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1) Effluent bsCOD

$$S = \frac{K_s[1 + b(SRT)]}{SRT(Yk - b) - 1} = \frac{10 \cdot (1 + 0.10 \cdot 6)}{6 \cdot (0.40 \cdot 12.5 - 0.10) - 1} = 0.56\ g\ bsCOD/m^3$$

caution: for simplicity units are not shown – check by yourself!

2) HRT required to achieve $X_{VSS} = 2500\ g/m^3$

$$X_{VSS} = \left(\frac{SRT}{\tau}\right)\left[\frac{Y(S^0 - S)}{1 + b(SRT)}\right] + (f_d)(b)(X_a)(SRT) + \frac{{X_i}^0(SRT)}{\tau}$$

$$2500 = \left(\frac{6}{\tau}\right)\left[\frac{0.40 \cdot (192 - 0.56)}{1 + 0.10 \cdot 6}\right] + 0.15 \cdot 0.10 \cdot X_a \cdot 6 + \frac{30 \cdot 6}{\tau}$$

Note that the first term of the left hand side, $\left(\frac{SRT}{\tau}\right)\left[\frac{Y(S^0 - S)}{1+b(SRT)}\right]$, equals to X_a

$$2500 = \frac{287.2}{\tau} + 0.15 \cdot 0.10 \cdot \frac{287.2}{\tau} \cdot 6 + \frac{30 \cdot 6}{\tau}$$

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$$2500 = \frac{493.0}{\tau}$$

$$\tau = 0.197\ d$$

3) Daily sludge production

$$P_{X,VSS} = \frac{X_{VSS}V}{SRT}$$

$$V = Q \cdot \tau = 1000\ m^3/d \cdot 0.197d = 197\ m^3$$

$$P_{X,VSS} = \frac{2500\ g/m^3 \cdot 197\ m^3}{6\ d} = 8.21 \times 10^4\ g\ VSS/d = 82.1\ kg\ VSS/d$$

$$P_{X,TSS} =$$

$$\frac{1}{0.85} \cdot \frac{QY(S^0 - S)}{1 + b(SRT)} + \frac{1}{0.85} \cdot \frac{(f_d)(b)YQ(S^0 - S)SRT}{1 + b(SRT)} + QX_i{}^0 + Q\left(X_{TSS}{}^0 - X_{VSS}{}^0\right)$$

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$$P_{X,TSS} = \frac{1}{0.85} \cdot \frac{1000 \cdot 0.40 \cdot (192 - 0.56)}{1 + 0.10 \cdot 6}$$

$$+ \frac{1}{0.85} \cdot \frac{0.15 \cdot 0.10 \cdot 0.40 \cdot 1000 \cdot (192 - 0.56) \cdot 6}{1 + 0.10 \cdot 6} + 1000 \cdot 30 + 1000 \cdot 10$$

$$= 1.01 \times 10^5\ g\ TSS/d = 101\ kg\ TSS/d$$

4) Fraction of active biomass in MLVSS

From

$$X_{VSS} = \left(\frac{SRT}{\tau}\right)\left[\frac{Y(S^0 - S)}{1 + b(SRT)}\right] + (f_d)(b)(X_a)(SRT) + \frac{{X_i}^0(SRT)}{\tau}$$

$$= \frac{287.2}{\tau} + \frac{25.8}{\tau} + \frac{180}{\tau}$$

The first term is active biomass

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$$Active\ biomass\ fraction = \frac{287.2/\tau}{287.2/\tau + 25.8/\tau + 180/\tau} = 0.58$$

5) Oxygen requirement

$$R_o = Q(S_o - S) - 1.42P_{X,bio}$$

Recall

$$P_{X,VSS} = \frac{QY(S^0 - S)}{1 + b(SRT)} + \frac{(f_d)(b)YQ(S^0 - S)SRT}{1 + b(SRT)} + Q{X_i}^0$$

$$P_{X,bio} = \frac{QY(S^0 - S)}{1 + b(SRT)} + \frac{(f_d)(b)YQ(S^0 - S)SRT}{1 + b(SRT)}$$

So:

$$P_{X,bio} = P_{X,VSS} - Q{X_i}^0$$

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$$P_{X,bio} = 82.1\ kg\ VSS/d - 1000\ m^3/d \cdot 30\ g/m^3 \cdot 10^{-3}\ kg/g$$

$$= 52.1\ kg\ VSS/d$$

$$R_o = 1000\ m^3/d \cdot (192 - 0.56)\ g/m^3 \cdot 10^{-3}\ kg/g - 1.42 \cdot 52.1\ kg\ VSS/d$$

$$= 117\ kg\ O_2/d$$