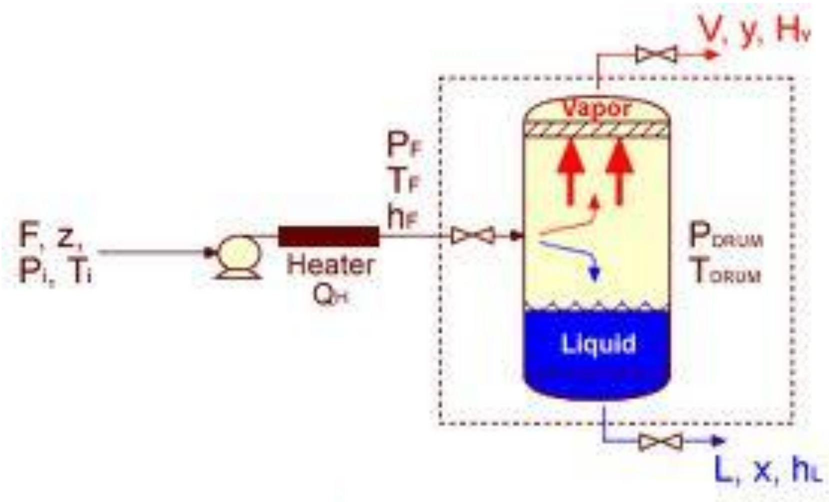
CHEMICAL ENGINEERING DESIGN & SAFETY

CHE 4253

Prof. Miguel Bagajewicz

Flash VLE Separator Design

FLASH DRUM DESIGN



Vertical vessel

Horizontal Vessel

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Installed Units

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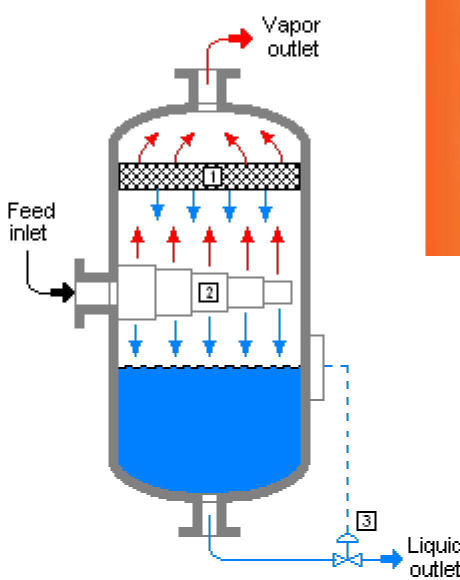
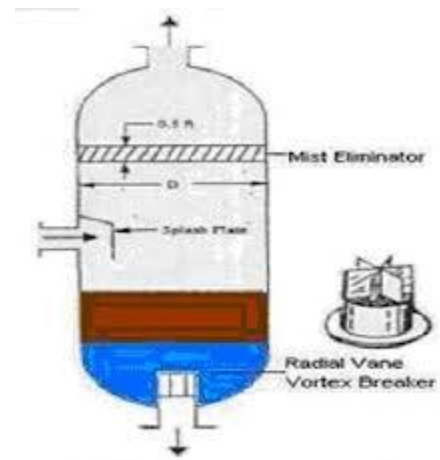
Deflectors, and Diffusers



