

Errata

Chapter 6 Design of Water Treatment Systems

On page 240, Table 6.1A, for **asbestos**, text within parenthesis should read "**fibers $\geq 10 \mu\text{m}$** "

On page 245, top left column, replace 0.0101 mg/L for bromate with **0.010** mg/L for bromate.....

On page 245, bottom left column, replace action level of 0.15 mg/L for lead with **0.015** mg/L...

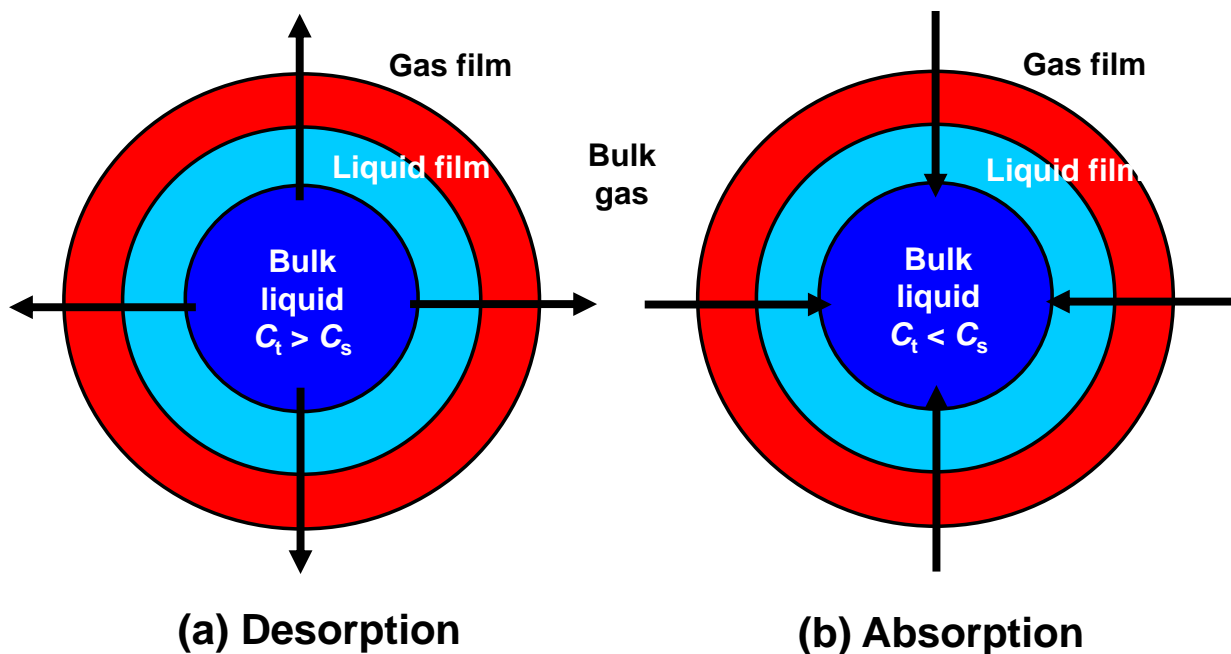
On page 245, top right column, under 6.1.3.11, should read as "waterborne diseases caused by **viruses**, *Legionella*, and *Giardia lamblia*."

On page 249, Table 6.5, the flow capacity of the **distribution system** should be listed as "**Peak hourly demand or coincident demand**"

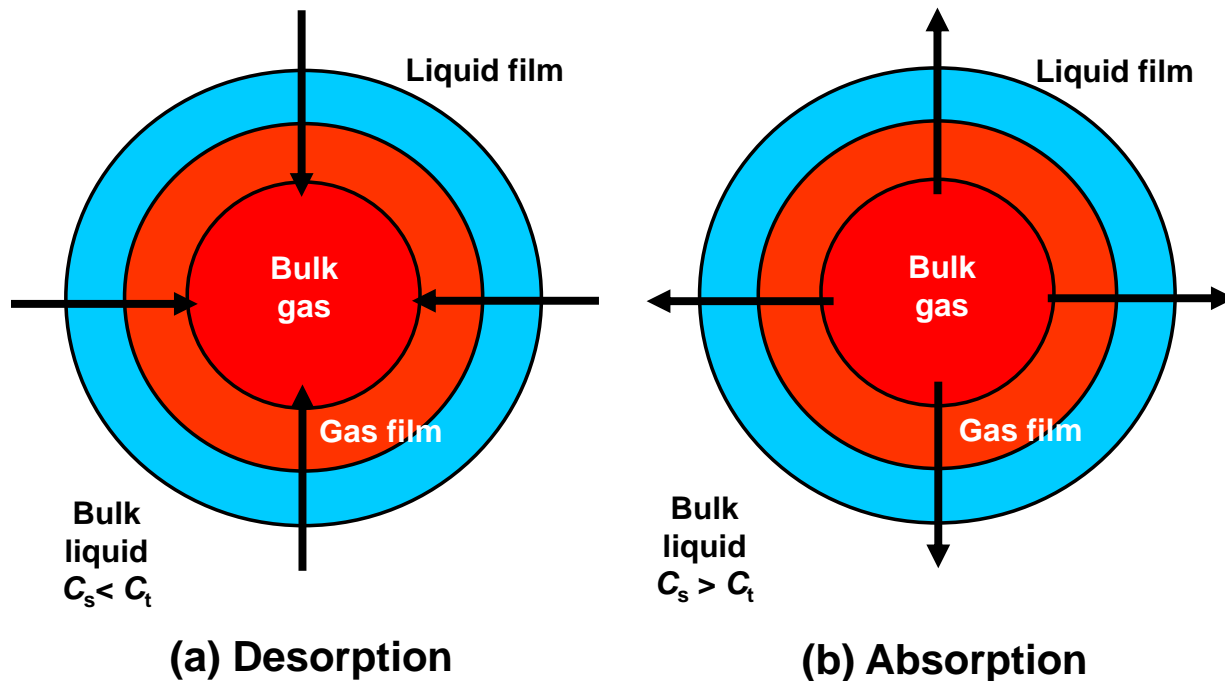
On page 249, Example 6.2, **Solution part c** should read as follows:

