Table 4 .... Unit Fuel Consumption Constants (U) for Gas[a]

Based on 0 F Outdoor Temperature, 70 F Indoor Temperature

Heating Value of Gas Btu per Cu Ft	Hot Water			Steam			Warm Air	
	Cu Ft Gas per Degree Day per Sq Ft EDR			Cu Ft Gas per Degree Day per Sq Ft EDR			Cu Ft Gas per Degree Day per 1000 Btu Hourly Design Heat Loss	
	Up to 500 Sq Ft	500 to 1200 Sq Ft	Over 1200 Sq Ft	Up to 300 Sq Ft	300 to 700 Sq Ft	Over 700 Sq Ft	Gravity	Fan Systems
500	0.149	0.142	0.134	0.254	0.242	0.231	0.896	0.861
535	0.139	0.132	0.126	0.237	0.226	0.216	0.840	0.805
800	0.094	0.087	0.085	0.159	0.151	0.144	0.560	0.538
1000	0.075	0.071	0.068	0.127	0.121	0.116	0.449	0.431
	Gas Consumption in Therms per Degree Day							
1 Therm = 100,000 Btu	0.000743	0.000709	0.000675	0.00127	0.00121	0.00116	0.00450	0.00430

[a] Abstracted from *Comfort Heating*, American Gas Association, 1933, and 5 percent added for operation without night reduction of temperature.

volume of a given building than to measure and evaluate the heating capacity of its heating system, or calculate its maximum hourly Btu loss. The comparison of buildings on a straight volume basis does not allow for variation in exposure, type of construction, ratio of exposed area to cubical contents, and type of occupancy. It is inaccurate for estimating purposes unless the buildings are of very similar nature.

The calculated heat loss or the heating capacity of the installed radiation may be used as the unit. The use of the heating capacity of the installed radiation is of questionable value when referring to heat-transfer surfaces used in warm air furnace or central air-conditioning systems. Where steam or hot water radiation is already installed, care should be exercised when using the installed radiation as the basis for estimating, since actual installed radiation may differ considerably from the exact radiation requirements. In view of all these considerations, it is believed that the unit based on *thousands of Btu of hourly calculated heat loss for the design hour* is probably the most desirable.

Estimating Gas Consumption

Values of the Unit Fuel Consumption Constant U for gas are given in Table 4 for various gas heating values, and different types and sizes of heating systems. They are based on an indoor design temperature of 70 F and an outdoor design temperature of 0 F, and apply only to these conditions. For other outdoor design conditions corrections must be made by applying factors given in Table 3.

The factors in Table 4, as corrected if necessary, are satisfactory for regions having 3500 to 6500 degree days per heating season. In regions with less than 3500 degree days the unit gas consumption is higher than given; where over 6500, the unit is less than given. Ten percent addition or deduction in these cases is recommended by A.G.A. publications. This table cannot be used for making estimates for industrial buildings where low inside temperatures are maintained.

For gas heat values other than those given in Table 4, simply interpolate or extrapolate. It will also be noted that Table 4 applies only to small installations. Since the unit gas consumption becomes smaller as the installation becomes larger, the values in the table should be used with care, if at all, for large gas-burning installations.

Example 4: Estimate the gas required to heat a building located in Chicago, Ill., where the heating season has 6310 degree days and the gas heating value is 800 Btu per cu ft. The calculated heating requirements are 1000 sq ft of hot water radiation based on design temperature of −10 F and 70 F.

Solution: From Table 4, the fuel consumption for a design temperature of 0 F with 800 Btu gas is found to be 0.087 cu ft of gas per (degree day) (square foot of hot water radiation).

Table 5 .... Unit Fuel Consumption[a] Constants (U) for Oil[b]

Based on 0 F Outside Temperature, 70 F Inside Temperature

Unit[c]	Efficiency in Percent	
	70	80
Gal oil per sq ft steam radiator	0.00105	0.00092
Gal oil per sq ft hot water radiator	0.00066	0.00058
Gal oil per 1000 Btuh heat loss	0.00437	0.00383

[a] Based on a heating value of 141,000 Btu per gallon.

[b] Abstracted by permission from *Degree-Day Handbook* (Second Edition, 1937), by C. Strock and C. H. B. Hotchkiss. Seven percent added for operation without night reduction of temperature and change to heating value of 141,000 Btu per gallon.

[c] Per degree day.

Table 6 .... Unit Fuel Consumption[a] Constants (U) for Coal[b]

Based on 0 F Outdoor Temperature, 70 F Inside Temperature

Unit[c]	Efficiency in Percent				
	40	50	60	70	80
Lb coal per sq ft steam radiator	0.0216	0.0172	0.0143	0.0123	0.0108
Lb coal per sq ft hot water radiator	0.0135	0.0108	0.0091	0.0078	0.0068
Lb coal per 1000 Btuh heat loss	0.0889	0.0717	0.0592	0.0507	0.0444

[a] Based on a heating value of 13,000 Btu per pound.

[b] Abstracted by permission from *Degree-Day Handbook* (Second Edition, 1937), by C. Strock and C. H. B. Hotchkiss. Eight percent added for operation without night reduction of temperature.

[c] Per degree day.

From Table 3, the correction factor is 0.875 for −10 F outdoor design temperature, hence, $0.875 \times 0.087 = 0.076$. By Equation 4,

$$F = 0.076 \times 1000 \times 6310 = 480{,}000 \text{ cu ft.}$$

Estimating Oil Consumption

Table 5 gives unit fuel consumption factors for oil, similar to those given for gas in Table 4.

