Applied Math for Water Treatment

Course # 1101

Fleming Training Center

Updated October 2020

Department of Environment & Conservation

Fleming Training Center

Applied Math for Water Treatment

Course # 1101

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Monday

8:30	Solving for the Unknown
10:00	Dimensional Analysis
11:00	Lunch
12:15	Dimensional Analysis cont'd
12:45	Area, Volume, Circumference
2:00	Flow and Velocity

Tuesday

8:30	Disinfection (pounds formula)
11:00	Lunch
12:15	Pumps, Power & Pressure

Wednesday

8:30	Chemical Feeders
11:00	Lunch
12:15	Sedimentation
2:15	Miscellaneous

Thursday

8:30	Filtration
10:00	Fluoridation
11:00	Lunch
12:15	Laboratory Calculations
2:00	Test review

Friday

8:30	Review
12:15	Exam

State of Tennessee

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Section 1

Basic Math Review

Basic Math Concepts

For Water and Wastewater Plant Operators
by Joanne Kirkpatrick Price

Solving for the Unknown Value (X)

Solving for X

- Solve for X

$$(4)(1.5)(x) = 1100$$

  - X must be by itself on one side of equal sign
    - 4 and 1.5 must be moved away from X

$$x = \frac{1100}{(4)(1.5)}$$

$$x = 183.3$$

    - How was this accomplished?

Movement of Terms

- To understand how we move the numbers, we will need to consider more closely the math concepts associated with moving the terms.
- An equation is a mathematical statement in which the terms or calculation on one side equals the terms or calculation on the other side.

Movement of Terms

$$3 * 6 = 2 * 9$$
$$18 = 18$$

Whatever you do to one side of the equation, you do the same to the other to maintain that "balance."

Movement of Terms

- When dealing with a variable, you want to get the variable by itself.
- This is done by performing the opposite function

$$(3)(x) = 14$$

- Since X is multiplied by 3, you can get rid of the 3 by using the opposite process: division.

Movement of Terms

$$3(x) = 14$$

- To preserve the equation, you must divide the other side of the equation as well.
- Since both sides of the equation are divided by the same number, the value of the equation remains unchanged.

Example 1

$$730 = \frac{x}{3847}$$

What you do to one side of the equation, must be done to the other side.

Example 2

$$0.5=\frac{(165)(3)(8.34)}{x}$$

Simplify

What you do to one side of the equation, must be done to the other side.

Solving for X when squared

- Follow same procedure as solving for X
- Then take the square root

$$x^2 = 15{,}625$$

$$\sqrt{x^2} = \sqrt{15{,}625}$$

Example 3

$$(0.785)(x^2) = 2826$$

Fractions and Percents

Converting Decimals and Fractions

- To convert a fraction to a decimal
  - Simply divide the numerator by the denominator

$$\frac{1}{2} =$$

$$\frac{10}{13} =$$

Percents and Decimals

- To convert from a decimal to a percent
  - Simply move the decimal point two places to the right

0.46 ➡

- To convert from a percent to a decimal
  - Simply move the decimal two points to the left

79.5% ➡

- Remember:

  You CANNOT have a percent in an equation!!

Writing Equations

- Key words
  - **Of** means "multiply"
  - **Is** means "equal to"
  - **Per** means "divide"

- Calculate 25% of 595,000

Example 5

448 is what percent of 560?

$$448 = x\% \times 560$$

Solving for the Unknown

Basics – finding x

1. $8.1 = (3)(x)(1.5)$

2. $(0.785)(0.33)(0.33)(x) = 0.49$

3. $\frac{233}{x} = 44$

4. $940 = \frac{x}{(0.785)(90)(90)}$

5. $x = \frac{(165)(3)(8.34)}{0.5}$

6. $56.5 = \frac{3800}{(x)(8.34)}$

7. $114 = \frac{(230)(1.15)(8.34)}{(0.785)(70)(70)(x)}$

8. $2 = \frac{x}{180}$

9. $46 = \frac{(105)(x)(8.34)}{(0.785)(100)(100)(4)}$

10. $2.4 = \frac{(0.785)(5)(5)(4)(7.48)}{x}$

11. $19{,}747 = (20)(12)(x)(7.48)$

12. $\dfrac{(15)(12)(1.25)(7.48)}{x} = 337$

13. $\dfrac{x}{(4.5)(8.34)} = 213$

14. $\dfrac{x}{246} = 2.4$

15. $6 = \dfrac{(x)(0.18)(8.34)}{(65)(1.3)(8.34)}$

16. $\dfrac{(3000)(3.6)(8.34)}{(0.785)(x)} = 23.4$

17. $109 = \dfrac{x}{(0.785)(80)(80)}$

18. $(x)(3.7)(8.34) = 3620$

19. $2.5 = \dfrac{1{,}270{,}000}{x}$

20. $0.59 = \dfrac{(170)(2.42)(8.34)}{(1980)(x)(8.34)}$

Finding x^2

21. $(0.785)(D^2) = 5024$

22. $(x^2)(10)(7.48) = 10{,}771.2$

23. $51 = \dfrac{64{,}000}{(0.785)(D^2)}$

24. $(0.785)(D^2) = 0.54$

25. $2.1 = \dfrac{(0.785)(D^2)(15)(7.48)}{(0.785)(80)(80)}$

Percent Practice Problems

Convert the following fractions to decimals:

1. ¾

2. ⅝

3. ¼

4. ½

Convert the following percents to decimals:

5. 35%

6. 99%

7. 0.5%

8. 30.6%

Convert the following decimals to percents:

9. 0.65

10. 0.125

11. 1.0

12. 0.05

Calculate the following:

13. 15% of 125

14. 22% of 450

15. 473 is what % of 2365?

16. 1.3 is what % of 6.5?

Answers for Solving for the Unknown

Basics – Finding x

1.	1.8	8.	360	15.	2816.67
2.	5.73	9.	1649.4	16.	4903.48
3.	5.30	10.	244.7	17.	547,616
4.	5,976,990	11.	11	18.	117.31
5.	8256.6	12.	4.99	19.	508,000
6.	8.06	13.	7993.89	20.	0.35
7.	0.005	14.	590.4		

Finding x^2

21.	80	23.	40	25.	10.94
22.	12	24.	0.83		

Percent Practice Problems

1.	0.75	7.	0.005	13.	18.75
2.	0.625	8.	0.306	14.	99
3.	0.25	9.	65%	15.	20%
4.	0.5	10.	12.5%	16.	20%
5.	0.35	11.	100%		
6.	0.99	12.	5%		

Section 2

Dimensional Analysis

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Dimensional Analysis

Mathematics Manual for Water and Wastewater Treatment plant Operators
by Frank R. Spellman

Dimensional Analysis

- Used to check if a problem is set up correctly
- Work with the units of measure, not the numbers
- Step 1:
  - Express fraction in a vertical format

$$gal/ft^3 \text{ to } \frac{gal}{ft^3}$$

- Step 2:
  - Be able to divide a fraction

$$\frac{\frac{lb}{day}}{\frac{min}{day}} \text{ becomes } \frac{lb}{day} \times \frac{day}{min}$$

Dimensional Analysis

- Step 3:
  - Know how to divide terms in the numerator and denominator
  - Like terms can cancel each other out
    - For every term that is canceled in the numerator, a similar term must be canceled in the denominator

$$\frac{lb}{\cancel{day}} \times \frac{\cancel{day}}{min}$$

- Units with exponents should be written in expanded form

$$ft^3 = (ft)(ft)(ft)$$

Example 1

- Convert 1800 ft^3 into gallons.
- We need the conversion factor that connects the two units
- This is a ratio, so it can be written two different ways
- We want to use the version that allows us to cancel out units

$\frac{1\ ft^3}{7.48\ gal}$ OR $\frac{7.48\ gal}{1\ ft^3}$

Example 1

$$\left(\frac{1800\ ft^3}{1}\right)$$

- Will anything cancel out?

NO

- Let's try the other version

- Will anything cancel out?

YES

Example 2

- Determine the square feet given $70\ ft^3/sec$ and $4.5\ ft/sec$
- Use units to determine set up
  - Two ways to write the number

$$\frac{4.5\ ft}{sec}\ OR\ \frac{sec}{4.5\ ft}$$

  - Which way is the right way?

  - Will anything cancel?

Example 2 Cont'd

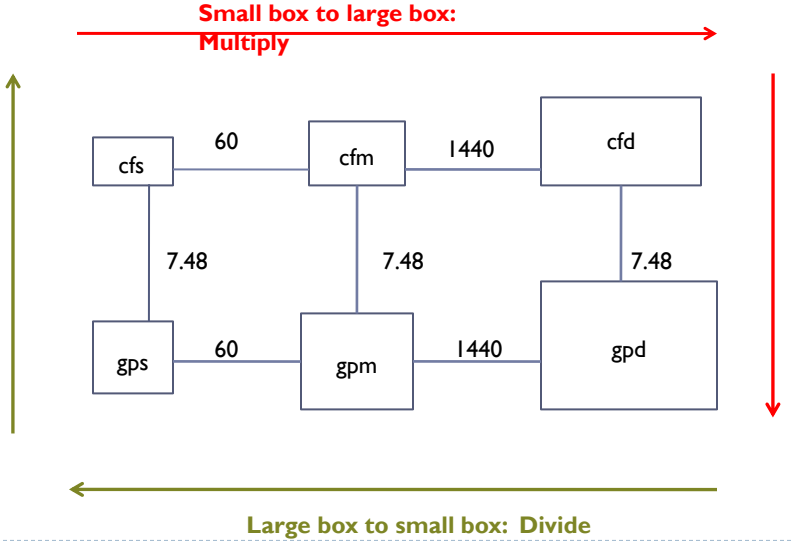
- Remember, units function the same as numbers.

$$ft^3 = (ft)(ft)(ft)$$

- Therefore

- Will anything cancel out?

Flow Conversions – Box Method



Metric Units

Kilo	Hecto	Deca	Basic Unit	Deci	Centi	Milli
King	Henry	Died	By	Drinking	Chocolate	Milk
1000X larger	100X larger	10X larger	Meter Liter Gram ***I unit***	10X smaller	100X smaller	1000X smaller

MULTIPLY numbers by 10 if you are getting smaller

DIVIDE number by 10 if you are getting bigger

Metric Units

King	Henry	Died	by	Drinking	Chocola te	Milk

- Convert 2500 milliliters to liters

$$2500\ mL =$$

- Convert 0.75 km into cm

$$0.75\ km =$$

Basic Math
Dimensional Analysis

Dimensional analysis is not just a way to work math problems. It is an easy way to verify that your formula is set up properly before the calculation is performed.

Rules to follow:

- ✓ Units written in abbreviated or horizontal form should be rewritten in a vertical format. For example:

$$\text{cfs} \Rightarrow \frac{\text{ft}^3}{\text{sec}} \qquad \text{gal/cu ft} \Rightarrow \frac{\text{gal}}{\text{ft}^3}$$

- ✓ Any unit that is a common factor to both the numerator and denominator of a fraction may be divided out. For example:

$$\left(\frac{20\ \text{ft}^3}{\text{sec}}\right)\left(\frac{60\ \text{sec}}{\text{min}}\right) = \frac{(20)(60)\text{ft}^3}{\text{min}}$$

- ✓ An exponent of a unit indicates how many times that unit is to be multiplied together. For example:

$$\text{ft}^3 = (\text{ft})(\text{ft})(\text{ft})$$

  - o Sometimes it is necessary to write terms with exponents in expanded form, while other times it is advantageous to keep the unit in exponent form. This choice depends on which other units are part of the calculation and how these units might divide out.

Remember: Fractions must be multiplied or divided to do any canceling. Fractions that are added and subtracted can't be cancelled.

Basics:
Use dimensional analysis to determine the **units** of the answers:

1. (0.785)(ft)(ft)(ft)

2. (120 ft^3/min)(1440 min/day)

3. $\frac{(8ft)(10ft)(xft)}{sec}$

Verify the mathematical setup for each problem. If the setup is incorrect, correct the setup:

4. (1.6 fpm)(60 sec/min) = fps

5. (70 in)(1 ft/12 in)(0.3048 m/ft) = m

1. ft^3 2. ft^3/day 3. ft^3/sec 4. Incorrect 5. Correct

Complex Fractions:

- ✓ When the units of a given problem are written as a complex fraction:
  - o Invert the denominator and multiply. For example:

$$\frac{2{,}808{,}000 \text{ gpd}}{1440 \text{ min/day}} = \frac{\frac{\text{gal}}{\text{day}}}{\frac{\text{min}}{\text{day}}} = \left(\frac{\text{gal}}{\text{day}}\right)\left(\frac{\text{day}}{\text{min}}\right)$$

  - o Shortcut: If the numerator is the same in both the top and bottom fractions, they will cancel when the bottom fraction inverts and multiplies. The same goes if the denominator is the same in both the top and the bottom fractions.

Use dimensional analysis to determine the **units**:

1. $\frac{(4140 \text{ gpm})}{(60 \text{ sec/min})}$

2. $\frac{(880 \text{ cu ft})(1440 \text{ min/day})}{6.2 \text{ cu ft/day}}$

3. $\frac{587 \text{ gal}}{246 \text{ gph}}$

Verify the mathematical setup for each problem. If the setup is incorrect, correct the setup:

4. $\frac{(40 \text{ in})(1.5 \text{ ft})(2.3 \text{ fpm})}{12 \text{ in/ft}} = \text{cfm}$

5. $\frac{\left(\frac{2{,}400{,}000 \text{ gpd}}{7.48 \text{ gal/ft}^3}\right)}{635{,}400 \text{ ft}^2} = \text{ft/day}$

1. gal/sec 2. min 3. hour 4. ft^3/min 5. ft/day

General Conversions

1. 325 ft^3 = gal

2. 2512 kg = lb

3. 2.5 miles = ft

4. 1500 hp = kW

5. 2.2 ac-ft = gal

6. 2100 ft^2 = ac

7. 92.6 ft^3 = lb

8. 17,260 ft^3 = MG

9. 0.6% = mg/L

10. 30 gal = ft^3

11. A screening pit must have a capacity of 400 ft^3. How many lbs is this?

12. A reservoir contains 50 ac-ft of water. How many gallons of water does it contain?

13. 3.6 cfs = gpm

14. 1820 gpm = gpd

15. 45 gps = cfs

16. 8.6 MGD= gpm

17. 2.92 MGD = lb/min

18. 385 cfm = gpd

19. 1,662 gpm = lb/day

20. 3.77 cfs = MGD

21. The flow through a pipeline is 8.4 cfs. What is the flow in gpd?

22. A treatment plant receives a flow of 6.31 MGD. What is the flow in cfm?

Basic Conversions Extra Problems

1. How many seconds are in a minute?

2. How many minutes are in an hour?

3. How many hours in a day?

4. How many minutes in a day?

5. How many inches in a foot?

6. How many feet in a mile?

7. How many feet in a meter?

8. How many meters in a mile?

9. How much does one gallon of water weigh?

10. How much does one cubic foot of water weigh?

11. Express a flow of 5 cfs in terms of gpm.

12. What is 38 gps expressed as gpd?

13. What is 0.7 cfs expressed as gpd?

14. What is 9164 gpm expressed as cfs?

15. What is 1.2 cfs expressed as MGD?

16. Convert 65 gpm into lbs/day.

17. Convert 345 lbs/day into gpm.

18. Convert 0.9 MGD to cfm.

19. Convert 1.2 MGD to ft^3/hour.

20. Convert a flow of 4,270,000 gpd to cfm.

21. What is 5.6 MGD expressed as cfs?

22. Express 423,690 cfd as gpm.

23. Convert 2730 gpm to gpd.

24. Convert 1440 gpm to MGD.

25. Convert 45 gps to ft^3/day.

Volume and Flow Conversions

1. 2,431 gal
2. 5,533 lb
3. 13,200 ft
4. 1,119 kW
5. 717,200 gal
6. 0.05 ac
7. 5,778.24 lb
8. 0.13 MG
9. 6,000 mg/L
10. 4.01 ft^3
11. 24,960 lb
12. 16,300,000 gal
13. 1,615.68 gal/min
14. 2,620,800 gal/day
15. 6.02 ft^3/sec
16. 5,968.4 gpm
17. 16,911.67 lb/min
18. 4,146,912 gal/day
19. 19,959,955.2 lb/day
20. 2.43 MGD
21. 5,428,684.8 gal/day
22. 585.82 ft^3/min

Basic Conversions Extra Problems

1. 60 sec/min
2. 60 min/hr
3. 24 hr/day
4. 1440 min/day
5. 12 in/ft
6. 5280 ft/mi
7. 3.28 ft/m
8. 1760 yd/mi
9. 8.34 lbs/gal
10. 62.4 lbs/ft^3
11. 2244 gpm
12. 3,283,200 gpd
13. 452,390 gpd
14. 20.42 cfs
15. 0.78 MGD
16. 780,624 lbs/day
17. 0.03 gpm
18. 83.56 ft^3/min
19. 6684.49 ft^3/hr
20. 396.43 ft^3/min
21. 8.67 cfs
22. 2200.83 gpm
23. 3,931,200 gpd
24. 2.07 MGD
25. 519,786.10 ft^3/day

Metric System and Temperature Conversion Practice Problems

Convert the following.

1. 23 g into _____ mg
2. 12,456 m into _____ km
3. 4235 mL into _____ L
4. 200 mg into _____ kg
5. 1000 watts into_____ kwatts
6. 0.05 g into _____ *u*g
7. 20 deciliters into _____ mL
8. 140 kg into _____ g
9. 9.5 cm into _____mm
10. 100 milliseconds into_____seconds

Answers

1. 23,000 mg
2. 12.456 km
3. 4.235 L
4. 0.0002 kg
5. 1 kwatt
6. 50,000 *u*g
7. 2000 mL
8. 140,000 g
9. 95 mm
10. 0.1 seconds

Conversions Practice Problems

1. Convert 723 gallons to liters

2. Convert 17°C to degrees Fahrenheit.

3. How many feet are in 2.5 miles?

4. Convert 56 grains per gallon to mg/L.

5. Convert 56 ft^3/s to gallons per minute.

6. Convert 34°C to degrees Fahrenheit.

7. Calculate 42.0% of 7,310.

8. Convert 72 ppm to percent.

9. A solution was found to be 7.6% hypochlorite. How many milligrams per liter of hypochlorite are in the solution?

10. Convert 8.77 acre-ft to gallons.

11. Convert 1.98 acres to square feet.

12. Convert 81 ft^3 liters.

13. Convert 212°F to degrees Celsius.

14. Convert 1,472 L to gallons.

15. Convert 0.25 miles to yds.

16. Convert a chlorine solution of 2.5 ppm to percent.

17. Convert 2,367 g to pounds.

18. Convert 3.45 MGD to cubic feet per second.

19. Convert 63.5% to ppm.

20. What percent is 12,887 of 475,258?

21. Convert the following:

    451°F to degrees Celsius

22. 8,711,400 gal to acre-feet.

23. 35 cfs to gpm

24. 8 lb/sec to lb/day

25. 45 gal/min to ft^3/day

26. 927 cfm to gps

27. 0.3 MGD to gal/hr

28. 89 cfd to cfs

29. 93 gal/sec to MGD

30. 2 ft^3/min to gal/day

31. 17 gal/day to lb/min

32. 1.7 acre-foot to gal

33. 78 mg/L to lbs/gal

34. 890 lb/day to cfm

35. 10,600 gpd to ft^3/sec

36. 900 grams to lbs

37. 29.78 lb/hr to gpd

38. 79 mL to gal

39. 830 yds/min to ft/day

40. 379 km/day to mph

Conversion Answers:

1.) 2,735.56 L
2.) 62.6°F
3.) 13,200 ft
4.) 957.6 mg/L
5.) 25,132.8 gpm
6.) 93.2°F
7.) 3,070.2
8.) 0.0072%
9.) 76,000
10.) 2,859,020 gal
11.) 86,248.8 ft^2
12.) 2,293.3 L
13.) 100°C
14.) 388.9 gal
15.) 440 yd
16.) 0.00025%
17.) 5.21 lb
18.) 5.34 cfs
19.) 635,000 mg/L
20.) 2.71%
21.) 232.78°C
22.) 26.72 ac-ft
23.) 15,708 gpm
24.) 691,200 lb/day
25.) 8,663.1 cfd
26.) 115.57 gps
27.) 12,500 gal/hr
28.) 0.001 cfs
29.) 8.04 MGD
30.) 21,542.4 gpd
31.) 0.098 lb/min
32.) 554,200 gal
33.) 0.00065 lb/gal
34.) 0.01 cfm
35.) 0.016 cfs
36.) 1.98 lb
37.) 85.7 gpd
38.) 0.02 gal
39.) 3,585,600 ft/day
40.) 9.81 mi/hr

Section 3

Circumference, Area, and Volume

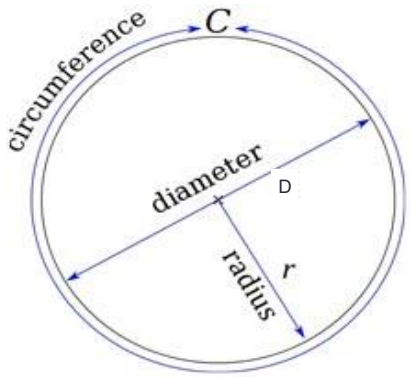
CIRCUMFERENCE AND AREA

Suggested Strategy to Solving Word Problems

- Disregarding all numbers, what type of problem is it?
- What diagram, if any, is associated with the concept identified?
- What information is required to solve the problem and how is it expressed in the problem?
- What is the final answer?
- Does the answer make sense?

Parts of a Circle

- Diameter is distance across the center of circle
- Radius is distance from circle's center to the edge
- Circumference is the distance around a circle or a circular object



Circumference & Perimeter

- Circumference of a Circle

$$Circumference = (3.14)(Diameter)$$

- Perimeter is obtained by adding the lengths of the four sides of a square or rectangle

$$Perimeter = 2(length) + 2(width)$$

Example 1

- Find the circumference in inches of a 6 inch diameter pipe.

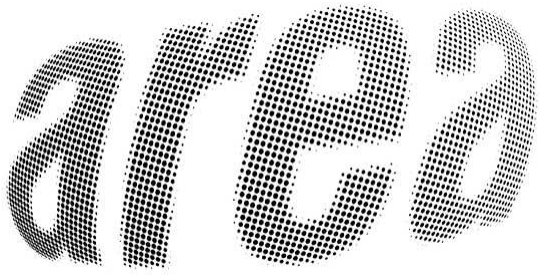
$$Circumference = (3.14)(diameter)$$

- Find the perimeter in feet of a rectangular tank that is 15 ft by 22 ft.

$$Perimeter = 2(length) + 2(width)$$

Area

- Area is the measurement of the amount of space on the surface of an object
- Two dimensional measurement
- Measured in: in^2, ft^2, acres, etc.

