Table 1. Heat Transfer Information on Typical Copper Circular Fin Coils

Dipped Metal Bond or Integral Fins

Test No.	Data Source	Working Fluid	No. of Rows	In-Line or Staggered	Tube Diam In.	O.D. Fins In.	Fins per In.	Per Cent Face Area	U at 500 fpm Face	n
	Air Heating Service									
1	Reported	Steam 2-100 lb	4	Stag	0.375	0.87	6	57	13.0	0.62
2	Research Tests	Steam 2 lb gage	2	In-line	0.625	1.37	7	42	10.8	0.61
3	Commercial	Steam 5-150 lb	1-6	Stag	0.625	1.44	8	50	10.7	0.52
4	Commercial	Steam 5-150 lb	1-6	Stag	0.625	1.37	7	50	10.5	0.57
5	Commercial	Steam 5-100 lb	1-6	......	0.625	......	7	....	10.5	0.60
6	Research Tests	Steam 5 lb gage	4	Stag	0.625	1.47	7	53	10.5	0.65
7	Commercial	Steam 5-150 lb	1	Cast-Iron Sec.	......	......	..	44	10.2	0.62
8	Research Tests	Steam 2 lb gage	2	In-line	0.625	1.12	6	37	10.1	0.55
9	Research Tests	Steam 5 lb gage	1	......	0.625	1.47	7	52	9.3	0.52
10	Research Tests	Steam 5 lb gage	1	......	0.625	1.37	7	56	9.1	0.49
11	Commercial	Steam 5-150 lb	6	Cast-Iron Sec.	......	......	..	44	9.1	0.62
12	Research Tests	Steam 2 lb gage	1	......	0.625	1.37	7	49	9.0	0.48
13	Research Tests	Steam 2 lb gage	1	......	0.625	1.12	6	37	9.0	0.46
14	Commercial	Steam 5 lb gage	1	Cast-Iron Sec.	......	......	..	....	7.0	0.50
15	Commercial	Steam 5 lb gage	6	Cast-Iron Sec.	......	......	..	....	6.5	0.60
	Air Cooling Without Dehumidification									
16	Commercial	Water 2 fps	1-6	Stag	0.625	1.37	7	50	8.9	0.47
17	Commercial	Water 2 fps	1-6	Stag	0.625	1.44	8	50	8.6	0.45
18	Reported	Water 2 fps	....	......	0.625	1.44	8	50	8.5	......
19	Research Tests	Water 2 fps	2	Stag	0.75	1.75	7	55	7.2	0.45
20	Research Tests	Water 2 fps	6	Stag	0.75	1.75	7	55	7.1	0.64
21	Commercial	Direct Expansion	1	......	0.75	1.62	4-6	....	5.8	0.62
22	Commercial	Direct Expansion	6	......	0.75	1.62	4-6	....	4.7	0.61
23	Research Tests	Direct Expansion	4	Stag	0.75	1.75	7	44	6.2	0.51

in which the term x, called the *fin efficiency* is introduced to allow for the resistance to heat flow encountered in the fins.

The term R, in this case, is the ratio of *total* external surface to internal surface. For typical designs of finned coils for heating or cooling, this ratio varies from 10 to 30. The use of this term R is again introduced to place the internal fluid film coefficient of heat transfer on a basis of external surface.

Whereas the Equation 4 appears to be comparatively simple, it is actually extremely difficult to use in practice due to lack of handbook data relating to its component terms h_f, x and h_a.

The difficulty of obtaining the values of terms h_f, x and h_a is due to the fact that they in themselves depend upon several factors.

The internal fluid film coefficient, h_f, depends upon: (1) nature of the fluid—i.e., its chemical composition, (2) velocity of the fluid within the tubes or pipes, (3) temperature of the fluid, (4) whether fluid is boiling or not, e.g., it may be boiling refrigerant or cold water, (5) the rate of boiling or the heat load upon unit area, and (6) whether the fluid is condensing, evaporating or liquid without changing state.

The air film coefficient of heat transfer, h_a, in turn depends upon: (1) air velocity over the tubes and the fins, (2) tube diameter, (3) tube spacing, (4) tube arrangement (staggered or parallel), (5) fin spacing, (6) fin design (flat or corrugated), and (7) air temperature and density.

The fin efficiency term x is even more difficult to obtain by computation because it involves very complicated differential equations. Practically, however, it is known that the fin efficiency term x is affected by: (1) external fin diameter or length, (2) internal fin diameter, actual or effective, (3) fin thickness, (4) material of construction, (5) fin cross-section area in radial direction, and (6) bond between fins and pipe or tubes.

From the foregoing, it is obvious that rating or selection of cooling or heating coils requires careful consideration of all factors involved and that hasty application of the involved theory is apt to produce unsatisfactory results.

Fortunately, for all practical purposes, many of the complex relationships given above can be combined into one and the effect be measured by laboratory tests with a comparative simplicity for any one given coil under fixed conditions of operation.

Thus, for a given coil design, either for heating or for dry cooling, its overall coefficient of heat transfer can be expressed by a simple empirical formula:

$$U = CW^n \tag{5}$$

where

U = overall coefficient of heat transfer, Btu per hour per square foot external surface per degree Fahrenheit mean temperature difference between air and internal fluid.

W = air mass velocity, pounds per hour per square foot of coil face area.

n = exponent depending upon air turbulence which is affected by: (1) tube diameter, (2) tube spacing and arrangement, (3) fin design and spacing, and (4) coil depth. For values of n for typical cooling coils see Table 1.

C = constant which is dependent upon all other factors affecting U as explained in the previous discussion.

GRAPHICAL SOLUTION OF A COIL CAPACITY PROBLEM

After the value of the overall coefficient of heat transfer for any given cooling or heating coil has been determined, it remains to compute the