The factors in Table 5 apply only to an indoor design temperature of 70 F and an outdoor design temperature of 0 F. For other outdoor design temperatures, the constants in Table 5 must be multiplied by the values in Table 3 as explained under Estimating Gas Consumption.

Values given in Table 5 are based on use of oil with a heating value of 141,000 Btu per gallon. For other heating values, multiply the values in Table 5 by the ratio of 141,000 divided by the heating value per gallon of fuel being used.

Example 5: Estimate the seasonal oil consumption of a boiler, designed for oil firing, in a building located in Toledo, Ohio. The building has a calculated heat loss of 240,000 Btu per hr. The oil heat value is 144,000 Btu per gal, and the assumed seasonal efficiency is 80 percent. The outdoor design temperature for Toledo is −10 F, and the indoor design temperature is 70 F.

Solution: From Table 5, under 80 percent efficiency and in the bottom line, the value of U is found to be 0.00383 gal per 1000 Btu hourly heat loss for 0 F outdoor temperature. The correction factor for −10 F outdoor design temperature from Table 3 is 0.875 which makes the correction $0.875 \times 0.00383 = 0.00335$. Making a further correction for the heating value, $0.00335 \times (141{,}000/144{,}000) = 0.00328$ gal per 1000 Btu per hr calculated heat loss per degree day.

From Table 2, the total normal degree days for Toledo are 6394. Since U is expressed in 1000 Btu, N is equal to 240. Substituting in Equation 4

$$F = 0.00328 \times 6394 \times 240 = 5030 \text{ gal.}$$

Estimating Coal or Coke Consumption

Coal or coke consumption estimates are made by following exactly the same procedure as for oil. Values of U are given in Table 6 which only apply to an indoor design temperature of 70 F and an outdoor design temperature of 0 F. A correction must be made for other conditions by use of the multiplying factors in Table 3. Data in Table 6 are based on 12,000 Btu per lb coal, and for other heating values of coal they must be multiplied by the ratio of 12,000 divided by the heating value of fuel used.

Example 6: A building in Scranton, Pa. has a calculated heat loss of 240,000 Btu per hr based on an indoor design temperature of 70 F and an outdoor design temperature of −10 F. What will be the estimated normal seasonal anthracite or coke consumption for heating if 13,000 Btu per lb fuel is burned in a hand-fired boiler, with automatic control, at a seasonal efficiency of 80 percent, and what part of the total will be used during November, December, and January?

Solution: From Table 6, U is 0.0444 of coal or coke per 1000 Btu per hr heat loss per degree day. Correcting for the outdoor design temperature of −10 F from Table 3, the value of U is $0.875 \times 0.0444 = 0.0389$. From Table 2, D is 6218 and from the problem, N is 240.

Substituting in Equation 4,

$$F = 0.0389 \times 240 \times 6047 = 56{,}500 \text{ lb.}$$

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 2, the average numbers of degree days for November, December, and January in Scranton are 693, 1057, and 1141 respectively, a total of 2891. The yearly total is 6047, so that during these three months the estimated consumption is

$$\frac{2891}{6047} \times 56{,}500 = 27{,}000 \text{ lb.}$$

Estimating Steam Consumption

In estimating steam consumption the efficiency is generally assumed at 100 percent. 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 3) when the unit figures are in terms of heat loss but not when the values are in terms of building volume or floor space.

Where the heat loss is calculated in Btu per (hour) (*degree difference in temperature*) the simple Equation 7 may be used:

$$F = \frac{H \times 24 \times D}{1000} \qquad (7)$$

F = pounds of steam required for estimate period.
H = calculated heat loss, Btu per (hour) (degree difference).
24 = hours in one day.
D = number of degree days for the period of estimation.
1000 = Btu delivered per pound of steam condensed.

In this method the number of degree days automatically takes care of average indoor and outdoor temperature difference. When degree days are taken from Table 2, an av-

Table 7 .... Steam Consumption of Buildings with Various Types of Occupancy[a]

Type of Building	No. Bldgs	Average Volume Heated Space 1000 Cu Ft	Steam for Heating Lb per DD per 1000 Cu Ft	Average Hours of Occupancy
Office	334	2160	0.685	12.1
Office and Bank	49	3000	0.577	13.1
Office and Printing	8	1895	1.230	17.7
Office and Theater	7	4950	0.412	12.9
Office and Stores or Shops	26	1615	0.617	13.2
Bank	16	806	0.786	11.7
Department Store	63	3400	0.385	11.1
Stores	73	310	0.624	10.4
Loft	63	865	0.588	10.0
Warehouse	24	2230	0.459	9.4
Hotel and Club	73	1795	0.990	22.3
Apartment or Residence	51	1425	0.962	21.8
Theater	22	1240	0.482	12.9
Garage	13	1540	0.202	21.4
Manufacturing	19	1350	0.808	9.5
Church	9	656	0.532	7.9
Hospital	4	3306	1.194	22.0
School	8	1115	0.592	11.5
Municipal or Federal	15	3215	0.587	15.6
Lodge, Gym, Hall, or Auditorium	12	880	0.390	12.4
Miscellaneous	7	1387	0.479	21.4

[a] *Principles of Economical Heating*, National Association of Building Owners and Managers.