Gas Absorption

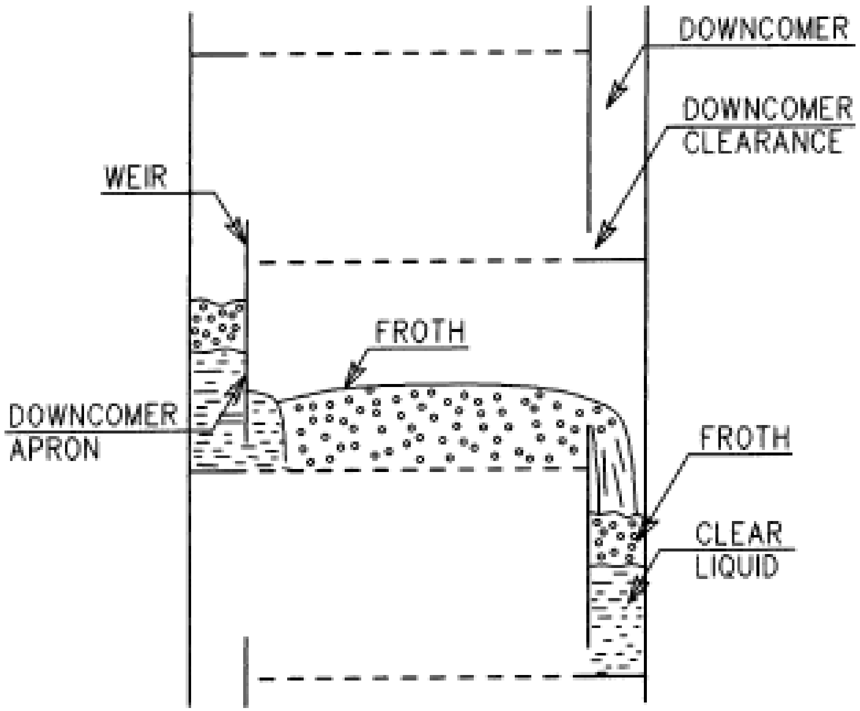
Isabel Coelhoso

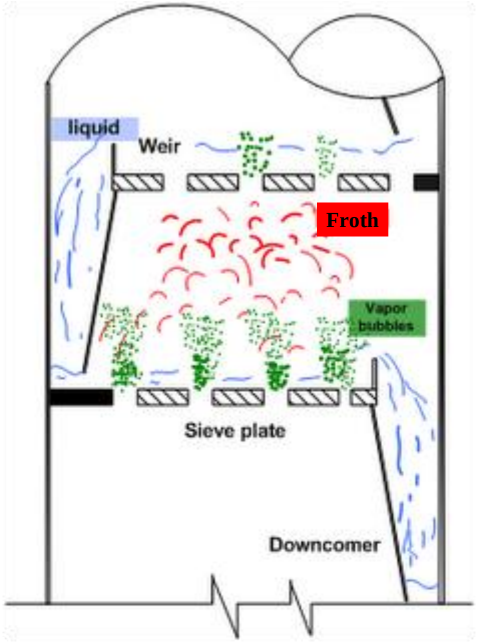
imrc@fct.unl.pt

Engenharia Química e Biológica

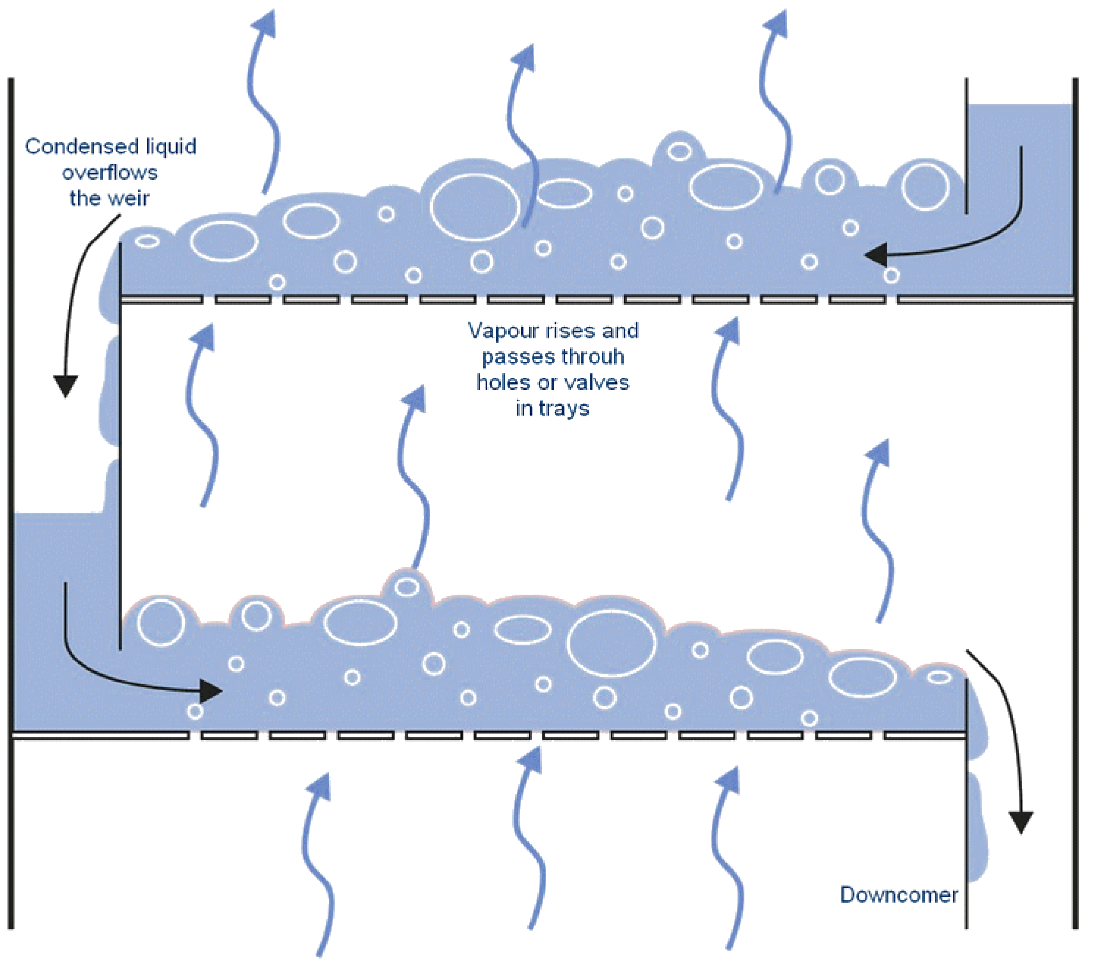
Processos de Separação