1 De-entrainment mesh pad
2 Inlet diffuser (distributor)
3 Liquid level control valve



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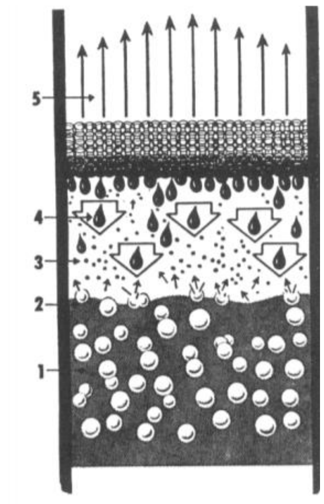
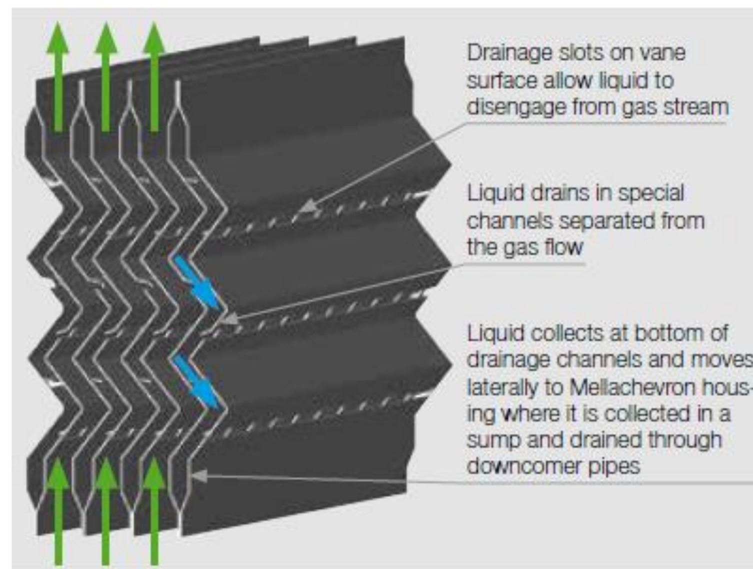
Demisters





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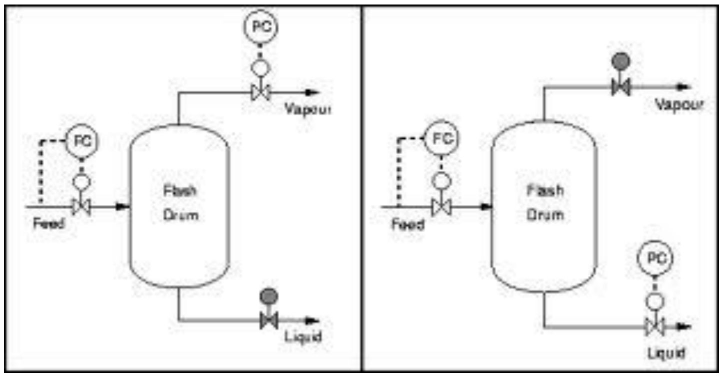
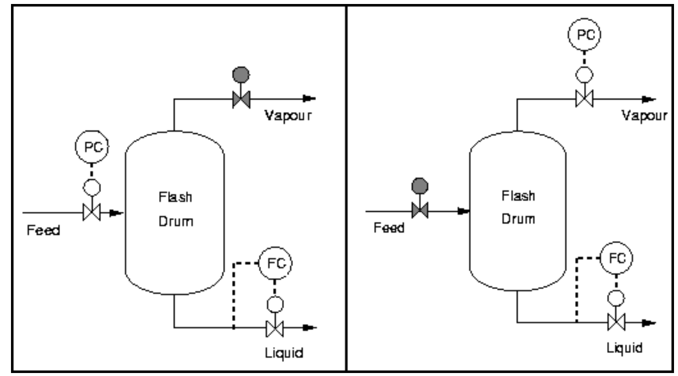
Control Schemes