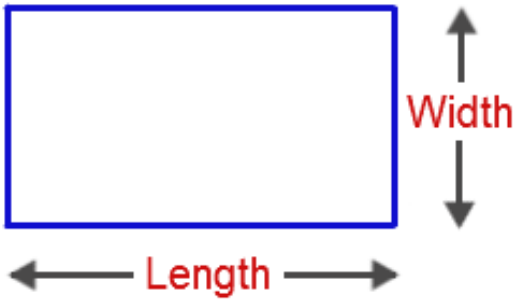


Area

- Area of Rectangle

$$Area = (length)(width)$$

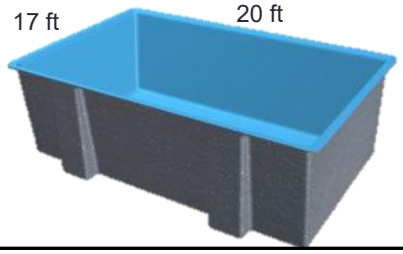
$$A = (L)(W)$$



Example 2

- Find the area in ft^2 of the top of a rectangular basin that is 20 feet long and 17 feet wide.

$$A = (L)(W)$$

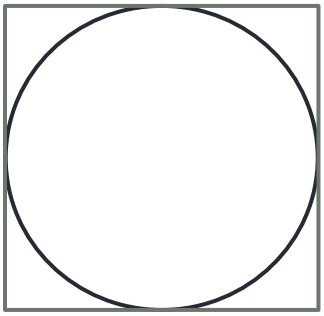


Area

- Area of Circle

$$Area = (0.785)\ (Diameter)^2$$

$$A = (0.785)(D)^2$$

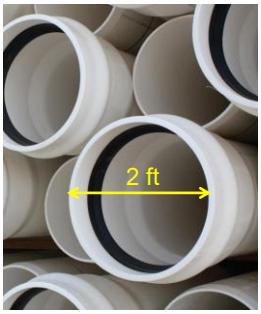


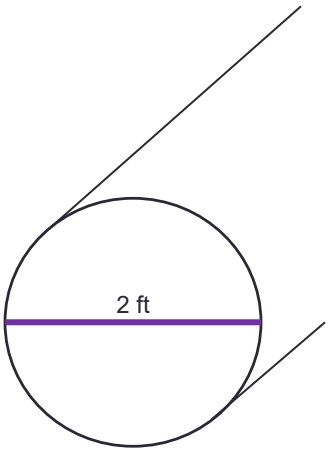
A circle takes up 78.5% of a circle.

Example 3

- Find the area of the cross section of a pipe in ft^2 that has a diameter of 2 feet.

$$Area = (0.785)(D)^2$$



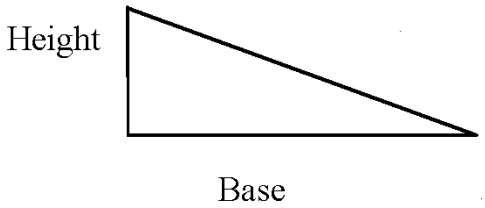


Area

- Area of Right Triangle

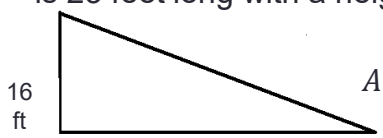
$$Area = \frac{(base)(height)}{2}$$

$$A = \frac{(b)(h)}{2}$$



Example 4

- Determine the area in ft^2 of a right triangle where the base is 23 feet long with a height of 16 feet.



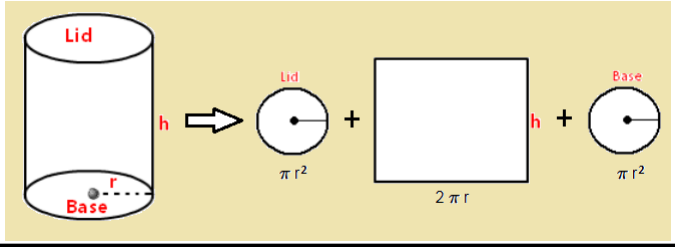
$$A = \frac{(b)(h)}{2}$$

Area

- Area of Cylinder (total exterior surface area)

$$Area = [surface\ area\ of\ end\ \#1] + [surface\ area\ of\ end\ \#2] + [(3.14)(Diameter)(height)]$$

$$A = A_1 + A_2 + [(3.14)(D)(h)]$$



Example 5

- Find the total surface area in ft^2 of a barrel that is 1.5 ft in diameter and 3 feet tall.

$$A = A_1 + A_2 + [(3.14)(D)(h)]$$

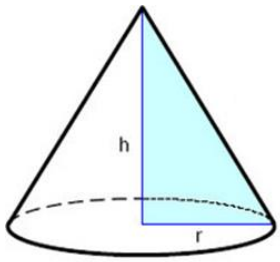
$$A_1 = A_2$$

Area

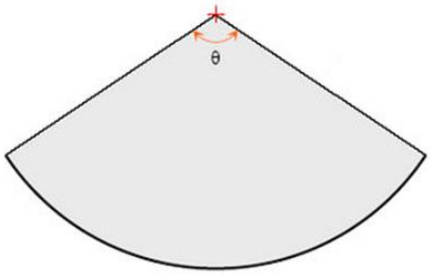
- Area of Cone (lateral area)

$$Area = (3.14)(radius)\sqrt{radius^2 + height^2}$$

$$A = (3.14)(r)\sqrt{r^2 + h^2}$$



Right Circular Cone



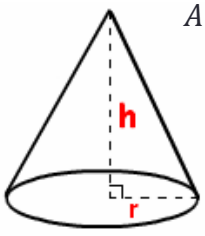
Unrolled Lateral Area

Example 6

- Find the lateral area (in ft^2) of a cone that is 3 feet tall and has a radius of 1.5 feet.

$$A = (3.14)(r)\sqrt{r^2 + h^2}$$

$$A = (3.14)(1.5ft)\sqrt{(1.5ft)(1.5ft) + (3ft)(3ft)}$$



$$A = (3.14)(1.5ft)\sqrt{2.25ft^2 + 9ft^2}$$

$$A = (3.14)(1.5ft)\sqrt{11.25ft^2}$$

$$A = (3.14)(1.5ft)(3.3541ft)$$

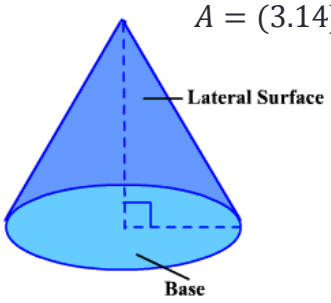
$$A = 15.79ft^2$$

Area

- Area of Cone (total surface area)

$$Area = (3.14)(radius)(radius + \sqrt{radius^2 + height^2}\ )$$

$$A = (3.14)(r)(r + \sqrt{r^2 + h^2}\ )$$



Example 7

- Find the total surface area in ft^2 of a cone that is 45 feet deep with a diameter of 60 feet.

$$A = (3.14)(r)(r + \sqrt{r^2 + h^2}\ )$$

$$A = (3.14)(30ft)(30ft + \sqrt{(30ft)(30ft) + (45ft)(45ft)}\ )$$

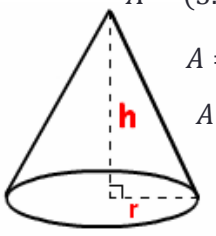
$$A = (3.14)(30ft)(30ft + \sqrt{900ft^2 + 2025ft^2})$$

$$A = (3.14)(30ft)(30ft + \sqrt{2925ft^2}\ )$$

$$A = (3.14)(30ft)(30ft + 54.083ft)$$

$$A = (3.14)(30ft)(84.083ft)$$

$$A = 7920.64ft^2$$



Volume

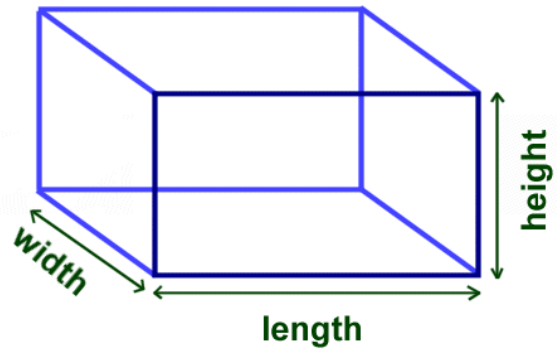
Volume

- Volume is the capacity of a unit or how much it will hold
- Measured in
  - cubic units (ft^3, m^3, yd^3) or
  - liquid volume units (gallons, liters, million gallons)
- The answer will come out in cubic units
  - You must then convert it to liquid volume units

Volume of a Rectangle

$$Volume = (length)(width)(height)$$

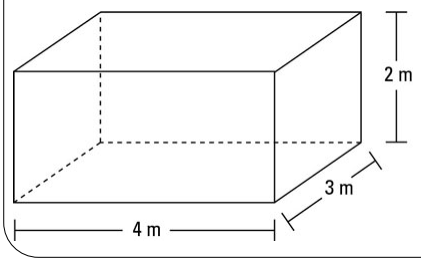
$$Vol = (l)(w)(h)$$



Example 1

- Determine the volume in m^3 for a tank that measures 3 meters by 4 meters by 2 meters.

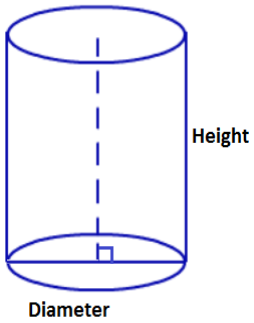
$$Vol = (l)(w)(h)$$



Volume of a Cylinder

$$Volume = (0.785)(Diameter^2)(height)$$

$$Vol = (0.785)(D^2)(h)$$

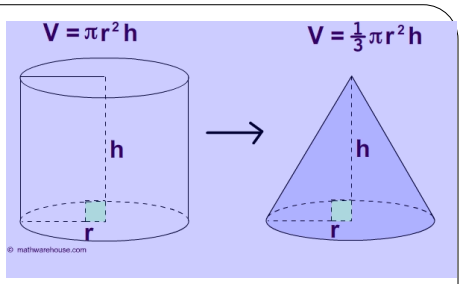


Example 2

- Determine the volume in ft^3 for a tank that is 20 feet tall with a diameter of 7.5 ft.

$$Vol = (0.785)(D)^2(h)$$

Volume of a Cone



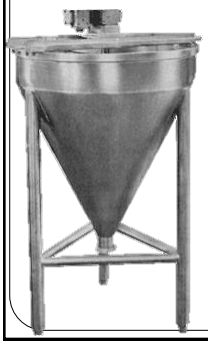
$$Volume = (1/3)(0.785)(Diameter^2)(height)$$

$$Vol = (1/3)(0.785)(D^2)(h)$$

Example 3

- Determine the volume in gallons of a conical tank that is 8 feet wide and 15 feet tall.

$$Vol = (1/3)(0.785)(D^2)(h)$$



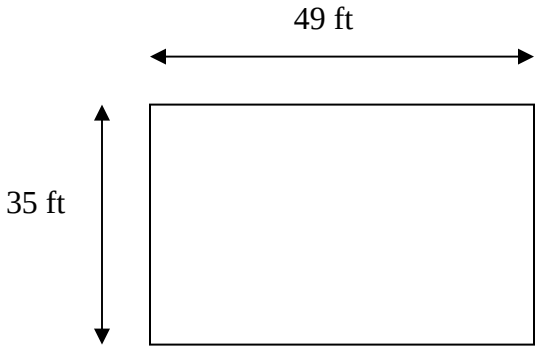
Math Problem Strategies

Strategy for solving word problems:

1) Read the problem, disregard the numbers (What type of problem is it? What am I asked to find?)
2) Refer to the diagram, if provided. If there isn't one, draw your own.
3) What information do I need to solve the problem, and how is it given in the statement of the problem?
4) Work it out.
5) Does it make sense?

It might be helpful to write out everything that is known in one column and the unknown (what am I asked to find?) in another column. Identify the correct formula and write it in the middle, plug in the numbers and solve.

Known		**Unknown**
Length = 35 ft Width = 49 ft	$A = (l)(w)$ $A = (35\ ft)(49\ ft)$ $A = 1715\ ft^2$	Area = ?

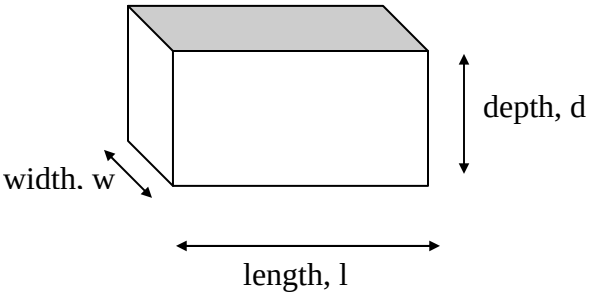


*****Remember: make sure measurements agree; if diameter of pipe is in inches then change to feet; if flow is in MGD and you need feet or feet/sec then change to ft^3/sec before you plug values into formula.***

mega (M)	..	kilo (k)	hecto (h)	deka (da)	no prefix	deci (d)	centi (c)	milli (m)	..	micro (µ)
1,000,000		1,000	100	10	1	$^1/_{10}$	$^1/_{100}$	$^1/_{1,000}$		$^1/_{1,000,000}$

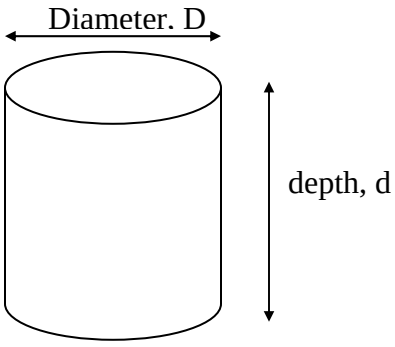
Tank Volume Calculations: Most tank volumes calculations are for tanks that are either rectangular or cylindrical in shape.

Rectangular Tank



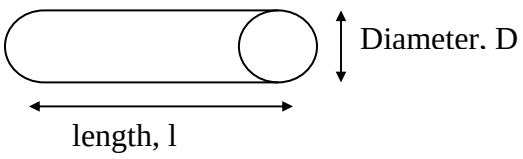
Volume = (l)(w)(d)

Cylindrical Tank



Volume = (0.785) (D)^2 (d)

Portion of a Pipeline



Volume = (0.785) (D)^2 (l)

Circumference, Area, and Volume

1. Calculate the circumference in ft of a circular clarifier that is 30 feet in diameter.

2. A sedimentation tank is 20 feet long and 12 feet wide and 15 ft deep. What is the area (ft^2) of the water surface in the tank?

3. What is the cross-sectional area (ft^2) of an 18 inch water main?

4. A triangular portion of the treatment plant grounds is not being used. How many square feet does this represent if the height of the triangle is 140 ft and the base is 180 ft?

5. Calculate the lateral surface area, in ft^2, for a conical tank that 30 feet tall and 20 feet wide.

6. Determine the total surface area, in ft^2, of a conical tank that is 15 feet tall and 30 feet wide.

7. A new water tank needs to be painted. What is the total exterior surface area if the cylindrical tank is 50 feet in diameter and 30 feet tall, in ft^2?

8. What is the volume in ft^3 of water contained in a round tank that is 20 feet across with water to a depth of 28 feet?

9. Calculate the holding capacity in gallons of a tank that is 15 feet wide, 15 feet long, and 20 feet tall.

10. How many cubic feet of water is contained in a conical clarifier if the water is 8 feet deep and the distance across the clarifier at the water level is 21.7 feet?

Applied Math for Water Treatment
Circumference, Area, and Volume

Circumference

1. What is the circumference of a tank that is 110.0 ft in diameter?

2. The radius of a circular concrete area is 42.5 ft. What is the circumference?

Area

3. What is the area (in ft^2) of a rectangle 5 ft by 4 ft?

4. A rectangle has a length of 5 feet and a width of 3 feet. What is the area (in ft^2) of the rectangle?

5. The diameter of a circle is 5 feet. What is its area (in ft^2)?

6. What is the cross-sectional area (in ft^2) of a pipe with a diameter of 7 inches?

7. What is the lateral surface area (in ft^2) of a cone with a radius of 12.5 ft and a height of 18 ft?

8. Calculate the total surface area (in ft^2) of a cone that has a diameter of 15 feet and a height of 7 feet.

Volume

9. The dimensions of a tank are 60 feet wide, 10 feet deep and 15 feet long. Calculate the volume of the tank in cubic feet.

10. A square tank is 25 ft wide, 75 ft long and can hold water to a depth of 10 ft. What is the volume of the tank, in gallons?

11. The diameter of a conical tank is 60 ft. When the water depth is 25 ft, what is the volume of the water in the tank, in ft^3?

Miscellaneous Questions

12. A basin has a length of 45 feet and a width of 12 feet. Calculate the area in ft^2.

13. Calculate the lateral surface area (in ft^2) of a cone with a radius of 3 feet and a height of 9 feet.

14. Calculate the area of the top of a basin (in ft^2) which is 90 feet long, 25 feet wide, and 10 feet deep.

15. Calculate the volume (in gallons) for a basin that measures 22 feet by 11 feet by 5 feet.

16. Calculate the area (in ft^2) for a 2 ft diameter main that has just been laid.

17. A chemical hopper is cone shaped and covered. It has a diameter of 4 feet and a depth of 7 feet. Calculate the total surface area of the hopper (in ft^2).

18. Calculate the volume (in ft^3) for a tank that measures 10 feet by 10 feet by 10 feet.

19. Calculate the cross-sectional area (in ft^2) for an 18" main that has just been laid.

20. Calculate the volume of water in a tank (in gallons), which measures 12 feet long, 6 feet wide, 5 feet deep, and contains 8 inches of water.

21. Calculate the volume (in ft^3) of a cone shaped chemical hopper with a diameter of 12 feet and a depth of 18 feet.

22. A new water main needs to be disinfected. The main is 30" in diameter and has a length of 0.25 miles. How many gallons of water will it hold?

23. A 3 million gallon water tank needs to be disinfected. The method you will use requires you to calculate 5% of the tank volume. How many gallons will this be?

24. Find the area in square feet for a rectangular shaped sedimentation basin that is 392 ft in length and 71.5 ft wide.

25. Find the cross-sectional area of a cylindrical tank if the tank's diameter is 30.4 ft.

26. What is the volume of a trench in cubic feet if it is 245 ft in length, 4.2 ft in width, and 5.8 ft in depth?

27. What is the capacity of a tank in cubic feet if it has a diameter of 75.2 ft and the height is 42.3 ft from the base?

28. How many liters of zinc orthophosphate can be contained in a tank that has a diameter of 10.5 ft and can be filled to a height of 9.0 ft?

29. A triangle has a height of 71 feet and a base of 22 feet. What is its area in square feet?

30. If a trench is 346 ft long, 4.4 ft wide, and 5.7 ft deep, how many cubic yards of soil were excavated?

31. A trench that is 156 ft long, 3.8 ft wide and 5.8 ft deep fills with water. How many gallons are contained in the trench?

32. A small tank has a diameter of 2.3 ft and a calcium hypochlorite level of 3.6 ft. How many gallons of calcium hypochlorite are contained in the tank?

33. What is the cross sectional, in ft^2, area of a trench that is 68 ft long and 4.5 ft wide?

34. What is the capacity of a tank in gallons if the diameter is 80.0 ft and the overflow is 32 ft from the base?

35. What is the cross-sectional area (in ft^2) of a pipe that is 14 inches in diameter?

36. A pipe is 7.26 miles long and has an inner diameter of 24 inches. How many gallons can fit in the pipeline?

37. What is the exterior surface area to be painted, in square feet, of a cylindrical tank that is 18.0 ft high and 112.0 ft in diameter? Assume the tank is on the ground and the top is flat.

38. How many liters are contained in 45 gal of water?

39. What is the volume of a trench in cubic feet if the trench is 24 ft by 3.0 ft by 6.0 ft?

40. What is the volume of a reservoir in gallons if it is 145 ft long, 76 ft wide, and averages 12 feet in depth?

41. A trench for a water main has to be 675 ft long, 4 ft wide, and 6 ft deep. How many cubic yards must be excavated?

42. What is the area of a triangular concrete slab that has a height of 12 ft and a base of 16 ft?

43. What is the external surface area of an elevated tank if it is 50 ft in diameter and 12 ft high? Assume the top and the bottom is flat.

44. If a circular tank covers an area of 1,962.5 ft, what is the diameter of the tank?

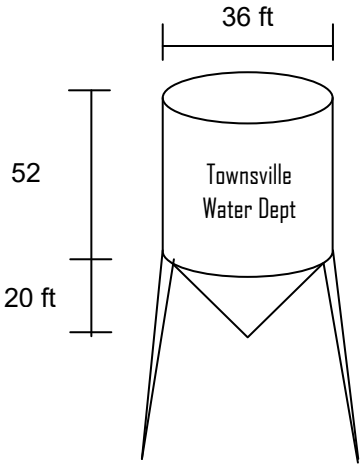
45. What is the exposed exterior surface area of a ground-level storage tank in square feet that is 16.25 ft high and has a diameter of 125 ft? Assume the top is flat.

46. If the area of a triangle is 24 ft^2 and the base of 8 ft, what is the height of the triangle?

47. Find the volume in gallons for a storage tank that is 18 ft in height and has a circumference of 215.8 ft.

48. A storage tank is 110 ft in diameter and has an overflow of 34.5 ft above the base of the tank. How many gallons of water are in the tank if it is 72.4% full?

49. A circular water tower that is tapered at the bottom has a diameter of 36 feet and a height of 52 feet from the top to the beginning of the taper. The cone created by the taper has a height of 20 feet. Calculate the total volume (in gallons) when the tower is full.



50. A trench that averages 3.5 ft wide and 4.0 ft in depth is dug for the purpose of installing a 24 inch diameter pipeline. If the trench is 1,663 ft long, how much soil in cubic feet will be put in the trench after pipe is in place, assuming that the only soil left over is that which the pipe now occupies?

51. The circumference of a tank is 188.5 ft. What is the tank's cross sectional area?

52. A distribution pipe is 2.32 miles long. What is the volume of water in gallons if the pipe is 2.0 ft in diameter for a length of 1.75 mile and 18 inch for the remainder?

53. A tank is conical at the bottom and cylindrical at the top. If the diameter of the cylinder is 12.0 ft with a depth of 20.0 ft and the cone depth is 12.0 ft, what is the volume of the tank in cubic feet?

54. Determine the volume of water in gallons for the following distribution system:

    Distribution pipe A is 985 ft in length and 3.0 ft in diameter
    Distribution pipe B is 645 ft in length and 2.0 ft in diameter
    The storage tank is 110 ft in diameter and has a water height of 25.36 ft.

55. If you double the size of a pipe, does it double the volume that can be carried? For example, if you have 1000 feet of 12 inch line and you replace it with a 24 inch line, does your volume double?

Answers

1. 345.4 ft
2. 266.9 ft
3. 20 ft^2
4. 15 ft^2
5. 19.63 ft^2
6. 0.27 ft^2
7. 860.15 ft^2
8. 418.23 ft^2
9. 9,000 ft^3
10. 140,250 gal
11. 23,550 ft^3
12. 540 ft^2
13. 89.37 ft^2
14. 2,250 ft^2
15. 9,050.8 gal
16. 3.14 ft^2
17. 45.72 ft^2
18. 1,000 ft^3
19. 1.77 ft^2
20. 359.06 gal
21. 678.24 ft^3
22. 48,442.35 gal
23. 150,000 gal
24. 28,028 ft^2
25. 725.47 ft^2
26. 5,968.2 ft^3
27. 187,778 ft^3
28. 22,052.52 L
29. 781 ft^2
30. 321.4 yd^3
31. 25,718.04 gal
32. 111.82 gal
33. 306 ft^2
34. 1,202,544.64 gal
35. 1.07 ft^2
36. 900,330.14 gal
37. 16,177.28 ft^2
38. 170.33 L
39. 432 ft^3
40. 989,155.2 gal
41. 600 yd^3
42. 96 ft^2
43. 5,809 ft^2
44. 50 ft
45. 18,643.75 ft^2
46. 6 ft
47. 499,271.12 gal
48. 1,774,656.43 gal
49. 446,444.7 ft^2
50. 18,060.18 ft^3
51. 2,828.83 ft^2
52. 256,783.21 gal
53. 20,292.94 gal
54. 186,899.81 gal
55. 4 times

Applied Math for Water Treatment
Area and Volume
Extra Problems

1. Find the area in square feet for a rectangular shaped sedimentation basin that is 392 ft in length and 71.5 ft in width.

2. What is the cross sectional area, in ft^2, of a tank if the tank's diameter is 30.4 feet?

3. A chemical holding tank has a diameter of 19 feet. What is the circumference of the tank in feet?

4. A tank is 60 feet long, 15 feet wide, and 10 feet deep. What is the area of the top of the tank in ft^2?

5. An oxidation ditch is 50 feet long, 30 feet deep and 20 feet wide. How many gallons of water can the ditch hold?

6. A basin is 12 ft by 22 ft. What is the surface area in ft^2?

7. A filter basin is 50 ft wide, 20 ft long and 15 feet deep. During a hook gage test, the water level dropped 6 inches. How many gallons of water were filtered?