All unit processes at the water treatment plant should be designed to treat the peak daily demand plus reserve of **68.2 MGD.**

On page 251, Figure 6.2 should be revised to appear as follows:



On page 251, Figure 6.3 should be revised to appear as follows:



On page 253, Equation (6.8) should be as follows:

$$P_A \cong H_A^x \frac{C_A}{55.6}$$

On page 253, top of right column below Figure 6.5, the text should read as follows:

Expressing **Equation (6.12)** mathematically results in:

On pages 256 to 258, Example 6.4 was incorrectly worked with the wrong air density. The correct problem is presented below:

EXAMPLE 6.4 Preliminary design of packed tray aerator

A packed tray aerator or air stripper is to be designed to lower the TCE concentration in a contaminated groundwater from 100 µg/L to 5µg/L. The water volumetric flow rate is 2000 m³/d and the Henry’s law coefficient for TCE is 307 atm and the mass transfer coefficient ($K_L a$) for TCE is 0.0176 s⁻¹. Assume that the diameter of the stripping column is 1.0 m, a temperature of 20°C, and an air-to-liquid ratio of 20:1. Pall rings with a packing factor of 50 will be used in the design. The air density (ρ_{air}) at 20°C = **1.204** kg/m³ and water density (ρ_{water}) at 20°C = 998.2 kg/ m³.

Determine the following:

- a. Dimensionless Henry’s constant.
- b. Stripping factor (S).
- c. Height of transfer unit (HTU) in meters and feet.

- d. Number of transfer units (NTU).
- e. Height of packing in column (Z) in meters and feet.
- f. Pressure drop through tower in Pascals.

Solution part a

Calculate the dimensionless Henry's constant using Equation(6.11).

$$H = (H_A^x \text{ atm}) \left(\frac{1 \text{ mole} \cdot \text{K}}{R \text{ atm} \cdot \text{L}} \right) \left(\frac{1}{T \text{ K}} \right) \left(\frac{\text{L}}{55.6 \text{ mole}} \right) = \frac{H_A^x}{RT(55.6)}$$

$$H = (307 \text{ atm}) \left(\frac{1 \text{ mole} \cdot \text{K}}{0.08206 \text{ atm} \cdot \text{L}} \right) \left(\frac{1}{273.15 + 20 \text{ K}} \right) \left(\frac{\text{L}}{55.6 \text{ mole}} \right) = \boxed{0.23}$$

Solution part b

The stripping factor is determined from Equation (6.22).

$$S = \frac{(Q_a/Q_l)}{(Q_a/L)_{\min}} = \frac{(Q_a/Q_l)}{(1/H)} = H \left(\frac{Q_a}{Q_l} \right)$$

$$S = 0.23 \left(\frac{20}{1} \right) = \boxed{4.6}$$

Solution part c

The height of a transfer unit is determined from Equation(6.40). First, the cross-sectional area of the column must be calculated as follows.

$$A = \frac{\pi D^2}{4} = \frac{\pi (1.0 \text{ m})^2}{4} = 0.79 \text{ m}^2$$

$$\text{HTU} = \frac{Q_l}{A K_L a}$$

$$\text{HTU} = \frac{2000 \text{ m}^3/\text{d}}{(0.79 \text{ m}^2)(0.0176 \text{ s}^{-1})} \left(\frac{1 \text{ d}}{24 \text{ h}} \right) \left(\frac{1 \text{ h}}{60 \text{ min}} \right) \left(\frac{1 \text{ min}}{60 \text{ s}} \right) = \boxed{1.7 \text{ m} = 5.6 \text{ ft}}$$

Solution part d

The number of transfer units is determined from Equation(6.41).

$$\text{NTU} = \left[\frac{S}{S-1} \right] \ln \left[\frac{(C_0/C_e)(S-1)+1}{S} \right]$$

$$NTU = \left[\frac{4.6}{4.6-1} \right] \ln \left[\frac{(100 \mu\text{g/L}/5 \mu\text{g/L})(4.6-1)+1}{4.6} \right] = \boxed{3.5}$$

Solution part e

The height of packing in column is calculated from Equation(6.39).

$$Z = HTU \times NTU = 1.7 \times 3.5 = \boxed{6.0 \text{ m}}$$

The actual height of the packing material will be increased by 20%.

$$Z = 6.0 \text{ m} \times 1.20 = 7.2 \cong \boxed{7.2 \text{ m} = 24 \text{ ft}}$$