Operation of a tray column

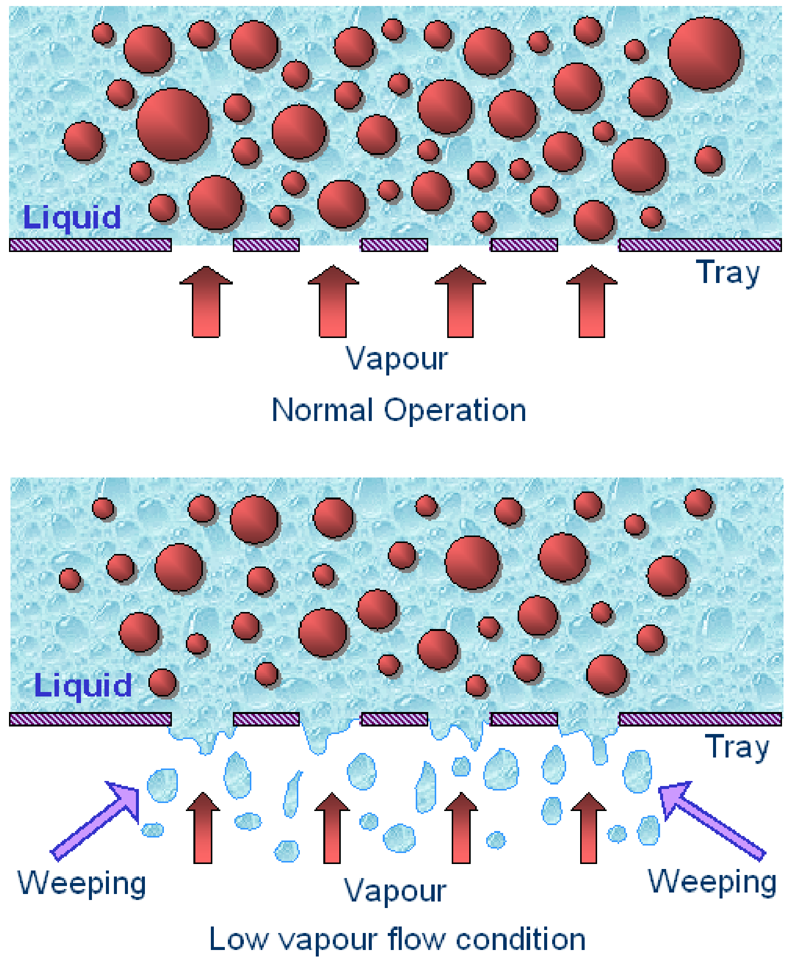




Operation of a tray column

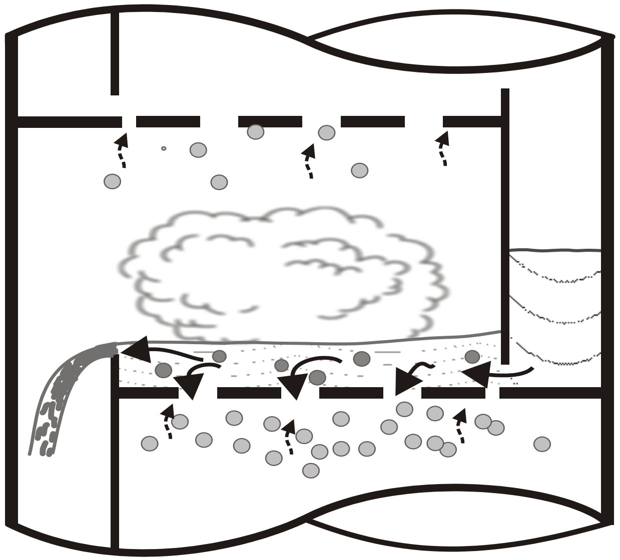


Anomalies on the operation of a tray column

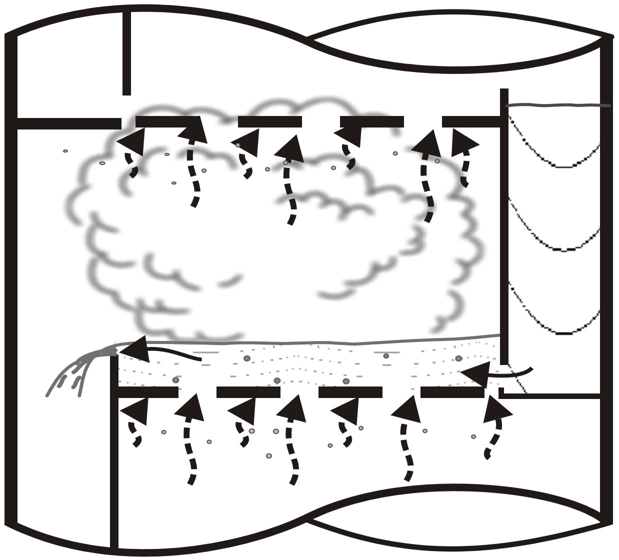


