

In the discussions which follow, coefficients h_r and ηh_a will be considered separately, and also various ways of combining them will be outlined.

The performances of all heating and dry cooling coils are influenced by these same factors. But, when cooling coils operate wet or act as dehumidifying coils, the performance cannot be predicted on the basis of over-all coefficients and an analysis must be made on the basis of individual film coefficients as will be explained.

PERFORMANCE OF DEHUMIDIFYING COILS

When a cooling coil operates with a surface temperature which is below the dew-point of the air entering the coil, moisture is condensed and the air leaves the coil with a humidity ratio lower than it had when

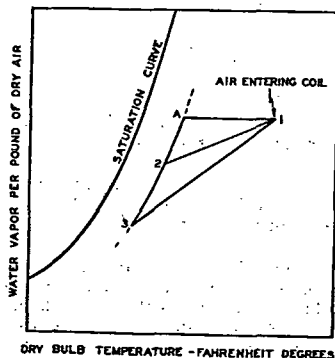


FIG. 1. PERFORMANCE OF DEHUMIDIFYING COIL

it entered the coil. To understand the performance of surface coils under such conditions, assume that air enters a cooling coil at conditions corresponding to point 1 in Fig. 1. As long as the surface temperature of the coil is above the dew-point, the air is cooled without dehumidification, and its condition leaving the coil will be somewhere on line 1-A. Its exact position on this line depends on the air velocity and the external film coefficient as well as upon the surface temperature. When the surface temperature just equals the dew-point, the air leaves with conditions represented by point A. If the surface temperature is below the dew-point, condensation takes place, and the air has a final condition somewhere along the line A-2-3 which is a line at a constant horizontal distance from the saturation curve. It should be understood that the line 1-A-2-3 is not intended to represent the path of the condition of the air as it passes through the coil from row to row. It is simply the path traced by the exit air conditions as the surface temperature is gradually reduced with other conditions remaining constant.²

In the process of dehumidification, since heat is being transferred to the coil surface by two different mechanisms, (convection and condensation), it is evident that an over-all coefficient of heat transfer cannot be determined by the same method used for heating and for dry cooling coils. However, if it is assumed that the sensible heat transfer of a dehumidifying coil is unaffected by the presence of moisture on its surface, Equation 5 may be obtained to express this part of the heat

transfer in terms of the external film coefficient and the surface temperature.

$$q_s = h_a \times A \times N \times (MTD_a) \quad (5)$$

where

q_s = sensible heat transferred, Btu per (hour) (square foot of coil face area).

t_1 = dry-bulb temperature of air entering coil, Fahrenheit degrees.

t_2 = dry-bulb temperature of air leaving coil, Fahrenheit degrees.

t_s = average temperature of coil external surface, Fahrenheit degrees.

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

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

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 h_a from test data):

$$\frac{h_a A N (t_1 - t_2)}{\log_e \frac{t_1 - t_s}{t_2 - t_s}} = 0.243 G (t_1 - t_2)$$

or,

$$\frac{h_a A N}{0.243 G} = \log_e \frac{t_1 - t_s}{t_2 - t_s} \quad (6)$$

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. 1 will reveal that when t_s is at the dew-point of the entering air:

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

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:

$$\frac{h_a A N}{0.243 G} = \log_e \frac{t_1 - t_{dp1}}{t_2 - t_{dp2}} = \log_e \frac{t_1 - t_s}{t_2 - t_s} \quad (7)$$

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 h_a is known for the coil, or it may be used to determine h_a 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 h_a for air passing parallel to a plane surface, they cannot be used directly