Size calculations

↳ cross sectional area and diameter

Based on u_{perm}

$$A_c = \frac{D\,(M_{wt})}{u_{perm} \cdot 3600\,\rho_v}$$

(D: molar flow rate /hr; M_{wt}: vapor)

$$d_{drum} = \sqrt{\frac{4A_c}{\pi}}$$

$\frac{L}{D}$ ratio is important

for a vertical flash drum

$3 \leq \frac{L}{D} \leq 5$

Appropriate value in the range can be calculated by minimizing the total vessel weight

⇒ most used ⇒ cylinder tanks why? has the lowest cost + easy to manufacture

(gases storage ⇒ in spherical tanks)

3.5. SIZE CALCULATION

Once the vapor and liquid compositions and flow rates have been determined, the flash drum can be sized. This is an empirical procedure. We will discuss the specific procedure for vertical flash drums, like the one shown in Figure 3-1.

Step 1. Calculate the permissible vapor velocity, u_{perm},

$$u_{perm} = K_{drum} \sqrt{\frac{\rho_L - \rho_v}{\rho_v}} \tag{3-50}$$

u_{perm} is the maximum permissible vapor velocity in feet per second at the maximum cross-sectional area. ρ_L and ρ_v are the liquid and vapor densities.

K_{drum} is an empirical constant whose value has been correlated graphically by Watkins (1967) for 85% of flood with no demister. Approximately 5% liquid will be entrained with the vapor. Use of the same design with a demister will reduce entrainment to less than 1%. The demister traps small liquid droplets on fine wires and prevents them from exiting. The droplets then coalesce into larger droplets, which fall off the wire and through the rising vapor into the liquid pool at the bottom of the flash chamber. Blackwell (1984) fit Watkins' correlation to the equation

$$K_{drum} = \exp[A + B \ln F_{lv} + C(\ln F_{lv})^2 + D(\ln F_{lv})^3 + E(\ln F_{lv})^4]$$

where $F_{lv} = \frac{W_L}{W_v}\sqrt{\frac{\rho_v}{\rho_L}}$ with W_L and W_v being the liquid and vapor flow rates in weight units per hour (e.g., lb/hr). The constants are (Blackwell, 1984):

A = −1.877478097	C = −0.1870744085	E = −0.001014851 8
B = −0.8145804597	D = −0.0145228667	

Step 2. Using the known vapor rate, V, convert u_{perm} into a horizontal area. The vapor flow rate, V, in lb moles/hr is

$$V\left(\frac{\text{lb moles}}{\text{hr}}\right) = \frac{u_{perm}\left(\frac{\text{ft}}{\text{s}}\right)\left(\frac{3600\ \text{s}}{\text{hr}}\right) A_c(\text{ft}^2)\ \rho_v\left(\frac{\text{lbm}}{\text{ft}^3}\right)}{MW_{vapor}\left(\frac{\text{lbm}}{\text{lb mole}}\right)}$$

Solving for the cross-sectional area,

$$A_c = \frac{V(MW_v)}{u_{perm}(3600)\rho_v} \tag{3-52}$$

For a vertical drum, diameter D is

$$D = \sqrt{\frac{4A_c}{\pi}} \tag{3-53}$$

Usually, the diameter is increased to the next largest 6-in. increment.

Step 3. Set the diameter/length ratio either by rule of thumb or by the required liquid surge volume. For vertical flash drums, the rule of thumb is that L/D ranges from 3.0 to 5.0. The appropriate value of L/D within this range can be found by minimizing the total vessel weight (which minimizes cost).

→ by differentiate it and equal it to zero.

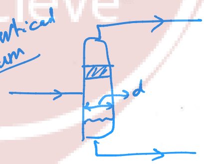
Flash drums are often used as liquid surge tanks in addition to separating liquid and vapor. The design procedure for this case is discussed by Watkins (1967) for petrochemical applications.

The height of the drum above the centerline of the feed nozzle, h_v, should be 36 in. plus one-half the diameter of the feed line (see Figure 3-6). The minimum of this distance is 48 in.

* if $\frac{L}{D_{drum}} < 3$ means that surge capacity should be increased.

* if $\frac{L}{D} > 5$ means that it should be used horizontal flash drum

* vertical drum



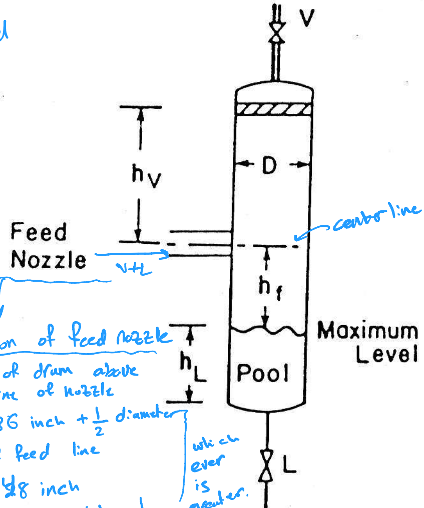


Figure 3-6. Measurements for vertical flash drum.

The height of the center of the feed line above the maximum level of the liquid pool, h_f, should be 12 in. plus one-half the diameter of the feed line. The minimum distance for this free space is 18 in.

The depth of the liquid pool, h_L, can be determined from the desired surge volume, V_{surge}.

$$h_L = \frac{V_{surge}}{\pi D^2/4} \tag{3-54}$$

The geometry can now be checked, since

$$\frac{L}{D} = \frac{h_V + h_f + h_L}{D}$$

should be between 3 and 5. If $L/D < 3$, a larger liquid surge volume should be allowed. If $L/D > 5$, a horizontal flash drum should be used. Calculator programs for sizing both vertical and horizontal drums are available (Blackwell, 1984).

More detailed design procedures and methods for horizontal drums are presented by Evans (1980), Blackwell (1984), and Watkins (1967). Note that in industries other than petrochemicals the sizing may vary.

A vertical flash drum is to flash a feed of 1500 lb moles/hr that is 40 mole % n-hexane and 60 mole % n-octane at 101.3 kPa (1 atm). We wish to produce a vapor that is 60 mole % n-hexane. Solution of the flash equations with equilibrium data gives x_H = 0.19, T_{drum} = 378K, and V/F = 0.51. What size flash drum is required?

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