

Fuel used over any period is, according to the theory of the degree-day, proportional to the number of degree-days during the period. From Table 3, the average numbers of degree-days for November, December, and January in Marquette are 951, 1314, and 1510, a total of 3775. The yearly total is 8721, so that during these three months the estimated consumption is:

$$\frac{3775}{8721} \times 108,419 = 46,945 \text{ lb.}$$

### Estimating Steam Consumption

In estimating steam consumption the efficiency is generally assumed at 100 per cent. If for low pressure steam an average heating value of 1000 Btu per pound of steam is used no correction is necessary. In comparing values from different cities, correction should be made for design temperature (see Table 7) when the unit figures are in terms of square foot of radiator or 1000 Btu per hour calculated heat loss, but not when the values are in terms of building volume or floor space.

Consideration has been given to the difference in steam utilization of different types of buildings and Table 8<sup>a</sup> shows actual average units for these various types. These figures are obtained from operating results in 196 buildings located in 21 different cities in the United States. Being averages, and for small groups in each type, the figures may need considerable modification to allow for local variations. It should be especially noted that the steam used for heating hot water is included in the values

TABLE 8. STEAM CONSUMPTION FOR VARIOUS CLASSES OF BUILDINGS<sup>a</sup>  
(Heating Season Only)

| BUILDING CLASSIFICATION              | No. OF BUILDINGS LISTED | STEAM CONSUMPTION<br>POUNDS PER DEGREE-DAY—65 F BASIS <sup>b</sup> |                                       |                                                    |
|--------------------------------------|-------------------------|--------------------------------------------------------------------|---------------------------------------|----------------------------------------------------|
|                                      |                         | Per M Cu Ft<br>of Heated<br>Space                                  | Per M Sq Ft<br>of Radiator<br>Surface | Per M Btu<br>per Hour of<br>Heat Loss <sup>d</sup> |
| Apartments.....                      | 16                      | 1.78                                                               | 97.5                                  | 0.359                                              |
| Hotels.....                          | 10                      | 1.46                                                               | 80.6                                  | 0.371                                              |
| Residences.....                      | 12                      | 1.32                                                               | 64.2                                  | -----                                              |
| Printing.....                        | 7                       | 1.25                                                               | 105.5                                 | -----                                              |
| Clubs and Lodges.....                | 10                      | 0.96                                                               | 77.0                                  | -----                                              |
| Retail Stores.....                   | 18                      | 0.90                                                               | 80.6                                  | 0.268                                              |
| Theaters.....                        | 6                       | 0.90                                                               | 75.0                                  | 0.498                                              |
| Loft and Mfg.....                    | 16                      | 0.89                                                               | 72.3                                  | 0.283                                              |
| Banks.....                           | 7                       | 0.88                                                               | 45.2                                  | -----                                              |
| Auto Sales and Service.....          | 8                       | 0.83                                                               | 62.2                                  | -----                                              |
| Churches.....                        | 6                       | 0.58                                                               | 49.4                                  | -----                                              |
| Department Stores.....               | 14                      | 0.57                                                               | 60.7                                  | 0.238                                              |
| Garages (Storage) <sup>e</sup> ..... | 6                       | 0.42                                                               | 72.3                                  | -----                                              |
| Offices (Total).....                 | 35                      | 1.09                                                               | 70.0                                  | 0.283                                              |
| Offices (Heating only).....          | 35                      | 0.975                                                              | 65.4                                  | 0.256                                              |

<sup>a</sup>Includes steam for heating domestic water for heating season only.

<sup>b</sup>The figures are a numerical—not a weighted—average for the several buildings in each class.

<sup>c</sup>Equivalent steam radiator surface.

<sup>d</sup>Heat loss calculated for maximum design condition (in most cases 70 F inside, zero outside).

<sup>e</sup>Based on zero consumption at 55 F.

<sup>a</sup>The Heat Requirements of Buildings, by J. H. Walker and G. H. Tuttle (A.S.H.V.E. TRANSACTIONS, Vol. 41, 1935, p. 171).

TABLE 9. BUILDING LOAD FACTORS AND DEMANDS OF SOME DETROIT BUILDINGS

| BUILDING CLASSIFICATION     | LOAD FACTOR | LB OF DEMAND PER HOUR—<br>PER SQ FT OF EQUIVALENT<br>INSTALLED RADIATOR SURFACE |
|-----------------------------|-------------|---------------------------------------------------------------------------------|
| Clubs and Lodges.....       | 0.318       | 0.184                                                                           |
| Hotels.....                 | 0.316       | 0.207                                                                           |
| Printing.....               | 0.287       | 0.217                                                                           |
| Offices.....                | 0.263       | 0.209                                                                           |
| Apartments.....             | 0.255       | 0.225                                                                           |
| Retail Stores.....          | 0.238       | 0.182                                                                           |
| Auto Sales and Service..... | 0.223       | 0.248                                                                           |
| Banks.....                  | 0.203       | 0.158                                                                           |
| Churches.....               | 0.158       | 0.152                                                                           |
| Department Stores.....      | 0.138       | 0.145                                                                           |
| Theaters.....               | 0.126       | 0.151                                                                           |

given in Table 8, but in the case of office buildings, the steam for heating only is also shown. Presentation of the unit consumption in three ways permits making the estimate if either the calculated heat loss or the volume of net heated space in the building is known.

**Example 8.** A store in Philadelphia with a heating system designed to maintain 70 F inside in 0 F weather has 1700 sq ft of equivalent direct steam radiator surface, and uses only moderate quantities of hot water. What would be the estimated average yearly steam consumption of purchased steam for heating and for hot water during the heating season?

**Solution.** According to Table 8, a store (0 to 70 F conditions) would use 80.6 lb of steam per thousand square feet of radiation per degree-day, including winter hot water. From Table 3, Philadelphia has 4784 degree-days per normal year. Inserting in Equation 2:

$$F = 80.6 \times 1.7 \times 4784 = 655,504 \text{ lb of steam.}$$

### Degree-Day as an Operating Unit

The use of the degree-day as a fuel *predicting* unit, explained in the foregoing, is perhaps the lesser of its two most used applications. It is also widely used as a unit for eliminating the weather (temperature) variable for existing plants from month to month or year to year. The degree-days given in Table 3 are *normals* or averages. For operating data the actual number occurring for a given month and year in a city under consideration is recorded. Since fuel consumption is proportional to the number of degree-days, plant operators frequently compute each month, the fuel burned per degree-day by the heating plant. The resulting unit figure, by eliminating the outside temperature variable, indicates whether the operating efficiency of the plant is above or below the previous month or year.

### MAXIMUM DEMANDS AND LOAD FACTORS

In one form of district heating rates, a portion of the charge is based upon the maximum demand of the building. The maximum demand may be measured in several different ways. It may be taken as the instantaneous peak or as the rate of use during any specified interval. One method is to take the average of the three highest hours during the