Anomalies on the operation of a tray column

Leaking



Flooding



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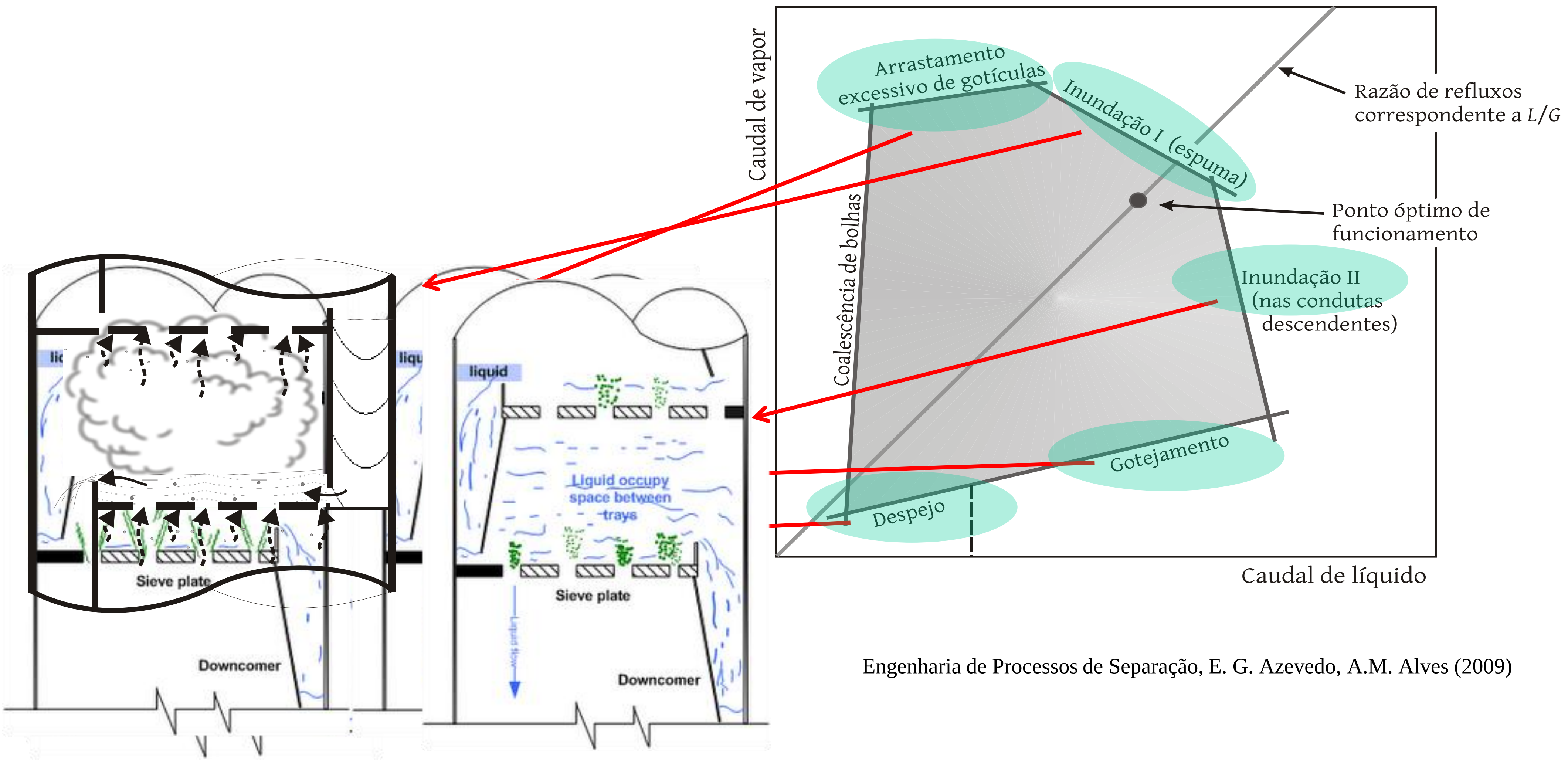
Anomalies on the operation of a tray column