8. Calculate the lateral surface area (in ft^2) of a cone shaped hopper with a diameter of 3 feet and a height of 9 feet.

9. A new 12 inch main must be installed. The total amount of pipe needed will be 5280 feet. What is the cross-sectional areal in ft^2?

10. What is the surface area (ft^2) of a rectangular settling basin 60 ft long by 15 ft wide?

11. What is the volume of a tank in gallons that is 5'8" wide, 9'7" long, and 3'1" deep?

12. What is the cross-sectional area in ft^2 of a pipe that is 14 inches in diameter?

13. A new 8 inch main must be laid for 1.5 miles. What is the total number of gallons of water to be disinfected?

14. A chemical hopper is cone shaped and covered. It has a diameter of 7 feet and a depth of 13 feet. Calculate the total surface area of the hopper (in ft^2).

15. A section of 6 inch diameter pipeline is to be filled with chlorinated water for disinfection. If a 1/4 mile of pipeline is to be disinfected, how many gallons of water will be required to fill the pipe completely?

16. A reservoir is found to average 56 ft in depth. The shape of the lake is approximately circular with a diameter of approximately 570 ft. How many acre-feet of water does the lake contain?

17. How many liters of chemical can be contained in a tank that has a diameter of 10.5 feet and can be filled to a height of 9.0 feet?

18. What is the total surface area in ft^2 for a 16 inch main that is 1250 feet long?

19. A new section of 12 inch diameter pipe is to be disinfected before it is put into service. If the length of the pipeline is 2000 ft, how many gallons of water will be needed to fill the pipeline?

20. If a trench is 346 ft long, 4.4 ft wide, and 5.7 ft deep, how many cubic yards of soil were excavated?

21. The diameter of a tank is 60 ft. When the water depth is 25 feet, what is the volume of water in the tank, in ft^3?

22. Calculate the volume (in ft^3) of a cone shaped chemical hopper with a diameter of 12 feet and a depth of 18 feet.

23. An aeration basin is 45 feet by 45 feet and is 30 feet deep. What is the total volume of water, in cubic feet, that the basin can hold?

24. A trench is to be excavated 2.5 feet wide, 4 feet deep and 900 feet long. What is the cubic yards volume of the trench?

25. A pipe is 16 inches in diameter and 550 ft long. How many gallons does the pipe contain when full?

26. A 1500 ft 10 inch diameter main flows full. How many gallons of water are contained in that section of line?

27. A trench that is 156 ft long, 3.8 ft wide and 5.8 ft deep fills with water. How many gallons are contained in the trench?

28. A tank is 12 ft wide, 20 ft long and 15 ft deep. If the depth of the water is 11 feet, what is the volume of water in the tank in gallons?

29. What is the volume of a trench in cubic feet if it is 245 ft in length, 4.2 feet in width and 5.8 ft deep?

30. A tank is 25 ft wide, 75 ft long, and can hold water to a depth of 10 ft. What is the total volume of the tank, in gallons?

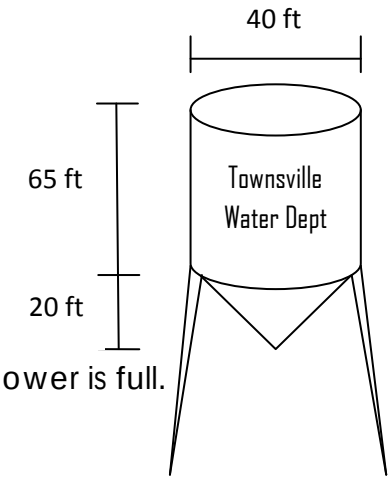
31. Calculate the volume, in cubic feet, of a circular clarifier 7 ft deep and 40 ft in diameter.

32. What is a tank's diameter if the surface area is 6720 ft^2?

33. Calculate the volume of an aeration basin, in gallons, that has the following dimensions: 10 ft high, 60 ft long, 20 ft wide.

34. What is the cubic yard volume of a trench 500 ft long, 2.25 ft wide and 4 feet deep?

35. a. A circular water tower that is tapered at the bottom has a diameter of 40 feet and a height of 75 feet from the top to the beginning of the taper. The cone created by the taper has a height of 20 feet. Calculate the total exterior surface area of the water tower.



35 b. Calculate the total volume (in gallons) when the tower is full.

Area and Volume Answers:

1) 28,028 ft^2

2) 725.47 ft^2

3) 59.66 ft

4) 900 ft^2

5) 224,400 gal

6) 264 ft^2

7) 3,740 gal

8) 43.06 ft^2

9) 0.79 ft^2

10) 1,500 ft^2

11) 1,252.46 gal

12) 1.07 ft^2

13) 20,670.8 gal

14) 186.42 ft^2

15) 193,769.4 gal

16) 327.71 ac-ft

17) 22,052.52 L

18) 1.4 ft^2

19) 11,743.6 gal

20) 321.4 yd^3

21) 70,650 ft^3

22) 678.24 ft^3

23) 60,750 ft^3

24) 333.3 yd^3

25) 5,741.03 gal

26) 6,115.97 gal

27) 25,718.04 gal

28) 19,747.2 gal

29) 5,968.2 ft^3

30) 140,250 gal

31) 8,792 ft^3

32) 92.52 ft

33) 89,760 gal

34) 166.67 yd^3

35) a. 11,196.25 ft^2

b. 673,299.73 gal

Section 4

Velocity and Flow

Velocity & Flow

Velocity

- The speed at which something is moving
- Measured in
  - o $^{ft}/_{min}$ $^{ft}/_{sec}$ $^{miles}/_{hr}$ etc

$$Velocity = \frac{distance}{time}$$

Example 1

- Blue dye is placed in a sewer line at a manhole. Three (3) minutes later, the dye appears in a manhole 125 feet down stream. What is the velocity of the flow in ft/min?

$$Velocity = \frac{distance}{time}$$

$$Vel = \frac{125\ ft}{3\ min}$$

$$Vel = 41.67\ {}^{ft}/_{min}$$

Flow

- The volume of water that flows over a period of time
  - o $\frac{volume}{time}$
- Measured in
  - o ${}^{ft^3}/_{sec}$ ${}^{ft^3}/_{min}$ ${}^{gal}/_{day}$ ${}^{MG}/_{D}$

$$Flow = (Area)(Velocity)$$

$$Q = AV$$

Example 2

- Water is flowing at velocity 3 ft/sec through a channel that is 2 feet wide and 18 inches deep. What is the flow in cubic feet per second?

$$Q = AV$$

$$\left(\frac{18\ in}{1}\right)\left(\frac{1\ ft}{12\ in}\right)$$
$$d = 1.5\ ft$$

$$Q = (l)(w)(velocity)$$

$$Q = (2ft)(1.5ft)\left(3\ {}^{ft}/_{sec}\right)$$

$$Q = 9\ {}^{ft^3}/_{sec}$$

Example 3

- Determine the flow in ft^3/sec through a 5 foot pipe that is flowing full at a velocity of 4.5 ft/sec.

$$Q = AV \qquad A = (0.785)(D^2)$$

$$Q = (0.785)(D^2)(vel)$$

$$Q = (0.785)(5ft)(5ft)\left(4.5\ {}^{ft}/_{sec}\right)$$

$$Q = 88.3\ {}^{ft^3}/_{sec}$$

Velocity

$$Velocity = \frac{Flow\ rate, {}^{ft^3}/_{sec}}{Area, ft^2}$$

- Use this formula when given the flow and area or dimensions

Example 4

- The flow through a 1.5 foot pipeline is 9.7 gallons per minute. What is the velocity of the water in ft/minute?

$$Velocity = \frac{Flow\ rate, {}^{ft^3}/_{sec}}{Area, ft^2}$$

$$\frac{9.7 \frac{gal}{min}}{7.48 \frac{gal}{ft^3}} = 1.30\ {}^{ft^3}/_{min}$$

$$Vel = \frac{1.30\ {}^{ft^3}/_{sec}}{(0.785)(1.5ft)(1.5ft)}$$

$$Vel = \frac{1.30\ {}^{ft^3}/_{sec}}{1.7663\ ft^2}$$

$$Vel = 0.74\ {}^{ft}/_{sec}$$

Velocity and Flow

1. A bobber is placed in a channel and travels 450 feet in 2 ½ minutes. What is the velocity of the water flowing in the channel in ft/min?

2. A channel 30 inches wide has water flowing to a depth of 2 feet. If the velocity of the water is 2.75 ft/sec, what is the flow in the channel in ft^3/sec? And gal/min?

3. The flow through a 24 inch pipe is moving at a velocity of 5.4 ft/sec. What is the flow rate in gal/min?

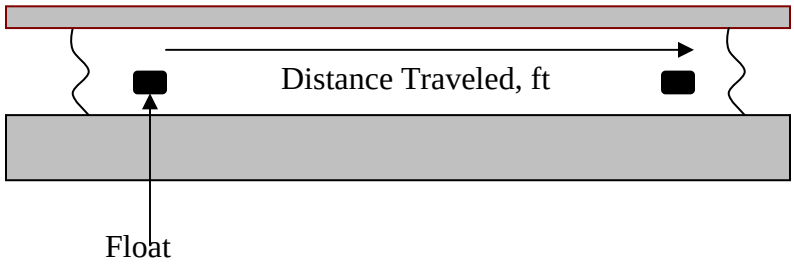
Applied Math for Water Treatment
Flow and Velocity

Velocity

1. A cork is placed in a channel and travels 370 feet in 2 minutes. What is the velocity of the wastewater in the channel, ft/min?

2. A float travels 300 feet in a channel in 2 minutes and 14 seconds. What is the velocity in the channel, ft/sec?

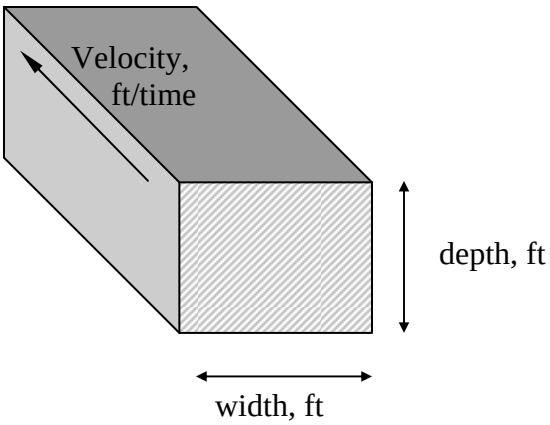
3. The distance between manhole #1 and manhole #2 is 105 feet. A fishing bobber is dropped into manhole #1 and enters manhole #2 in 30 seconds. What is the velocity of the wastewater in the sewer in ft/min?



$$\text{Velocity} = \frac{\text{Distance Traveled, ft}}{\text{Duration of Test, min}}$$

$$= \text{ft/min}$$

1.) 185 ft/min 2.) 2.2 ft/sec 3.) 210 ft/min



$$\underset{ft^3/time}{Q} = \underset{(ft)(ft)}{(A)} \quad \underset{(ft/time)}{(V)}$$

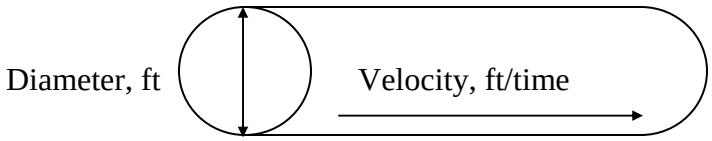
Flow in a channel

4. A channel 48 inches wide has water flowing to a depth of 1.5 feet. If the velocity of the water is 2.8 ft/sec, what is the flow in the channel in cu ft/sec?

5. A channel 3 feet wide has water flowing to a depth of 2.5 feet. If the velocity through the channel is 120 feet/min, what is the flow rate in cu ft/min? in MGD?

6. A channel is 3 feet wide and has water flowing at a velocity of 1.5 ft/sec. If the flow through the channel is 8.1 ft^3/sec, what is the depth of the water in the channel in feet?

4.) 16.8 ft^3/sec 5.) 900 ft^3/min; 9.7 MGD 6.) 1.8 ft



$$\underset{ft^3/time}{Q} = \underset{ft^2}{(A)} \quad \underset{(ft/time)}{(V)}$$

$$\underset{ft^3/time}{Q} = (0.785)\,(D)^2\,(vel)$$
$$(ft)(ft)\ (ft/time)$$

Flow through a full pipe

7. The flow through a 2 ft diameter pipeline is moving at a velocity of 3.2 ft/sec. What is the flow rate in cu ft/sec?

8. The flow through a 6 inch diameter pipeline is moving at a velocity of 3 ft/sec. What is the flow rate in ft^3/sec?

9. The flow through a pipe is 0.7 ft^3/sec. If the velocity of the flow is 3.6 ft/sec, and the pipe is flowing full, what is the diameter of the pipe in inches?

10. An 8 inch diameter pipeline has water flowing at a velocity of 3.4 ft/sec. What is the flow rate in gpm?

7.) 10.05 ft3/sec 8.) 0.59 ft3/sec 9.) 6 in 10.) 532.4 gpm

APPLIED MATH FOR WATER FLOW RATE

$Q = AV$

1. A channel is 3 feet wide with water flowing to a depth of 2 feet. If the velocity in the channel is found to be 1.8 fps, what is the cubic feet per second flow rate in the channel?

2. A 12-inch diameter pipe is flowing full. What is the cubic feet per minute flow rate in the pipe if the velocity is 110 feet/min?

3. A water main with a diameter of 18 inches is determined to have a velocity of 182 feet per minute. What is the flow rate in gpm?

4. A 24-inch main has a velocity of 212 feet/min. What is the gpd flow rate for the pipe?

5. What would be the gpd flow rate for a 6” line flowing at 2 feet/second?

6. A 36” water main has just been installed. If the main is flushed at 2.5 ft/second, how many gallons/minute of water should be flushed from the hydrant?

7. A 36” water main has just been installed. If the main is flowing at a velocity of 2 ft/second, how many MGD will the pipe deliver?

8. A certain pipe has a diameter of 18 inches. If the pipe is flowing full, and the water is known to flow a distance of 830 yards in 5 minutes, what is the MGD flow rate for the pipe?

9. A water crew is flushing hydrants on a 12-inch diameter main. The pitot gage reads 560 gpm being flushed from the hydrant. What is the flushing velocity (in feet/min) through the pipe?

VELOCITY (OPEN CHANNEL)

10. A float is placed in a channel. It takes 2.5 minutes to travel 300 feet. What is the flow velocity in feet per minute in the channel? (Assume that float is traveling at the average velocity of the water.)

11. A cork placed in a channel travels 30 feet in 20 seconds. What is the velocity of the cork in feet per second?

12. A channel is 4 feet wide with water flowing to a depth of 2.3 feet. If a float placed in the channel takes 3 minutes to travel a distance of 500 feet, what is the cubic-feet-per-minute flow rate in the channel?

AQUIFER FLOW

13. Geologic studies show that the water in an aquifer moves 25 feet in 60 days. What is the average velocity of the water in ft/day?

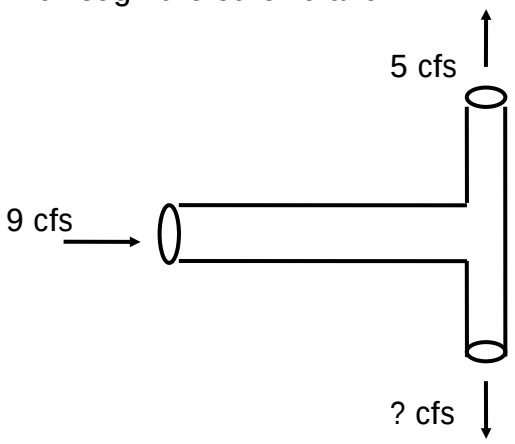
14. If the water in a water table aquifer moves 2 feet per day, how far will the water travel in 13 days?

15. If the water in a water table aquifer moves 2.25 feet per day, how long will it take the water to move 61 feet?

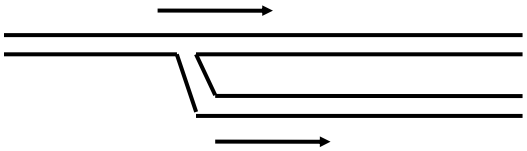
FLOW

16. The average velocity in a full-flowing pipe is measured and known to be 2.9 fps. The pipe is a 24" main. Assuming that the pipe flows 18 hours per day and that the month in question contains 31 days, what is the total flow for the pipe in MG for that one month?

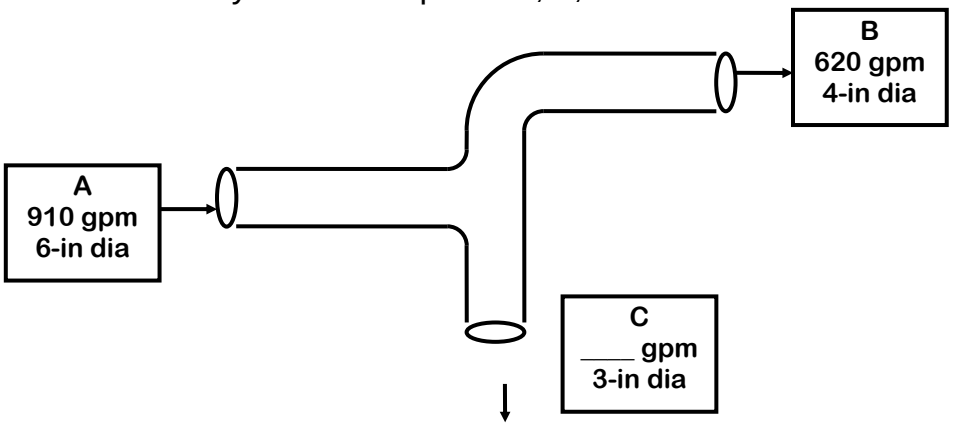
17. The flow entering the leg of a tee connection is 9 cfs. If the flow through one branch of the tee is 5 cfs, what is the flow through the other branch?



18. A water line has been run to a new subdivision. The flow through the main line is 468 gpm. The line splits into two lines (each serving half of the subdivision). If one line flows 210 gpm, what should be the flow from the other line?



19. Determine the velocity in ft/sec at points A, B, & C.



ANSWERS:

1. 10.8 ft^3/sec
2. 86.35 ft^3/min
3. 2,404.50 gpm
4. 7,170,172.42 gpd
5. 253,661.76 gpd
6. 7,926.93 gpm
7. 9.13 MGD
8. 9.47 MGD
9. 95.37 ft/min
10. 120 ft/min
11. 1.5 ft/sec
12. 1,533.3 ft^3/min
13. 0.42 ft/day
14. 26 ft
15. 27.11 days
16. 136.83 MG
17. 4 ft^3/sec
18. 258 gpm
19. A. 10.33 ft/sec
    B. 15.84 ft/sec
    C. 13.17 ft/sec

Applied Math for Water Treatment
Velocity and Flow Extra Problems

1. What is the velocity of flow in feet per second for a 10 inch diameter pipe if it delivers 740 gpm?

2. What is the velocity of flow in feet per second for a 6 inch diameter pipe if it delivers 350 gpm?

3. Water is flowing in a pipeline at 2.65 ft^3/sec. What is the flow in gallons per minute?

4. A water hydrant is flowing 285 gpm. How many cubic feet per second is this?

5. A meter indicates water is flowing from a fire hydrant at 1.50 ft^3/min. How many gallons will flow from the hydrant if it is flushed for exactly 30 min?

6. A water tank with a capacity of 3 MG is being filled at a rate of 2,450 gpm. How many hours will it take to fill the tank?

7. A water tank is being filled by a water line at a rate of 26 gpm. If the tank's capacity is 4,500 gal, how many minutes will it take to fill the tank?

8. A meter indicates that water is flowing from a fire hydrant at 3.2 ft^3/min. How many gallons will flow from the hydrant in 43 minutes?

9. If a water line is flowing at 1.73 ft^3/sec, what is the flow in gallons per minute?

10. A water hydrant is flowing at 245 gpm. How many cubic feet per second is this?

11. How many gallons per minute are flowing from a water main if the flow rate is 3.5 ft^3/sec?

12. A water tank with a capacity of 1.2 MG is being filled at a range of 2,140 gpm. How many hours will it take to fill the tank?

13. An 8.0 inch diameter distribution pipe delivers 1,011,000 gallons in 24 hours. What is the average velocity during the 24 hour time period in feet per second?

14. A water channel is 8.25 ft wide and averages 3.75 ft in depth. What is the velocity of the water (ft/sec) if the flow is 45 ft^3/sec?

15. The velocity through a channel is 2.10 ft/sec. If the channel is 6.5 ft wide and 2.8 ft in depth, what is the flow in cubic feet per second?

16. Water is flowing through a faucet at 15.5 gpm. How long will it take to fill a swimming in hours and minutes if the pool is 45 ft by 22 ft and averages 5.5 ft in depth?

17. If a 5 gallon bucket is filled in 17 seconds, what is the flow from the faucet in gallons per minute?

18. What should the flow meter read in gallons per minute if a 12 inch diameter main is to be flushed at 4.9 ft/sec?

19. What should the flow meter read in gallons per minute if an 18 in. diameter main is to be flushed at 4.75 ft/sec?

20. If a pump discharges 8,240 gal in 1 hour, what will it discharge in 15 hr and 15 min?

21. The velocity through a channel is 1.88 ft/sec. If the channel is 9.45 ft wide and 3.1 ft deep, what is the flow in cubic feet per second? Assume the channel is basically square.

22. Determine the velocity in feet per second if a water flow of 677 gpm is going through an 8 in. pipe.

23. Water is flowing at a velocity of 2.63 ft/sec in an 8 inch diameter pipe. If the pipe changes from the 8 inch to a 14 inch pipe, what will the velocity be in the 14 inch pipe?

24. What is the velocity in ft/min through a 4 inch diameter pipe if it is delivering 175 gpm?

25. Determine the amount of gallons that were used from a storage tank for a particular day in question, given the flowing data:

    Diameter of the tank = 100.0 ft
    Initial water level at beginning of day = 32.56 ft
    Final water level at end of day = 28.33 ft
    Water pumped to tank = 802 gpm

26. A 12 inch main line needs to be flushed. How many minutes will it take to flush the line at 30 gpm if the desired length of pipeline to be flushed is 200 ft.

27. A 31 ft, 1 inch service line requires flushing. How many minutes are required to flush the line if the line is flushed at a rate of 12 gpm and 25 volumes are removed?

28. A 14 inch main line needs to be flushed. If a 100 ft section of the pipeline was flushed for 28 min, what was the flushing rate in gallons per minute?

29. A distribution pipe that is 36 inches in diameter delivers 17,600,000 gallons in 24 hours. What is the average velocity during the 24 hour time period in feet per second?

30. Water is flowing at a velocity of 3.95 ft/sec in an 6 inch diameter pipe. If the pipe changes from the 6 inch to a 10 inch pipe, what will the velocity be in the 10 inch pipe?

31. Water is flowing at a velocity of 1.28 ft/s in an 14 inch diameter pipe. If the pipe changes from the 14 inch to an 8 inch pipe, what will the velocity be in the 8 inch pipe?

