

Example 13. Heating. Air at 0 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 $0.80 \times 0.0007852 = 0.000628$ lb per pound dry air (table). This same value is read directly on the chart. The initial enthalpy is $0.00 + (0.80 \times 0.832) = 0.666$ Btu per pound dry air (table) or $0.04 + (1000 \times 0.00063) = 0.67$ (chart).

The final degree of saturation is $0.000628 \div 0.08093 = 0.0078$ (table); hence the final enthalpy is $28.80 + (0.0078 \times 90.09) = 29.50$ Btu per pound (table) or $28.87 + (1000 \times 0.00063) = 29.50$ (chart).

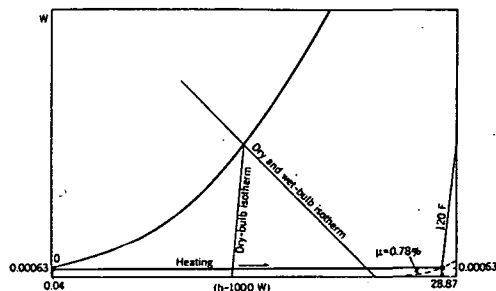


FIG. 3. DIAGRAM ILLUSTRATING EXAMPLE 13

The increase in enthalpy is the quantity of heat to be supplied, namely, $29.50 - 0.666 = 28.83$ 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 $28.87 - 0.04 = 28.83$ Btu per pound dry air (chart).

The final volume is $14.60 + (0.0078 \times 1.90) = 14.61$ cu ft per pound (table). Therefore, if 20,000 cfm of heated air is to be supplied, the quantity of heat required is $(20,000 \div 14.61) \times 28.83 = 39,460$ Btu per minute.

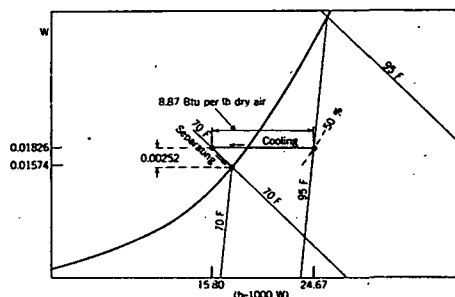


FIG. 4. DIAGRAM ILLUSTRATING EXAMPLE 14

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 $0.50 \times 0.03652 = 0.01826$ (table). The initial enthalpy is $22.80 + (0.50 \times 40.25) = 42.93$ Btu per pound dry air (table) or $24.67 + (1000 \times 0.01826) = 42.93$ (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 therefore $33.96 + (0.00252 \times 38.04) = 34.06$ Btu per pound dry air (table) or $15.80 + (1000 \times 0.01826) = 34.06$ (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 $13.97 + (0.50 \times 0.82) = 14.38$ cu ft per pound (table). Therefore, if 20,000 cfm of initial air is to be processed, the refrigeration required is $(20,000 \times 8.87) \div (14.38 \times 200) = 61.7$ tons. The weight of water to be removed is $(20,000 \times 0.00252) \div 14.38 = 3.51$ 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. 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 $0.60 \times 0.01873 = 0.01124$ lb water per pound dry air (table); its enthalpy is $17.99 + (0.60 \times 20.47) = 30.27$ Btu per pound

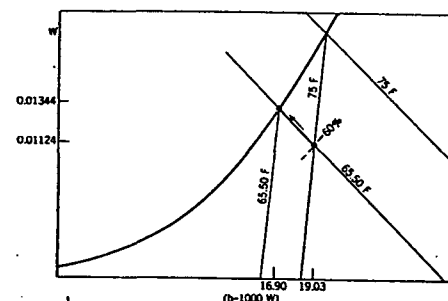


FIG. 5. DIAGRAM ILLUSTRATING EXAMPLE 15

dry air (table) or $19.03 + (1000 \times 0.01124) = 30.27$ 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 $h_s = 30.27 + (0.01320 - 0.01124) \times 33.05 = 30.34$ Btu per pound dry air. The weight of water to be added is $0.01344 - 0.01124 = 0.00220$ lb per pound dry air.

The volume of the entering air is $13.47 + (0.60 \times 0.40) = 13.71$ 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 $(20,000 \times 0.00220) \div 13.71 = 2.92$ 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 and 3 in a similar manner to designate stream 2 and the resulting mixture respectively, write:

$$\begin{aligned} M_1 + M_2 &= M_3 & (\text{weight balance for the dry air}) \\ M_1 W_1 + M_2 W_2 &= M_3 W_3 & (\text{weight balance for the water}) \\ M_1 h_1 + M_2 h_2 &= M_3 h_3 & (\text{energy balance, no heat absorbed}) \end{aligned}$$