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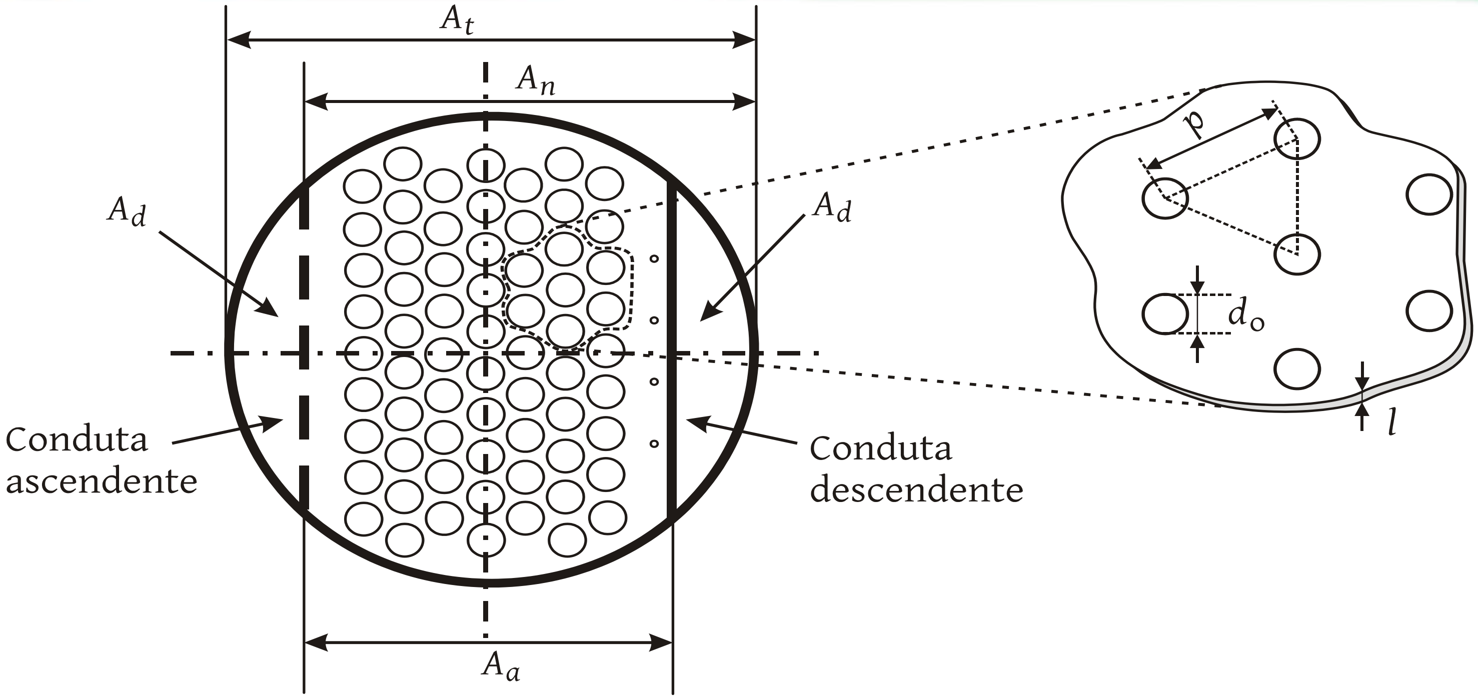
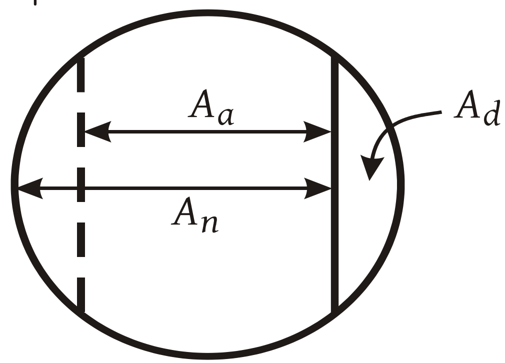
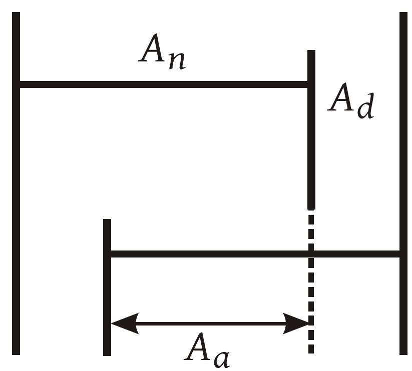
Areas of perforated trays