Answers

1. 3.03 ft/sec
2. 3.97 ft/sec
3. 1,189.32 gal/min
4. 0.64 ft^3/sec
5. 336.6 gal
6. 20.41 hr
7. 173.07 min
8. 1,029.25 gal
9. 776.42 gpm
10. 0.55 cfs
11. 1570.8 gpm
12. 9.35 hr
13. 4.47 ft/sec
14. 1.45 ft/sec
15. 38.22 ft^3/sec
16. 43 hr 47 min
17. 17.65 gal/min
18. 1,726.31 gpm
19. 3,765.29 gpm
20. 125,660 gal
21. 55.07 ft^3/sec
22. 4.32 ft/sec
23. 0.86 ft/sec
24. 268.28 ft/min
25. 1,403,257 gal
26. 39.14 min
27. 2.63 min
28. 28.55 gal/min
29. 3.85 ft/sec
30. 1.42 ft/sec
31. 3.92 ft/sec

Section 5

Disinfection

Disinfection

Chlorination

- The pounds formula will be one of the most important formulas to learn this week.

$$feed\ rate, \frac{lb}{day} = \frac{(dose)(flow)(8.34\frac{lb}{gal})}{\%\ purity}$$

- If no purity provided, assume it is 100%

Example 1

- A water plant that treats 3,200,000 gallons per day. If the required dosage is 5.4 mg/L of 12.5 % sodium hypochlorite, what is the feed rate in lb/day?

$$feed\ rate, \frac{lb}{day} = \frac{(dose)(flow)(8.34\frac{lb}{gal})}{\%\ purity}$$

$$feed\ rate, \frac{lb}{day} = \frac{(5.4\ mg/L)(3.2\ MGD)(8.34\frac{lb}{gal})}{0.125}$$

$$feed\ rate, \frac{lb}{day} = 1152.92\ lb/day$$

Chlorination

- When asked to find dose, solve pounds formula for the unknown (dose).

$$dose, \frac{mg}{L} = \frac{(feed\ rate, \frac{lb}{day})(\%\ purity)}{(flow, MGD)(8.34\frac{lb}{gal})}$$

CT Calculation

Kill = C x T

- Concentration and contact time are two of the most important parameters in chlorination
- They are inversely proportional
  - As one decreases, the other must increase
- CT is simply the concentration of chlorine in your water times the time of contact that the chlorine has with your water
  - Measured in $\frac{mg \cdot min}{L}$

$$CT = (disinfectant\ residual, \frac{mg}{L})(time, min)$$

Example 3

- Treated water is dosed with 5 mg/L of chlorine for 30 minutes. What is the CT?

$$CT = (disinfectant\ residual, \frac{mg}{L})(time, min)$$

$$CT = (5\,\frac{mg}{L})(30\ min)$$

$$CT = 150\,\frac{mg \cdot min}{L}$$

Hypochlorite

- 2 types of hypochlorite used for disinfection in typical drinking water systems
  - Sodium hypochlorite
    - NaOCl
    - Bleach
    - 5-15% concentration
  - Calcium hypochlorite
    - $Ca(OCl)_2$
    - High test hypochlorite (HTH)
    - 65% concentration

Hypochlorite Strength

$$Hypochlorite\ strength, \% = \frac{chlorine\ required, lbs}{(hypochlorite\ solution\ needed, gal)(8.34\frac{lb}{gal})} x100$$

- To be used when using bleach in the place of chlorine gas
- Can be used for HTH
  - Just drop the 8.34 conversion

Example 4

- A water plant is switching from chlorine gas to sodium hypochlorite. If 133 lbs of gas was fed each day and they now feed 130 gallons of bleach, what concentration of NaOCl is being used?

$$\%\ strength = \frac{chlorine\ required, lbs}{(hypochlorite\ solution\ needed, gal)(8.34\frac{lb}{gal})} x100$$

$$\%\ strength = \frac{133\ lbs}{(130\ gal)(8.34\frac{lb}{gal})} \times 100$$

$$\%\ strength = 12.3\%$$

Two Normal equation

- C =concentration
- $V = volume\ or\ flow$

$$C_1 \times V_1 = C_2 \times V_2$$

$$want = \ have$$

Example 5

- A distribution operator needs to make 10 gallons of a bleach dilution with a concentration 25 mg/L. The bleach on hand has a concentration of 100 mg/L. How many gallons of the concentrate must be used to achieve the dilution?

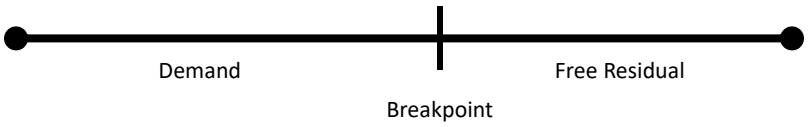
$$C_1 \times V_1 = C_2 \times V_2$$

$$(25\,mg/L)(10\,gal) = (100\ mg/L)(V)$$

$$\frac{(25\ mg/L)(10\,gal)}{100\ mg/L} = V$$

$$2.5\,gal = V$$

Breakpoint Chlorination

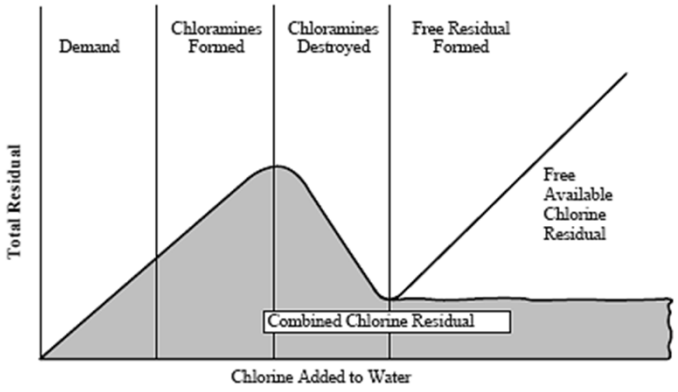


- Total chlorine dose = residual + demand

  -residual - residual
- Dose – residual = demand

Breakpoint Chlorination

- Total chlorine = free residual + combined residual



Disinfection

1. Determine the feed rate in lb/day for a system that wants to dose 2.6 mg/L of 65% HTH. The plant averages 150,000 gallons per day.

2. How many gallons per day of 0.08% sodium hypochlorite would a system need to feed to obtain the required dose of 1.9 mg/L if the system treats 2.0 MGD?

3. Calculate the chlorine dose required if the demand of a water source is 3.7 mg/L and the utility wants to maintain a chlorine residual of 0.8 mg/L in the system.

4. A booster chlorination station feeds 90 lbs/day of chlorine gas to disinfect 900,000 gpd. What is the dose in mg/L?

5. An operator desires 5 gallons of 10 percent bleach. How many gallons of 50 % bleach is required to make the dilution?

6. Treated water travels through a water storage tank in 2 hours. When the water is tested at the end of the 2 hours, the free chlorine residual is approximately 2.3 mg/L. What is the CT in mg•min/L?

Applied Math for Water Treatment
Disinfection

Feed Rate

1. A storage tank is to be disinfected with 60 mg/L of chlorine. If the tank holds 86,000 gallons, how many lb of chlorine (gas) will be needed?

2. Determine the chlorinator setting in lb/day required to treat a flow of 3.5 MGD with a chlorine dose of 1.8 mg/L.

3. A total chlorine dosage of 10 mg/L is required to treat the water in a unit process. If the flow is 1.8 MGD and the hypochlorite has 65% available chlorine, how many lb/day of hypochlorite will be required?

4. A water flow of 928,000 gpd requires a chlorine dose of 2.7 mg/L. If calcium hypochlorite (65% available chlorine) is to be used, how many lb/day of hypochlorite are required?

5. A total of 51 lb/day sodium hypochlorite is required for disinfection of a flow of 2.28 MGD. How many gallons per day sodium hypochlorite is this? Assume the bleach weighs the same as water.

6. A chlorine dose of 2.8 mg/L is required for adequate disinfection of a water unit. If a flow of 1.33 MGD will be treated, how many gpd of sodium hypochlorite will be required? The sodium hypochlorite contains 12.5% available chlorine. Assume the bleach weighs the same as water.

Dosage

7. A chlorine dose of 42 lb/day is required to disinfect a flow of 2,220,000 gpd. If the calcium hypochlorite to be used contains 65% available chlorine, how many mg/L hypochlorite will be required?

8. The water-filled casing of a well has a volume of 540 gallons. If 0.48 lb of chlorine were used in disinfection, what was the chlorine dosage in mg/L?

Breakpoint Chlorination

9. The chlorine demand of a water process is 1.6 mg/L. If the desired chlorine residual is 0.5 mg/L, what is the desired chlorine dose (in mg/L)?

10. The chlorine dosage for a water process is 2.9 mg/L. If the chlorine residual after 30 minutes of contact time is found to be 0.7 mg/L, what is the chlorine demand expressed in mg/L?

Two-Normal

11. How many pounds of 65% available HTH is needed to make 5 gallons of 18% solution?

12. How many pounds of HTH (65% available chlorine) will it take to make a 2% solution when dissolved in enough water to make 15 gallons of hypochlorite?

Practice Problems

13. A flow totalizer reading at 9 am on Thursday was 18,815,108 and at 9 am on Friday was 19,222,420 gallons. If the chlorinator setting is 16 lb for this 24 hour period, what is the chlorine dosage in mg/L?

14. Water from a well is disinfected by a hypochlorinator. The flow totalizer indicates that 2,330,000 gallons of water were pumped during a 7 day period. The 3% sodium hypochlorite solution used to treat the well water is pumped from a 3-foot diameter storage tank. During the 7 day period, the level in the tank dropped 2 ft 10 inches. What is the chlorine dosage in mg/L?

15. How many lb of chloride of lime (25% available chlorine) will be required to disinfect a well if the casing is 18 inches in diameter and 200 ft long with the water level 95 ft from the top of the well? The desired chlorine dosage is 100 mg/L.

16. A chlorinator setting is 43 lb per 24 hours. If the flow being treated is 3.35 MGD, what is the chlorine dosage expressed as mg/L?

17. The chlorine dosage at a plant is 5.2 mg/L. If the flow rate is 6,250,000 gpd, what is the chlorine feed rate (in lb/day)?

18. A sodium hypochlorite solution (3% available chlorine) is used to disinfect water pumped from a well. A chlorine dose of 2.9 mg/L is required for adequate disinfection. How many gallons per day of sodium hypochlorite will be required if the flow being chlorinated is 955,000 gpd?

19. A flow of 3,021,000 gpd is disinfected with calcium hypochlorite (65% available chlorine). If 49 lb of hypochlorite are used in a 24-hour period, what is the chlorine dosage (in mg/L)?

20. A storage tank that is going to be put back into service requires disinfection at a dosage of 30 mg/L. If the tank has a diameter of 102 ft and is 28.1 ft in height at the overflow, how many gallons of 10.25% sodium hypochlorite solution will be needed if the tank is filled to 10% capacity?

21. Determine the chlorinator setting (lb/day) required to treat a flow of 5.5 MGD with a chlorine dose of 2.5 mg/L.

22. Hypochlorite is used to disinfect water pumped from a well. The hypochlorite solution contains 3% available chlorine. A chlorine dose of 2.2 mg/L is required for adequate disinfection throughout the distribution system. If the flow from the well is 245,000 gpd, how much sodium hypochlorite (gallons per day) will be required?

23. Determine the chlorinator setting (lb/day) needed to treat a flow of 980,000 gpd with a chlorine dose of 2.3 mg/L.

24. A chlorine dose of 2.7 mg/L is required for adequate disinfection of a water unit. If a flow of 810,000 gpd will be treated, how many gallons per day of sodium hypochlorite will be required? The sodium hypochlorite contains 12% available chlorine.

25. A new well is to be disinfected with chlorine at a dosage of 40 mg/L. If the well casing diameter is 6 inches and the length of the water-filled casing is 140 ft, how may lb of chlorine will be required?

26. A flow of 1.34 MGD is to receive a chlorine dose of 2.5 mg/L. What should be the chlorinator setting in lb/day?

27. What should the chlorinator setting be (in lb/day) to treat a flow of 4.8 MGD if the chlorine demand is 8.8 mg/L and a chlorine residual of 3 mg/L is desired?

28. A flow of 3,880,000 gpd is to be disinfected with chlorine. If the chlorine demand is 2.6 mg/L and a chlorine residual of 0.8 mg/L is desired, what should be the chlorinator setting lb/day?

29. A hypochlorite solution (4% available chlorine) is used to disinfect a water unit. A chlorine dose of 1.8 mg/L is desired to maintain an adequate chlorine residual. If the flow being treated is 400 gpm, what hypochlorite solution flow (in gallons per day) will be required?

30. A total of 54 lb of hypochlorite (65% available chlorine) is used in a day. If the flow rate treated is 1,512,000 gpd, what is the chlorine dosage (in mg/L)?

31. A flow of 0.83 MGD requires a chlorine dosage of 8 mg/L. If the hypochlorite has 65% available chlorine, how many lb/day of hypochlorite will be required?

32. A total of 36 lb/day sodium hypochlorite is required for disinfection of a flow of 1.7 MGD. How many gallons per day sodium hypochlorite is this?

33. A new well with a casing diameter of 12 inches is to be disinfected. The desired chlorine dosage is 40 mg/L. If the casing is 190 ft long and the water level in the well is 81 feet from the top of the well, how many lb of chlorine will be required?

34. A chlorine dose of 42 mg/L is required to disinfect a flow of 2.22 MGD. If the calcium hypochlorite to be used contains 65% available chlorine, how many lb/day hypochlorite will be required?

35. The chlorine demand of a water unit is 1.8 mg/L. If the desired chlorine residual is 0.9 mg/L, what is the desired chlorine dose (in mg/L)?

36. The chlorine dosage for a water unit is 3.1 mg/L. If the chlorine residual after 30 minutes of contact time is found to be 0.6 mg/L, what is the chlorine demand expressed in mg/L?

37. What chlorinator setting (in lb/day) is required to treat a flow of 1620 gpm with a chlorine dose of 2.8 mg/L?

38. A pipeline 8 inches in diameter and 1600 ft long is to be treated with a chlorine dose of 60 mg/L. How many lb of chlorine will this require?

39. The average calcium hypochlorite use at a plant is 34 lb/day. If the chemical inventory in stock is 310 lb, how many days' supply is this?

40. The flow totalizer reading at 7 a.m. on Wednesday was 43,200,000 gallons and at 7 a.m. on Thursday was 44,115,670 gallons. If the chlorinator setting is 18 lb for this 24-hour period, what is the chlorine dosage (in mg/L)?

41. A chlorine dose of 32 mg/L is required to disinfect a flow of 1,990,000 gpd. If the calcium hypochlorite to be used contains 60% available chlorine, how many lb/day hypochlorite will be required?

42. A flow of 3,350,000 gpd is to be disinfected with chlorine. If the chlorine demand is 2.5 mg/L and a chlorine residual of 0.5 mg/L is desired, what should be the chlorinator setting (in lb/day)?

43. Water from a well is disinfected by a hypochlorinator. The flow totalizer indicates that 2,666,000 gallons of water were pumped during a 7-day period. The 2% sodium hypochlorite solution used to treat the well water is pumped from a 4-foot-diameter storage tank. During the 7-day period, the level in the tank dropped 3 ft 4 inches. What is the chlorine dosage (in mg/L)?

44. A total of 72 lb of hypochlorite (65% available chlorine) is used in a day. If the flow rate treated is 1,885,000 gpd, what is the chlorine dosage (in mg/L)?

45. How many lb of dry hypochlorite (65% available chlorine) must be added to 80 gallons of water to make a 2% chlorine solution?

46. An average of 32 lb of chlorine is used each day at a plant. How many lb of chlorine would be used in a week if the hour meter on the pump registers 140 hours of operation that week?

47. An average of 50 lb of chlorine is used each day at a plant. How many 150-lb chlorine cylinders will be required each month? Assume a 30-day month.

Answers

1.)	43.03 lb	17.)	271.05 lb/day	33.)	0.21 lb
2.)	52.54 lb/day	18.)	92.32 gal/day	34.)	1,196.34 lb/day
3.)	230.95 lb/day	19.)	1.26 mg/L	35.)	2.7 mg/L
4.)	32.15 lb/day	20.)	50.25 gal	36.)	3.7 mg/L
5.)	6.12 gal/day	21.)	114.68 lb/day	37.)	54.48 lb/day
6.)	29.79 gal/day	22.)	17.97 gal/day	38.)	2.09 lb
7.)	1.49 mg/L	23.)	18.8 lb/day	39.)	9.12 days
8.)	106.58 mg/L	24.)	27.78 gal/day	40.)	2.36 mg/L
9.)	2.1 mg/L	25.)	0.07 lb	41.)	19,215.36 lb/day
10.)	2.2 mg/L	26.)	27.94 lb/day	42.)	83.82 lb/day
11.)	1.38 gal	27.)	472.38 lb/day	43.)	7.83 mg/L
12.)	3.85 lb	28.)	110.02 lb/day	44.)	2.98 mg/L
13.)	4.71 mg/L	29.)	25.92 gal/day	45.)	20.53 lb
14.)	1.92 mg/L	30.)	2.78 mg/L	46.)	186.67 lb
15.)	4.62 lb	31.)	85.2 lb/day	47.)	10 cyl/month
16.)	1.54 mg/L	32.)	4.32 gal/day		

Applied Math for Water Treatment
Disinfection Extra Problems

1. If the chlorine residual is 0.8 mg/L and the chlorine demand is 2.8 mg/L, what is the chlorine dose?

2. How many pounds per day of calcium hypochlorite are needed to treat 20.8 MGD with a 1.08 mg/L dosage if the calcium hypochlorite ($Ca(OCl)_2$) has 63% available chlorine?

3. If the chlorine dose is 3.95 mg/L and the chlorine demand is 2.43 mg/L, what is the chlorine residual?

4. How many pounds per day of 61% calcium hypochlorite are required to maintain a 2 mg/L dosage for a treatment plant producing 8,625 gpm?

5. If the desired dose for chlorine is 2.0 mg/L, how many pounds of chlorine per day will be needed to treat 2.1 MGD?

6. A sodium hypochlorite (NaOCl) solution is going to be prepared in a 55-gallon drum. If 10 gal of a 12% solution is added to the drum, how much 12% bleach should be added to make a 2% sodium hypochlorite solution?

7. A water treatment plant has a filter effluent flow of 5,400 gpm and is being treated with 850 gpd of a hypochlorite solution. If the desired dose is 2.25 mg/L, determine the concentration of the hypochlorite solution in percent.

8. A water treatment facility is treating 8.25 MGD. If the desired dose for chlorine is 1.8 mg/L, how many pounds of chlorine per day are required?

9. If the chlorine residual is 1.72 mg/L and the chlorine demand is 1.3 mg/L, what is the chlorine dose?

10. A water treatment facility is treating 5.8 MGD. If the desired dose for chlorine is 1.5 mg/L, how many pounds of chlorine per day are required?

11. Determine the pounds per day of chlorine required if a treatment plant is treating 12.25 MGD with a dosage of 2.20 mg/L.

12. How many gallons of sodium hypochlorite (5.25% available chlorine) are required to disinfect a well with the following parameters: (1) depth of well is 316 ft; (2) 12 in. diameter well casing extends down to 100 ft; (3) the remainder of is a 10 inch diameter casing; (4) the residual desired is 50 mg/L; (5) the depth to water is 83.5 ft; and (6) the chlorine demand is 6 mg/L.

13. A treatment plant is using 880 lb/day of chlorine gas. If the chlorine demand is 2.8 mg/L and the chlorine residual is 1.5 mg/L, how many million gallons per day are being treated?

14. A water treatment plant has a filter flow of 3,250 gpm and is being treated with 650 gpd of a hypochlorite solution. If the desired dose is 3.0 mg/L, determine the concentration of the hypochlorite solution in percent.

15. A well is to be disinfected with 60.0% calcium hypochlorite. The well is 365 ft in depth and 1.5 feet in diameter. Depth to water from the top of the casing is 208 ft. If the desired dose is 50.0 mg/L, how many pounds of calcium hypochlorite are required?

16. A 2 ft diameter pipe that is 3.2 miles long was disinfected with chlorine. If 82.9 lb of chlorine were used, what was the dosage in mg/L?

17. How many pounds of 64% calcium hypochlorite are required for a 2.0 mg/L dosage for a tank that is 100 ft in diameter and has a water level of 28 ft?

18. A plant is treating water at 72.3 MGD. If lime is being added at a rate of 1,645.94 g/min, what is the lime usage in pounds per day?

19. What is the chlorine dosage in mg/L if 14.1 MGD is treated with 289 lb/day of chlorine?

20. Water flowing from a well is being treated with a 5.0% sodium hypochlorite solution. The hypochlorinator is pumping at a rate of 33.6 gpd. What is the chlorine dosage in mg/L if the well is producing 325 gpm? Assume the hypochlorite solution is 8.34 lb/gal.

21. How many pounds per day of 60% calcium hypochlorite are required to maintain a 4 mg/L dosage for a 3,250 gpm treatment plant?

22. A water treatment plant has a flow of 25 MGD and is being treated with 4,010 gpd of a hypochlorite solution. If the desired dose is 2.5 mg/L, determine the concentration of the hypochlorite solution in percent?

23. What is the chlorine dosage in mg/L if 35.2 MGD is treated with 562 lb/day of chlorine?

24. A small tank containing 775 gal of water is to be disinfected using a sodium hypochlorite solution. If the dosage is 50.0 mg/L and the available chlorine in the solution is 5.0%, how many gallons of hypochlorite solution should be added? Assume the sodium hypochlorite (hypo) weighs 8.92 lb/gal.

25. The feed rate for chlorine at a treatment plant is 650 lb/day for a flow of 21 ft^3/sec. If the flow is adjusted to 17 ft^3/sec, what would the theoretical chlorine feed rate be in pounds per day if everything else remained the same?

26. A 325,000-gal water tank is to be disinfected with a 61% hypochlorite solution. The dosage desired is 50.0 mg/L. How many liters of hypochlorite will be required?

27. If the chlorine dose is 4.65 mg/L and the chlorine residual is 1.83 mg/L, what is the chlorine demand?

28. A water treatment facility is treating 9.6 MGD. If the desired dose for chlorine is 1.2 mg/L, how many pounds of chlorine per day are required?

29. A water treatment plant has a filter flow of 6,500 gpm and is being treated with 850 gpd of a hypochlorite solution. The desired dose is 2 mg/L; determine the concentration of the hypochlorite solution, in percent.

30. A water treatment plant is treating 3.5 MGD with 44 lb/day of chlorine. What is the chlorine dosage in mg/L?

31. How many pounds of 64% calcium hypochlorite are required for a 2.5 mg/L dosage for a tank that is 80 ft in diameter and has a water level of 16 ft?

32. A water treatment facility is treating 12.9 MGD. If the desired dose for chlorine is 1.75 mg/L, how many pounds of chlorine per day are required?

33. How many pounds of 64% calcium hypochlorite are required for a 50 mg/L dosage for a tank that is 60 ft in diameter and has a water level of 24 ft?

34. A well that is 220 ft deep and has a diameter of 14 in. required disinfection. Depth to water from the top of the casing is 83 ft. If the desired dose is 50 mg/L, how many pounds of calcium hypochlorite (65% available chlorine) are required?

35. How many pounds per day of calcium hypochlorite are needed to treat 7.1 MGD with a dosage of 2.0 mg/L if the calcium hypochlorite has 62% available chlorine?

36. What is the chlorine dosage in milligrams per liter if 4.6 MGD is treated with 55 lb/day of chlorine?

37. A water treatment plant is treating 14.5 MGD with 274 lb/day of chlorine. What is the chlorine dosage in mg/L?

38. What is the chlorine dosage in mg/L if 38.2 MGD is treated with 956 lb/day of chlorine?

39. How many pounds per day of 60% calcium hypochlorite are required to maintain 2.5 mg/L dosage for a 7500 gpm treatment plant.

40. A water treatment plant is treating 18.5 MGD with 304 lb/day of chlorine. What is the chlorine dosage in mg/L?

41. How many gallons of sodium hypochlorite (5.5% available chlorine) are required to disinfect a well with the following parameters:

    depth of well is 185.5 ft
    12-inch diameter well casing extends down to 100 ft
    the remainder is an 8-inch diameter casing
    the desired dose is 50 mg/L
    the depth to water is 50.1 ft
    sodium hypochlorite weighs 8.99 lb/gal

42. A plant treats 8.5 MGD with alum and a coagulant aid that weighs 10.27 lb/gal. The results of a drawdown test are 98 mL for the coagulant aid in 5 minutes. What is the coagulant aid dosage in mg/L?

