

Overall Coefficient of Heat Transfer

The overall coefficient of heat transfer for cooling coils operating with dehumidification is actually a sum of two overall coefficients: (1) the sensible overall coefficient due to flow of sensible heat under the pressure of temperature difference between the air and the cooling medium and (2) the latent overall coefficient due to flow of the latent heat of condensation from the moisture condensed due to difference in temperature between air dew-point and the external coil surface.

The relationship of the sensible and latent overall coefficients to the average external coil surface temperature and the temperature of the cooling medium within the coil is very complicated and, therefore, not subject to practical computations. Fortunately, an empirical relationship has been established by experimental data which permit a practical means of determining heat transfer in cooling coils operating with dehumidification.

On the basis of experimental data, it has been established that the total heat (sensible plus latent) transferred to a dehumidifying cooling coil by the air passing over it is for all practical purposes a function of the difference between the wet-bulb temperature of the air and the external coil surface temperature. The general formula for *total* (cooling and dehumidification) capacity of any given *wet* cooling coil operating at a definite fixed set of conditions can be expressed by the equation:

$$Q = U \times MTD \times A \quad (8)$$

where

Q = total (sensible and latent) heat transferred by the coil, Btu per hour.

U = overall total (sensible plus latent) coefficient of heat transfer, Btu per hour per square foot of external coil surface per degree Fahrenheit difference between the wet-bulb temperature of the air passing over the coil and the temperature of the cooling medium within the coil.

MTD = mean temperature difference, degrees Fahrenheit between the wet-bulb temperature of the air passing over the coil and the temperature of the cooling medium within the coil.

A = external surface area of the given coil (fins and tubes), square feet.

The primary difficulty which accompanies the use of Equation 8 is that further computations are necessary to obtain the average (effective) external coil surface temperature before the latent to total heat removal ratio can be ascertained. A practical means of determining effective coil surface temperature has been determined².

For all practical purposes the performance of a given cooling coil (operating wet or dry) can be presented in a graphical form without sacrifice of accuracy within the limits of most air conditioning practice. A typical graphical presentation of a cooling coil performance (operating with dehumidification) is shown in Fig. 14. An analysis of this chart indicates how a given coil's performance may be affected by a change in any of the variables enumerated herewith.

1. Wet-bulb temperature of air entering the coil, degrees Fahrenheit.
2. The average (effective) external coil surface temperature, degrees Fahrenheit.

²Graphical Method of Determining Finned Coil Capacities Described, by E. P. Wells (*Heating, Pipin and Air Conditioning*, December, 1936, p. 665).

3. Mass air velocity through the cooling coil, pounds per hour per square foot coil face area. (This mass velocity includes linear velocity as fpm and air density as pounds per cubic foot).

Construction of a coil capacity chart such as shown in Fig. 14 is accomplished as outlined herewith:

1. A series of tests are run to determine the sensible, latent and total coil capacity, changing one at a time such variables as: air velocity, inlet air dry-bulb, inlet air wet-bulb, average refrigerant temperature within the coil, and total load upon the coil.
2. From test data obtained in (1) the ratio of latent to total heat removal is computed for various test runs and tabulated against the wet-bulb temperature of air at coil inlet and total coil capacity.

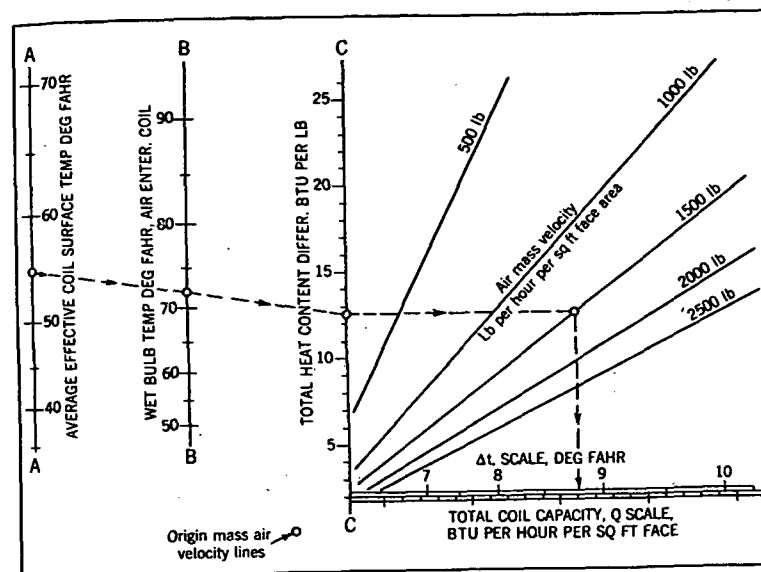


FIG. 14. TYPICAL COIL PERFORMANCE CHART

3. The three axes of the nomogram on the left side of the chart are drawn in such a manner that the C axis represents the differences in total heat content between the air at wet-bulb temperature along B axis and air at wet-bulb temperature along A axis. Thus, the C axis represents the total heat (Btu per pound of air, sensible and latent) which could be removed from the air at some inlet wet-bulb temperature on B axis if the coil heat transfer efficiency were 100 per cent and the wet-bulb temperature of the air could be reduced to some average (effective) external coil temperature on A axis. For example if a straight line is drawn through 72 F wet-bulb temperature of entering air on axis B and the 55 F average effective coil (external surface) temperature on axis A, then this straight line will intersect the C axis at 12.6, which figure represents the difference in total heat content of air between 72 and 55 F wet-bulb temperature.

4. Next scale Q is drawn to cover the range of the likely practical loading for the given coil in Btu per hour per square foot coil face area.

5. Lastly, the diagonal mass air velocity lines are drawn in at the intersection of various values on C axis and the corresponding values on the Q scale. The values on the Q scale corresponding to various values on C axis are obtained by multiplying the