Solution part f

The air density (ρ_{air}) at $20^\circ\text{C} = 1.204 \text{ kg/m}^3$ and water density (ρ_{water}) at $20^\circ\text{C} = 998.2 \text{ kg/m}^3$ and $\mu_l = 1.002 \times 10^{-3} \text{ N}\cdot\text{s/m}^2$.

$$\frac{G_m}{L_m} = \left(\frac{Q_a}{Q_l} \right) \left(\frac{\rho_g}{\rho_l} \right) = \left(\frac{20}{1} \right) \left(\frac{1.204 \text{ kg/m}^3}{998.2 \text{ kg/m}^3} \right) = 0.024 \frac{\text{kg air}}{\text{kg water}}$$

$$\text{value for } x\text{-axis} = \frac{L_m}{G_m} \left(\frac{\rho_g}{\rho_l - \rho_g} \right)^{0.5} = \frac{\text{kg water}}{0.024 \text{ kg air}} \left(\frac{1.204 \text{ kg/m}^3}{998.2 \text{ kg/m}^3 - 1.204 \text{ kg/m}^3} \right)^{0.5}$$

$$\text{value for } x\text{-axis} = \boxed{1.45}$$

$$\frac{Q_a}{Q_l} = 20 \quad Q_a = 20 \times Q_l = 20 \times 2000 \frac{\text{m}^3}{\text{d}} = 40,000 \frac{\text{m}^3}{\text{d}}$$

$$G_m = 40,000 \frac{\text{m}^3}{\text{d}} \left(\frac{1.204 \text{ kg}}{\text{m}^3} \right) \left(\frac{1 \text{ d}}{24 \text{ h}} \right) \left(\frac{1 \text{ h}}{3600 \text{ s}} \right) \left(\frac{1}{0.79 \text{ m}^2} \right)$$

$$G_m = 0.71 \frac{\text{kg}}{\text{m}^2 \cdot \text{s}}$$

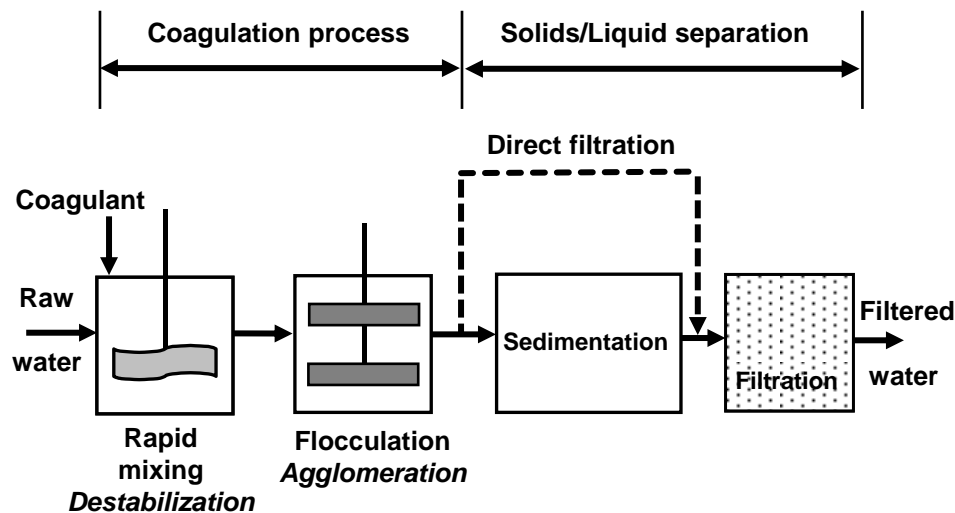
$$\text{value from } y\text{-axis} = \left[\frac{(G_m)^2 (C_f) (\mu_l)^{0.1}}{\rho_g (\rho_l - \rho_g)} \right] = \left[\frac{\left(0.71 \frac{\text{kg}}{\text{m}^2 \cdot \text{s}} \right)^2 (50) (1.002 \times 10^{-3} \text{ N}\cdot\text{s/m}^2)^{0.1}}{1.204 \text{ kg/m}^3 (998.2 \text{ kg/m}^3 - 1.204 \text{ kg/m}^3)} \right]$$

$$\text{value from } y\text{-axis} = \boxed{0.0105}$$

From Figure 6.7 using the x- and y- coordinates calculated above, the pressure drop in $\text{N}/(\text{m}^2)$ per meter of packing is approximately 250.

$$\text{Pressure Drop} = 110 \frac{\text{N}}{\text{m}^2 \cdot \text{m}} (7.2 \text{ m}) = 792 \frac{\text{N}}{\text{m}^2} = 7,92 \text{ Pa}$$

On page 259, replace Figure 6.8 with the following figure.



On page 263, Example 6.5 should be revised as follows:

EXAMPLE 6.5 Coagulant dose

A surface water containing 100 mg/L of natural alkalinity as CaCO_3 is coagulated with an alum dose of 125 mg/L. Determine if there is sufficient alkalinity present in the source water to prevent inhibition of alum coagulation. If there is insufficient alkalinity present, calculate the amount of lime necessary to react with the alum.

