TYPICAL AIR CONDITIONING PROCESSES

Illustrative Examples. The use of Table 6 and the Mollier diagram in analyzing typical air conditioning processes is best explained by the use of illustrative examples. In each of these examples, the observed pressure is assumed to be standard atmospheric pressure (29.921 in. Hg).

Example 13. Heating. Air at 20 F and 80 per cent saturation is to be heated to 120 F. Analyze the process as illustrated in Fig. 3.

Solution. The initial humidity ratio is 0.80 × 0.002144 = 0.001715 lb per pound dry air (table). This same value is read directly on the chart. The initial enthalpy is

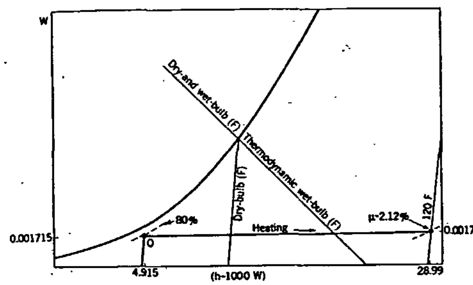

FIG. 3. DIAGRAM ILLUSTRATING EXAMPLE 13

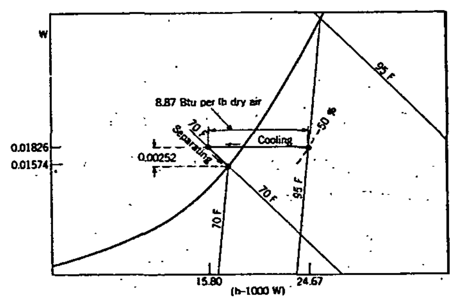

FIG. 4. DIAGRAM ILLUSTRATING EXAMPLE 14

4.798 + (0.80 × 2.290) = 6.630 Btu per pound dry air (table) or 4.915 + (1000 × 0.001715) = 6.630 (chart).

The final degree of saturation is 0.001715 ÷ 0.08093 = 0.0212 (table); hence the final enthalpy is 28.80 + (0.0212 × 90.09) = 30.71 Btu per pound dry air (table) or 28.99 + (1000 × 0.001715) = 30.71 (chart).

The increase in enthalpy is the quantity of heat to be supplied, namely, 30.71 − 6.63 = 24.08 Btu per pound dry air (table). Since humidity ratio W and therefore $1000W$ is constant, this is also simply the horizontal distance between the representative points on the chart; thus, the heat to be supplied is also 28.99 − 4.915 ≈ 24.08 Btu per pound dry air (chart).

The final volume is 14.60 + (0.0212 × 1.90) = 14.64 cu ft per pound (table); or direct from the volume chart. Therefore, if 20,000 cfm of heated air is to be supplied, the quantity of heat required is (20,000 ÷ 14.64) × 24.08 = 32,900 Btu per minute.

Example 14. Cooling and Separating. Air at 95 F and 50 per cent saturation is to be cooled to 70 F and the liquid separated out. Analyze the process as shown in Fig. 4.

Solution. The initial humidity ratio is 0.50 × 0.03652 = 0.01826 (table). The initial enthalpy is 22.80 + (0.50 × 40.25) = 42.93 Btu per pound dry air (table) or 24.67 + (1000 × 0.01826) = 42.93 (chart).

The final state is in the two-phase region and consists of 0.01574 lb water per pound dry air in the vapor phase, and 0.00252 lb water per pound dry air in the liquid phase. The final enthalpy is therefor 33.96 + (0.00252 × 38.0) = 34.06 Btu per pound dry air (table) or 15.80 + (1000 × 0.01826) = 34.06 (chart).

The decrease of enthalpy is the refrigeration to be supplied and is 42.93 − 34.06 = 8.87 Btu per pound dry air (table). Since the weight of water per pound of dry air is constant, this is also the horizontal distance between the representative points on the chart, namely, 24.67 − 15.80 = 8.87 Btu per pound dry air (chart).

The initial volume is 13.97 + (0.50 × 0.82) = 14.38 cu ft per pound (table); or direct from the volume chart. Therefore, if 20,000 cfm of initial air is to be processed, the refrigeration required is (20,000 × 8.87) ÷ (14.38 × 200) = 61.7 tons. The weight of water to be removed is (20,000 × 0.00252) ÷ 14.38 = 3.51 lb per minute.

Example 15. Adiabatic Saturation with Recirculated Spray Water. Air at 75 F and 60 per cent saturation is saturated adiabatically with spray water which is recirculated.

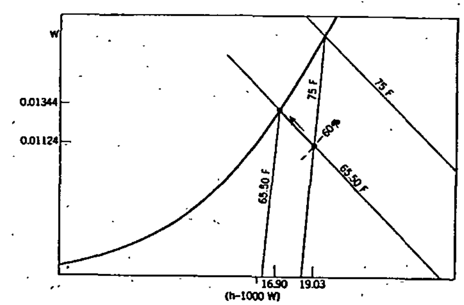

FIG. 5. DIAGRAM ILLUSTRATING EXAMPLE 15

Find the resulting temperature and the weight of water added per pound of dry air as outlined in Fig. 5.

Solution. The recirculated water will assume the thermodynamic wet-bulb temperature of the entering air which will also be the temperature of the resulting saturated mixture. The humidity ratio of the entering air is 0.60 × 0.01873 = 0.01124 lb water per pound dry air (table); its enthalpy is 17.99 + (0.60 × 20.47) = 30.27 Btu per pound dry air (table) or 19.03 + (1000 × 0.01124) = 30.27 Btu per pound dry air (chart). To determine the resulting temperature, the following equation must be solved.

$$30.27 + (W_s - 0.01124)\, h'_w = h_s$$

A trial value is 65 F corresponding to h_s = 30.27. The final value is 65.50 F corresponding to h_s = 30.27 + (0.01320 − 0.01124) × 33.05 = 30.34 Btu per pound dry air. The weight of water to be added is 0.01344 − 0.01124 = 0.00200 lb per pound dry air.

The volume of the entering air is 13.47 + (0.60 × 0.40) = 13.71 cu ft per pound. If 20,000 cfm of entering air is to be saturated, the weight of water to be added per minute is (20,000 × 0.00200) ÷ 13.71 = 2.92 lb per minute.

Adiabatic Mixing of Two Air Streams

A typical process requiring special discussion is the adiabatic mixing of two air streams. Let stream 1 contain M_1 pounds of dry air per minute and let its enthalpy be h_1 and its humidity ratio W_1. Using subscripts 2