mends a C factor of 15 for dwellings having a floor area over 1200 sq ft and located in an area having a design temperature difference exceeding 65 F.

The use of C factors lower than 18.5 for thoroughly insulated structures is in accordance with experience records of the electric industry over a wide range of geographical and climatic characteristics. Values of C as low as 12 have been reported on individual residential installations. Application of the C factor is not recommended for commercial and industrial applications.

Operating Costs—(Commercial and Industrial)

Energy usage of electrically heated commercial and industrial buildings do not follow a pattern like residential. The wide differences in thermal construction, design and type of building, occupancy habits, magnitude and duration of internal heat sources and various other factors combine to make each application somewhat different from any other.

A procedure for determining the capacity required is described in Chapter 25 of the 1961 Guide And Data Book. A procedure for estimating energy consumption is described in Chapter 12 of this volume. Records of buildings having electric heat installations have demonstrated that these procedures result in higher estimates of required capacity and energy consumed than is actually obtained. Due to thewide variations in actual experience compared to estimates, it is suggested the local power supplier be consulted regarding performance of similar installations in the area involved and also for proper evaluation of electric power rates.

Voltage Requirements

Voltages stipulated for secondary distribution systems are for the point of service entrance to the building. The preferred nominal system voltage, for single-phase 3-wire systems with space heating, is 120/240 volts, as stipulated by standards of the electrical industry (E.E.I. Publication R-6 and NEMA Publication No. 117 issued May, 1949).

For commercial and industrial applications higher power supply voltages of 440 to 480 volts, 3-phase, 3-wire and 3-phase, 4-wire are frequently used.

Specific information should be obtained from the local electric power supplier on both existing and anticipated future conditions at the location before specifying the capacity and voltage for equipment, wiring and controls.

Effect of Voltage Variations

The actual electrical input (and consequently heating effect available) can be adjusted for the difference between the rated voltage and service voltage by the following formula:

$$W_a = W_r \left(\frac{V_s}{V_r}\right)^n$$

where

W_a = actual watts input
W_r = rated watts input of equipment
V_s = service voltage or power supply volts
V_r = rated voltage of equipment
n = 2 for low temperature coefficient alloy resistors, 1.5 for tungsten resistors, and between 1 and 2 for conductive films and other resistors not included above.

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CHAPTER 12

ESTIMATING FUEL CONSUMPTION OR ENERGY FOR SPACE HEATING

Bases of Fuel Estimates; Efficiency of Utilization; Calculated Heat Loss Method: Computation and Application, Short Methods for Estimating Heat Loss; Degree-Day Method: Computation and Application, Unit Fuel Consumption per Degree Day, Estimating Consumption for Various Fuels, Degree Day as an Operating Unit; Industrial Degree Days; Maximum Demand and Load Factors

IT IS often necessary to estimate the anticipated heat requirements and fuel consumptions of heating plants for either short or long terms of operation. These quantities can be much more difficult to calculate than design heat loss or required system capacity, since they involve essentially the summing up of the net result over the period in question of the influence of many factors which may vary greatly with time. It will seldom be possible to predict with any great accuracy the way in which all the factors involved will vary throughout the prediction period. In addition to this, the calculations required to take all such variations into account become very involved. For these and other reasons records of past operating experience, when these are available, provide the most reliable and usually the most accurate basis for the prediction of future requirements.

Records of past heat requirements or of fuel consumption of a particular building are a better basis for estimates than are averages of records from similar buildings. In the absence of past records for a particular building the data from similar plants in the same locality may have to be used. Averages of consumption figures taken from many types of plants in many types of buildings in various localities can only produce an average estimate which may prove to be inaccurate when applied to a particular building.

Where unusual operating conditions exist due to factors such as excessive ventilation, abnormal inside temperatures, and heat gains from external sources, or where, in the case of proposed buildings of unusual design, no information is available regarding former consumption, it is necessary to estimate fuel consumption from the computed heat losses.

In preparing fuel consumption estimates it is well to realize that any estimating method used will produce a more reliable result over a long period operation than over a short period. Nearly all of the methods in common use will give trustworthy results over a full *annual* heating season, and in some cases such estimates will prove consistent within themselves for monthly periods. As the period of the estimate is shortened, there is more chance that some factor not taken into account directly in the estimating method will deviate from its long-time average value, and thus lead to serious error in the predicted heat requirement.

Except when specific statement is made to the contrary, the data in this chapter are based on the performance of residential heating installations. The application of these data to commercial or industrial installations may produce misleading results.

EFFICIENCY OF UTILIZATION

Any method of estimating fuel requirements based primarily on calculation of heat losses must, of necessity, also take into account considerations of the efficiency with which the heat in the fuel is used. Efficiency can be defined in a variety of ways for various purposes, and the values in any given case can vary widely depending on the conditions. For estimating purposes, as will be shown later, it is the *efficiency of utilization* of the fuel over the calculation period which is wanted. This is distinct from *heating unit efficiency* which expresses the heat delivered by a furnace or boiler as a percentage of the heat provided in the fuel and which is the efficiency normally used in describing the performance of a unit under rated, or stated, load conditions. It has been shown, at the University of Illinois for example,[1] that in the case of a dwelling with an inside chimney, as much as 35 percent of the heat delivered to the chimney which is normally considered to be a loss so far as efficiency of the heating unit is concerned may be delivered to the house through the heated chimney walls. This recovered heat amounted to as much as 12 percent of the heat required by a house. Much of this recovered heat may be available for heating. It has been said in connection with the same study that at times only about 50 percent of the heat utilized by a house was supplied by radiators, while the other 50 percent of the heat utilized was supplied from such sources as chimney, piping, boiler jacket and smoke pipe, people, lights, etc. A summary[2,3] of many tests in two research residences at the University of Illinois using many fuels and systems give values of 67 to 90 percent for overall house efficiency (the ratio of the heat loss from the structure to the heat input to the unit).

The efficiency of utilization of the fuel burned can at times be relatively very high for houses. It can also vary quite widely from one house to another because of variations in chimney location and design, utilization of heat lost to the basement from the heating unit and smoke pipe, utilization of electricity, occupancy of the house, water heating requirements, etc. The efficiency of utilization may also vary with time of year as the average load on the furnace varies. Some of the reasons for this in the case of intermittently-fired oil furnaces have been demonstrated.[4]

In buildings other than houses the efficiency of utilization of the heat supplied in the fuel may also vary widely. There will, in general, be less tendency in many larger buildings toward effective use for heating purposes of the heat which is normally lost from chimney, furnace, and piping surfaces, and, consequently, efficiency is seldom likely to be as high as in the case of many houses.

The average fuel consumption of various types of approved gas-fired equipment has been obtained from a large number of heating systems.[5] Corresponding efficiencies of utilization over the heating season can be calculated from