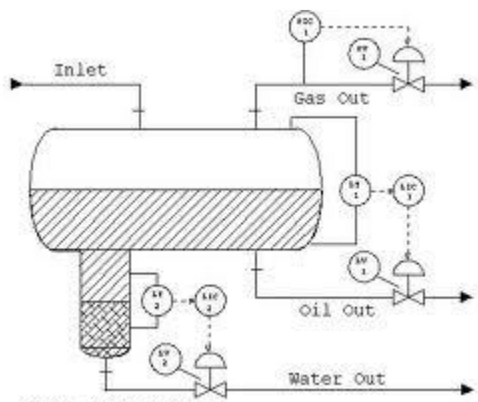


Fig. 6-6. A Crude Oil Separator

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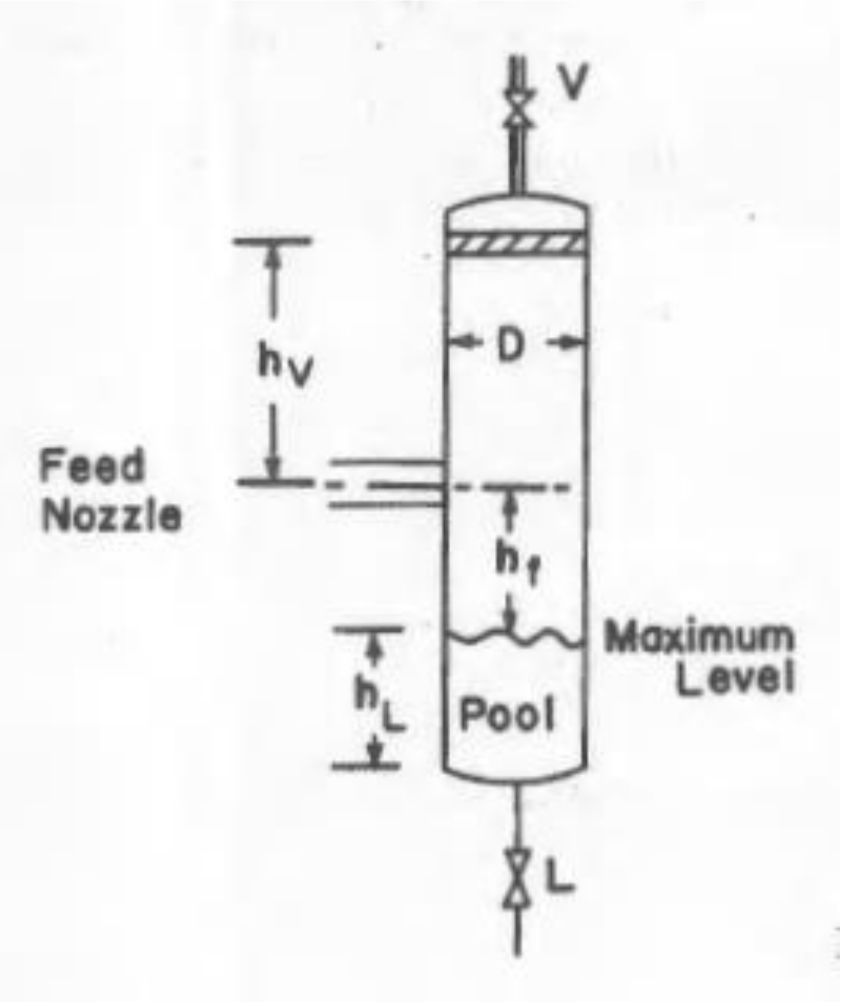
Dimensions to decide