43. How many gallons of sodium hypochlorite (5.3% available chlorine) are required to disinfect a well with the following parameters: (1) depth of well is 276 ft; (2) 14 in. diameter well casing extends down to 100.0 ft; (3) remainder of casing is 10 in. in diameter; (4) the residual desired dose is 50.0 mg/L; (5) the depth to water is 64.3 ft; and (6) the chlorine demand is 17 mg/L? Assume the sodium hypochlorite solution weighs 8.95 lb/gal.

Answers

1. 3.6 mg/L
2. 297.38 lb/day
3. 1.52 mg/L
4. 339.6 lb/day
5. 35 lb/day
6. 9.17 gal
7. 2.06%
8. 123.8 lb/day
9. 3.02 mg/L
10. 72.6 lb/day
11. 224.76 lb/day
12. 1.04 gal
13. 24.54 MGD
14. 2.16%
15. 1.44 lb
16. 25.05 mg/L
17. 42.85 lb
18. 5520.6 lb/day
19. 2.46 mg/L
20. 3.6 mg/L
21. 260.21 lb/day
22. 1.56%
23. 1.91 mg/L
24. 0.72 gal
25. 526.19 lb/day
26. 100.83 L
27. 2.82 mg/L
28. 96 lb/day
29. 2.2%
30. 1.5 mg/L
31. 19.58 lb
32. 188 lb/day
33. 330.34 lb
34. 0.7 lb
35. 191.01 lb/day
36. 1.4 mg/L
37. 2.26 mg/L
38. 3 mg/L
39. 375.3 lb/day
40. 1.97 mg/L
41. 0.44 gal
42. 1.1 mg/L
43. 1.18 gal

Section 6

Pumps, Pressure, and Power

Pumps, Power and Force

Horsepower and Efficiency

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Understanding Work & Horsepower

- Work: The exertion of force over a specific distance.
  - Example: Lifting a one-pound object one foot.
- Amount of work done would be measured in foot-pounds
  - (feet) (pounds) = foot-pounds
- (1 pound object) (moved 20 ft) = 20 ft-lbs of work

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Understanding Power

- Power is the measure of how much work is done in a given amount of time
- The basic units for power measurement is foot-pounds per minute and expressed as (ft-lb/min)
  - in electric terminology ⇒ Watts
- This is work performed per time (work/time)
- One Horsepower
  - 1 HP = 33,000 ft-lb/min
- In electric terms
  - 1 HP = 746 Watts

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Types of Horsepower

- **Motor Horsepower** is related to the watts of electric power supplied to a motor
- **Brake Horsepower** is the power supplied to a pump by a motor
- **Water Horsepower** is the portion of power delivered to a pump that is actually used to lift the water
  - Water horsepower is affected by elevation and location of the pump.

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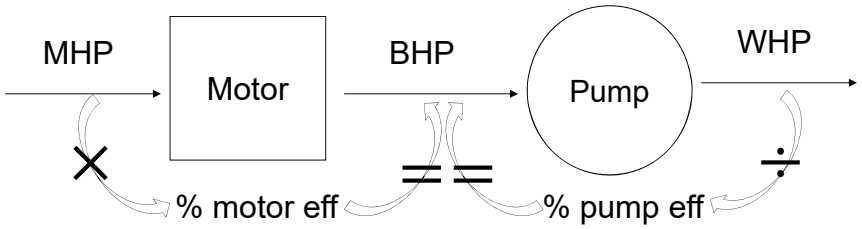

Left to right → multiply

Right to left → divide

Computing Water Horsepower

- Water horsepower is the amount of horsepower required to lift the water

$$WHP = \frac{(flow\ gpm)\ (total\ head\ feet)}{3{,}960}$$

$$\frac{33{,}000\ ft - lb/_{min}}{8.34\ lbs/_{gal}} = 3960$$

Example 1

- A pump must pump 3,000 gpm against a total head of 25 feet. What water horsepower will be required?

$$WHP = \frac{(flow)(head)}{3960}$$

$$WHP = \frac{(3000\ gpm)(25\ ft)}{3960}$$

$$WHP = 18.94\ hp$$

Brake Horsepower

$$bhp = \frac{(flow, gpm)(head, ft)}{(3960)(\%\ pump\ eff.)}$$

OR

$$bhp = \frac{water\ hp}{\%\ pump\ eff.}$$

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Example 2

- Determine the horsepower produce by a motor at a flow of 1500 gpm against a total head of 25 ft if the pump is 82% efficient.

$$bhp = \frac{(flow, gpm)(head, ft)}{(3960)(\%\ pump\ eff.)}$$

$$bhp = \frac{(1500\ gpm)(25\ ft)}{(3960)(0.82)}$$

$$bhp = \frac{37500}{3247.2}$$

$$bhp = 11.5\ hp$$

Motor Horsepower

$$mhp = \frac{(flow, gpm)\ (head, ft)}{(3960)(\%\ pump\ eff)(\%\ motor\ eff)}$$

$$mhp = \frac{water\ hp}{(\%\ pump\ eff)(\%\ motor)}$$

$$mhp = \frac{bhp}{\%\ motor\ eff}$$

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Example 3

- A certain pumping job will require 9 hp. If the pump is 80% efficient and the motor is 72% efficient, what motor horsepower will be required?

$$mhp = \frac{water\ hp}{(\%\ pump\ eff)(\%\ motor)}$$

$$mhp = \frac{9\ hp}{(0.80)(0.72)}$$

$$mhp = \frac{9\ hp}{0.576}$$

$$mhp = 15.6\ hp$$

Motor and Pump Efficiency

- Neither the motor nor the pump will ever be 100% efficient
- Not all the power supplied by the motor to the pump (Brake Horsepower) will be used to lift the water (Water Horsepower)
- Power for the motor and pump is used to overcome friction
- Power is also lost when energy is converted to heat, sound, etc.

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Typical Efficiency

- Pumps are generally 50-85 % efficient
- Motors are usually 80-95% efficient

- Combined efficiency of the motor and pump is called wire-to-water efficiency

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Wire-to-Water Efficiency

$$w - w = \frac{water\ hp}{motor\ hp} \times 100$$

OR

$$w - w = \frac{(flow, gpm)(head, ft)(0.746\ {}^{kW}/_{hp})}{(3960)(electric\ demand, kW)} \times 100$$

Example 4

- A pump must move 2500 gpm against a total dynamic head of 115 feet. If the motor requires 75 kW of power, what is the wire-to-water efficiency?

$$w - w = \frac{(flow, gpm)(head, ft)(0.746\ {}^{kW}/_{hp})}{(3960)(electric\ demand, kW)} \times 100$$

$$w - w = \frac{(2500gpm)(115ft)(0.746\ {}^{kW}/_{hp})}{(3960)(75kW)} \times 100$$

$$w - w = \frac{214475}{297000} \times 100$$

$$w - w = 72.2\%$$

Electrical

A Few Electrical Terms...

- Power (Watts) - amount of work done
- Voltage (volts) - electrical “pressure” available to cause flow of electricity
- Amperage (amps) - the amount of flow of electricity
- Power = (voltage)(amperage)
  or
- Watts = (volts)(amps)

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Amperage

- Current is equal to the voltage applied to the circuit divided by the resistance of the circuit
- Ohm's Law:

$$amps = \frac{volts}{ohms}$$

Example 5

- A circuit contains a resistance of 6 ohms and a source voltage of 3 volts. How much current (amps) flows in the circuit?

$$amps = \frac{volts}{ohms}$$

$$amps = \frac{3\ volts}{6\ ohms}$$

$$amps = 0.5\ amps$$

Electromotive Force

- Electromotive force is the characteristic of any energy source capable of driving electric charge around a circuit
  - Aka voltage

$$emf, volts = (current, amps)(resistance, ohms)$$

Example 6

- A circuit has a resistance of 12 ohms with a current of 0.25 amps. What is the electromotive force in volts?

$$emf, volts = (current, amps)(resistance, ohms)$$

$$emf = (0.25\ amps)(12\ ohms)$$

$$emf = 3\ volts$$

Watts

- Unit of power
- $1\,hp = 0.746\,kW$
- $1\,hp = 746\,W$
- Alternating current (AC circuit)

$$Watts = (volts)(amps)(power\ factor)$$

$$W = V * A * pf$$

- Direct current (DC circuit)

$$Watts = (volts)(amps)$$

$$W = V * A$$

Example 7

- An alternating current motor has a voltage of 5 volts and a current of 3 amps. If the nameplate show that the motor has a power factor of 0.97, what is the power of the motor in watts?

$$Watts = (volts)(amps)(power\ factor)$$

$$W = (5\ volts)(3\ amps)(0.97)$$

$$W = 14.55\ watts$$

Force

Force

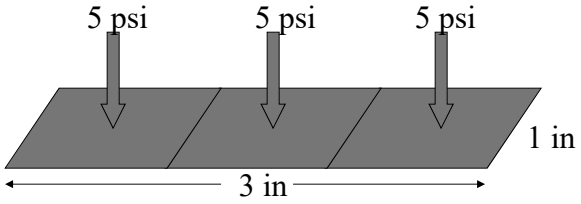
- Force is a push or pull on an object resulting from the object's interaction with another object
- Measured in pounds (lbs)
- $1\,psi = 2.31\,ft\ of\ head$

$$Force, lbs = (pressure, psi)(area, in^2)$$

$$F = P * A$$

Force

- Pressure exerted on a surface corresponds to the force applied to the surface.
- Force = pressure x area



$$Force = (5\ psig)(3in)(1in) = 15\ lb$$

27

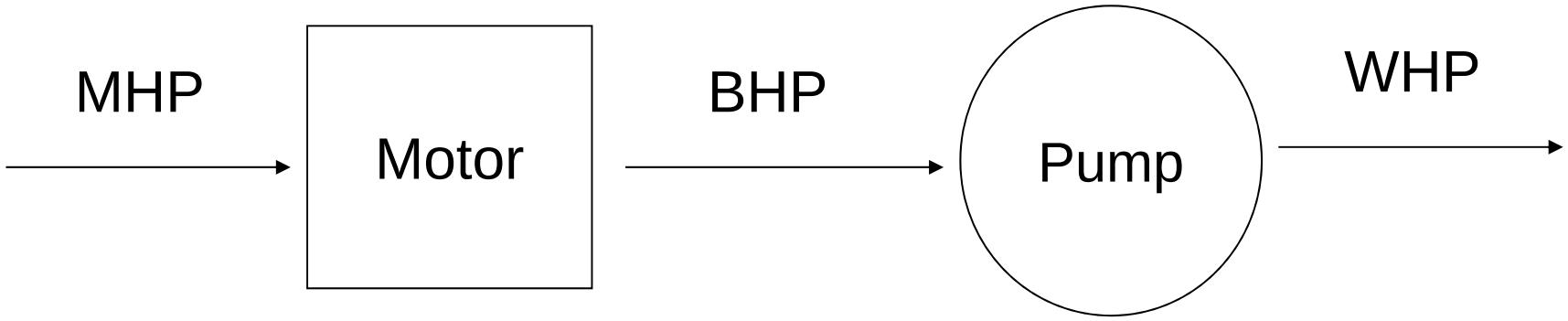
Example 8

- Determine the force, in lbs, being exerted on a surface that is 3 inches by 4 inches with 15 psi of pressure.

$$Force, lbs = (pressure, psi)(area, in^2)$$

$$Force, lbs = (15\ psi)(3\ in)(4\ in)$$

$$Force, lbs = 180\ lbs$$



Left to right → multiply

Right to left → divide

Pumps, Power and Force

1. Determine the water horsepower for a pumping job that must pump 531 gpm against 25 feet of head.

2. What is the horsepower produced by a motor if the water horsepower is 34 hp? The pump in use is 80% efficient.

3. Calculate the motor horsepower for a job that is pumping 1325 gpm against a total dynamic head of 55 ft. The pump is 85% efficient while the motor is 90% efficient.

4. The pump supplies 59 hp to perform a job. If the motor is 91% efficient and the pump is 47% efficient, how much mhp will be supplied to the pump?

5. A pump must transport 1550 gpm against 175 ft of head. If the motor requires 115 kilowatts of power, what is the wire-to-water efficiency of the job?

6. Determine the force, in lbs, exerted on a surface that is 45 in^2 with a pressure of 29 psi.

Applied Math for Water Treatment
Pumps, Pressure, and Power

Pressure

1. If the pressure head on a fire hydrant is 210 ft, what is the pressure in psi?

2. What is the water level in a tank if the pressure at the bottom of a tank is 65 psi?

Water Horsepower

3. A pump is delivering a flow of 835 gpm against a total head of 35.6 feet. What is the water horsepower?

4. A pump must pump 2,500 gpm against a total head of 73 feet. What horsepower (water horsepower) will be required to do the work?

Brake Horsepower

5. A total of 40 hp is required for a particular pumping application. If the pump efficiency is 80%, what is the brake horsepower required?

6. What is the brake horsepower if 62 hp is supplied to a motor with 87% efficiency?

Motor Horsepower

7. You have calculated that a certain pumping job will require 6 whp. If the pump is 80 percent efficient and the motor is 90 percent efficient, what motor horsepower will be required?

8. The brake horsepower is 34.4 hp. If the motor is 86% efficient, what is the motor horsepower?

Pumping Rate

9. If a pump discharges 840 gpm, how many gallons will it discharge in 4 hours and 20 minutes?

10. If a pump discharges 7,880 gal in 2 hours and 13 minutes, how many gallons per minute is the pump discharging?

11. A flow of 555 gpm must be pumped against a head of 40 feet. What is the horsepower required?

12. Based on the gallons per minute to be pumped and the total head the pump must pump against, the water horsepower requirement was calculated to be 18.5 whp. If the motor supplies the pump with 21 hp, what must be the efficiency of the pump?

13. You have calculated that a certain pumping job will require 10.1 whp. If the pump is 84% efficient and the motor is 73% efficient, what motor horsepower will be required?

14. If 20 hp is supplied to a motor (mhp), what is the whp if the motor is 85% efficient and the pump is 80% efficient?

15. Convert a pressure of 26 ft to pounds per square inch.

16. A supply tank is located at an elevation of 118 ft. The discharge point is at an elevation of 215 ft. What is the static head (in feet)?

17. A pump must pump against a total dynamic head of 70 ft at a flow rate of 700 gpm. The liquid to be pumped has a specific gravity of 1.3. What is the water horsepower required for this pumping application?

18. If the pressure at the bottom of the tank is 14.7 psi, what is the height (in ft) of the water in the tank?

19. The motor nameplate indicated that the output of a certain motor is 35 hp. How much horsepower must be supplied to the motor, if the motor is 90% efficient?

20. What would be the horsepower on a motor that is rated at 16 amps and 440 volts?

21. What would be the horsepower on a motor that is rated at 36 amps and 440 volts?

22. The motor horsepower requirement has been calculated to be 45 hp. How many kilowatts electric power does this represent? (Remember, 1 hp = 746 watts)

23. A pump must pump 1600 gpm against a total head of 50 ft. What horsepower is required for this work?

24. A pressure of 42 psig is equivalent to how many feet of water?

25. What is the motor horsepower for a pump with the following parameters?

Motor eff: 91%	Total head: 98 ft
Pump eff: 81%	Flow: 2.44 MGD

26. A hypochlorite solution is being pumped from a small tank that is 2.5 ft in diameter. If the level in the tank drops 2.05 ft in 3.5 hrs, how many gallons per minute of hypochlorite solution was used?

27. What is the motor hp if the bhp is 68 and the motor efficiency is 87%?

28. If a pump is to deliver 360 gpm of water against a total head of 95 feet, and the pump has an efficiency of 85 percent, what horsepower must be supplied to the pump?

29. You have calculated that a certain pumping job will require 9 whp. If the pump is 80 percent efficient and the motor is 72 percent efficient, what motor horsepower will be required?

30. The motor horsepower of a pump is 22 hp. If the water horsepower is 17 hp, what is the wire to water efficiency of the pump?

31. A pump must pump 1500 gpm against a total head of 40 ft. What horsepower is required for this work?

32. The pressure gauge on the discharge line from an influent pump reads 72.3 lbs per square inch (psi). What is the equivalent head in feet?

33. Determine the number of gallons a pump discharges in 1 hour if it is pumped at a rate of 1,340 gpm.

34. If the water level in a tank is 31.78 ft, what is the pressure in psi at the bottom?

35. If 25 horsepower is supplied to a motor (mhp), what is the water horse power (whp) if the motor is 80% efficient and the pump is 75% efficient?

36. The elevations of two water surfaces are 780 ft and 624 ft what is the total dynamic head in feet?

37. Suppose a pump is pumping against a total head of 46 feet. If 850 gpm is to be pumped, what is the horsepower requirement?

38. What is the water horsepower of a pump that is producing 1,523 gpm against a head of 65 feet?

39. Suppose that 10 kilowatts (kW) power is supplied to a motor. If the water horsepower is 12 hp, what is the wire-to-water efficiency of the motor?

40. The motor nameplate indicated that the output of a certain motor is 20 hp. How much horsepower must be supplied to the motor if the motor is 90 percent efficient?

41. If a pump is to deliver 630 gpm of water against a total head of 102 feet, and the pump has an efficiency of 78%, what power must be supplied to the pump?

42. The motor horsepower is 25 hp. If the motor is 89% efficient, what is the brake horsepower?

43. What is the depth of water in a lake if the psi is 56.7?

44. Convert 32 psig to ft of head.

45. A water tank has 250 feet of water in it. What is the pressure gauge reading at ground level in psi?

46. A water tank has a pressure gauge located 2 ft below the ground level in a pit. Its current reading is 60 psig. How many feet of water are in the tank?

47. The elevations of two water surfaces are 320 ft and 241 feet. What is the total static head in feet?

48. What is the pressure head at a fire hydrant in feet if the pressure gauge reads 189 psi?

49. The pressure at the bottom of a reservoir is 132 psi. What is the depth at that point?

50. If the water level in a reservoir is 625 ft, what is the pressure in pounds per square in at an inlet if it is 165 ft from bottom?

51. A total of 50 hp is supplied to a motor. If the wire-to-water efficiency of the pump and motor is 62%, what will the whp be?

52. A total of 35 hp is required for a particular pumping application. If the pump efficiency is 85%, what is the brake horsepower required?

53. A pump is delivering a flow of 1,035 gpm against 46.7 feet of head. What horsepower will be required?

54. A pump must pump 3,000 gpm against a total head of 25 feet. What horsepower (water horsepower) will be required to do the work?

55. If a pump is to deliver 450 gpm of water against a total head of 90 feet, and the pump has an efficiency of 70 percent, what horsepower must be supplied to the pump?

56. If the pressure head at a fire hydrant is 210 ft, what is the psi?

57. A head of 310 ft of water is equivalent to what pressure in psi?

58. A water tank has a pressure gauge located 4 ft above the ground. Its current reading is 60 psig. How many feet of water are in the tank?

59. Suppose a pump is pumping a total head of 76.2 feet. If 900 gpm is to be pumped, what is the water horsepower requirement?

60. Suppose that 31 kilowatts (kW) power is supplied to a motor. If the brake horsepower is 19 bhp, what is the efficiency of the motor?

61. What would be the horsepower on a motor that is rated at 12 amps and 440 volts?

62. If the motor horsepower is 50 hp and the brake horsepower is 43 hp, what is the percent efficiency of the motor?

63. Determine the brake horsepower if the motor has an efficiency of 88 % and the horsepower is 45.

64. If the pressure head at a blow off valve is 136 ft, what is the pressure in psi?

ANSWERS

1)	90.91 psi	23)	20.2 hp	45)	108.23 psi
2)	12.18 psi	24)	97.02 ft	46)	136.6 ft
3)	7.5 hp	25)	56.9 mhp	47)	79 ft
4)	46.1 hp	26)	0.36 gpm	48)	436.59 ft
5)	50 hp	27)	78.2 hp	49)	304.92 ft
6)	53.9 hp	28)	10.2 hp	50)	199.13 psi
7)	8.3 hp	29)	15.6 hp	51)	31 hp
8)	40 hp	30)	77.27%	52)	41.2 hp
9)	218,400 gal	31)	15.2 hp	53)	12.2 hp
10)	59.25 gpm	32)	167.01 ft	54)	18.9 hp
11)	5.6 hp	33)	80,400 gal	55)	14.6 hp
12)	88.1%	34)	13.76 psi	56)	90.91 psi
13)	16.5 hp	35)	15 whp	57)	134.2 psi
14)	13.6 whp	36)	156 ft	58)	142.6 ft
15)	11.26 psi	37)	9.9 hp	59)	17.3 hp
16)	97 ft	38)	25 hp	60)	45.7%
17)	16.1 hp	39)	89.55%	61)	7.1 hp
18)	33.96 ft	40)	22.2%	62)	86%
19)	38.9 hp	41)	20.8 hp	63)	39.6 hp
20)	9.4 hp	42)	22.3 hp	64)	58.87 psi
21)	21.2 hp	43)	130.98 ft		
22)	33.57 kW	44)	73.92 ft		

Applied Math for Water Treatment
Pumps, Pressure and Force Extra Problems

1. The difference between the inlet and outlet pressure gauges for a pump that is off is 72 psi. What is the total head in ft if friction and minor head losses are 11 ft?

2. A tank is 30 ft in diameter and 20 ft tall. If there are 78,500 gal of water in the tank, what is the psi at the bottom of the tank?

3. What is the psi at the bottom of a tank if the water level is 24.3 ft deep?

4. What is the total head in feet for a pump that is operating when the inlet pressure gauge reads 65 psi and the outlet gauge reads 100 psi?

5. What is the depth of water in feet in a like if the psi is 40.7?

6. What is the total head, in feet, for a pump that is operating when the inlet pressure gauge reads 79 psi and the outlet gauge reads 128 psi?

7. If the water depth in a reservoir is 13.06 ft, what is the pressure at 12 ft below the water surface in pounds per square inch?

8. A tank is 60 ft in diameter and 24 ft tall. If there are 240,500 gal of water in the tank, what is the pounds per square inch at the gauge 5 ft above the bottom of the tank?

9. If a pump discharges 8,750 gal in 2 hr and 45 minutes, how many gallons per minute is the pump discharging?

10. A force of 10 lb is applied to a small cylinder on a hydraulic jack. The diameter of the small cylinder on a hydraulic jack is 3 inches. If the diameter of the large cylinder is 1.75 ft, what is the total lifting force?

11. How long will it take, in hours, for a pump to discharge 86,400 gal if it is pumping at a rate of 30 gpm?

12. A force of 50 lb is applied to a small cylinder on a hydraulic jack. The diameter of the small cylinder is 10 inches. If the diameter of the large cylinder is 2.5 ft, what is the total lifting force?

13. A pumps output is averaging 36 gpm. How many gallons will it pump in one day?

14. Determine the cost to operate a 100 hp motor for 1 month (assume 30 days) if it runs an average of 7.23 hr/day, is 83% efficient, and the electrical costs are $0.045 per kW.

15. How many gallons will a pump discharge if it pumps an average of 65 gpm for 1 hour and 42 minutes?

16. A small cylinder on a hydraulic jack is 6 inch in diameter. A force of 200 lb is applied to the small cylinder. If the diameter of the large cylinder is 3 ft, what is the total lifting force?

17. Determine a pump's total output in million gallons per day if it is pumping 1,550 gal/min.

18. A small cylinder on a hydraulic jack is 8 inches in diameter. A force of 100 lb is applied to the small cylinder. If the diameter of the large cylinder is 3 ft, what is the total lifting force?

19. Find the total head in feet for a pump with a total static head of 22 ft and a head loss of 2 ft.

20. What is the total head for a pump that is operating when the inlet pressure gauge reads 62 psi and the outlet gauge reads 114 psi?

21. What is the motor horsepower if 40 hp is required discharged by a pump with a motor efficiency of 92% and a pump efficiency of 83%?

22. Water is being pumped from a water source with an elevation of 290 ft to an elevation of 365 ft. What is the total head in feet if friction and minor head losses are 12 ft?

23. What is the motor horsepower if the brake horsepower (bhp) is 48 and the motor efficiency is 88%?

24. A force of 25 lb is applied to a small cylinder on a hydraulic jack. The diameter of the small cylinder is 6 inches. If the diameter of the large cylinder is 1.5 ft, what is the total lifting force?

