1)

$$C'_m{}_{(s)} = \frac{K_p}{\tau_p s+1} \cdot \bar{C}_{(s)}$$

$5\tau_p = 6 \rightarrow \tau_p = 1{,}2$

9,0

$$K_p = \frac{\Delta C_m}{\Delta \bar{C}(s)} \quad \frac{3}{3} = 1$$

2)

a) $$\bar{h}(s) = \frac{1/\beta}{\frac{A}{\beta} s+1} \cdot \bar{F}_1(s) \xrightarrow{} q_i \; - \cancel{\frac{1/\beta}{\frac{A}{\beta} s+1} \cdot \bar{F}_3(s)}$$

$$\rightarrow \bar{h}(s) = \frac{1/\beta}{\frac{A}{\beta} s+1} \cdot q_i(s) \quad (1)$$

p/ 2° caso: $\bar{h}s = \frac{1}{A \cdot s} \cdot \bar{q_i}s - \frac{1}{A \cdot s} \cdot \bar{q}s \rightarrow \frac{1}{A \cdot s} \cdot q_i \cdot s$

$$\rightarrow \frac{1/A}{\frac{A \cdot s}{A}} \cdot q_i s \rightarrow h_s = \frac{0{,}2109}{s^2}$$

p/ área:

$$A = \frac{\pi D^2}{4} \rightarrow A = 12{,}56 \text{ ft}^2$$

Dados convertidos:

$q(t) = 8{,}33$ gal/min $\rightarrow 1{,}11$ ft³/min (β)

$q_i = 70$ gal/min $\rightarrow 9{,}3576$ ft³/min

degrau $= 20 \rightarrow 2{,}67$ ft³/min

$K_p = 1/\beta = 1/1{,}11 \rightarrow K_p = 0{,}9$ ft³/min

$\rightarrow$ Substituindo em (1):

$$\bar{h}(s) = \frac{\overbrace{1/\beta}^{\rightarrow K_p}}{\underbrace{\frac{A}{\beta}}_{\rightarrow \tau_p} s+1} \cdot \frac{q_i}{s} \rightarrow \frac{0{,}9}{\frac{12{,}56}{1{,}11} s+1} \cdot \frac{2{,}67}{s}$$

b) $$\bar{h}(s) = \frac{1/\beta}{\frac{A}{\beta} s+1} \cdot \frac{q_i}{s} \rightarrow \mathcal{L}^{-1}\{h(\beta)\} = 1/\beta \, \mathcal{L}^{-1}\left\{\frac{q_i}{s(A/\beta s+1)}\right\}$$

$$\rightarrow h'(t) = \frac{1}{\beta} \cdot (q_i \cdot e^{-\beta/A \, t}) \rightarrow \frac{1}{\beta} \cdot q_i (1 - e^{-t/\tau_p}) \rightarrow \frac{1}{1{,}11} \cdot 2{,}67 (1 - e^{-t/11{,}31})$$

p/ 2° caso:

$$\mathcal{L}^{-1}\{\bar{h}s\} = 0{,}2191 \cdot \mathcal{L}^{-1}\left\{\frac{1}{s^2}\right\} \rightarrow h(t) = 0{,}2191 \cdot t$$

c) $\lim_{s \to 0} s \cdot h_s$

$\to \lim_{s \to 0} \cancel{s} \cdot \dfrac{0{,}9}{\underbrace{12{,}56}_{1{,}11} s+1} \cdot \dfrac{2{,}67}{\cancel{s}} = \underline{2{,}403}$

p/ 2º caso:

$\lim_{s \to 0} s \cdot \bar{h}_s \to s \cdot \dfrac{1}{A \cdot s} \cdot \dfrac{A}{s} = \underline{+\infty}$

d) p/ $h = \underline{8\,ft}$:

$8\,ft = 0{,}9\ ft^3/min \cdot 2{,}67\left(1 - e^{t/11{,}31}\right)$

$8\,ft = 2{,}403\left(1 - e^{t/11{,}31}\right) \to 2{,}403 - 2{,}403\, e^{t/11{,}31}$

$\to \ln 5{,}597 = -2{,}403 \ln e^{t/11{,}31}$

$\to 1{,}72 = 2{,}403 \cdot t/11{,}31 \to t = \underline{8{,}19\ min}$

p/ 2º caso:

$8\,ft = 0{,}2191 \cdot t \to t = \underline{36{,}5\cancel{1}\ min}$

A partir dos cálculos acima, pode-se considerar que o tanque do 1º caso transbordará primeiro.