D
h_V
h_L
h_f



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Calculations to make

$$F = L + V$$

$$Fz_i = Lx_i + Vy_i$$

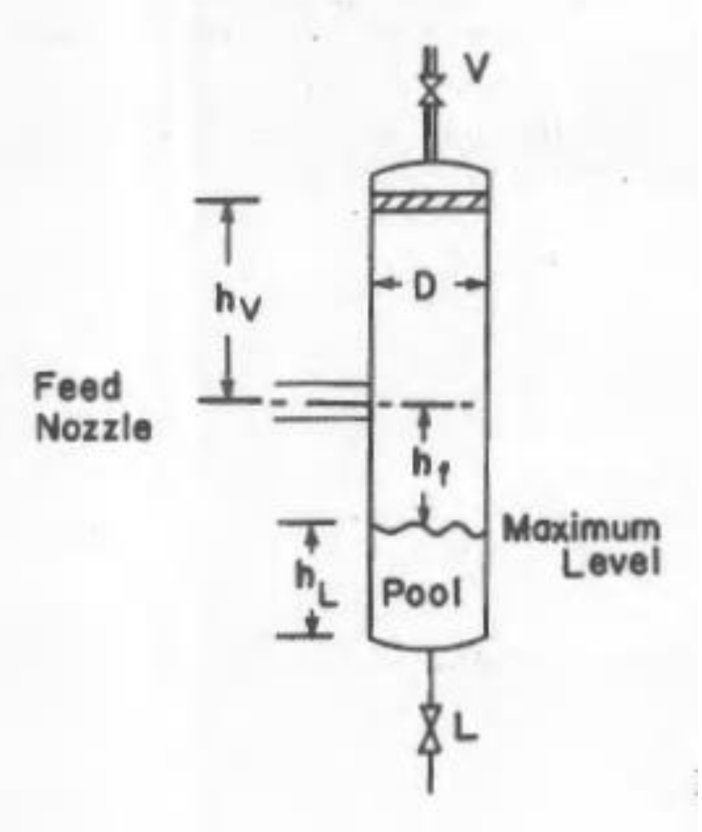
$$y_i = K_i x_i$$

$$\sum_i x_i = 1$$

$$\sum_i y_i = 1$$

$$\Rightarrow \begin{cases} x_i = \dfrac{z_i}{\left[1 + V/F\,(K_i - 1)\right]} \\ y_i = \dfrac{K_i z_i}{\left[1 + V/F\,(K_i - 1)\right]} \end{cases} \Rightarrow$$

Ratchford Rice Equation (look for it!!)



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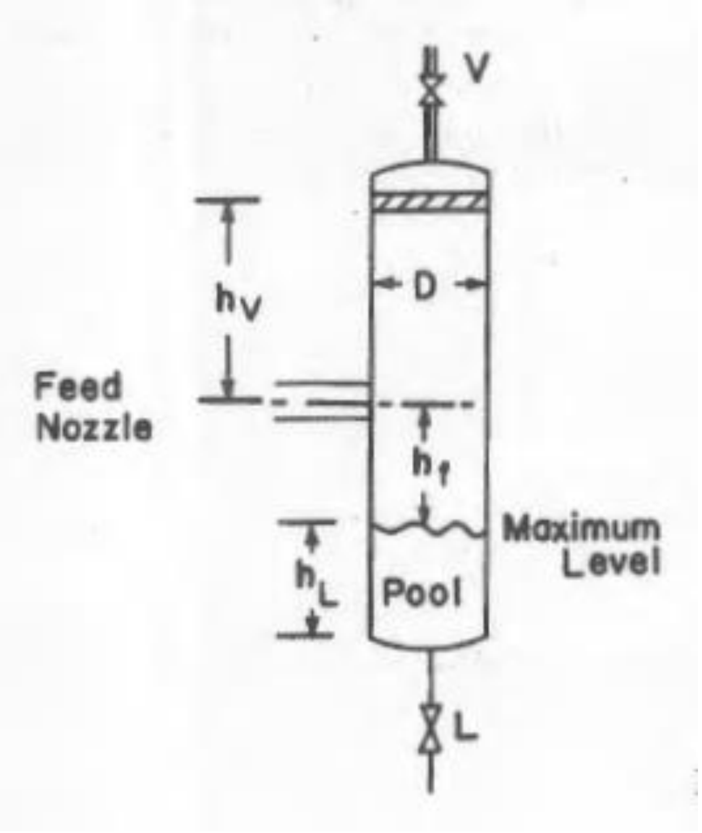
Dimensions to decide

D related to vapor velocity.
h_V related to vapor velocity.
h_L related to level control
h_f related to flooding