25. What is the brake horsepower if 10 hp is supplied to a motor with 88% efficiency?

26. What is the flow in gallons per minute from a faucet that fills a 5 gallon container in 3 minutes and 6 seconds?

27. What is the brake horsepower if the water horsepower is 40 and the pump efficiency is 78%?

28. A small cylinder on a hydraulic jack is 6.0 inches in diameter. A force of 133 lb is applied to the small cylinder. If the diameter of the large cylinder is 2.5 ft, what is the total lifting force?

29. Find the water horsepower if the brake horsepower is 45.7 and the pump is efficiency is 81%.

30. A tank is 60.0 ft in diameter and 24 ft tall. If there are 240,500 gal of water in the tank, what is the pounds per square inch at the bottom of the tank?

31. What is the motor horsepower if 60 hp is required to perform a pumping job with a motor efficiency of 93% and a pump efficiency of 85%?

32. Find the water horsepower if the brake horsepower is 38.4 and the pump efficiency is 84%

33. A tank is 30 ft in diameter and 20 ft tall. If there are 78,500 gal of water in the tank, what is the pounds per square inch 5 ft from the bottom of the tank?

Answers

1. 177.32 ft
2. 6.43 psi
3. 10.5 psi
4. 80.85 ft
5. 94 ft
6. 113.19 ft
7. 5.2 psi
8. 2.8 psi
9. 53 gpm
10. 490 lb
11. 48 hr
12. 450.34 lb
13. 51,840 gal
14. $604.35
15. 6,630 gal
16. 7,200 lb
17. 2.23 MGD
18. 2,025 lb
19. 24 ft
20. 120.12 ft
21. 52.4 hp
22. 87 ft
23. 54hp
24. 225 lb
25. 9 hp
26. 1.6 gpm
27. 51.3 hp
28. 3,325 lb
29. 37 hp
30. 4.93 psi
31. 75.9 hp
32. 32.3 hp
33. 4.26 psi

Section 7

Chemical Feeders

Chemical Feeders

Mass

- Mass is a measurement of how much matter is in an object
  - On Earth, it will be the same as weight

$$\text{mass, lbs} = (\text{volume, MG})\left(\text{concentration, }\frac{\text{mg}}{\text{L}}\right)\left(8.34\frac{\text{lb}}{\text{gal}}\right)$$

Feed Rate

- When adding chemicals to the water flow, a measured amount of chemical is required that depends on such factors as the type of chemical being used, the reason for dosing and the flow rate being treated.
- To go from mg/L to lb/day:

$$\text{loading rate}, \frac{\text{lb}}{\text{day}} = (\text{dose}, \text{mg/L})(\text{flow}, \text{MGD})(8.34\ {}^{\text{lb}}/_{\text{gal}})$$

Example 1

- Jar tests indicate that the best alum dose for a water is 8 mg/L. If the flow to the be treated is 2,100,000 gpd, what should the lb/day setting be on the dry alum feeder?

$$\text{loading rate}, \frac{\text{lb}}{\text{day}} = (\text{dose}, \text{mg/L})(\text{flow}, \text{MGD})(8.34\ {}^{\text{lb}}/_{\text{gal}})$$

$$\frac{\text{lb}}{\text{day}} = (8\ {}^{\text{mg}}/_{\text{L}})(2.10\text{MGD})(8.34\ {}^{\text{lb}}/_{\text{gal}})$$

$$\frac{\text{lb}}{\text{day}} = 140\ {}^{\text{lb}}/_{\text{day}}$$

Example 2

- An operator collects three 1 minute samples of lime from the dry feeder. The weights collected are 5 grams, 7 grams and 5 grams, respectively. Determine the average feed rate in lbs/day.

$$\text{average} = \frac{5\text{g} + 7\text{g} + 5\text{g}}{3} = \frac{17\text{g}}{3} = 5.67\text{grams}$$

$$\left(\frac{5.67\ \text{grams}}{1\ \text{minute}}\right)\left(\frac{60\ \text{min}}{1\ \text{hr}}\right)\left(\frac{24\ \text{hr}}{1\ \text{day}}\right)\left(\frac{1\ \text{kg}}{1000\ \text{g}}\right)\left(\frac{1\ \text{lb}}{0.454\ \text{kg}}\right)$$

$$\frac{(5.67)(60)(24)(1)(1)}{(1)(1)(1)(1000)(0.454)} = \frac{8164.8}{454}$$

Chemical Solution Feeder Setting

- When solution concentration is expressed as lb chemical per gallon solution (lb/gal), the required feed rate can be determined
  - Use the lb/day formula and convert it to gal/day

$$\text{gal}/\text{day} = \frac{\text{chemical, lb}/\text{day}}{\text{lb chemical}/\text{gal solution}}$$

Example 3

- Jar tests indicate that the best alum dose for a water is 7 mg/L. The flow to be treated is 1.52 MGD. Determine the gallons per day setting for the alum solution feeder if the liquid alum contains 5.36 lbs of alum per gallon of solution.

$$\text{loading rate}, \frac{\text{lb}}{\text{day}} = (\text{dose})(\text{flow})(8.34\ {}^{\text{lb}}/_{\text{gal}})$$

$$\frac{\text{lb}}{\text{day}} = (7\ {}^{\text{mg}}/_{\text{L}})(1.52\ \text{MGD})(8.34\ {}^{\text{lb}}/_{\text{gal}})$$

$$\frac{\text{lb}}{\text{day}} = 88.7376\ {}^{\text{lb}}/_{\text{day}}$$

Example 3 Cont'd

- Chemical Solution Feeder Setting

$$\text{gal/day} = \frac{\text{chemical}\ {}^{\text{lb}}/_{\text{day}}}{\text{lb chemical}/_{\text{gal solution}}}$$

Chemical Feed Pump Setting

- Some solution chemical feeders dispense chemical as millimeters per minute (mL/min).

$$\frac{\text{mL}}{\text{min}} = \frac{(\text{Flow, MGD})\left(\text{dose}, \frac{\text{mg}}{\text{L}}\right)\left(3.785\frac{\text{L}}{\text{gal}}\right)\left(1{,}000{,}000\frac{\text{gal}}{\text{MG}}\right)}{\left(\text{liquid}, \frac{\text{mg}}{\text{mL}}\right)\left(1440\frac{\text{min}}{\text{day}}\right)}$$

**If percent purity is provided, divide final number by decimal

Example 4

- A flow of 2.12 MGD is to be treated with a solution of chemical. The desired dose is 1.4 mg/L. The chemical to be fed weighs 1175.5 mg/mL. What should be the mL/min solution feed rate?

$$\frac{\text{mL}}{\text{min}} = \frac{(\text{Flow, MGD})\left(\text{dose}, \frac{\text{mg}}{\text{L}}\right)\left(3.785\frac{\text{L}}{\text{gal}}\right)\left(1{,}000{,}000\frac{\text{gal}}{\text{MG}}\right)}{\left(\text{liquid}, \frac{\text{mg}}{\text{mL}}\right)\left(1440\frac{\text{min}}{\text{day}}\right)}$$

$$\frac{\text{mL}}{\text{min}} = \frac{(2.12\text{MGD})\left(1.4\frac{\text{mg}}{\text{L}}\right)(3.785\frac{\text{L}}{\text{gal}})(1{,}000{,}000\frac{\text{gal}}{\text{MGD}})}{(1175.5\frac{\text{mg}}{\text{mL}})(1440\frac{\text{min}}{\text{day}})}$$

$$\frac{\text{mL}}{\text{min}} = \frac{11{,}233{,}880\text{mg}}{1692720\frac{\text{mg}\cdot\text{min}}{\text{mL}}} = \quad 6.64\frac{\text{mL}}{\text{min}}$$

Chemical Feed Pump Setting

- Chemical feed pumps are generally positive displacement pumps (e.g. piston pumps)
- This type of pump displaces, or pushes out, a volume of chemical equal to the volume of the piston
- The length of the piston, called the stroke, can be lengthened or shortened to increase or decrease the amount of chemical delivered by the pump

$$\%\ \text{stroke} = \frac{\text{desired flow}}{\text{maximum flow}} \times 100$$

Example 5

- The required chemical pumping rate has been calculated as 8 gpm. If the maximum pumping rate is 90 gpm, what should the percent stroke setting be?

$$\%\ \text{stroke} = \frac{\text{desired flow}}{\text{maximum flow}} \times 100$$

$$\%\ \text{stroke} = \frac{8\ \text{gpm}}{90\ \text{gpm}} \times 100$$

$$\%\ \text{stroke} = 8.9\%$$

Chemical Feeders

1. Jar tests indicate that the best alum dose for a unit process is 10 mg/L. The liquid alum contains 648 milligram per milliliter of solution. What should the setting be on the solution chemical feeder (in milliliters per minute) when the flow to be treated is 3.45 MGD?

2. A flow of 1,850,000 gpd is to be treated with alum. Jar tests indicate that the optimum alum dose is 10 mg/L. If the liquid alum contains 5.4 pounds per gallon solution, what should be the gallons per day setting for the alum solution feeder?

3. The average gallons of polymer solution used each day at a treatment plant is 88 gpd. A chemical feed tank has a diameter of 3 ft and contains solution to a depth of 3 ft 4 inches. How many days' supply are represented by the solution in the tank?

4. The maximum pumping rate is 110 gpm. If the required pumping rate is 40 gpm, what is the percent stroke setting?

Chemical Feeders

1. A water plant fed 130 lbs of alum each day to treat 1.3 MGD. Calculate the dose in mg/L.

2. The average flow for a water plant is 3.25 MGD. A jar test indicates that the best alum dosage is 2.5 mg/L. How many pounds per day will the operator feed?

3. Jar tests indicate that the best liquid alum dose for a water unit is 11 mg/L. The flow to be treated is 2.13 MGD. Determine the gallons per day setting for the liquid alum chemical feeder if the liquid alum is a 60% solution. Assume the alum solution weighs about 8.34 lb/gal.

4. Jar tests indicate that the best liquid alum dose for a water unit is 10 mg/L. The flow to be treated is 4.10 MGD. Determine the gallons per day setting for the liquid alum chemical feeder if the liquid alum contains 5.88 lbs of alum per gallon of solution.

5. A water treatment plant used 14 pounds of cationic polymer to treat 2.0 million gallons of water during a 24-hour period. What is the polymer dosage in mg/L?

6. A water treatment plant used 27 pounds of cationic polymer to treat 1.6 million gallons of water during a 24-hour period. What is the polymer dosage in mg/L?

7. A jar test indicates the 4.3 mg/L of liquid alum is required in treating 6.7 MGD. How many mL/min should the metering pump deliver? The liquid alum delivered to the plant contains 645 mg alum per mL of liquid solution.

8. The operator measured the amount of dry chemical fed in one day as 114.5 lbs. How many grams/min should the dry feeder have delivered?

9. The maximum pumping rate is 110 gpm. If the required pumping rate is 40 gpm, what is the percent stroke setting?

10. The required chemical pumping rate has been determined to be 14 gpm. What is the percent stroke setting if the maximum rate is 70 gpm?

11. A jar test indicates the 3.4 mg/L of liquid alum is required in treating 7.6 MGD. How many mL/min should the metering pump deliver? The liquid alum delivered to the plant contains 645 mg alum per mL of liquid solution.

12. Liquid alum delivered to a water treatment plant contains 642.3 milligrams of alum per milliliter of liquid solution. Jar tests indicate that the best alum dose is 8 mg/L. Determine the setting on the liquid alum chemical feeder in milliliters per minute if the flow is 2.2 MGD.

13. An operator is checking the calibration on a chemical feeder. The feeder delivers 102 grams in 5 minutes. How many pounds per day does the feeder deliver?

14. The average flow for a water plant is 8.3 MGD. A jar test indicates that the best alum dosage is 2.2 mg/L. How many grams per minute should the feeder deliver?

15. You collect three 2-minute samples from an alum dry feeder. What is the feed rate in lb/day when the flow rate is 2 MGD?
    a. Sample 1 = 25 grams
    b. Sample 2 = 22 grams
    c. Sample 3 = 24 grams

16. A water plant used 167 gallons of a liquid chemical in one day. How many mL/min was pumped?

17. The average daily flow for a water plant is 7.5 MGD. Jar test results indicate the best polymer dosage is 1.8 mg/L. How many pounds of polymer will be used in 90 days?

18. Liquid alum delivered to a water treatment plant contains 642.3 milligrams of alum per milliliter of liquid solution. Jar tests indicate that the best alum dose is 15 mg/L. Determine the setting on the liquid alum chemical feeder in milliliters per minute when the flow is 7.2 MGD. There are 3.785 liters in one gallon.

19. A pond has an average length of 250 ft, an average width of 75 ft and an average depth of 10 ft. If the desired dose of copper sulfate is 0.8 lbs/acre-ft, how many pounds of copper sulfate will be required?

20. Jar tests indicate that the best alum dose for a water unit is 8 mg/L. The flow to be treated is 1,440,000 gpd. Determine the gallons per day setting for the liquid alum chemical feeder if the liquid alum contains 6.15 lb of alum per gallon of solution.

21. The required chemical pumping rate has been calculated to be 22 gpm. If the maximum pumping rate is 80 gpm, what should the percent stroke setting be?

22. An operator collects 3 two-minute samples from a dry feeder to check the calibration. What is the average feed rate in lb/day?
    a. Sample 1 weighs 47.3 grams
    b. Sample 2 weighs 44.8 grams
    c. Sample 3 weighs 42.4 grams

23. A water plant is treating 1.8 MGD with 2.0 mg/L liquid alum. How many gpd of liquid alum will be required? The liquid alum contains 5.36 lbs dry alum/gallon.

24. An operator checks the calibration of a dry feeder by catching samples and weighing them on a balance. Each catch lasts 1 minute. Based on the following data, what is the average feed rate in lb/hour?
    a. Sample 1 weighs 37.0 grams
    b. Sample 2 weighs 36.2 grams
    c. Sample 3 weighs 39.4 grams
    d. Sample 4 weighs 38.6 grams

25. The flow to the plant is 4,440,000 gpd. Jar testing indicates that the optimum alum dose is 9 mg/L. What should the gallons per day setting be for the solution feeder if the alum solution is 60% solution. Assume the solution weighs 8.34 lb/gal.

26. $KMnO_4$ has been made according to the manufacturer recommendations (30 mg/mL). The water plant operator wants to dose 3.6 MGD with 2.0 mg/L KMnO4. How many mL/min must be delivered by the metering pump?

27. Determine the setting on a dry alum feeder in pounds per day when the flow is 1.3 MGD. Jar tests indicate that the best alum dose is 12 mg/L.

28. The required chemical pumping rate has been calculated to be 30 gpm. If the maximum pumping rate is 80 gpm, what should the percent stroke setting be?

29. An operator collects 5 two-minute samples from a dry feeder. What is the average feed rate in lb/day?
    a. Sample 1 weighs 49.2 grams
    b. Sample 2 weighs 44.0 grams
    c. Sample 3 weighs 41.9 grams
    d. Sample 4 weighs 48.3 grams
    e. Sample 5 weighs 47.6 grams

30. Determine the setting on a dry alum feeder when the flow is 5.4 MGD. Jar tests indicate that the best alum dose is 8 mg/L. What would be the setting in grams per minute?

31. A water plant is treating 8.2 MGD with 2.0 mg/L liquid alum. How many gpd of liquid alum will be required? The liquid alum contains 5.36 lbs dry alum/gallon.

32. The average daily flow for a water plant is 0.75 MGD. If the polymer dosage is kept at 1.8 mg/L, how many pounds of polymer will be used in 30 days?

33. A chemical feeder feeds a liquid chemical to a 1000 mL graduated cylinder for 48 seconds. At the end of the 48 seconds, the graduated cylinder is completely full. What is the chemical feed rate for the metering pump in gallons per day?

34. An operator collects 3 two-minute samples from a dry feeder. What is the average feed rate in lb/day?
    a. Sample 1 weighs 22.2 grams
    b. Sample 2 weighs 24.0 grams
    c. Sample 3 weighs 21.9 grams

35. A water plant treats 3.5 MGD with a dose of 2.2 mg/L $KMnO_4$. If the water plant uses 257 gallons of permanganate per day, how many mL/min must be pumped?

36. For algae control of a reservoir, a dosage of 0.5 mg/L copper is desired. The reservoir has a volume of 20 MG. How many pounds of copper sulfate (25% available copper) will be required?

37. A jar test indicates that 1.8 mg/L of liquid ferric chloride should be fed to treat 2,778 gpm of water. How many mL/min should be fed by a metering pump? Ferric chloride contains 4.59 lbs dry chemical per gallon of liquid solution.

38. Liquid polymer is supplied to a water treatment plant as an 8% solution. How many gallons of liquid polymer should be used to make 55 gallons of a 0.5% polymer solution?

39. The average flow for a water plant is 13.5 MGD. The jar test indicates that the best alum dose is 1.8 mg/L. How many pounds per day will the operator feed?

40. A water plant fed 52 grams per minute of dry alum while treating 2.6 MGD. Calculate the mg/L dose.

41. The average flow for a water plant is 6.3 MGD. A jar test indicates that the best alum dosage is 19 mg/L. How many pounds per day will the operator feed?

42. The average flow for a water plant is 8,890 gpm. A jar test indicates that the best polymer dose is 3.1 mg/L. How many pounds will the plant feed in one week? (Assume the plant runs 24 hour/day, 7 days/week.)

43. A water plant fed 48.5 grams per minute while treating 2.2 MGD. Calculate the mg/L dose.

44. The desired copper sulfate dose in a reservoir is 5 mg/L. The reservoir has a volume of 62 acre-ft. How many lbs of copper sulfate (25% available copper) will be required?

Answers

1.)	11.99 mg/L	16.)	438.95 mL/min	31.)	25.52 gal/day
2.)	67.76 lb/day	17.)	10,133.1 lb	32.)	337.77 lb
3.)	325.68 lb/day	18.)	441.97 mL/min	33.)	22,826.95 gal/day
4.)	39.05 gal/day	19.)	3.44 lb	34.)	72.06 lb/day
5.)	0.84 mg/L	20.)	15.62 gal/day	35.)	67.08 mL/min
6.)	2.02 mg/L	21.)	27.5%	36.)	333.6 lb
7.)	117.41 mL/min	22.)	142.32 lb/day	37.)	34.61 mL/min
8.)	36.07 g/min	23.)	5.60 gal/day	38.)	3.44 gal
9.)	36.36%	24.)	5 lb/hr	39.)	202.66 lb/day
10.)	20%	25.)	555.44 lb/day	40.)	998.3 lb/day
11.)	105.3 mL/min	26.)	630.83 mL/min	41.)	7.61 mg/L
12.)	72.02 mL/min	27.)	130.10 lb/day	42.)	2,316.52 lb
13.)	64.76 lb/day	28.)	37.5%	43.)	8.39 mg/L
14.)	47.97 g/min	29.)	146.67 lb/day	44.)	3,371.36 lb
15.)	37.56 lb/day	30.)	113.49 g/min		

Section 8

Sedimentation

Sedimentation

Sedimentation

- Sedimentation is the separation of solids and liquids by gravity
- Calculating volume must be done based on the shape of the tank
  - Typically rectangular or cylindrical
- Detention time is the amount of time the water is supposed to spend in the tank

Volume

- Cylindrical tank

$$volume, ft^3 = (0.785)(D^2)(h)$$

- Rectangular tank

$$volume, ft^3 = (l)(w)(d)$$

Detention Time

$$detention\ time = \frac{volume}{flow}$$

- Units must be compatible within the equation

Example 1

- A sedimentation tank has a volume of 137,000 gallons. If the flow to the tank is 121,000 gph, what is the detention time in the tank (in hours)?

$$detention\ time = \frac{volume}{flow}$$

$$DT = \frac{137{,}000\ gal}{121{,}000\frac{gal}{hr}}$$

$$DT = 1.13\ hours$$

Surface Overflow Rate

- Hydraulic loading rate (HLR) is used to determine loading on sedimentation basins and circular clarifiers
  - Measures the total water entering the process

$$HLR = \frac{total\ flow\ applied, gpd}{area, ft^2}$$

- Surface overflow rate (SOR) measures only the water overflowing the process

$$SOR = \frac{flow, gpd}{area, ft^2}$$

Example 2

- A circular clarifier has a diameter of 80 ft. If the flow to the clarifier is 2.6 MGD, what is the surface overflow rate in gpd/sq.ft?

$A = (0.785)(D^2)$

$$SOR = \frac{flow, gpd}{area, ft^2}$$

$$SOR = \frac{2{,}600{,}000\ gpd}{(0.785)(80ft)(80ft)}$$

$$SOR = \frac{2{,}600{,}000\ gpd}{5024\ ft^2}$$

$$SOR = 517.51\ \frac{gpd}{ft^2}$$

Weir Overflow Rate

- Weir overflow rate (WOR) is the amount of water leaving the settling tank per linear foot of weir
- Calculation result can then be compared to design
- Mesaured in gpd/ft

$$WOR = \frac{flow, gpd}{weir\ length, ft}$$

Example 3

- A circular clarifier receives a flow of 3.55 MGD. If the diameter of the weir is 90 ft, what is the weir overflow rate in gpd/ft?

$$circumference = 3.14 * Diameter$$
$$Circ = (3.14)(90ft)$$
$$Circ = 282.6\ ft$$

$$WOR = \frac{flow, gpd}{weir\ length, ft}$$

$$WOR = \frac{3{,}550{,}000\ gpd}{282.6\ ft}$$

$$WOR = 12561.92\ \frac{gpd}{ft}$$

Reduction in Flow

- To determine the reduction in flow after a period of time

$$Reduction\ in\ flow, \% = \left(\frac{original\ flow - reduced\ flow}{original\ flow}\right) \times 100$$

Example 4

- A sedimentation tank was designed to produce 500,000 gpd at start up. After 5 years in operation, the tank produces 425,000 gpd. What is the reduction in flow?

$$Reduction\ in\ flow, \% = \left(\frac{original\ flow - reduced\ flow}{original\ flow}\right) \times 100$$

$$Reduction = \left(\frac{500{,}000\ gpd\ - 425{,}000\ gpd}{500{,}000\ gpd}\right) \times 100$$

$$Reduction = \left(\frac{75{,}000\ gpd}{500{,}000\ gpd}\right) \times 100$$

$$Reduction = 15\%$$

Solids

- Total suspended solids are the amount of filterable solids in a water sample
  - Weigh dried filter
- Settleable solids will settle out due to gravity
  - Imhoff cone
- Dissolved solids are the amount of solids that pass through a filter in a water sample
  - Weigh filtered water

Solids Concentration

$$Solids\ concentration, \frac{mg}{L} = \frac{weight, mg}{volume, L}$$

$$Solids, \frac{mg}{L} = \frac{(dry\ solids, grams)(1{,}000{,}000)}{sample\ volume, mL}$$

Settleable Solids

- The settleable solids test is an easy, quantitative method to measure sediment found in water
- An Imhoff cone is filled with 1 liter of sample, stirred and allowed to settle for 60 minutes

$$Removal, \% = \left(\frac{in - out}{in}\right) \times 100$$

Example 6

- Calculate the percent removal of settleable solids if the settleable solids of the sedimentation tank influent is 13 mL/L and the settleable solids of the effluent is 0.5 mL/L.

$$Removal, \% = \left(\frac{in - out}{in}\right) \times 100$$

$$Removal = \left(\frac{13\frac{mL}{L} - 0.5\frac{mL}{L}}{13\frac{mL}{L}}\right) \times 100$$

$$Removal = \left(\frac{12.5\frac{mL}{L}}{13\frac{mL}{L}}\right) \times 100$$

$$Removal = 0.96 \times 100$$

$$Removal = 96\%$$

Sedimentation

1. A flocculation basin is 8 ft deep, 16 ft wide, and 30 ft long. If the flow through the basin is 1.45 MGD, what is the detention time (in minutes)?