Solution

MW of CaCO_3 is: $40 + 12 + 3(16) = 100 \text{ g/mole}$

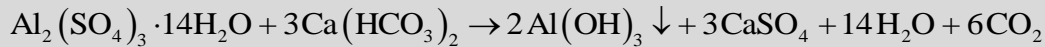
$$\text{EW of } \text{CaCO}_3 \text{ is: } \frac{100 \text{ g/mole}}{2 \text{ eq}} = 50 \frac{\text{g}}{\text{eq}}$$

MW of $\text{Ca}(\text{HCO}_3)_2$ is: $40 + (1+12+3 \times 16) \times 2 = 162 \text{ g/mole}$

$$\text{EW of Ca(HCO}_3)_2 \text{ is: } \frac{162 \text{ g / mole}}{2 \text{ eq}} = 81 \frac{\text{g}}{\text{eq}} .$$

MW of $\text{Al}_2(\text{SO}_4)_3 \cdot 14\text{H}_2\text{O}$ is: $2(27) + (32+4 \times 16) \times 3 + 14(2 \times 1 + 16) = 594 \text{ g/mole}$

From Equation(6.47) calculate the alkalinity required to react with the alum.



Approximately 63 mg/L of alkalinity expressed as $\text{Ca}(\text{HCO}_3)_2$ is required to react with the alum.

$$125 \frac{\text{mg Alum}}{\text{L}} \left(\frac{3 \times 162 \text{ g Ca}(\text{HCO}_3)_2}{594 \text{ g Alum}} \right) \left(\frac{\text{eq}}{81 \text{ g Ca}(\text{HCO}_3)_2} \right) \left(\frac{50 \text{ g CaCO}_3}{\text{eq}} \right) =$$

$$63 \frac{\text{mg CaCO}_3}{\text{L}}$$

On page 272, Example 6.12 should be revised slightly as shown below.

EXAMPLE 6.12 Selective calcium removal

Calculate the lime, soda ash (if necessary), carbon dioxide dosages for recarbonation, and solids production for selective calcium removal given the following water analysis. Develop a bar graph showing the original theoretical species in the water.

$\text{CO}_2 = 13.2 \text{ mg/L}$ Alkalinity (HCO_3^-) = 125 mg/L as CaCO_3 $\text{Mg}^{2+} = 12.2 \text{ mg/L}$
 $\text{Na}^+ = 50.6 \text{ mg/L}$ $\text{Ca}^{2+} = 94 \text{ mg/L}$ $\text{SO}_4^{2-} = 139.2 \text{ mg/L}$ $\text{Cl}^- = 88.75 \text{ mg/L}$

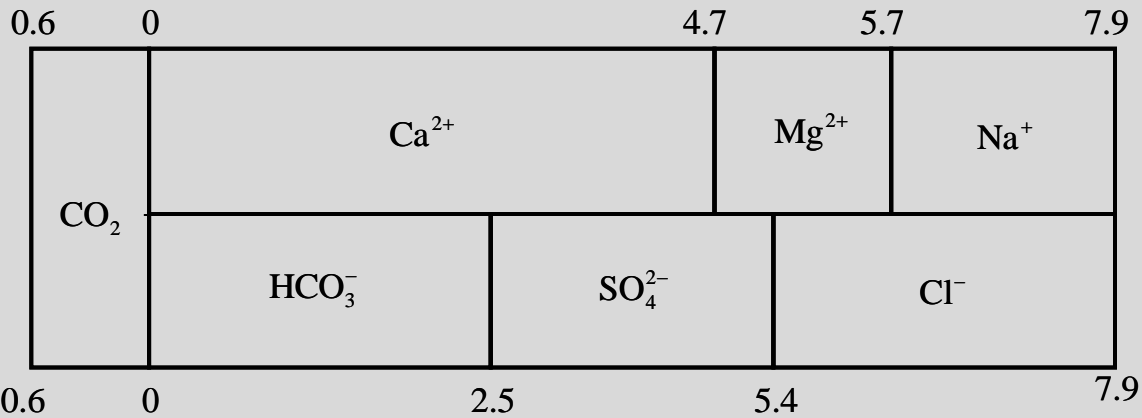
Solution

The following table presents concentrations, equivalent weights, and milliequivalents of all species analyzed.

Component	Concentration (mg/L)	Equivalent weight	Calculation	Concentration (meq/L)
$\text{CO}_2/\text{H}_2\text{CO}_3$	13.2	22	$13.2/22 =$	0.60
Ca^{2+}	94	20	$94/20 =$	4.70
Mg^{2+}	12.2	12.2	$12.2/12.2 =$	1.00
Na^+	50.6	23	$50.6/23 =$	2.20
Alkalinity (HCO_3^-)	125	50	$125/50 =$	2.50
SO_4^{2-}	139.2	48	$139.2/48 =$	2.90
Cl^-	88.75	35.5	$88.75/35.5 =$	2.50

The figure below is a bar graph showing the theoretical combination of chemical species in the raw water. Carbon dioxide is placed to the left of the bar graph if present. Cations are always placed at the top of the bar graph; calcium, magnesium, sodium, and potassium are shown in this order. Anions are shown at the bottom of the bar graph and should be sequenced as follows: hydroxide, carbonate,

bicarbonate, sulfate, and chloride. The water should be electrically neutral so the concentration of cations must balance the anions. If not, the water analysis is suspect. Viessman et al. (2009, pp. 409 – 419) and McGhee (1991, pp. 246 – 253) provide details on bar graph development.



Bar graph of the raw water for Example 6.12.