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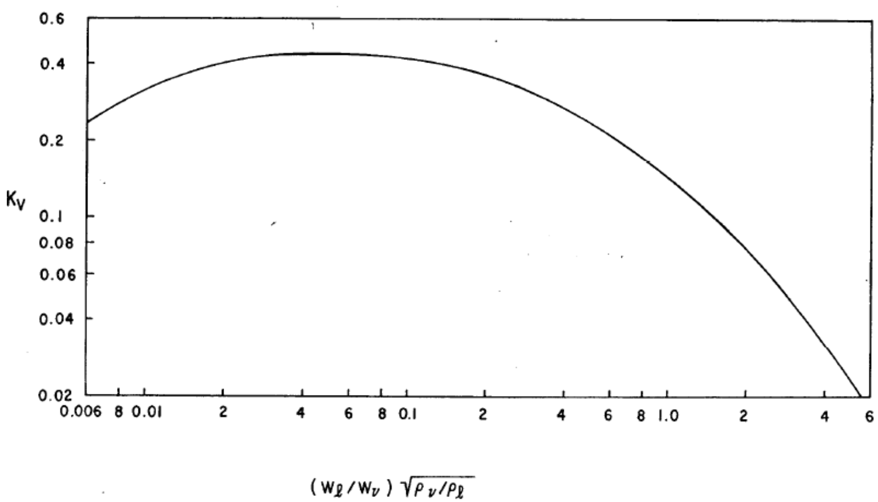
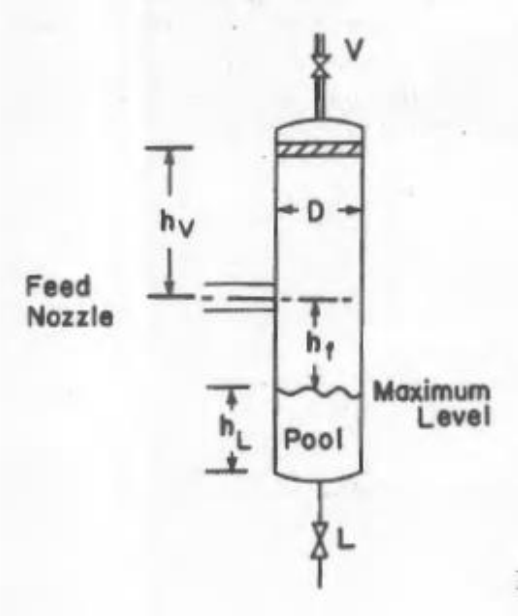
D related to vapor velocity.

Permitted velocity

$$v_{perm} = K\sqrt{\frac{(\rho_L - \rho_V)}{\rho_V}}$$





$$K = e^{A + B\ln F_{lv} + C(\ln F_{lv})^2 + d(\ln F_{lv})^3 + E(\ln F_{lv})^4}$$

$$F_{lv} = \frac{W_L}{W_V}\sqrt{\frac{\rho_V}{\rho_L}}$$

$A = -1.877478$

$B = -0.814580$

$C = -0.187074$

$D = -0.014523$

$E = -0.001015$

Where do these come from ?

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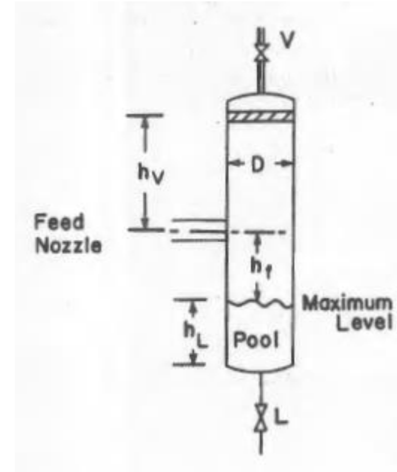
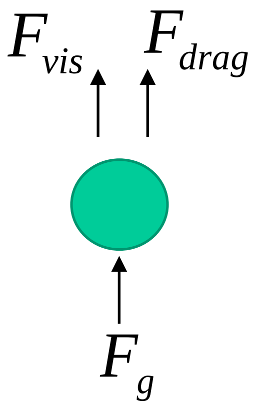