2. A circular clarifier has a diameter of 80 ft and an average water depth of 12 ft. If the flow to the clarifier is 2,920,000 gpd, what is the detention time (in hours)?

3. A circular clarifier receives a flow of 2.98 MGD. If the diameter of the weir is 70 ft, what is the weir overflow rate (in gpd/ft)?

4. A dissolved air flotation (DAF) thickener receives a sludge flow of 910 gpm. If the DAF unit is 40 ft in diameter, what is the hydraulic loading rate (in gallons per day per square foot)?

5. The average flow to a secondary clarifier is 2610 gpm. What is the surface overflow rate (in gpd/sq ft) if the secondary clarifier has a diameter of 60 ft?

6. A rectangular clarifier has a total of 112 ft of weir. What is the weir overflow rate (in gpd/ft) when the flow is 1,520,000 gpd?

7. Calculate the percent removal of settleable solids if the settleable solids of the sedimentation tank influent are 16 milliliters per liter and the settleable solids of the effluent are 0.8 milliliters per liter.

Applied Math for Water Treatment
Sedimentation

Detention Time

1. A rectangular sedimentation basin is 70 ft long 25 ft wide and has water to a depth of 10 ft. The flow to the basin is 2,220,000 gpd. Calculate the detention time in hours for the sedimentation basin.

2. A flocculation basin is 8 ft deep, 16 ft wide, and 30 ft long. If the flow through the basin is 1.45 MGD, what is the detention time (in minutes)?

Weir Overflow Rate

3. A circular clarifier receives a flow of 2.12 MGD. If the diameter of the weir is 60 ft, what is the weir overflow rate (in gpd/ft)?

4. The weir in a basin measures 30 feet by 15 feet. What is the weir overflow rate (gpd/ft) when the flow is 1,098,000 gpd?

Surface Overflow Rate

5. A rectangular sedimentation basin is 60 ft long and 25 ft wide. When the flow is 510 gpm, what is the surface overflow rate in gpm/ft^2?

6. A rectangular clarifier receives a flow of 5.4 MGD. The length of the clarifier is 99 feet 7 inches and the width is 78 feet 6 inches. What is the SOR in gpd/ft^2?

Percent Removal

7. Calculate the percent removal of settleable solids if the settleable solids of the sedimentation tank influent are 21.2 mL/L and the settleable solids of the effluent are 1.3 mL/L.

Practice Problems

8. A sedimentation basin is 70 ft long by 30 ft wide. If the water depth is 14 ft, what is the volume of water in the tank in gallons?

9. A 22-ac pond receives a flow of 3.6 ac-ft per day. What is the hydraulic loading rate in gpd/ft^2?

10. A circular clarifier receives a flow of 2,520,000 gpd. If the diameter of the weir is 70 ft, what is the weir overflow rate (in gpd/ft)?

11. A tank is 30 ft wide and 80 ft long. If the tank contains water to a depth of 12 ft, how many gallons of water are in the tank?

12. The flow to a sedimentation tank that is 80 ft long, 20 ft wide, and 12 ft deep is 1.8 MGD. What is the detention time in the tank (in hours)?

13. A flash mix chamber is 6 ft long, 5 ft wide, and 5 ft deep. It receives a flow of 9 MGD. What is the detention time in the chamber in seconds?

14. A sedimentation basin is 80 ft long and 25 ft wide. To maintain a surface overflow rate of 0.5 gallons per day per square foot, what is the maximum flow to the basin in gallons per day?

15. A flash mix chamber is 4 ft square and has a water depth of 42 inches. If the flash mix chamber receives a flow of 3.25 MGD, what is the detention time (in seconds)?

16. A sedimentation tank has a total of 150 feet of weir over which the water flows. What is the weir overflow rate in gallons per day per foot of weir when the flow is 1.7 MGD?

17. A sedimentation tank is 90 feet long and 40 feet wide and receives a flow of 5.04 MGD. Calculate the SOR in gpd/ft^2.

18. A tank has a length of 100 feet, a width of 25 feet and a depth of 15 feet. What is the area of the water's surface in ft^2?

19. What is the gpd/ft^2 overflow to a circular clarifier that has the following:
    i. Diameter: 70 feet
    ii. Flow: 1,950 gpm

20. The flow to a sedimentation tank that is 75 ft long, 30 ft wide, and 14 ft deep is 1,640,000 gpd. What is the detention time in the tank (in hours)?

21. A sedimentation tank 70 ft by 25 ft receives a flow of 2.05 MGD. What is the surface overflow rate (in gpd/sq ft)?

22. A flocculation basin is 50 ft long by 20 ft wide and has a water level of 8 ft. What is the detention time (in minutes) in the basin if the flow to the basin is 2.8 MGD?

23. The diameter of a tank is 90 ft. If the water depth in the tank is 25 ft, what is the volume of water in the tank (in gallons)?

24. A backwash lagoon receives a flow of 18,800 gpd. If the surface area of the pond is 16 acres, what is the hydraulic loading rate in gpd/ft^2?

25. The average width of a pond is 400 ft and the average length is 440 ft. The depth is 6 ft. If the flow to the pond is 200,000 gpd, what is the detention time (in days)?

26. A rectangular sedimentation basin has a total of 170 ft of weir. If the flow to the basin is 1,890,000 gpd, what is the weir overflow rate in gpd/ft^2?

27. A clarifier has a diameter of 82 feet and a depth of 12 feet. What is the length of the weir around the clarifier in ft?

28. The diameter of the weir in a circular clarifier is 125 feet. The flow is 6.33 MGD. What is the weir overflow rate (gpd/ft)?

29. A clarifier has a diameter of 82 feet and a depth of 12 feet. What is the surface area of the clarifier in ft^2?

30. A clarifier has a flow rate of 4,600 gpm and a diameter of 75 feet. What is the surface overflow rate in gpd/ft^2?

31. The flow rate to a particular clarifier is 528 gpm and the tank has a length of 30 feet and a width of 17.5 feet. What is the gpd/ft of weir?

32. Calculate the percent removal of settleable solids if the settleable solids of the sedimentation tank influent are 13.9 mL/L and the settleable solids of the effluent are 0.7 mL/L.

33. The flow rate to a clarifier is 1400 gpm. If the diameter of the weir is 80 ft, what is the weir overflow rate (in gpd/ft)?

34. The flow to a flocculation basin is 6,625,000 gpd. If the basin is 60 ft long, 25 ft wide, 15 ft deep, and contains water to a depth 9 ft, what is the detention time of the flocculation basin in minutes?

35. A circular clarifier has a diameter of 70 ft. If the flow to the clarifier is 1610 gpm, what is the surface overflow rate in gpm/ft^2?

36. A waste treatment pond is operated at a depth of 6 ft. The average width of the pond is 500 ft and the average length is 600 ft. If the flow to the pond is 222,500 gpd, what is the detention time (in days)?

37. A sedimentation tank has a total of 200 feet of weir which the water flows over. What is the weir overflow rate (gpd/ft) when the flow is 2.2 MGD?

38. A tank has a length of 100 feet, a width of 25 feet, and a depth of 15 feet. What is the weir length around the basin in feet?

39. The flow to a sedimentation tank is 3.05 MGD. If the tank is 80 feet long and 20 feet wide, what is the surface overflow rate in gallons per day per square foot?

40. What is the weir overflow rate of a clarifier that is 50 feet 4 inches by 44 feet 3 inches and has an influent flow of 1.87 MGD?

41. The flow through a flocculation basin is 1.82 MGD. If the basin is 40 ft long, 20 ft wide, and 10 ft deep, what is the detention time (in minutes)?

42. A tank is 80 ft long, 20 ft wide, and 16 ft deep. What is the volume of the tank (in cubic feet)?

43. The flow to a circular clarifier is 2.66 MGD. If the diameter of the clarifier is 70 ft, what is the surface overflow rate (in gpd/sq ft)?

44. A clarifier with a diameter of 55 feet receives a flow of 2.075 MGD. What is the surface overflow rate (gpd/ft^2)?

45. A circular clarifier has a diameter of 60 ft and an average water depth of 12 ft. What flow rate (MGD) corresponds to a detention time of 3 hours?

46. A basin 3 ft by 4 ft is to be filled to the 3-ft level. If the flow to the tank is 6 gpm, how long will it take to fill the tank (in hours)?

47. The diameter of the weir in a circular clarifier is 85 feet. What is the weir overflow rate (gpd/ft) if the flow over the weir is 2.24 MGD?

48. A sedimentation tank is 110 ft long and 50 ft wide. If the flow to the tank is 3.45 MGD what is the surface overflow rate (in gpd/sq ft)?

49. A tank 6 ft in diameter is to be filled to the 4-ft level. If the flow to the tank is 12 gpm, how long will it take to fill the tank (in minutes)?

50. A rectangular clarifier has a total of 163 ft of weir. What is the weir overflow rate (in gpd/ft) when the flow is 1,410,000 gpd?

51. A circular clarifier has a diameter of 80 feet. If the flow to the clarifier is 3.8 MGD, what is the surface overflow rate (gpd/ft^2)?

52. The diameter of the weir in a circular clarifier is 85 feet. What is the weir overflow rate (gpd/ft) if the flow over the weir is 2.24 MGD?

53. The flow to a flocculation basin is 3,625,000 gpd. If the basin is 60 ft long by 25 ft wide and contains water to a depth of 9 ft, what is the detention time of the flocculation basin (in minutes)?

54. A rectangular clarifier has a total of 240 ft of weir. What is the weir overflow rate (in gpd/ft) when the flow is 2.7 MGD?

55. A circular clarifier has a diameter of 80 feet. If the water depth is 12 ft, how many gallons of water are in the tank?

56. A tank has a diameter of 49.4 feet. What is the gallons/day per foot of weir overflow when the tank receives 1,953,000 gpd?

57. A flocculation basin is 50 ft long by 20 ft wide and has a water depth of 10 ft. If the flow to the basin is 2,250,000 gpd, what is the detention time (in minutes)?

58. The flow to a sedimentation tank is 50,000 gpd. If the tank is 55 feet long and 15 feet wide, what is the surface overflow rate (gpd/ft^2)?

59. A circular clarifier has a diameter of 80 ft and an average water depth of 12 ft. If the flow to the clarifier is 2,920,000 gpd, what is the detention time in hours?

60. A pre-sedimentation pond receives a flow of 1.2 MGD. This particular pond is 115 ft long, 40 ft wide and averages a depth of 15 ft. Determine the hydraulic loading rate in gpd/ft^2?

61. A rectangular sedimentation basin has a total weir length of 189 ft. If the flow to the basin is 4.01 MGD, what is the weir-loading rate (in gpd/ft)?

62. The flow rate to a circular clarifier is 5.20 MGD. If the clarifier is 80 ft in diameter with water to a depth of 10 ft, what is the detention time (in hours)? 1.7 hr

ANSWERS

ANSWERS

1.) 1.42 hr
2.) 28.53 min
3.) 11,282.65 gpd/ft
4.) 12,200 gpd/ft
5.) 0.34 gpm/ft^2
6.) 690.78 gpd/ft^2
7.) 93.87%
8.) 219,912 gal
9.) 1.22 gpd/ft^2
10.) 11,464.91 gpd/ft
11.) 215,424 gal
12.) 1.91 hr
13.) 10.77 sec
14.) 1,000 gpd
15.) 11.13 sec
16.) 11,333.33 gpd/ft
17.) 1,400 gpd/ft^2
18.) 2,500 ft^2
19.) 730.01 gpd/ft^2
20.) 3.45 hr
21.) 1,171.43 gpd/ft^2
22.) 30.77 ming
23.) 1,189,039.5 gal
24.) 0.03 gpd/ft^2
25.) 39.49 days
26.) 11,117.65 gpd/ft
27.) 257.48 ft
28.) 16,127.39 gpd/ft
29.) 5,278.34 ft^2
30.) 1,500.13 gpd/ft^2
31.) 8,003.37 gpd/ft
32.) 94.96%
33.) 8,025.48 gpd/ft
34.) 21.95 min
35.) 0.42 gpm/ft^2
36.) 60.51 day
37.) 11,000 gpd/ft
38.) 250 ft
39.) 1,906.25 gpd/ft^2
40.) 9,885.47 gpd/ft
41.) 47.35 min
42.) 25,600 ft^3
43.) 691.54 gpd/ft^2
44.) 873.82 gpd/ft^2
45.) 2.03 MGD
46.) 0.75 gal/hr
47.) 8,392.66 gpd/ft
48.) 627.27 gpd/ft
49.) 70.46 min
50.) 8,650.31 gpd/ft
51.) 756.37 gpd/ft^2
52.) 8,392.66 gpd/ft
53.) 40.11 min
54.) 11,250 gpd/ft
55.) 450,954.24 gal
56.) 12,590.57 gpd/ft
57.) 47.87 min
58.) 60.61 gpd/ft^2
59.) 3.71 hr
60.) 260.87 gpd/ft^2
61.) 21,216.93 gpd/ft
62.) 1.73 hr

Applied Math for Water Treatment
Sedimentation Extra Problems

1. Calculate the detention time in hours for the following portion of a treatment plant: Five flocculation basins in series each measure 50.1 ft by 18 ft with an average water depth of 11.5 ft. A sedimentation basin is 322 ft long, 75 ft wide, and has an average water depth of 10.0 ft. The flow through these basins is 15.6 MGD.

2. A rectangular clarifier has a weir length of 250 ft. What is the weir overflow rate in gallons per day per foot if the flow is 3.5 MGD?

3. What is the surface loading rate for a sedimentation basin that is 385 ft by 74 ft if it is treating an instantaneous flow of 19 cfs?

4. Find the detention time in hours for a clarifier that has a diameter of 160 ft, a water depth of 10.25 ft, and a flow of 3.86 MGD.

5. A rectangular clarifier has a weir length of 250 ft. What is the weir overflow rate in gallons per day per foot if the flow is 7.7 MGD?

6. What is the surface loading rate for a sedimentation basin that is 249.5 ft by 58 ft if it is treating an instantaneous flow rate of 33 ft^3/sec?

7. A circular clarifier has a weir length of 120 ft (measured to the nearest foot. What is the weir overflow rate in gpd/ft if the flow is 2.34 MGD?

8. Calculate the detention time in hours for the portion of a treatment plant with the following characteristics: Five flocculation basins in series each measure 62.4 ft by 18.1 ft with an average water depth of 12.3 ft and a sedimentation basin that is 298.5 ft long, 83.2 ft wide, and has an average depth of 10.5 ft. The flow is 20.9 MGD.

9. A rectangular clarifier has a weir length of 95.5 ft. What is the WOR in gpd/ft if the flow is 1.45 MGD?

10. What is the surface loading rate for a sedimentation basin that is 350 ft by 65 ft if it is treating an instantaneous flow rate of 14 cfs?

11. Calculate the detention time in hours for the portion of a treatment plant with the following characteristics: Five flocculation basins in series each measure 48 ft by 20.3 ft with a water depth of 11.8 ft; a sedimentation basin that is 452 ft long, 79.9 ft wide, with an average water depth of 11 ft; and eight filters in parallel each measure 40.1 ft by 30.2 ft with an average water depth of 10.5 ft; the flow is 15.4 MGD.

12. A circular clarifier has a weir length of 155 ft. What is the weir overflow rate in gallons per day per foot if the flow is 3.08 MGD?

13. What is the surface loading rate for a sedimentation basin that is 265 ft by 61 ft if it is treating an instantaneous flow of 13.4 cfs?

14. A circular clarifier has a weir length of 185 ft. What is the weir overflow rate in gallons per day per foot if the flow is 7.15 MGD?

15. Calculate the theoretical detention time in hours for a sedimentation basin that is 690 ft long, 48 ft wide, and has a water depth of 8.5 ft if the flow is 12.2 MGD.

16. Calculate the theoretical detention time in hours for a plant's flocculation and sedimentation basin if the flow is 8.9 MGD. Five flocculation basins in series are 40 ft by 15 ft with a water depth of 12 ft and one sedimentation basin is 400 ft long, 60 ft wide, and has a water depth of 9.0 ft.

17. Find the theoretical detention time in minutes for a clarifier that has a diameter of 120 ft and a water depth of 14 ft if the flow rate is 1.84 MGD.

18. Find the theoretical detention time in hours for a clarifier that has a diameter of 100 ft and a water depth of 12.5 ft if the flow rate is 1.72 MGD.

19. Calculate the detention time in hours for four flocculation basins in series each measure 50 ft by 12 ft with a water depth of 11 ft and a sedimentation basin that is 380 ft long, 70 ft wide, and has a water depth of 10 ft. The flow is 10.8 MGD.

20. Find the detention time in hours for a treatment plant that includes the following: a sedimentation basin 750 ft long, 75 ft wide, and with a water depth of 11 ft; eight filters operating in parallel each 36 ft long, 24 ft wide, with an average water depth of 9 ft; flow is 7.82 MGD.

21. Find the detention time in minutes for a clarifier that has a diameter of 160 ft and a water depth of 16 ft if the flow rate is 3.9 MGD.

22. Find the detention time in hours for a treatment plant that includes the following: a sedimentation basin 272 ft long, 79 ft wide, and with an average water depth of 11.5 ft; 12 filters 40 ft long, 32 ft wide and with an average water depth of 9 ft; flow is 16.5 MGD.

23. Calculate the theoretical detention time, in hours, for the following water treatment plant:

    Flow rate of 18.2 MGD
    Five flocculation basins in series measuring 48.0 ft by 10.0 ft by 10.0 ft in average depth each
    Sedimentation basin measuring 398 ft by 62.0 ft by 10.5 ft in average depth
    Eight filters measuring 40.0 ft by 28.0 ft by 12.0 ft in depth each.
    Clear well averages 1.8 MG

24. Calculate the theoretical detention time, in hours, for the following treatment plant:
    Flow rate of 45 MGD
    Clear well with 15 MG capacity
    The following measurements were made to the nearest foot:
        Four flocculation basins in series measuring 60 ft by 10 ft 10 ft each
        A sedimentation basin measuring 350 ft by 80 ft by 12 ft
        Twelve filters measuring 40 ft by 30 ft by 15 ft

25. Calculate the theoretical detention time, in hours, for the following treatment plant:
    Flow rate of 33 MGD
    Six flocculation basins in series measuring 40 ft by 10 ft by 10 ft each
    A sedimentation basin measuring 400 ft by 50 ft by 10 ft
    Twelve filters measuring 40 ft by 30 ft by 12 ft
    Clear well with 7.9 million gallons

26. A backwash tank has a volume of 550,000 gallons. It currently has 270,000 gal left over from the previous day's backwashes because the power to the three recirculation pumps failed. The power has now been restored, but one of the pumps does not work. The operator has determined that six filters require backwashing for the shift. Each filter takes 80,000 gal to backwash. If the two remaining recirculation pumps are removing the backwash water at a rate of 20,000 gal/hr and each backwash takes 1 hour and 10 minutes, will the operator have enough room such that no waiting will be required?

Answers

1. 3.38 hr
2. 14,000 gpd/ft
3. 431 gpd/ft^2
4. 9.58 hr
5. 30,800 gpd/ft
6. 1473.8 gpd/ft^2
7. 19,500 gpd/ft
8. 2.84 hr
9. 15,183 gpd/ft
10. 397.7 gpd/ft^2
11. 6.49 hrs
12. 19,870.97 gpd/ft
13. 535.7 gpd/ft^2
14. 38,648.65 gpd/ft
15. 4.14 hr
16. 5.1 hr
17. 926.26 min
18. 10.2 hr
19. 4.86 hr
20. 15.6 hr
21. 888 min
22. 4.19 hr
23. 6.33 hr
24. 10.29 hr
25. 7.9 hr
26. Operator will have to wait or only wash 5 filters that day

Section 9

Filtration

Filtration

1

Filtration

- Process of separating suspended and colloidal particle waste by passing the water through a granular material
- Involves straining, settling, and adsorption

2

Filter Loading Rate & Backwash Rate

- Rate at which water flows through the filter
- Can be used to verify flow meter readings

$$\frac{gpm}{ft^2} = \frac{flow, gpm}{filter\ area, ft^2}$$

3

Example 1

- A filter 18 ft by 22 ft receives a flow of 1750 gpm. What is the filtration rate in gpm/ft^2?

$$\frac{gpm}{ft^2} = \frac{flow, gpm}{filter\ area, ft^2}$$

$$\frac{gpm}{ft^2} = \frac{1750\ gpm}{18ft \times 22ft}$$

$$\frac{gpm}{ft^2} = 4.4\ {}^{gpm}/_{ft^2}$$

4

Example 2

- A filter that is 30 ft by 10ft has a backwash rate of 3120 gpm. What is the back wash rate in gpm/sq. ft?

$$\frac{gpm}{ft^2} = \frac{flow, gpm}{filter\ area, ft^2}$$

$$\frac{gpm}{ft^2} = \frac{3120\ gpm}{30ft \times 10ft}$$

$$\frac{gpm}{ft^2} = 10.4\ {}^{gpm}/_{ft^2}$$

5

Filter Drop Test Velocity

- Speed at which water flows through the filter

$$\frac{ft}{min} = \frac{water\ drop, ft}{time\ of\ drop, min}$$

6

Example 3

- The influent to a filter is closed while the effluent valve remains open. It is measured that in 1 minute, the water level drops 1.5 feet. What is the filter drop test velocity in ft/min?

$$\frac{ft}{min} = \frac{water\ drop, ft}{time\ of\ drop, min}$$

$$\frac{ft}{min} = \frac{1.5\ ft}{1\ min}$$

$$\frac{ft}{min} = 1.5\frac{ft}{min}$$

7

Filter Backwash Rise Rate

- Upward velocity of the water during backwashing

$$\frac{in}{min} = \frac{(backwash\ rate, \frac{gpm}{ft^2})(12\frac{in}{ft})}{7.48\frac{gal}{ft^3}}$$

8

Example 4

- A filter has a backwash rate of 16 gpm/sq. ft. What is the inch per minute backwash rate?

$$\frac{in}{min} = \frac{(backwash\ rate, \frac{gpm}{ft^2})(12\ \frac{in}{ft})}{7.48\ \frac{gal}{ft^3}}$$

$$\frac{in}{min} = \frac{(16\ \frac{gpm}{ft^2})(12\ \frac{in}{ft})}{7.48\ \frac{gal}{ft^3}}$$

$$\frac{in}{min} = 25.7\ \frac{in}{min}$$

9

Filtration

1. A filter is 30 ft long and 25 ft wide. To verify the flow rate through the filter, the filter influent is closed for a 5-minute period and the water drop is measured. If the water level in the filter drops 16 inches during the 5 minutes, what is the gpm flow rate through the filter?

2. A filter is 40 ft long and 20 ft wide. During a test of the filter flow rate, the influent valve to the filter is closed for 5 minutes. The water level drops 25 inches during this period. What is the filtration rate for the filter in gpm/sq ft?

3. A filter with a surface area of 375 square feet has a backwash flow rate of 3440 gpm. What is the filter backwash rate in gpm/ft^2?

4. For a backwash flow rate of 9,050 gpm and a total backwash time of 8 minutes, how many gallons of water will be required for backwashing?

5. A filter has a backwash rate of 16 gpm/sq ft. What is this backwash rise rate expressed as an in./min?

6. Determine the filter drop velocity in ft/min if the filter water level drops 6 inches in 38 seconds.

Applied Math for Water Treatment
Filtration

Filtration/Backwash Rate

1. A filter 40 ft by 20 ft receives a flow of 2230 gpm. What is the filtration rate (in gpm/sq ft)?

2. A filter 18 ft long by 14 ft wide has a backwash flow rate of 3580 gpm. What is the filter backwash rate (in gallons per minute per square foot)?

Flow Rate

3. During an 80 hour filter run, a total of 14.2 million gallons of water are filtered. What is the average gpm flow rate through the filter during this time?

4. The influent valve to a filter is closed for 6 minutes. The water level in the filter drops 18 inches during the 6 minutes. If the filter is 35 ft long by 18 ft wide, what is the gpm flow rate through the filter?

