Δt_o = logarithmic mean temperature difference between air and coil surface =

$$\frac{t_1 - t_2}{\log_e \dfrac{t_1 - t_s}{t_2 - t_s}}$$

If Equation 5 is combined with another equation expressing sensible heat transfer in terms of mass velocity and temperature difference, the variables may be arranged in the following form (which is useful for the solution of dehumidification problems and for the determination of f_o from test data):

$$\frac{f_o AN(t_1 - t_2)}{\log_e \dfrac{t_1 - t_s}{t_2 - t_s}} = 0.243G(t_1 - t_2)$$

or,

$$\frac{f_o AN}{0.243G} = \log_e \frac{t_1 - t_s}{t_2 - t_s} \tag{6}$$

where

0.243 = specific heat of humid air, Btu per (pound) (Fahrenheit degree).
G = air mass velocity, pounds per (hour) (square foot of coil face area).

An examination of Fig. 12 will reveal that when t_s is at the dew-point of the entering air:

$$\frac{t_1 - t_s}{t_a - t_s} = \frac{t_1 - t_{dp1}}{t_a - t_{dp1}}$$

and when t_s is below the dew-point:

$$\frac{t_1 - t_s}{t_2 - t_s} = \frac{t_1 - t_{dp1}}{t_2 - t_{dp2}}$$

Therefore, Equation 6 may be written in its most useful form as:

$$\frac{h_a AN}{0.243G} = \log_e \frac{t_1 - t_{dp1}}{t_2 - t_{dp2}} = \log_e \frac{t_1 - t_a}{t_2 - t_a} \tag{7}$$

where

t_a = minimum dry-bulb possible without dehumidification, Fahrenheit degrees.
t_{dp1} = dew-point of air entering coil, Fahrenheit degrees.
t_{dp2} = dew-point of air leaving coil, Fahrenheit degrees.

This equation may be used to establish a line, as A-2-3, for a given coil if f_o is known for the coil, or it *may be used to determine f_o from test data for the purpose of rating coils.* The use of this equation for coil selection is illustrated in Example 1 at the end of the chapter. Equation 7 is also important as a means of determining the external film coefficient.

External Film Coefficient

While formulas have been developed expressing the film coefficient f_o for air passing parallel to a plane surface, they cannot be used directly for fins on tubes because of air turbulence, and because of the temperature gradient

prevalent from the edge of a fin to its center. It is therefore necessary to make tests to evaluate the combined term ηf_o. The term, ηf_o, will be written merely f_o in this discussion as there is no necessity for separately evaluating η, and because values of f_o are usually applied only to the particular coils for which tests are made.

The air side coefficient, f_o, of a coil of particular dimensions is an exponential function of the mass velocity of the air:

$$f_o = Z\,G^n \tag{8}$$

where

f_o = film coefficient of heat transfer, Btu per (hour) (square foot external surface) (Fahrenheit degree mean temperature difference between air and average surface temperature).
G = air mass velocity, pounds per (hour) (square foot of coil face area).
Z and n = constants which depend upon both air turbulence and surface arrangement.

Evaluation of constants Z and n may be accomplished through the use of test data in Equation 7 which gives values of h_a directly from the results of any *wet coil test.* If f_o, calculated in this manner, is plotted against values of G which prevailed during the tests a straight line should result on logarithmic coordinates. The slope of this line is the value of n. The value of Z may then be determined by direct substitution in Equation 8.

For finned coils of different designs, values of Z and n are extremely variable, depending on the particular design and arrangement of the coil surface. Therefore, it is desirable that these constants be determined directly from test data for each type of coil surface.

Internal Film Coefficient

The internal film coefficient, f_i which appears in Equation 3, is evaluated in various ways, depending upon the nature of the fluid, and whether the fluid is changing state.

When evaporating refrigerants are used in tubes, the temperature of the 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 f_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 f_i in Equation 9.

$$f_i = \frac{q_t}{\dfrac{AN}{R}(t_s - t_r)} \tag{9}$$