

A numerical integration (Table 4) is employed to determine the Number of Transfer Units (NTU) required. Temperature increments of 2 F are used between successive determinations of the quantity $\frac{1}{h^a - h_a}$. The energy balance indicates that the enthalpy increments corresponding to these temperature increments are:

$$\Delta h = \frac{Lc}{G} \Delta t = \frac{36,000}{30,000} \times 2 = 2.4 \text{ Btu per pound.}$$

The result of the integration is that the Number of Transfer Units required (NTU) = 0.757.

Unit gas mass velocity, $\frac{G}{S} = \frac{30,000}{6 \times 6} = 830 \text{ lb per hour per square foot.}$

From Fig. 6, $Ka = 138 \text{ lb per hour per cubic foot.}$

The tower volume required is:

$$V = \frac{G}{Ka} (NTU) = \frac{30,000}{138} \times 0.757 = 217 \times 0.757 = 164 \text{ cu ft.}$$

Height of the packed section is:

$$\frac{164}{6 \times 6} = 4.6 \text{ ft.}$$

The graphical solution for the Number of Transfer Units required for the desired performance is plotted in Fig. 7. $\frac{1}{h^a - h_a}$ is plotted as a function of h , and the area under the curve from the initial enthalpy of the air, 25 Btu per pound, to the final enthalpy of the air, 77.8 Btu per pound is 0.757, the Number of Transfer Units required. The effect of the rapid decrease in potential due to the cooling of the water is indicated by comparison of area A_1 , A_2 , and A_3 of Fig. 7. Each represents the Number of Transfer Units required to achieve a water temperature reduction of about 15 F.

$$\begin{aligned} A_1 &= 0.132 \text{ NTU (144 to 130 F)} \\ A_2 &= 0.251 \text{ NTU (130 to 115 F)} \\ A_3 &= 0.369 \text{ NTU (115 to 100 F)} \end{aligned}$$

TABLE 4. INTEGRATION OF NUMBER OF TRANSFER UNITS

t	h_a	h^a	$h^a - h_a$	$\frac{\Delta h}{h^a - h_a}$
100	25.0	71.4	46.4	0.052
102	27.4	75.0	47.6	0.050
104	29.8	78.9	49.1	0.049
106	32.2	83.0	50.8	0.047
108	34.6	87.3	52.7	0.045
110	37.0	91.8	54.8	0.044
112	39.4	96.7	57.3	0.042
114	41.8	101.7	59.9	0.040
116	44.2	107.1	62.9	0.038
118	46.6	112.8	66.2	0.036
120	49.0	118.9	69.9	0.034
122	51.4	125.2	73.8	0.032
124	53.8	132.1	78.3	0.030
126	56.2	139.2	83.0	0.029
128	58.6	146.8	88.2	0.027
130	61.0	154.9	93.9	0.025
132	63.4	163.7	100.3	0.023
134	65.8	172.9	107.1	0.022
136	68.2	182.6	114.4	0.021
138	70.6	193.1	122.5	0.020
140	73.0	204.3	131.3	0.018
142	75.4	216.3	140.9	0.017
144	77.8	229.0	151.2	0.016
				0.757

When the relationship between the enthalpy of the saturated air and the temperature is linear over the range of water temperatures involved, it can be shown⁷ that the logarithmic mean of the terminal potentials, Δh_{lm} , is the correct driving force. This is true to a good approximation when the water cooling does not exceed 15 F. The approximation to linearity may be determined by inspection of Table 6, Chapter 1, or the temperature enthalpy diagram of Fig. 5. When the logarithmic mean is a valid potential, Equation 6 may be written:

$$\frac{h_1 - h_2}{\Delta h_{lm}} = \frac{KaV}{G} \quad (7)$$

and the need for the numerical integration for the determination of the tower volume is eliminated.

The application of the foregoing design method to atmospheric towers is difficult because rate coefficients and flow conditions are not yet well

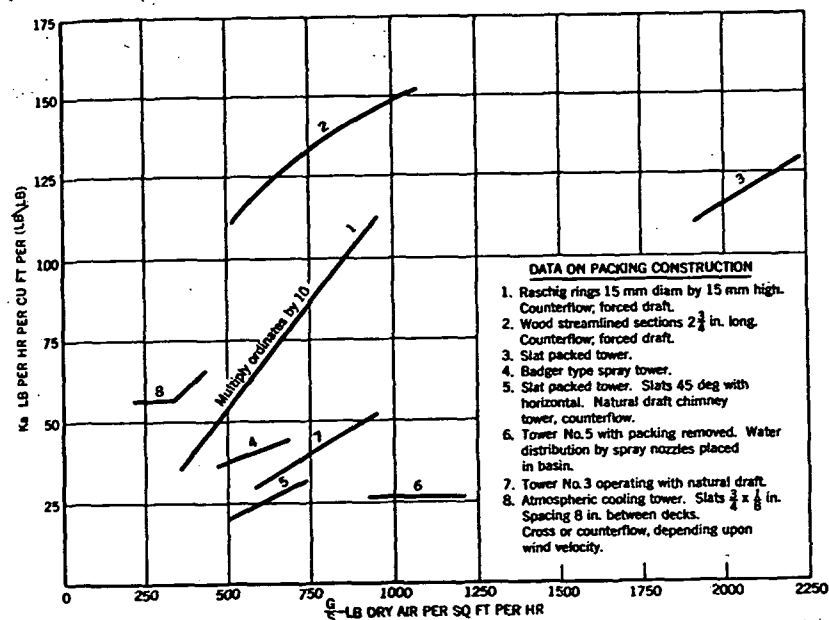


FIG. 6. UNIT CONDUCTANCES FOR VARIOUS TYPES OF PACKING CONSTRUCTION

defined for such equipment. If these are known, application of Equation 7 to sections of the tower small enough to justify use of the logarithmic mean potential will yield the tower volume required for each section. The sections must be taken perpendicular to the path of water flow. A correction to adjust the logarithmic mean potential, evaluated as for counter-flow, to the reduced effectiveness of cross-flow, has been derived for heat transfer and may be applied to this case⁸.

Atmospheric towers operate with natural draft, produced in a vertical direction by the stack action of the tower structure, at zero velocity of the

⁷Loc. Cit. Note 3, p. 79.

⁸Heat Transmission, by W. H. McAdams (McGraw-Hill Co., New York City, 1933, p. 157).