cooling and dehumidification, the logarithmic difference does not apply strictly, and such problems should be handled as described in a later section on Performance of Dehumidifying Coils. With volatile refrigerants there is often an appreciable pressure drop and corresponding change in evaporating temperature through the refrigerant circuit. The problem is further complicated by the fact that the refrigerant is evaporating in part of the circuit, and superheating in the remainder. In spite of this, heat transfer and ratings for coils using volatile refrigerants are usually based on a refrigerant temperature corresponding to the average pressure in the coil.

The design and surface arrangement of the coil include such items as materials, type, thickness, height and spacing of the fins, and the ratio of this surface to that of the tube, the use of the staggered or in-line tube arrangement, and provisions to increase the air turbulence such as the use of corrugated as against flat fins. Staggered tubes increase the total heat transfer, as against the in-line arrangement, and corrugated fins may be more effective than flat. This design and surface arrangement has a large effect on the air film heat transfer resistance.

The velocity of the air usually considered is the coil face velocity. This bears a *varied relation to the actual velocity* over the surface, depending upon the individual coil design. As long as a fixed design of coil is under consideration face velocities may be used, but they may be unsatisfactory in comparing different designs, as it is the *actual surface velocity that is significant*. The air volume is often based on standard air at 70 F and a barometric pressure of 29.92 in. Hg. The use of air volume in coil *rating* information may be misleading. *The significant value is mass velocity in pounds per (minute) (square foot of face area) and not cubic feet per minute,* because for a fixed volume the corresponding weight may vary widely, depending upon the temperature and barometric pressure.

At the same mass air velocity, varying performance can be obtained depending upon the turbulence of the air flow into the coil, and upon the uniformity of distribution of air over the coil face. The latter is very important in obtaining reliable test ratings, and in realizing rated performance in practical installations. The resistance through the coils will assist in distributing the air properly, but where the inlet duct connections are brought in at sharp angles to the coil face, the effect is frequently bad and there may even be reverse air currents through the coils. This reduces the capacity, but can be avoided by proper layout or by the use of directing baffles.

Heat transfer depends also upon the velocity of the medium in the tubes and upon its character, whether flowing water, condensing steam or evaporating volatile refrigerant. Heat transfer rates expressed as Btu per (square foot of internal surface) (degree logarithmic mean effective temperature difference between the fluid and tube wall) are, for example: about 150 to 300 for evaporating dichlorodifluoromethane, about 350 to 1200 for water at 2 and 6 fps, and about 1200 for condensing steam. The influence of the medium in the tubes on the overall heat transfer rate is therefore apparent.

Because of these variables, reliable rating and performance information for any design of coil must be based on actual tests on that coil under the expected conditions of operation. A comparison between the performance of two designs, unless based on such tests on each, may lead to entirely erroneous conclusions. Details on coil calculation and performance follow.

PERFORMANCE OF HEATING AND DRY COOLING COILS

The performance of heating and dry cooling coils depends in general upon:

1. The overall coefficient of heat transfer from the fluid within the coil to the air it heats or cools.
2. The mean temperature difference between the fluid within the coil and the air flowing over the coil.
3. The physical dimensions of the coil.

Thus, for any one definite operating condition, the heating or cooling capacity of a given coil is expressed by the following basic formula:

$$q_t = U \times (\Delta t_m) \times A \times N \tag{1}$$

where

q_t = total heat transferred by the coil, Btu per (hour) (square foot of coil face area).

U = overall coefficient of heat transfer, Btu per (hour) (square foot of external coil surface) (Fahrenheit degree temperature difference between the fluid within the coil and the air flowing over the coil).

Δt_m = mean temperature difference, Fahrenheit degrees, between the fluid within the coil and the air passing over it. (This is commonly taken as the logarithmic mean temperature difference).

A = external surface area of the given coil, square feet per (square foot of coil face area) (row of coil depth).

N = number of rows of coil depth.

Overall Coefficient of Heat Transfer

Of all factors affecting the performance of heating or dry cooling coils, the overall coefficient of heat transfer is the most difficult to determine, as it is influenced by several factors which depend upon coil design and conditions of operation.

Considering any coil, whether of bare pipe or of finned type, the overall heat transfer coefficient for a given size and design of coil can always be considered as a combined effect of three individual heat transfer coefficients, namely:

1. The film coefficient of heat transfer between air and the external surface of the coil, usually given in Btu per (hour) (square foot external surface) (Fahrenheit degree mean temperature difference).
2. The coefficient of heat transfer through the coil material—tube wall, fins, ribs, etc.
3. The film coefficient of heat transfer between the internal surface of the coil and the fluid flowing within the coil, usually given in Btu per (hour) (square foot internal surface) (Fahrenheit degree mean temperature difference).

These three individual coefficients acting in series result in an overall coefficient of heat transfer in accordance with the basic laws given in Chapters 5 and 9. For a *bare pipe* coil the overall coefficient of heat transfer, whether for heating or for cooling (without dehumidification), can be expressed by a simplified basic formula as follows:

$$U = \frac{1}{\frac{R}{f_i} + \frac{L}{k} + \frac{1}{f_o}} \tag{2}$$