

$$R = (1 - E)^n \quad t_F = \frac{\mu \alpha' \rho_c}{2 \Delta P^{1-s}} \left(\frac{v_F}{A} \right)^2$$

$$t_W = 2t_F n f$$

$$f = v_R / v_F$$

$$n = v_W / v_R$$

$$v_F = Q t_C$$

$$t_F = \beta t_C$$

$$J = k \cdot \ln(c_G / c_F)$$

$$\frac{c_G}{c_F} = \exp \left[\frac{J}{k} \right]$$

$$k = \frac{D}{\delta}$$

Turbulent Flow (Re > 4000)

$$Sh = 0.023(Re)^{0.8} (Sc)^{0.33}$$

Laminar Flow (Re < 1800)

$$Sh = 1.86(Re)^{0.33} (Sc)^{0.33} (d_h / L)^{0.33}$$

$$Sh = \frac{k d_h}{D}$$

$$Re = \frac{d_h v_B \rho}{\mu}$$

$$Sc = \frac{\mu}{\rho D}$$

Constant Pressure Filtration (with $V = 0$ at $t = 0$)

$$\frac{t}{V/A} = \frac{\mu\alpha\rho_c}{2\Delta P} \left(\frac{V}{A} \right) + \frac{\mu R_M}{\Delta P}$$

Constant Pressure Filtration (with $V = V_s$ at $t = t_s$)

$$\frac{(t - t_s)}{(V - V_s)} = \frac{\mu\alpha\rho_c}{2A^2 \Delta P} (V + V_s) + \frac{\mu R_M}{A\Delta P}$$

Constant Rate Filtration

$$\Delta P = \alpha\mu\rho_c v^2 t + \mu R_M v$$

Constant Rate then, after t_s , Constant Pressure Filtration

Phase I: constant rate

$$\Delta P = \mu \alpha \rho_c v^2 t + \mu R_M v \quad (t < t_s)$$

$$V = Q_f t = \text{constant} \quad (V \leq V_s)$$

Phase II: constant pressure

$$\Delta P = \Delta P_s = \text{constant} \quad (t \geq t_s)$$

$$\frac{(t - t_s)}{(V - V_s)} = \frac{\mu\alpha\rho_c}{2A^2 \Delta P} (V + V_s) + \frac{\mu R_M}{A\Delta P} \quad (V > V_s)$$