Since selective calcium hardness removal is being practiced and the concentration of magnesium hardness is relatively low, 50 mg/L as CaCO₃ (1.0 meq/L × 50 mg/meq), lime and soda ash will be required to lower the calcium hardness to approximately 30 mg/L as CaCO₃. Lime addition will be required for the neutralization of carbon dioxide according to Equation (6.73) and for the conversion of calcium bicarbonate to calcium carbonate according to Equation (6.74). Non-calcium carbonate hardness (CaSO₄) can only be removed by precipitating with sodium carbonate according to Equation (6.79).

Component (1)	Equation number (2)	Concentration, meq/L (3)	CaO, meq/L (4)	Na ₂ CO ₃ , meq/L (4)
CO ₂ /H ₂ CO ₃	(6.73)	0.6	0.6	0
Ca(HCO ₃) ₂	(6.74)	2.5	2.5	0
CaSO ₄	(6.79)	2.2	0	2.2

*Residual calcium in water is equal to 30 mg/L as CaCO₃ or 0.6 meq/L.

The final hardness of the water is calculated as follows and is related to the original magnesium concentration in the water plus the remaining calcium in the water, which is equal to the practical solubility of 30 mg/L as CaCO₃.

Lime Dosage

$$\left(0.6 \frac{\text{meq}}{\text{L}} + 2.5 \frac{\text{meq}}{\text{L}}\right) \times 28 \frac{\text{mg CaO}}{\text{meq}} = \boxed{87 \frac{\text{mg CaO}}{\text{L}}}$$

Soda Ash Dosage

$$\left(2.2 \frac{\text{meq}}{\text{L}}\right) \times 53 \frac{\text{mg Na}_2\text{CO}_3}{\text{meq}} = 117 \frac{\text{mg Na}_2\text{CO}_3}{\text{L}}$$

Carbon Dioxide Dosage

First-stage recarbonation will be required to stabilize the water. Assume a CaCO_3 concentration of 30 mg/L in the effluent from the settling basin and that 50% of the carbonate is converted into bicarbonate resulting in an equilibrium concentration of 15 mg/L of CaCO_3 .

From Equation (6.81) the carbon dioxide required is:

$$\left(15 \frac{\text{mg CaCO}_3}{\text{L}}\right) \left(\frac{\text{meq CaCO}_3}{50 \text{ mg CaCO}_3}\right) \left(\frac{\text{meq CO}_2}{\text{meq CaCO}_3}\right) \left(\frac{22 \text{ mg CO}_2}{\text{meq CO}_2}\right) = 6.6 \frac{\text{mg CO}_2}{\text{L}}$$

Solids production as CaCO_3

$$\left(0.6 \frac{\text{meq}}{\text{L}} + 2.5 \frac{\text{meq}}{\text{L}} + 2.2 \frac{\text{meq}}{\text{L}} - 0.6 \frac{\text{meq}}{\text{L}}\right) \times 50 \frac{\text{mg CaCO}_3}{\text{meq}} = 235 \frac{\text{mg CaCO}_3}{\text{L}}$$

Bar graph of finished water based on the following concentration of ions.

$$\text{Ca}^{2+} = 0.6 \frac{\text{meq}}{\text{L}} \quad \text{Mg}^{2+} = 1.0 \frac{\text{meq}}{\text{L}}$$

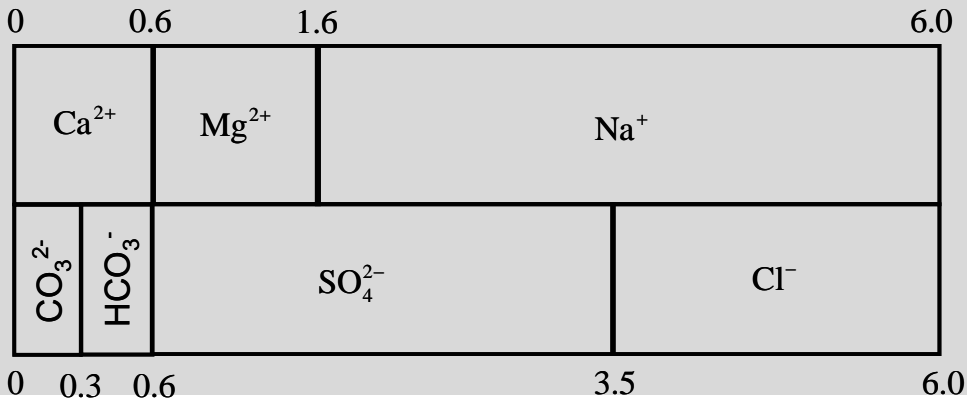
$$\text{Na}^+ = 2.2 \frac{\text{meq}}{\text{L}} + 2.2 \frac{\text{meq}}{\text{L}} = 4.4 \frac{\text{meq}}{\text{L}}$$

$$\text{CO}_3^{2-} = 0.5 \times \left(\frac{30 \text{ mg CaCO}_3/\text{L}}{50 \text{ mg CaCO}_3/\text{meq}}\right) = 0.3 \frac{\text{meq}}{\text{L}}$$

$$\text{HCO}_3^- = 0.5 \times \left(\frac{30 \text{ mg CaCO}_3/\text{L}}{50 \text{ mg CaCO}_3/\text{meq}}\right) = 0.3 \frac{\text{meq}}{\text{L}}$$

$$\text{SO}_4^{2-} = 2.9 \frac{\text{meq}}{\text{L}} \quad \text{Cl}^- = 2.5 \frac{\text{meq}}{\text{L}}$$

Finished Water Bar Graph



On page 277, left column, units are not shown correctly; should be as follows:

- g = acceleration of gravity, ft/s^2 (m/s^2),
- C_d = coefficient of drag (Dimensionless),
- ρ_p = mass density of particle, $\text{lb}\cdot\text{s}^2/\text{ft}^4$ (kg/m^3), and
- ρ = mass density of liquid, $\text{lb}\cdot\text{s}^2/\text{ft}^4$ (kg/m^3).