D related to vapor velocity.



$$F_{vis} = 6\pi\mu R_d v_d$$ Stokes

$$F_{drag} = C_D \frac{1}{2} A\rho_V v_d^2$$ drag

$$F_g = (\rho_L - \rho_V) g \frac{4}{3}\pi R_d^3$$ gravity-Buoyancy

$$F_{drag} + F_{vis} \approx F_{drag} = F_g \Rightarrow C_D \frac{1}{2}\left(\pi R_D^2\right)\rho_V v_d^2 = (\rho_L - \rho_V) g \frac{4}{3}\pi R_d^3$$

$F_{drag} >> F_{vis}$

$$\Rightarrow v_{perm} = K\sqrt{\frac{(\rho_L - \rho_V)}{\rho_V}}$$

$$K = \sqrt{\frac{8gR_d}{3C_D}}$$

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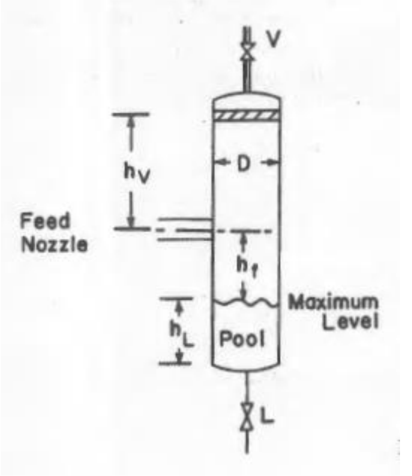
Dimensional analysis for drag: Force is dependent on velocity, cross sectional area, density and viscosity.

$$f_a\,(F_{drag}, v_d, A, \rho_V, \mu) = 0$$

Two nondimensional numbers:

$$\mathrm{Re} = \frac{v_d\sqrt{A/\pi}}{\mu} \qquad C_D = \frac{F_{drag}}{\frac{1}{2}\rho_V A v_d^2}$$



Therefore

$$f_b\,(\mathrm{Re}, C_D) = 0 \quad \rightarrow \quad C_D = \frac{F_D}{\frac{1}{2}\rho_V A v_d^2} = f_c\,(\mathrm{Re})$$

Thus C_D ***is a function of the particle Reynolds number.*** → $K = \sqrt{\dfrac{8gR_d}{3f_c(\mathrm{Re})}}$

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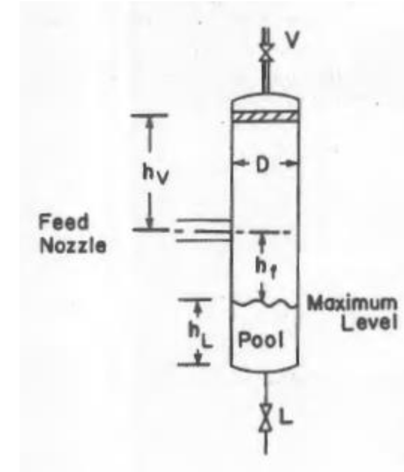
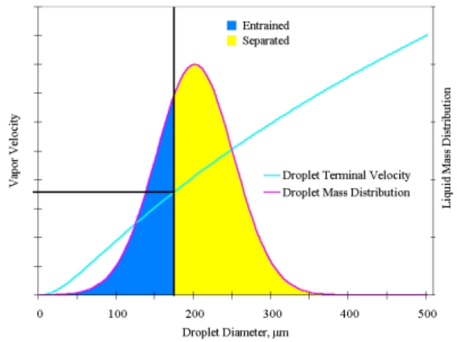


But, what R_d should be used? The criteria is that 5% of the liquid is entrained.