d_o= 3 -12 mm

p= 2.5 – 5 d_o





$A_n = A_a + A_d$

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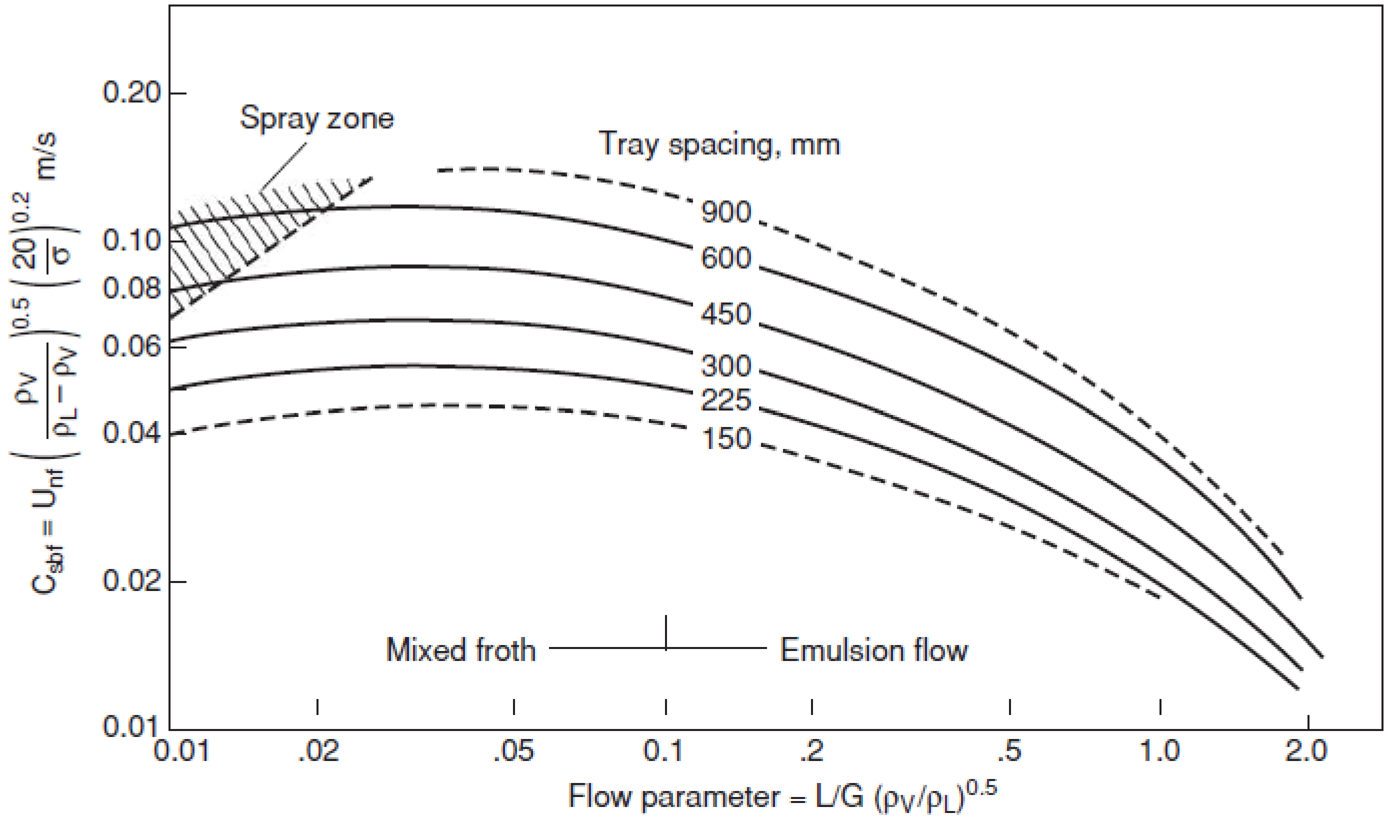
Evaluation of the diameter- tray columns



Fair correlation [*Pet/Chem Eng.* **33**(10), 45 (1961)]

U_{nf} = gas velocity through net area at flood, m/s
C_{sbf} = capacity parameter corrected for surface tension, m/s

σ = liquid surface tension, mN/m (dyn/cm)
ρ_L = liquid density, kg/m^3
ρ_G = gas density, kg/m^3

• Para L e G $\longrightarrow$ C_{sb}, flood

$\downarrow$

$\boxed{U_{nf}}$

$\boxed{U = a\, U_{nf}}$ $\quad 0.65 < a < 0.90$

Example 14.1 Column sizing and rating

An absorber column is to be designed for lowering the concentration of acetone in a stream of air using water as the absorbent. The results of a simulation run are summarized herewith:

	Mole Fraction			
	Absorbent	**Gas Feed**	**Liquid Bottoms**	**Vapor Overhead**
Nitrogen		0.771	1.0×10^{-5}	0.763
Oxygen		0.207	5.0×10^{-6}	0.205
Acetone		0.015	0.005	8.19×10^{-5}
Water	1.00	0.007	0.995	0.032
Flow rate, kmol/hr	2000.0	725.0	1992.5	732.5
Temperature, °C	26.0	27.0	23.0	25.0
Pressure, kPa	105.0	105.0	105.0	100.0
Molecular weight	18.01	29.22	18.21	28.51
Density, kg/m³	997.0	1.23	998.0	1.15

The absorber will be a trayed column, using sieve trays with the following specifications:

Hole area/total tray area	$A_h/A = 0.10$
Hole diameter	$d_h = 3/16$ inch
Weir height	$h_w = 2.0$ inch
Tray thickness	$l_t = 0.078$ inch
Height of downcomer clearance	$h_a = 1.5$ inch
Tray spacing	18 inch