On page 281, Table 6.11, the units for weir loading rate are incorrect. See the corrected table below.

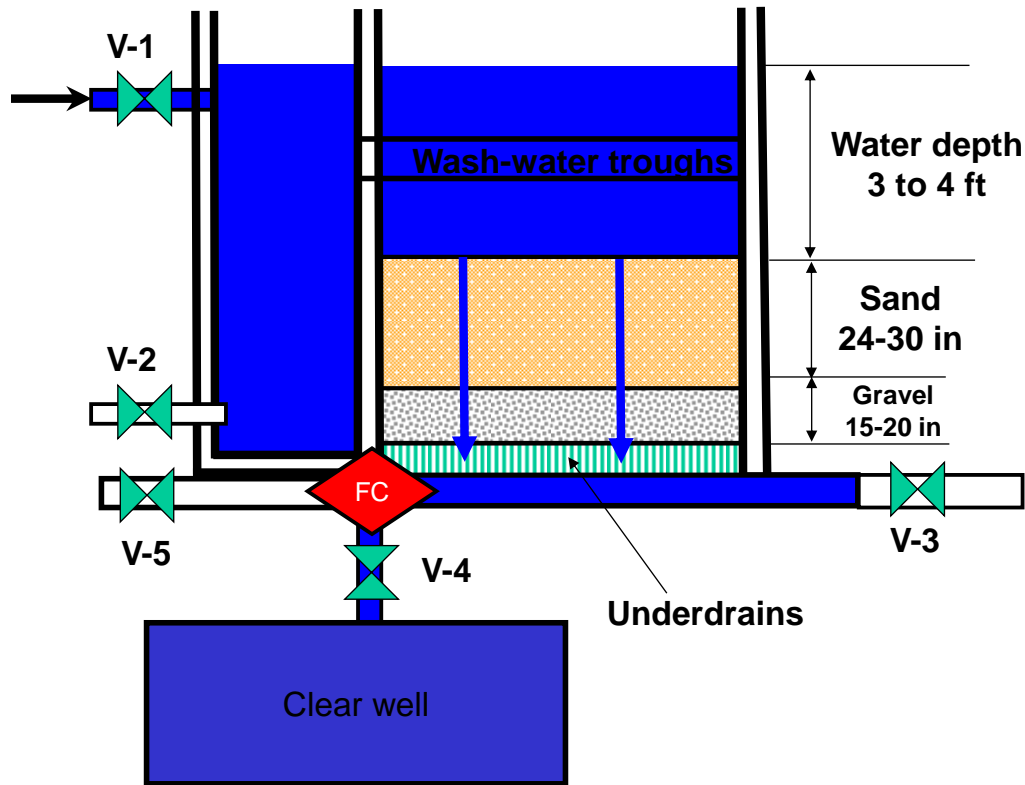
Table 6.11 Design Criteria for Settling Basins

Type of settling basin	Overflow rate	Depth	Detention time or settling time	Weir loading
Rectangular (horizontal flow)	0.34 – 1 gpm/ft^2 (0.83 – 2.5 m/h)	10 – 16 ft (3 – 5 m)	1.5 – 3.0 h	< 15 gpm/ft [11 $\text{m}^3/(\text{m}\cdot\text{h})$]
Circular or square radial upflow	0.5 – 0.75 gpm/ft^2 (1.3 – 1.9 m/h)	10 – 16 ft (3 – 5 m)	1.0 – 3.0 h	10 gpm/ft [7 $\text{m}^3/(\text{m}\cdot\text{h})$]
Reactor clarifier	0.8 – 1.2 gpm/ft^2 (2.0 – 3.0 m/h)	-----	1.0 – 2.0 h	10 – 20 gpm/ft [7.3 – 15 $\text{m}^3/(\text{m}\cdot\text{h})$]

Adapted from Kawamura (1991) pp. 138 – 139

On page 284, top right column, “The uniformity coefficient is a measure of the size range of the media and is defined as d_{60}/d_{10} sizes....

On page 286, flow arrows should be removed from Figure 6.27 and should appear as below.



On page 287, middle of right column, replace Carman-Kozney with **Carman-Kozeny**....

On page 291, Example 6.20 should be revised slightly since the diameter for the 14-20 sieve size should be 3.283×10^{-3} ft. Correct solution presented below.

EXAMPLE 6.20 Calculating expanded bed depth in English units

Find the expanded bed depth in a rapid sand filter that is 24 inches deep and has a porosity of 0.40 for the sieve analysis given in the table below. Assume a water temperature of 55°F and a specific gravity (S.G.) for sand of 2.65. The shape factor (ϕ) is 0.95, $\mu = 2.55 \times 10^{-5}$ lb·s/ft², and $\rho = 1.94$ lb·s²/ft⁴.