Thus

$$K = e^{A + B\ln F_{lv} + C(\ln F_{lv})^2 + d(\ln F_{lv})^3 + E(\ln F_{lv})^4} \quad ; \quad F_{lv} = \frac{W_L}{W_V}\sqrt{\frac{\rho_V}{\rho_L}}$$

were obtained fitting experimental data.

Therefore $$D = \sqrt{\frac{4}{\pi}A} = \sqrt{\frac{4}{\pi}\frac{V}{v_{perm}\rho_V}}$$. Here V is mass flowrate

Demisters should take care of 4% (or less) of the 5%. **IF DEMISTER IS PRESENT USE K=0.15.**

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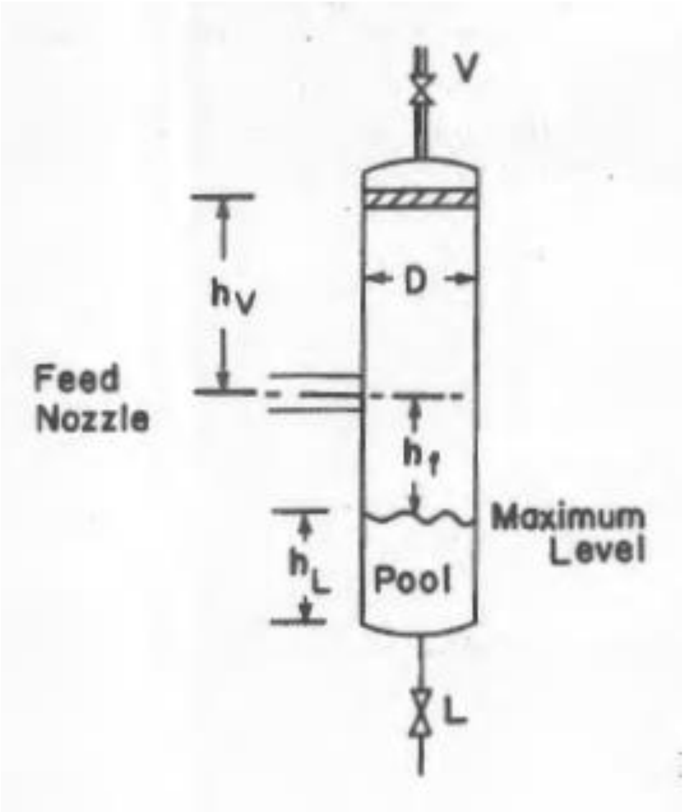
$$h_V = 36'' + \frac{1}{2} diameter\ of\ \ feedline$$

$$h_f = 12'' + \frac{1}{2} diameter\ of\ \ feedline$$



Who came up with this rule and why?
Not known exactly what is the rationale

$$h_L = \frac{V_{pool}}{\pi D^2 / 4}$$

Residence Time, Failure Analysis, Other Control issues?)

or ~2 minutes residence time. RESIDENCE TIME PREFERRED WHEN V_{pool} IS NOT AVAILABLE

Finally:

$$H = h_V + h_f + h_L$$

Nozzle size

$$(u_{max})_{nozzle} = 100/\sqrt{\rho_{mix}},\ \text{ft./sec.}$$

$$(u_{min})_{nozzle} = 60\sqrt{\rho_{mix}},\ \text{ft./sec.}$$

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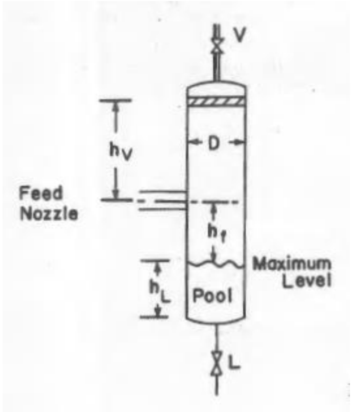

Final considerations

IF $\dfrac{L}{D} < 3$ increase V_{pool} (Why???)

IF $\dfrac{L}{D} > 5$ Use horizontal drum (Why???)

Different design protocol: Why?