

fluid is fairly constant, being affected principally by pressure drop through the tubes, by superheat of the evaporated refrigerant, and by the presence of oil in solution. To obtain maximum coil capacity it is necessary to keep the pressure drop through the tubes at a minimum, to keep the superheat as low as possible without carrying liquid back to the compressor, and to arrange for good separation and return of oil to the compressor. Another important factor is the removal of gas to keep the tube surface flooded with liquids as much as possible. The internal film coefficient is markedly increased by heavy heat loads, because the increased turbulence and gas velocity cause good contact of the liquid with the tubes. Values of h_i usually lie between 150 and 450. For rating of dehumidifying coils, satisfactory results are obtainable by first determining the average external surface temperature from Equation 7, and then using the difference between the external film temperature and the refrigerant for evaluating h_i in Equation 9.

$$h_i = \frac{q_i}{\frac{AN}{R} (t_s - t_r)} \quad (9)$$

where

h_i = internal film coefficient of heat transfer, Btu per (hour) (square foot of internal tube surface) (Fahrenheit degree).

t_r = average refrigerant temperature, Fahrenheit degrees.

The term $(t_s - t_r)$ is commonly written Δt . To evaluate h_i by this method the same tests that were required to determine h_o may be used.

When water is the cooling medium in tubes, the rate of heat transfer is a function of its velocity, which influences the number of contacts of the water molecules with the tube surface, per unit of time. Increased water velocity and reduced tube diameter cause increased heat transfer. Heat transfer is also greater at higher temperatures of the water. The basic formula for the film coefficient of heat transfer for flow of water in smooth tubes is as follows:

$$h_i = 1.5(t + 100) \frac{V^{0.8}}{D^{0.2}} \quad (10)$$

where

V = water velocity, feet per second.

D = internal diameter of tube, inches.

t = average water temperature, Fahrenheit degrees.

Equation 10 should not be used when Reynolds Number is less than 2000.

Since, in the case of finned tubes using water as a refrigerant, test values of h_i based on the calculated surface temperature for the entire coil may be lower than those obtained by use of Equation 10, actual test results are preferred if available.

When saturated steam is condensed in the tubes of coils, the film coefficient h_i varies from 1000 to 2000, depending on freedom from air in the steam, and upon good drainage of the tubes. The coefficient is fairly constant for a particular coil, giving values of Δt that are directly proportional to q_i . However, if water coil test results are analyzed on a row-by-row basis good agreement with Equation 10 will result.

Performance of Air Heating and Cooling Coils

The use of turbulence promoters increases the value of h_i for liquids in tubes at the expense of pressure drop. The increase obtained depends upon the type of turbulence promoter and the rate of flow. No general statement can be made regarding their use and it is best to refer to detailed papers on this subject for further information.^{3,4}

Determining Size of Cooling Coil

To illustrate the use of individual film coefficients in coil calculations, the procedure for selecting the proper size cooling coil and for determining exit air condition, coil surface temperature, total coil load and refrigerant temperature is outlined in Example 1.

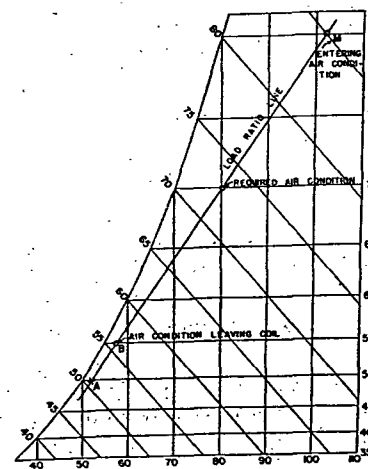


FIG. 2. PSYCHROMETRIC LAYOUT FOR COIL SELECTION

Example 1. An industrial application requires the cooling of a certain quantity of air from a condition of 102 F dry-bulb and 85 F wet-bulb to a final condition of 80.5 F dry-bulb and 73 F wet-bulb. The air velocity across the coil is to be 400 fpm and coil data are as follows: $h_o = 10.7$ at 400 fpm, $h_i = 325$, external surface area = 15 sq. ft. per (square foot of face) (row of coil depth), ratio of external surface area to internal surface area = 15.

Solution. (1) Lay out the problem psychrometry as indicated in Fig. 2 and note that the minimum horizontal distance between the load ratio line and the saturation curve is 1.8 F dry-bulb at point A Fig. 2. This means that $t_s - t_{dpt}$ in Equation 7 must not be less than 1.8. Therefore, Equation 7 should be solved for N to determine the proper number of rows to be used for the coil.

$$\frac{h_o AN}{0.243G} = \log_e \frac{t_1 - t_{dpt}}{t_2 - t_{dpt}} = \log_e \frac{102 - 80}{1.8} = \log_e 12.22 = 2.5$$

Then substituting values for h_o , A , and G , N may be found as follows:

$$\frac{10.7 \times 15N}{0.243 \times 1740} = 2.5 \text{ from which, } N = 6.58$$