(1) Sieve #	(2) % Sand Retained (X_{ij})	(3) d_{ij} (ft H 10 ⁻³)	(4) V_s (fps)	(5) ϵ_e	(6) $\frac{X_{ij}}{(1 - \epsilon_e)}$
14 - 20	1.05	3.2883	0.456	0.40	0.0176
20-28	6.65	2.333	0.309	0.44	0.1187
28-32	15.70	1.779	0.227	0.47	0.2967
32-35	18.84	1.500	0.186	0.49	0.3705
35-42	18.98	1.258	0.152	0.51	0.3904
42-48	17.72	1.058	0.125	0.54	0.3824
48-60	14.25	0.888	0.102	0.56	0.3245
60-65	5.15	0.746	0.0839	0.59	0.1244
65-100	1.66	0.583	0.0633	0.62	0.0441
	100				Σ 2.0694

Solution

To calculate the settling velocities in Column 4 above, it is necessary to develop a settling velocity equation using Newton's law, Equation (6.90) for a shape factor of 0.95, S.G. of 2.65, and viscosity at 55°F as shown in Example 6.19. For these parameters, the relationship between settling velocity and particle diameter is as follows:

$$V_s = 315d^{1.143}$$

The backwash velocity (V_b) is calculated by rearranging Equation (6.144) and substituting ε for ε_e as follows:

$$V_b = V_s \varepsilon^{4.5}$$

Next, substituting the settling velocity (V_s) for the largest diameter media particle that is retained between sieves 14 – 20, ($V_s = 0.457$ feet per second) yields a backwash velocity of 0.0074 fps.

$$V_b = V_s \varepsilon^{4.5} = 0.456 (0.40)^{4.5} = 7.4 \times 10^{-3} \text{ fps}$$

In Column 5, the expanded bed porosities (ε_e) are calculated using Equation 6.144).

$$\varepsilon_e = [V_b/V_s]^{0.22} = [7.4 \times 10^{-3} / 4.56 \times 10^{-1}]^{0.22} = 0.404$$

For the largest sieve size (14 – 20), ε_e (0.404) should be approximately equal to ε , the unexpanded bed porosity, which is 0.40.

Column 6 is calculated using the following equation:

$$X_{ij} / (1 - \varepsilon_e) = \frac{(1.05/100)}{(1 - 0.404)} = 0.0176$$

The expanded bed depth is calculated using Equation (6.146).

$$L_e = L(1 - \varepsilon) \sum \frac{X_{ij}}{(1 - \varepsilon_e)} = 2 \text{ ft} (1 - 0.40) (2.0694) = \boxed{2.48 \text{ ft}}$$

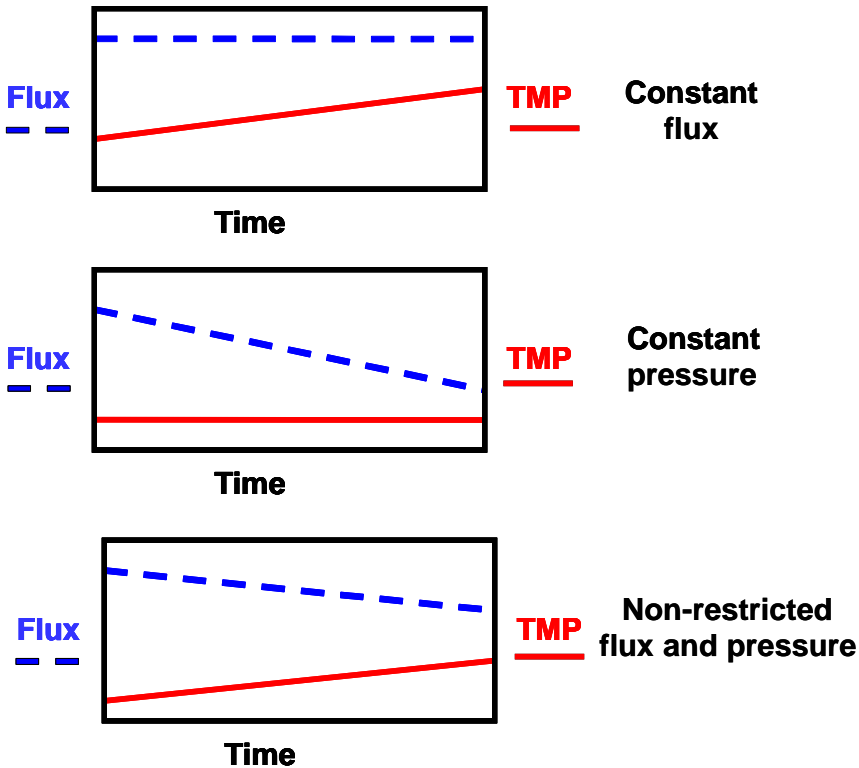
Since the bed was 2 feet deep originally, note that the bed expanded 0.48 feet. Depending on the backwash rate utilized, it is not unusual for the bed to expand by 50% (Viessman and Hammer, 2005, p. 401).

At the beginning of the backwash process, the head loss is calculated using Equation (6.141).

$$h_L = [(S.G.)_p - 1] (1 - \varepsilon) L = [2.65 - 1] (1 - 0.40) (2 \text{ ft}) = \boxed{1.98 \text{ ft}}$$

On page 292, Example 6.21, the units in columns (3) and (4) are incorrect. Column (3) should read ($m \times 10^{-4}$) and column (4) should read (mps).