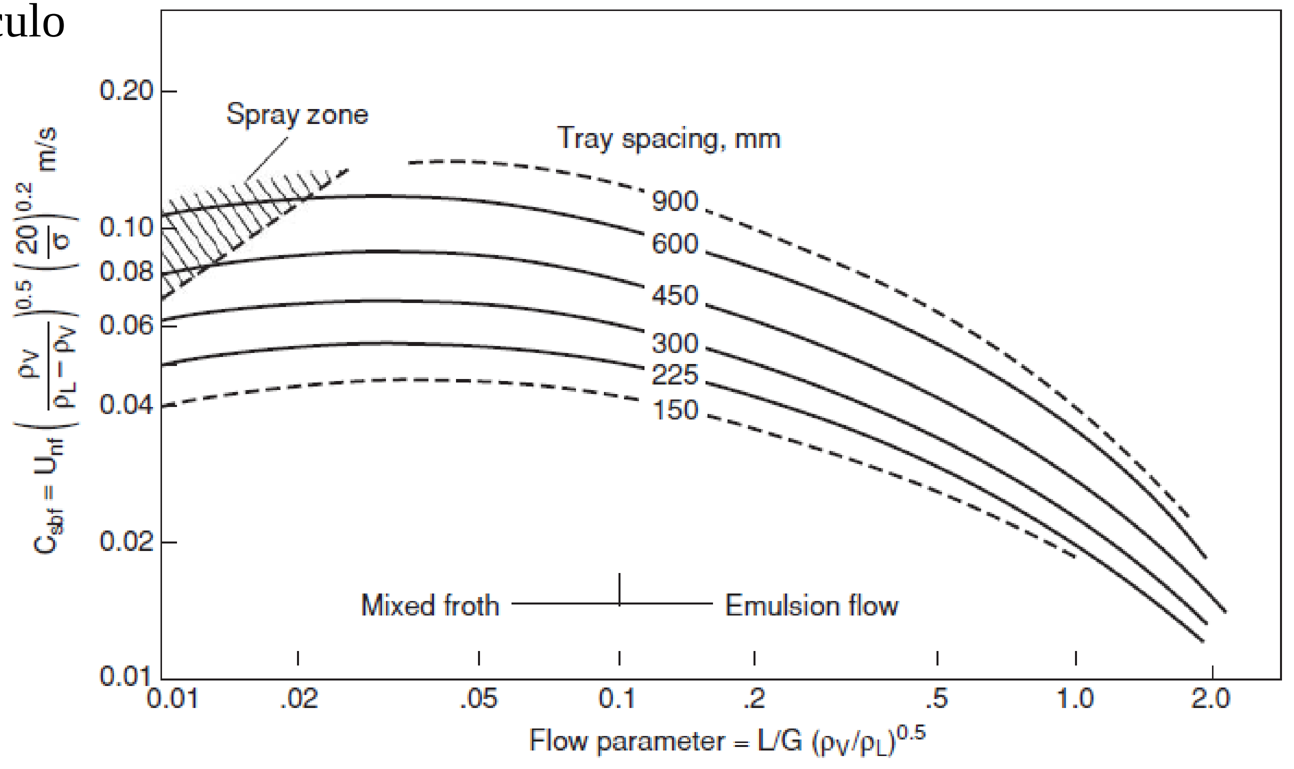
Additional properties and specifications include the following:

Surface tension	$\sigma = 68$ dyne/cm
Foaming factor	$F_F = 0.80$
Froth density in the downcomer	$\phi_d = 0.5$
Fraction of flood velocity	$f = 0.75$

Escolher zona da coluna para o cálculo do seu diâmetro

$$F = \left(\frac{L\,M_L}{V\,M_V}\right)\left(\frac{\rho_V}{\rho_L}\right)^{0.5}$$

$$= \left(\frac{2000.0 \times 18.01}{732.5 \times 28.51}\right)\left(\frac{1.15}{997.0}\right)^{0.5} = 0.0586$$



C_{sbf}:

- Tray spacing, 18-in = 457mm

=> C_{sbf} = 0.085 m/s

$$U_{nf} = C_{sbf}\left(\frac{\rho_L - \rho_V}{\rho_V}\right)^{0.5}\left(\frac{\sigma}{20}\right)^{0.2}$$

=> U_{nf} = 3.2 m/s

=> U = 0.75*3.2m/s = 2.4 m/s

Diâmetro?

