

perature 95 F and 80 F, respectively? The roof is of uninsulated 6 in. concrete with its underside exposed, and with a black upper surface.

b. What time of day will maximum cooling load due to the roof exist?

a.  $H_t + H_R = [AU(t_o - t)] + [AFaI]$  (Formulas 1 and 2).

$U$  for roof = 0.64 (Table 11, Wall 4 A, Chapter 5).

$F$  = 0.147 (Fig. 2).

$a$  = 0.9 (Table 6).

$I$  = 293 (Table 4).

$H_t + H_R = [1 \times 0.64(95-80)] + [1 \times 0.147 \times 0.9 \times 293] = 48.5$  Btu per square foot per hour.

b. Maximum sun intensity occurs at noon (Table 4). Maximum effect in cooling load will occur at 3 p.m. (Table 7).

4 • a. What is the maximum rate of heat delivered to a room through a bare window in the west wall of a building located in New Orleans (30 deg latitude)?

b. What time of day will it occur?

c. What will maximum rate be if window is protected by awning?

a.  $H_G = A_G I_G$  (Formula 3).

$I_G = 177$  (Table 2).

$H_G = 1 \times 177 = 177$  Btu per square foot per hour.

b. At 4 p.m. (Table 2).

c.  $177 \times 0.28 = 49.6$  Btu per square foot per hour (Table 8).

5 • What is the heat gain per cubic foot of outside air introduced, under the following conditions if the barometric pressure is 29.5 in. Hg.?

Outdoor temperatures, 90 F dry-bulb and 75 F wet-bulb.

Inside temperatures, 78 F dry-bulb and 65 F wet-bulb.

Density of air at 90 F dry-bulb, 75 F wet-bulb and 29.5 in Hg. is 0.0705 lb per cubic foot (Table 4, Chapter 1).

Dew-point of outdoor air is 68.2 F (psychrometric chart).

Pressure of saturated vapor at 68.2 F is 0.6946 in. Hg. (Table 6, Chapter 1).

$W = 0.622 \left( \frac{e}{B - e} \right) = 0.622 \left( \frac{0.6946}{29.5 - 0.6946} \right) = 0.015$  lb water vapor per pound dry air (Formula 5a, Chapter 1).

$\frac{1}{1 \text{ plus } 0.015} = 0.985$  lb dry air per pound outside air.

$d_o = 0.0705 \times 0.985 = 0.06944$  lb dry air per cubic foot outside air.

Heat content outside dry air at 75 F wet-bulb = 38.46 Btu per pound.

Heat content inside dry air at 65 F wet-bulb = 29.96 Btu per pound.

Total heat,  $H = 0.06944(38.46 - 29.96) = 0.59$  Btu per cubic foot.

6 • A 7 × 4 ft west window is equipped with an inside aluminum finished Venetian blind which is adjusted to fully cover the window when the sun shines. The net glass area is 75 per cent of the total area of the window. What is the cooling load due to the window at 10 a.m. and 4 p.m.? Temperatures are: 10 a.m., outside 85 F and inside 77 F; 4 p.m., outside 95 F and inside 80 F. Latitude 40 deg.

10 a.m.:  $H_t = 28 \times 1.13(85-77) = 253$  Btu per hour (Equation 1, and Table 13A, Chapter 5).

4 p.m.:  $28 \times 0.75 = 21$  sq ft net glass area.

$H_G = 21 \times 182 \times 0.58 = 2217$  Btu per hour (Tables 4 and 8).

## Chapter 9

## FUELS AND COMBUSTION

Classification of Coal, Air for Combustion, Draft Required, Combustion of Anthracite, Firing Bituminous Coal, Burning Coke, Hand Firing, Classification and Use of Oil, Classification and Use of Gas

THE choice of fuel for heating is a question of economy, cleanliness, fuel availability, operation requirements, and control. The principal fuels to be considered are coal, oil, and gas.

## CLASSIFICATION OF COALS

The complex composition of coal makes it difficult to classify it into clear-cut types. Its chemical composition is some indication but coals having the same chemical analysis may have distinctly different burning characteristics. Users are mainly interested in the available heat per pound of coal, in the handling and storing properties, and in the burning characteristics. A description of the relationship between the qualities of coals and these characteristics requires considerable space; a treatment applicable to heating boilers is given in *U. S. Bureau of Mines Bulletin* 276.

A classification of coals is given in Table 1, and a brief description of the kinds of fuels is given in the following paragraphs, but it should be recognized that there are no distinct lines of demarcation between the kinds, and that they graduate into each other:

*Anthracite* is a clean, dense, hard coal which creates very little dust in handling. It is comparatively hard to ignite but it burns freely when well started. It is non-caking, it burns uniformly and smokelessly with a short flame, and it requires little attention to the fuel beds between firings. It is capable of giving a high efficiency in the common types of hand-fired furnaces. A tabulation of the quality of the various anthracite sizes will be found in *U. S. Bureau of Mines Report of Investigations* No. 3283.

*Semi-anthracite* has a higher volatile content than anthracite, it is not as hard and ignites somewhat more easily; otherwise its properties are similar to those of anthracite.

*Semi-bituminous coal* is soft and friable, and fines and dust are created by handling it. It ignites somewhat slowly and burns with a medium length of flame. Its caking properties increase as the volatile matter increases, but the coke formed is relatively weak. Having only half the volatile matter content of the more abundant bituminous coals it can be burned with less production of smoke, and it is sometimes called *smokeless coal*.

The term *bituminous coal* covers a large range of coals and includes many types having distinctly different composition, properties, and burning characteristics. The coals range from the high-grade bituminous coals of the East to the poorer coals of the West. Their caking properties range from coals which completely melt, to those from which the volatiles and tars are distilled without change of form, so that they are classed as non-caking or free-burning. Most bituminous coals are strong and non-friable enough to permit of the screened sizes being delivered free from fines. In general, they ignite