64.8
Auto Sales and Service	4	61.2
Newspaper and Printing	3	67.7
Warehouse and Loft	3	67.7
Office and Loft	2	65.2
Manufacturing	8	65.4
Average for 163 Buildings		66.0 F

[a]Report of Commercial Relations Committee, *Proceedings, National District Heating Association*, 1932.

Studies made by the *National District Heating Association* of the metered steam consumption of 163 buildings located in 22 different cities and served with steam from a district heating company substantiates the fact that the 65 F base originally chosen by the gas industry is approximately correct as shown in Table 2.

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

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