$G = 732.5*28.51/1.15 = 18159.6\ m^3/h$

$U = 2.4\ m/s = 8640\ m/h$

$A_h = 2.1\ m^2$

Como $A_h/A = 0.1$ $\quad A = 21\ m^2$

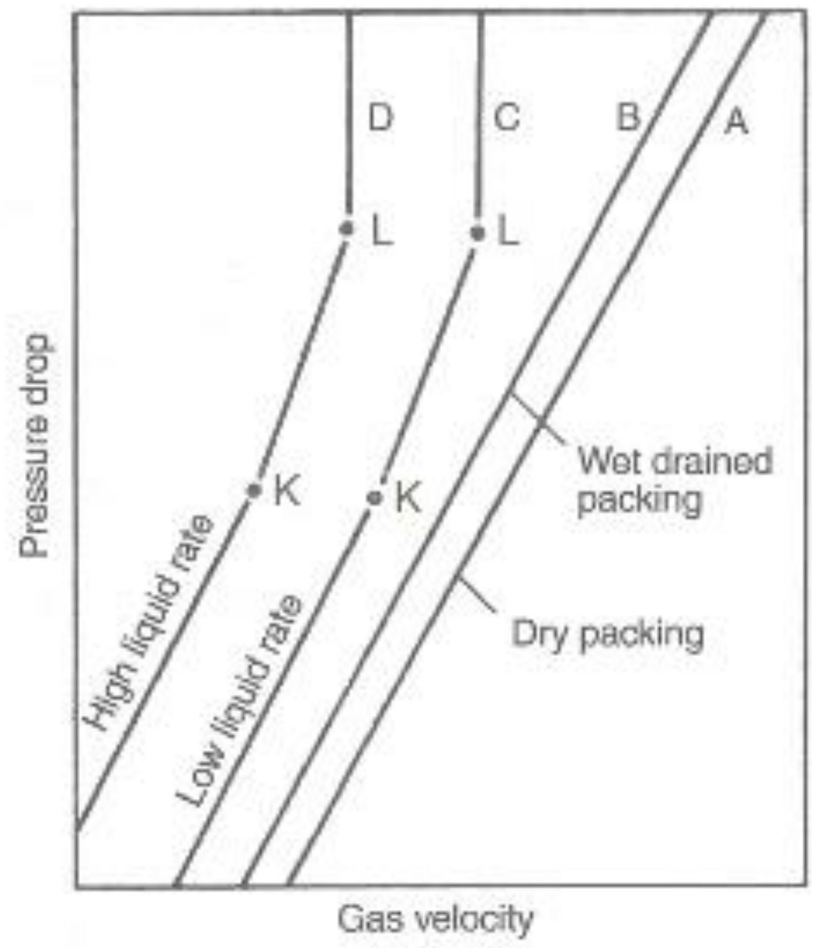
$D = 5.2\ m$

Pressure drop in a packing column

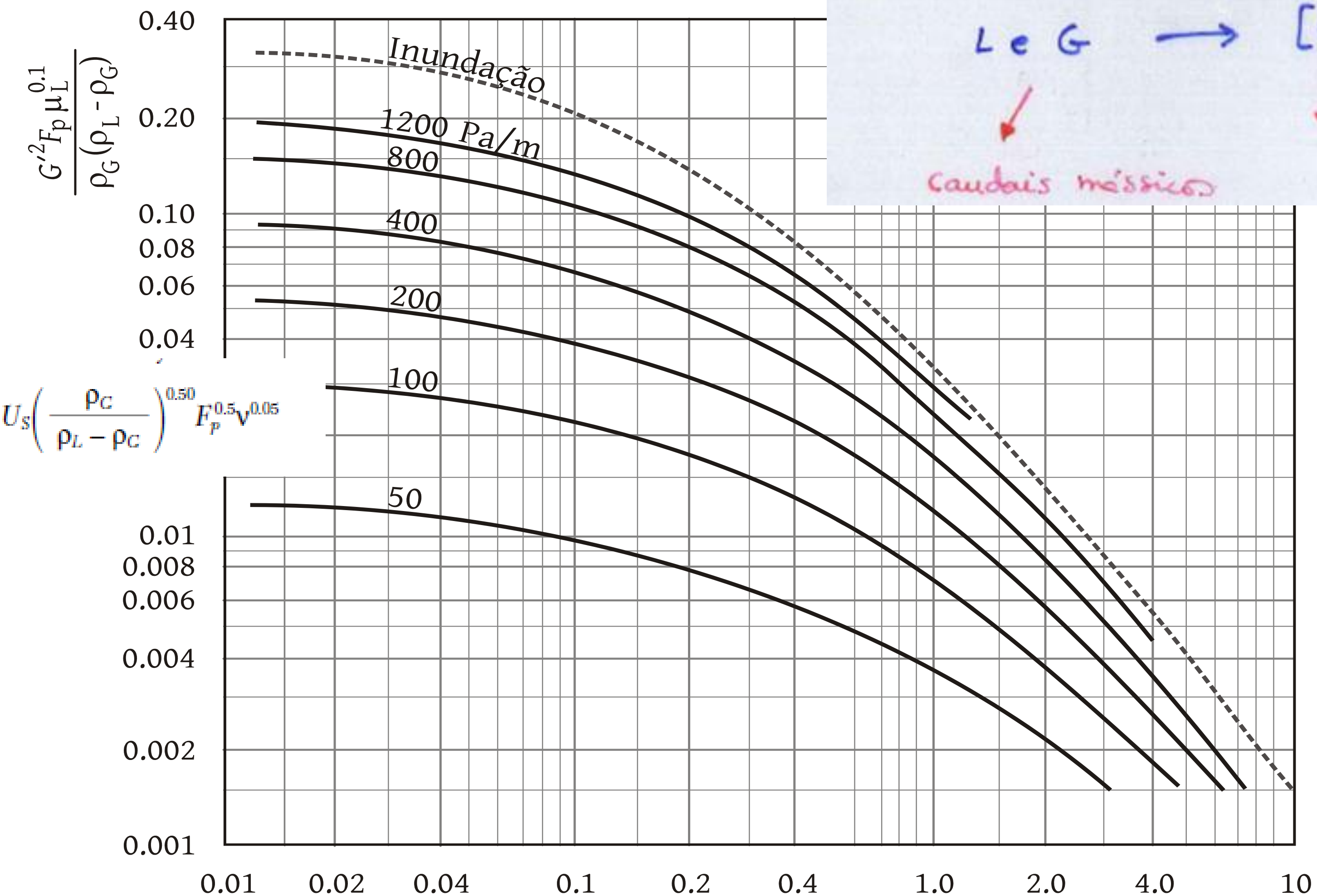
Point K is the loading point
Point L is the flooding point for the given liquid flow.

Loading point is a point where liquid hold up starts to increase and caused a change in the slope of the pressure drop

Flooding point is a point where the gas velocity will result in the pressure drop start to become almost vertical. Liquid rapidly accumulates, the entire column filled with liquid.



