NOMENCLATURE

A	Cross sectional area of vertical separator, sq ft
A_L	Cross sectional area of horizontal vessel occupied by liquid phase, sq ft
A_T	Total cross sectional area of horizontal vessel, sq ft
A_v	Minimum cross sectional area of vertical separator, sq ft
D	Vessel diameter, ft
H_L	Liquid height, ft
H_v	Vapor height, ft
K	Proportionality constant
K_H	Vapor velocity factor for horizontal separator
K_v	Vapor velocity factor for vertical separator
L	Horizontal vessel level, ft
S.Fac	Separation factor
Q_L	Liquid volumetric flow, cfs
Q_v	Vapor volumetric flow, cfs
T	Liquid surge time, min
V_{max}	Maximum vapor velocity, fps
V_{VES}	Horizontal vessel volume, cu ft
WL	Liquid flowrate, lb/hr
WV	Vapor flowrate, lb/hr
X	ln (S.Fac)
ρ_L	Liquid density, lb/cu ft
ρ_v	Vapor density, lb/cu ft
τ	Residence time, min

EQUATIONS

$$S.Fac = \frac{WL}{WV}\left(\frac{\rho_v}{\rho_L}\right)^{0.5} \quad (1)$$

$$X = \ln(S.Fac) \quad (2)$$

$$K_v = \exp(B + DX + EX^2 + FX^3 + GX^4), \text{ where } B = -1.877478,\ D = -0.814580,\ E = -0.187074,\ F = -0.014523, \text{ and } G = -0.001015 \quad (3)$$

$$V_{max} = K_v\left(\frac{\rho_L - \rho_v}{\rho_v}\right)^{0.5} \quad (4)$$

$$Q_v = \frac{WV}{3{,}600\ \rho_v} \quad (5)$$

$$A_v = \frac{Q_v}{V_{max}} \quad (6)$$

$$D_{min} = \left(\frac{4A_v}{\pi}\right)^{0.5} \quad (D = D_{min} \text{ to next largest 6 in.}) \quad (7)$$

$$\text{Area} = \frac{\pi D^2_{min}}{4} \quad (8)$$

$$(U_{max})_{nozzle} = \frac{100}{\rho^{0.5}_{mix}} \quad (9)$$

$$(U_{min})_{nozzle} = \frac{60}{\rho^{0.5}_{mix}} \text{ where } \rho_{mix} = \left(\frac{WL + WV}{\frac{WL}{\rho_L} + \frac{WV}{\rho_v}}\right) \frac{lb}{cu\ ft} \quad (10)$$

$$Q_L = \frac{WL}{3{,}600\rho_L} \quad (11)$$

$$V = (Q_L)(\text{design time to fill}) = (60.0)(Q_L)(T) \quad (12)$$

$$H_L = V\left(\frac{4}{\pi D^2}\right) \quad (13)$$

$$K_H = 1.25K_v \quad (14)$$

$$(U_v)_{max} = K_H\left(\frac{\rho_L - \rho_v}{\rho_v}\right)^{0.5} \quad (15)$$

$$(A_v)_{min} = \frac{Q_v}{(U_v)_{max}} \quad (16)$$

$$(A_{total})_{min} = \frac{(A_v)_{min}}{0.2} \quad (17)$$

$$D_{min} = \left(\frac{4(A_{total})_{min}}{\pi}\right)^{0.5} \quad (18)$$

$$L = (3)(D_{min}) \quad (19)$$

$$A_L = (0.8)(A_{total})_{min} \quad (20)$$

$$V_{VES} = (A_{total})_{min}(L) \quad (21)$$

$$T = \frac{(60.0)(A_L)(L)(\rho_L)}{WL} \quad (22)$$

$$V_d = 2F_4(F_1 + F_2)(L + F_3D) \text{ gal, full} \quad (23)$$

$$\tau = \frac{V_d}{(L + D)} \quad (24)$$

mentation and response to control, the efficiency of labor and chronic mechanical problems, and the possibility of short or long-term interruptions.[3]

The multiplying factors F_1 and F_2 represent the instrument and labor factors. A multiplying factor F_3 is applied to the net overhead product going downstream. F_4 depends on the kind and location of level indicators.

It is recommended that 36 in. plus one half the feed nozzle OD (48 in. minimum) be left above the feed nozzle for vapor. Below the feed nozzle, 12 in. plus one half the feed nozzle OD is required for clearance between the maximum liquid level and the feed nozzle (minimum of 18 in.).

At some value between L/D ratios of 3 and 5, a minimum vessel weight will occur, resulting in minimum costs for the separator. Fig. 4 shows the dimensions of a vertical separator.

Calculation method

The following steps are used to size a vertical drum.

1. Calculate the vapor-liquid separation factor using Equation 1 (see Equations).
2. From Blackwell's correlation, determine the design vapor velocity factor K_V, and the maximum design vapor velocity (Equations 2-4).
3. Calculate the minimum vessel cross sectional area (Equations 5 and 6).
4. Set a vessel diameter based on 6-in. increments and calculate cross sectional area (Equations 7 and 8).
5. Estimate the vapor-liquid inlet nozzle based on the velocity criteria given in Equations 9 and 10.
6. From Fig. 4, make a preliminary vessel sizing for the height above the center line of a feed nozzle to top seam, use 36 in. + one half the feed nozzle OD or 48 in. minimum. Use 12 in. + one half the feed nozzle OD or 18 in. minimum to determine the distance below the center line of the feed nozzle to the maximum liquid level.
7. From Tables 1 or 2 select the appropriate full surge volume in seconds. Calculate the required vessel volume (Equations 11 and 12). The liquid height is calculated as shown in Equation 13.
8. Check the geometry. The result of $(H_L + H_V)/D$ must be between 3 and 5.

For small volumes of liquid, it may be necessary to provide more liquid surge than is necessary to satisfy the L/D greater than 3. If the required liquid surge volume is greater than that obtained in a vessel having L/D less than 5, a horizontal drum must be provided.

Horizontal drum

Horizontal vessels are used for substantial vapor-liquid separation where the liquid holdup space must be large. Maximum vapor velocity and minimum vapor space are determined as in the vertical drum, except that K_H for horizontal separators is generally set at 1.25 K_V.

The following steps are used to size horizontal separators:

1. Calculate the vapor-liquid separation factor by Equation 1 and K_V by Equations 2 and 3.
2. For horizontal vessels, calculate K_H by Equation 14.
3. Calculate the maximum design vapor velocity (Equation 15).
4. Calculate the required