On page 295, Figure 6.33, the color nomenclature for the lines is incorrect. They should appear as follows.



On page 300, Table 6.17, superscripts **2** and **3** are missing from the source. Should appear as follows.

CA = cellulose acetate; PA = polyamide

Source: Values from¹Bergman (2005) pp. 13.25 and 13.28; ²Qasim et al. (2000) p. 769, and ³MWH (2005) p. 959.

On page 305, top left column, A plot of $\ln(C)$ versus $\ln(t)$ will produce a straight line with a slope of n^{-1} .

On page 311, right column, additional parameters for Equation (6.185) need to be defined as follows.

where:

M_v = mass of volatile solids, lb_m (kg),

M_f = mass of fixed solids, lb_m (kg),

S_v = specific gravity of volatile solids =1.0, and

S_f = specific gravity of fixed solids = 2.5.

On page 311, Equation (6.189) is incorrect and should be replaced with the following equation.

$$P_s = \frac{M_s}{M_{sl}} \quad (6.189)$$

On page 311, in the bottom right column, replace V_s with V_{sl} = volume of sludge with mass M_{sl} , ft^3 (m^3).

On page 314, Equation (6.192) should read as follows:

$$A_t = \frac{Q_{\text{sludge}} C_{\text{sludge}}}{\text{SLR}} = \frac{Q_{\text{sludge}} C_{\text{sludge}}}{G_L}$$

On page 315, top left column, replace the existing calculations with the following:

$$Q_{\text{underflow}} = 0.112 \text{ MGD} = 112,000 \frac{\text{gal}}{\text{d}}$$

$$0.3000 \frac{\text{MG}}{\text{d}} = 1.000 Q_{\text{supernatant}} + 1.000 Q_{\text{underflow}}$$

$$0.300 \frac{\text{MG}}{\text{d}} = 1.000 Q_{\text{supernatant}} + 0.112 \frac{\text{MG}}{\text{d}}$$

$$Q_{\text{supernatant}} = 0.188 \text{ MGD} = 188,000 \frac{\text{gal}}{\text{d}}$$

On page 320, top right column, Example 6.32, revise V_{sl} calculation as follows:

$$V_{sl} = \frac{M_s}{S_{sl} \rho P_s} = \frac{7,840 \text{ kg/d}}{(1.0) \left(\frac{1,000 \text{ kg}}{\text{m}^3} \right) (0.28)} = 28.0 \frac{\text{m}^3}{\text{d}}$$

On page 326 for problem 8, μ and ρ are equal to $2.735 \times 10^{-5} \text{ lb}\cdot\text{s}/\text{ft}^2$ and $1.936 \text{ lb}\cdot\text{s}^2/\text{ft}^4$, respectively.

On page 327, problem 14, replace with “Determine the overall removal efficiency that can be achieved at a **detention time of 36 minutes** and a depth of 8.0 ft. “

On page 327, problem 17, Assume a kinematic viscosity of $1.306 \times 10^{-6} \text{ m}^2/\text{s}$.

On page 327, problem 18, Assume a kinematic viscosity of $1.306 \times 10^{-6} \text{ m}^2/\text{s}$.

On page 327, problem 19, Assume a kinematic viscosity of $1.41 \times 10^{-5} \text{ ft}^2/\text{s}$.

On page 327, problem 20, Assume a kinematic viscosity of $1.41 \times 10^{-5} \text{ ft}^2/\text{s}$.

On page 328, problem 21, Assume a kinematic viscosity of $1.306 \times 10^{-6} \text{ m}^2/\text{s}$.

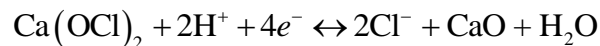
On page 328, problem 22, Assume a kinematic viscosity of $1.306 \times 10^{-6} \text{ m}^2/\text{s}$.

On page 328, problem 24, column 3 should be revised as follows:

(3)
d_{ij} ($\text{ft} \times 10^{-3}$)
3.283
2.333
1.779
1.500
1.258
1.058
0.888
0.746
0.583

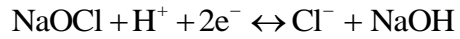
On page 329, problem 31 should read as follows:

Determine the percent actual and percent available chlorine for calcium hypochlorite. The half reaction for calcium hypochlorite ($\text{Ca}(\text{OCl})_2$) is given below.



On page 329, problem 32 should read as follows:

Determine the percent actual and percent available chlorine for sodium hypochlorite. The half reaction for sodium hypochlorite [NaOCl] is given below.



On page 330, problem 6.36 should read as follows:

The water content of a solids slurry is reduced from 99% to 96% by gravity thickening. Assume that the dry solids contain 20% organic matter with a specific gravity of 1.0 and 80% inorganic or mineral matter with a specific gravity of 2.0. Assume that 25% of these solids are volatile and that the specific gravity of the fixed and volatile fractions in the solids is 2.5 and 1.0, respectively.

- Determine:
- The specific gravity (S_s) of the dry solids in the slurry.
 - The specific gravity (S_{sl}) **of the solids slurry with 99% moisture content.**
 - The specific gravity (S_{sl}) **of the solids slurry with 96% moisture content.**
 - The percent reduction in volume when the water content is reduced from 99% to 96%.