Evaluation of the diameter- packing columns



$$CP = C_S F_p^{0.5} \nu^{0.05} = U_S \left(\frac{\rho_G}{\rho_L - \rho_G} \right)^{0.50} F_p^{0.5} \nu^{0.05}$$

L e G → $[G]_{flood} = \frac{\text{massa}}{\text{tempo área}}$

caudais mássicos

$G_{op} = a\, G_{flood}$

$0.65 < a < 0.90$

$$\Psi = \frac{L'}{G'} \left(\frac{\rho_G}{\rho_L - \rho_G} \right)^{0.5}$$

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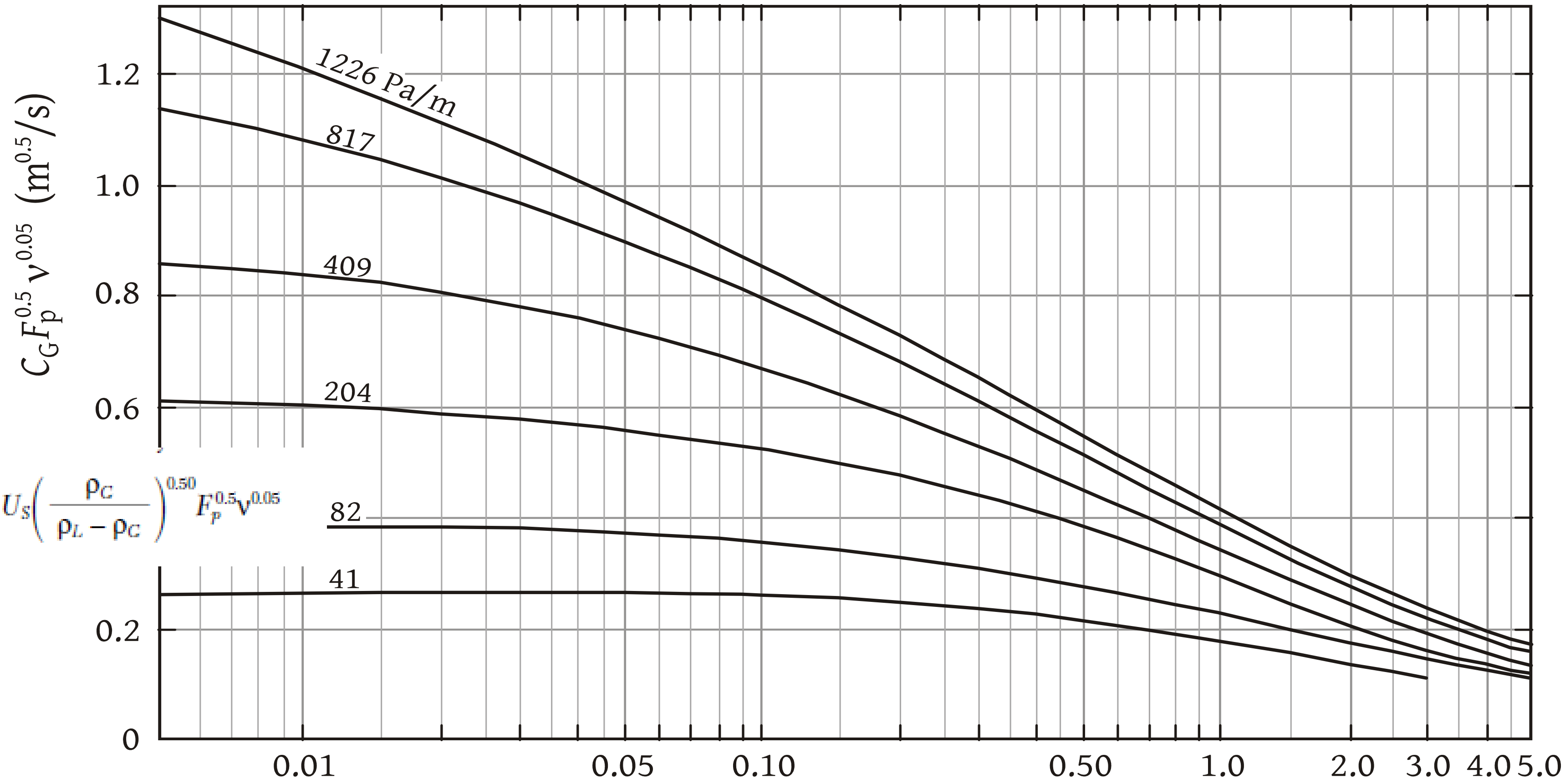
Random packing



$$CP = C_S F_p^{0.5} \nu^{0.05} = U_S \left(\frac{\rho_G}{\rho_L - \rho_G} \right)^{0.50} F_p^{0.5} \nu^{0.05}$$

$$\Psi = \frac{L'}{G'} \left(\frac{\rho_G}{\rho_L} \right)^{0.5}$$

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Amonia is absorbed from air at atmospheric pressure and temperature of 20ºC with water in a column operating in countercurrent mode.
The gas flowrate is 43.6 m^3/h and the water flowrate is 37.5 kg/h.
If amonia is reduced from 3.52% (v/v) to 1.3% (v/v) determine:

a) The compostion of amonia in the water leaving the column.
b) The minimum water flowrate.

The equilibrium line is $Y^*=1.3X$ with Y and X molar ratios.

$Y_{A1}=0.0365$ $Y_{A2}=0.013$ $L_s=2083$ mol/h $G_s=1750$ mol/h

a) $X_{A1}=0.0198$

b) $L_{s\,min}=1469$ mol/h