Volume

5. A backwash flow rate of 6750 gpm for a total of 6 minutes would require how many gallons of water?

6. A backwash flow rate of 7050 gpm for a total backwashing period of 5 minutes would require how many gallons of water for backwashing?

Practice Problems

7. A filter with a surface area of 380 square feet has a backwash flow rate of 3510 gpm. What is the filter backwash rate (in gallons per minute per square foot)?

8. A filter 38 ft long by 22 ft wide receives a flow of 3,550,000 gpd. What is the filtration rate (in gallons per minute per square foot)?

9. A filter 40 ft by 20 ft treats a flow of 2.2 MGD. What is the filtration rate (in gpm/sq ft)?

10. A filter is 40 ft long by 30 ft wide. To verify the flow rate through the filter, the filter influent valve is closed for a 5-minute period and the water drop is measured. If the water level in the filter drops 14 inches during the 5 minutes, what is the gpm flow rate through the filter?

11. A filter has a surface area of 32 ft by 18 ft. If the filter receives a flow a 2,150,000 gpd, what is the filtration rate (in gallons per minute per square foot)?

12. The influent valve to a filter is closed for a 5-minute period. During this time, the water level in the filter drops 12 inches. If the filter is 45 ft long by 22 ft wide, what is the gpm flow rate through the filter?

13. The backwash flow rate for a filter is 3700 gpm. If the filter is 15 ft by 20 ft, what is the backwash rate expressed as gpm/ft^2?

14. A filter is 38 ft long by 18 ft wide. During a test of filter flow rate, the influent valve to the filter is closed for 5 minutes. The water level drops 22 inches during this period. What is the filtration rate for the filter (in gallons per minute per square foot)?

15. A filter 30 ft by 18 ft has a backwash flow rate of 3650 gpm. What is the filter backwash rate (in gallons per minute per square foot)?

16. The desired backwash pumping rate for a filter is 24 gallons per minute per square foot. If the filter is 26 ft long by 22 ft wide, what backwash pumping rate (gallons per minute) will be required?

17. A filter 14 ft by 14 ft has a backwash flow rate of 4750 gpm. What is the filter backwash rate in gpm/sq ft?

18. A filter 38 ft long by 24 ft wide produces a total of 18.1 million gallons during a 71.6-hour filter run. What is the average filtration rate for this filter run in gpm/ft^2?

19. During an 80-hour filter run, a total of 14.2 million gallons of water are filtered. What is the average gpm flow rate through the filter during this time?

20. A filter 40 ft by 25 ft receives a flow of 3100 gpm. What is the filtration rate (in gpm/sq ft)?

21. A total of 59,200 gallons of water will be required to provide a 7-minute backwash of a filter. What depth of water in feet is required in the backwash water tank to provide this backwashing capability? The tank has a diameter of 40 ft.

22. A filter 20 ft long by 18 ft wide receives a flow of 1760 gpm. What is the filtration rate (in gallons per minute per square foot)?

23. A filter is 42 ft long by 22 ft wide. If the desired backwash rate is 19 gallons per minute per square foot, what backwash pumping rate (gallons per minute) will be required?

24. For a backwash flow rate of 9100 gpm and a total backwash time of 7 minutes, how many gallons of water will be required for backwashing?

25. At an average flow rate through a filter of 3200 gpm, how long a filter run (in hours) would be required to produce 16 million gallons of water?

26. A filter is 33 ft long by 24 ft wide. During a test of flow rate, the influent valve to the filter is closed for 6 minutes. The water level drops 21 inches during this period. What is the filtration rate for the filter (in gallons per minute per square foot)?

27. A backwash rate of 7150 gpm is desired for a total backwash time of 7 minutes. What depth of water in feet is required in the backwash water tank to provide this much water? The diameter of the tank is 40 ft.

28. A filter 25 ft by 15 ft. If the backwash flow rate is 3400 gpm, what is the filter backwash rate (in gpm/sq. ft)?

29. A filter 33 ft long by 24 ft wide produces a total of 14.2 million gallons during a 71.4-hour filter run. What is the average filtration rate for this filter run in gpm/ft^2?

30. A filter has a surface area of 880 sq ft. If the flow treated is 2850 gpm, what is the filtration rate (in gpm per sq. ft)?

31. At an average flow rate through a filter of 3200 gpm, how long a filter run (in hours) would be required to produce 16 million gallons of filtered water?

32. A filter 26 ft by 60 ft receives a flow of 2500 gpm. What is the filtration rate (in gpm/sq ft)?

33. A filter 18 ft long by 14 ft wide has a backwash rate of 3080 gpm. What is this backwash rate expressed in inches per minute of water?

34. A filter 25 ft by 30 ft at a rate of 3300 gpm. What is this backwash rate expressed as gpm/ft^2?

35. The flow rate through a filter is 2.97 MGD. What is the flow rate in gpm?

36. How many gallons of water would be required to provide a backwash flow rate of 4670 gpm for a total of 5 minutes?

37. A filter is 22 ft square. If the desired backwash rate is 16 gallons per minute per square foot, what backwash pumping rate (gallons per minute) will be required?

38. The desired backwash pumping rate for a filter is 20 gallons per minute per square foot. If the filter is 36 ft long by 26 ft wide, what backwash pumping rate (gallons per minute) will be required?

39. The Quahog Water Treatment Plant treats an average of 5.18 MGD. The water is split equally to each of the 8 filters. Each filter measures 12 feet wide by 16 feet long and 24 feet deep. The influent to Filter 6 is closed while the effluent remains open to perform a drop test. Using a stop watch and a hook gauge, it is noted that the water level in the filter drops 6 inches in 80 seconds. A hook gauge was used to determine the rate of rise in the filter basin during the backwash cycle. The water rose 6 inches in 15 seconds.
    a. What is the filtration rate in gallons per minute per square foot?
    b. What is the backwash rate in gallons per minute per square foot?

40. The Central City Water Treatment Plant treats an average of 7.2 MGD. The water is split equally to each of the 12 filters. Each filter measures 12.5 feet wide by 16.5 feet long and 24 feet deep. Influent to Filter 6 is closed while the effluent remains open to perform a drop test. Using a stop watch and a hook gauge, it is noted that the water level in the filter drops 6 inches in 75 seconds. A hook gauge was used to determine the rate of rise in the filter basin during the backwash cycle. The water rose 6 inches in 13 seconds.
    a. What is the filtration rate in gallons per minute per square foot?
    b. What is the backwash rate in gallons per minute per square foot?

Answers

1.) 2.79 gpm/ft^2
2.) 14.21 gpm/ft^2
3.) 2,958.33 gal/min
4.) 1,178.1 gal/min
5.) 40,500 gal
6.) 35,250 gal
7.) 9.24 gpm/ft^2
8.) 2.95 gpm/ft^2
9.) 1.91 gpm/ft^2
10.) 1.75 gpm/ft^2
11.) 2.59 gpm/ft^2
12.) 1.50 gpm/ft^2
13.) 12.33 gpm/ft^2
14.) 2.74 gpm/ft^2
15.) 6.76 gpm/ft^2
16.) 13,720 gal/min
17.) 24.23 gpm/ft^2
18.) 4.62 gpm/ft^2
19.) 2,958.33 gal/min
20.) 3.1 gpm/ft^2
21.) 6.3 ft
22.) 4.89 gpm/ft^2
23.) 17,556 gpm
24.) 69,700 gal
25.) 83.33 hr
26.) 2.18 gpm/ft^2
27.) 5.33 ft
28.) 9.07 gpm/ft^2
29.) 4.19 gpm/ft^2
30.) 3.24 gpm/ft^2
31.) 83.33 hr
32.) 1.60 gpm/ft^2
33.) 19.61 in/min
34.) 4.4 gpm/ft^2
35.) 2,062 gpm
36.) 23,350 gal
37.) 7,744 gpm
38.) 18,720 gpm
39.) A. 2.81 gpm/ft^2
B. 14.96 gpm/ft^2
40.) A. 2.99 gpm/ft^2
B. 17.26 gpm/ft^2

Applied Math for Water Treatment
Filtration Extra Problems

1. A filter has a surface area of 450 ft^2. What is the filtration rate in gallons per minute per square foot if it receives a flow of 1,500 gpm?

2. A filter is 24 ft by 32 ft. What is the filtration rate in gallons per minute per square foot if it receives a flow of 4,050 gpm?

3. A filter is 25 ft by 32 ft. What is the filtration rate in gallons per minute per square foot if the filter receives a flow of 3,000 gpm?

4. A filter has a surface area of 525 ft^2. What is the filtration rate in gallons per minute per square foot if the filter receives a flow of 3,120 gpm?

5. What is the backwash rate for a filter that has a surface area of 320 ft^2 and a backwash flow of 3,820 gpm in gallons per minute per square foot?

6. What is the backwash rate in gallons per minute per square foot given the following:
   Filter is 18 ft long and 15 ft wide
   Backwash flow is 12 cfs

7. Four filters have a surface area of 760 ft^2 each. What is the filtration rate in gallons per minute per sq. ft. if they receive a total flow of 23 cfs?

8. Four filters have a surface area of 840 ft^2 each, measured to the nearest foot. What is the filtration rate in gpm/ft^2 if they receive a total flow of 44 cfs?

9. A water treatment plant has four filters with an average flow rate of 4.8 gpm/ft^2. If the plant flow is 21.4 cfs, what is the filtration area of each filter in gpm/ft^2?

10. A water treatment plant has 8 filters with an average flow rate of 6.43 gpm/ft^2. If the plant flow is 86 cfs, what is the area of each filter in gpm/ft^2?

11. A filter has a surface area of 750 ft^2. What is the filtration rate in gpm/ft^2 if it receives a flow of 6 cfs?

12. A water treatment plant has six filters with an average flow rate of 5.89 gpm/ft^2. If the plant flow is 63 cfs, what is the area of each filter in gpm/ft^2?

13. A filter has an area of 780 ft^2 with a backwash pumping rate of 15 cfs. What is the backwash rate in gpm/ft^2?

14. What is the backwash rate in gallons per minute per square foot if a filter has an area of 780 ft^2 with a backwash rate of 12.5ft^3/sec?

15. What is the backwash rate in gallons per minute per sq. ft. if a filter has an area of 750 ft^2 with a backwash pumping rate of 13.25 ft^3/sec?

16. What is the backwash rate in gpm/sq. ft. if a filter has an area of 580 ft^2 with a backwash pumping rate of 11.74 cfs?

17. What is the backwash rate in gallons per minute per square foot if a filter has an area of 600 ft^2 with a backwash pumping rate of 13 cfs?

18. What is the backwash gallon per minute pumping rate if the desired backwash rate is 6 gpm/ft^2 for a filter that is 40 ft by 32 ft?

19. What is the backwash rate in gallons per minute per square foot if a filter has an area of 620 ft^2 with a backwash pumping rate of 14 cfs?

Answers	
1. 3.3 gpm/ft^2	11. 3.59 gpm/ft^2
2. 5.27 gpm/ft^2	12. 800 ft^2
3. 3.75 gpm/ft^2	13. 8.63 gpm/ft^2
4. 5.94 gpm/ft^2	14. 7.19 gpm/ft^2
5. 11.94 gpm/ft^2	15. 7.93 gpm/ft^2
6. 19.95 gpm/ft^2	16. 9.08 gpm/ft^2
7. 3.4 gpm/ft^2	17. 9.72 gpm/ft^2
8. 5.9 gpm/ft^2	18. 7680 gpm
9. 500.23 ft^2	19. 10.13 gpm/ft^2
10. 750 ft^2	

Section 10

Laboratory Calculations

LABORATORY CALCULATIONS

MOLARITY & NORMALITY

AWWA Basic Science Concepts and Applications

TERMS

- Mole - a gram molecular weight; that is, the molecular weight expressed as grams
- Molecular weight - the weight of one molecule
  - Example: NaCl
    - Na weight = 22.9898 g/mol
    - Cl weight = 35.453 g/mol
    - Molecular weight of NaCl = 22.9898 + 35.453 = 58.4428 g/mol

NUMBER OF MOLES

- If 150 g of sodium hydroxide (NaOH) is mixed into water to make a solution, how many moles of solute have been used? (molecular weight of NaOH is 40.00 gram/mol)

$$\#\ of\ moles = \frac{total\ weight}{molecular\ weight}$$

$$\#\ of\ mol = \frac{150\ g}{40.00\ g/mol}$$

$$\#\ of\ mol = 3.75\ mol\ of\ NaOH$$

MOLARITY

- Once the number of moles of solute has been determined, the molarity of a solution may be calculated
  - Molarity is the concentration of a solution

$$Molarity = \frac{moles\ of\ solute}{liters\ of\ solution}$$

$$M = \frac{mol}{L}$$

EXAMPLE 1

- If 0.4 mol of NaOH is dissolved in 2 L of solution, what is the molarity of the solution?

$$Molarity = \frac{moles\ of\ solute}{liters\ of\ solution}$$

$$M = \frac{0.4\ mol}{2\ L}$$

$$M = 0.2\ \mathrm{M}$$

EQUIVALENT WEIGHTS

- The equivalent weight of an element or compound is the weight of that element or compound that in a given reaction has the same combining capacity as 8 grams of oxygen or as 1 gram of hydrogen
- The equivalent weight of a reactant will be *equal* to the reactant's molecular weight

$$milliequivalent = (mL\ of\ sol'n)(normality)$$

EXAMPLE 2
NUMBER OF EQUIVALENT WEIGHTS

- If 90 grams of sodium hydroxide (NaOH) were used in making up a solution, how many equivalent weights were used. Use 40.00 g as the equivalent weight for NaOH.

$$\#\ equivalent\ weights = \frac{total\ weight}{equivalent\ weight}$$

$$\frac{amt.\ used\ in\ sol'n}{weight\ of\ compound}$$

$$\#\ equivalent\ weights\ = \frac{90\ g}{40\ g}$$

$$\#\ equivalent\ weights = 2.25\ equivalent\ weights$$

NORMALITY

- When you have determined the number of equivalent weights of the dissolved solute, you can determine the normality of the solution
- Normality is a measure of the reacting power of a solution
  - i.e. 1 equivalent of a substance reacts with 1 equivalent of another substance

$$Normality = \frac{\#\ of\ equivalent\ weights\ of\ solute}{liters\ of\ solution}$$

$$N = \frac{equivalents}{L}$$

EXAMPLE 3

- If 2.1 equivalents of NaOH were used in making up 1.75 L of solution, what is the normality of the solution?

$$Normality = \frac{\#\ of\ equivalent\ weights\ of\ solute}{liters\ of\ solution}$$

$$N = \frac{2.1\ equivalents}{1.75\ liters}$$

$$N = 1.2\ N$$

TWO NORMAL EQUATION

- $C = concentration$
- $V = volume\ or\ flow$

$$C_1 \times V_1 = C_2 \times V_2$$

want = have

EXAMPLE 4

- To titrate a sample for alkalinity, 200 mL 0.02 N H_2SO_4 is needed. How much mL of 1.0 N H_2SO_4 is needed to obtain the desired amount and concentration?

$$C_1 \times V_1 = C_2 \times V_2$$

THREE NORMAL EQUATION

- $N = normality$
- $V = volume\ or\ flow$

$$(N_1 \times V_1) + (N_2 \times V_2) = (N_3 \times V_3)$$

Be sure to follow order of operations!

HARDNESS, ALKALINITY

AWWA Basic Science Concepts and Applications

HARDNESS

- Measurement of the effects that water impurities have on corrosion scaling and soap
- Measured in mg/L as $CaCO_3$

$$Hardness = \frac{(Titrant\ volume, mL)(1000)}{sample\ volume, mL}$$

EXAMPLE 5

- If 18 mL of EDTA were used to titrate a sample to the end point of a 100 mL sample, what is the hardness in mg/L as $CaCO_3$?

$$Hardness = \frac{(titrant\ volume, mL)(1000)}{sample\ volume, mL}$$

ALKALINITY

- A measure of the water's ability to resist change to pH
- Measured in mg/L as $CaCO_3$
- Composed of the carbonate, bicarbonate, and hydroxide content of the water

$$Alkalinity = \frac{(titrant\ vol, mL)(acid\ normality)(50{,}000)}{sample\ volume, mL}$$

EXAMPLE 6

- A 100 mL sample was titrated a pH of 8.3 with 9 mL of 0.02N H_2SO_4. What is the alkalinity?

$$alkalinity = \frac{(titrant\ vol., mL)(acid\ normality)(50{,}000)}{sample\ volume, mL}$$

TOTAL AND PHENOLPHTHALEIN ALKALINITY

- Phenolphthalein alkalinity (P) found by titrating sample to pH of 8.3
  - Phenolphthalein powder pillow
- Total alkalinity (T) found by titrating sample to pH of 4.5
  - Bromcresol green – methyl red powder pillow
  - Methyl orange powder pillow
- Alkalinity is composed of the carbonate, bicarbonate, and hydroxide content of the water

ALKALINITY RELATIONSHIPS

Result of Titration	Hydroxide	Carbonate	Bicarbonate
$P = 0$	0	0	T
$P < {}^1/_2\ T$	0	$2P$	$T - 2P$
$P = {}^1/_2\ T$	0	$2P$	0
$P > {}^1/_2\ T$	$2P - T$	$2(t - p)$	0
$P = T$	T	0	0

P = Phenolphthalein alkalinity
T = Total alkalinity

EXAMPLE 7

- A water sample is tested for phenolphthalein and total alkalinity. If the phenolphthalein alkalinity is 10 mg/L as $CaCO_3$, and the total alkalinity is 52 mg/L as $CaCO_3$, what are the bicarbonate, carbonate, and hydroxide alkalinities of the water?

EXAMPLE 7 CONT'D

P = 10 mg/L
T = 52 mg/L
$P < {}^1/_2\,T$

$$Hydroxide =$$

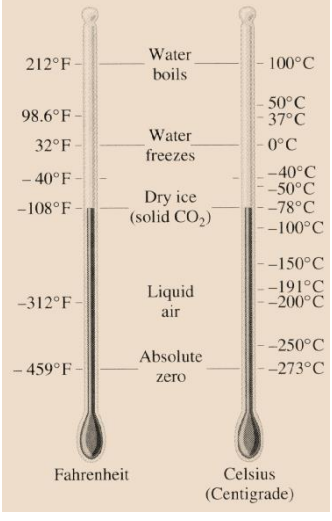
$$Carbonate =$$
$$Carbonate =$$
$$Carbonate =$$

$$Bicarbonate =$$
$$Bicarbonate =$$
$$Bicarbonate =$$
$$Bicarbonate =$$

TEMPERATURE CONVERSIONS

TEMPERATURE SCALES

The **Fahrenheit** scale is named for the 18th-century German physicist Daniel Fahrenheit.
His scale is based on 32 for the freezing point of water and 212 for the boiling point of water, the interval between the two being divided into 180 parts.
The scale was in common use in English speaking countries until the 1970's when Europe and Canada adopted the centigrade (Celsius) scale.
The U.S is the only country that still uses the Fahrenheit scale.



The **Celsius** temperature scale is named for the in the Swedish astronomer Anders Celsius who invented the scale in 1742.

The scale is based on 0 for the freezing point of water and 100 for the boiling point of water.

It is sometimes called the centigrade scale because of the 100-degree interval between the defined points.

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TEMPERATURE FORMULAS

- Degrees Fahrenheit

$$°F = (°C)(1.8) + 32$$

Remember your Order of Operations!!

- Degrees Celsius

$$°C = \frac{(°F - 32)}{1.8}$$

EXAMPLE 8

- Determine the temperature in $°F$ if the temperature is measured as $43°C$.

$$°F = (°C)(1.8) + 32$$

EXAMPLE 9

- Water temperature is measured with a pH probe to be 87 °F. What is this in Celsius?

$$°C = \frac{(°F - 32)}{1.8}$$

LANGELIER SATURATION INDEX (LSI)

LANGELIER SATURATION INDEX

- Used to determine the stability of the water
  - Aggressive vs scale forming
  - More negative the number = more aggressive water
  - More positive the number = more scale forming water

$$LSI = pH - pH_s$$

- pH_S = pH of Saturation
  - Temperature (°C)
  - Total Dissolved Solids (TDS in mg/L)
  - Alkalinity (mg/L as $CaCO_3$)
  - Calcium Hardness (mg/L as $CaCO_3$)

LANGELIER SATURATION INDEX

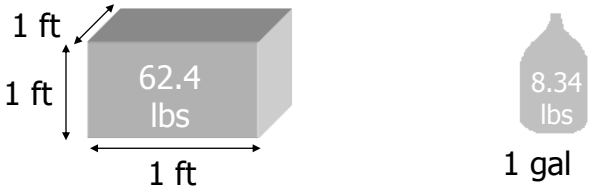
Corrosivity Characteristics as Addressed by Indices		
Corrosive Characteristics	Langelier Index (LSI)	Aggressive Index (AI)
Highly Aggressive	< - 2.0	< 10.0
Moderately Aggressive	- 2.0 to < 0.0	10.0 to < 12.0
Non-aggressive	> 0.0	> 12.0

SPECIFIC GRAVITY AND DENSITY

DENSITY

- weight per unit volume
  - solids and gases expressed in lb/ft^3
  - liquids measured in lb/gal or lb/ft^3
- density of water varies slightly with temperature and pressure
- density of gases changes significantly with changes in temperature and pressure

DENSITY OF WATER



The density of water is

8.34 lbs/gal

or

62.4 lbs/ft^3

SPECIFIC GRAVITY

- compares density of a substance to a standard density
- does not have units
- for solids and liquids
  - compare to standard density of water
    - 62.4 lb/ft^3
    - 8.34 lb/gal

SPECIFIC GRAVITY

$$Specific\ Gravity = \frac{weight\ of\ substance}{weight\ of\ water}$$

- Weights can be measured in $^{lb}/_{gal}$ or $^{lb}/_{ft^3}$
  - Be sure the units are consistent within the equation

EXAMPLE 10

- Determine the specific gravity of a liquid chemical that has a density of 10.5 lb/gal.

$$Specific\ Gravity = \frac{weight\ of\ substance}{weight\ of\ water}$$

COMPOSITE SAMPLES

COMPOSITE SAMPLES

- Composite samples
  - Representative of average water quality of location over a period of time
  - Series of grab samples mixed together
  - Determines average concentration
  - Not suitable for all tests

$$Composite\ Sample\ Single\ Portion = \frac{(Instantaneous\ Flow)(Total\ Sample\ Volume)}{(Number\ of\ Portions)(Average\ Flow)}$$

EXAMPLE 11

- Filter effluent flows at 2.0 gpm/ft^2 on average. You want to collect 5 samples for a composite sample of 10 gallons. If the water is flowing at 2.7 gpm/ft^2 at the time of sampling, what should the volume of sample #1 be in gallons?

$$Composite\ Sample\ Single\ Portion = \frac{(Instantaneous\ Flow)(Total\ Sample\ Volume)}{(Number\ of\ Portions)(Average\ Flow)}$$

EXAMPLE 11 CONT'D

Avg flow= 2.0 gpm/ft^2
samples = 5
Total volume = 10 gal
Inst. Flow = 2.7 gpm/ft^2

$$Composite\ Sample\ Single\ Portion = \frac{(Instantaneous\ Flow)(Total\ Sample\ Volume)}{(Number\ of\ Portions)(Average\ Flow)}$$

THRESHOLD ODOR NUMBER

THRESHOLD ODOR NUMBER (TON)

- Threshold Odor Numbers are whole numbers that indicate how many dilutions it takes to produce odor-free water
- Dilute multiple volumes of the odored water to 200 mL with odor free water
  - Include 2 blanks (2 - 200 mL flasks of odor free water)
  - After heating and shaking flasks, smell each flask (starting with the pure odor free water) proceeding from the lowest to the highest concentration of sample water
  - Record the volume of sample water in the first flask an odor is detected by each tester

THRESHOLD ODOR NUMBER (TON)

$$TON = \frac{A + B}{A}$$

- Where A = volume of odor causing sample

  and B = volume of odor free water

$$A + B \; will \; always = 200 \; mL$$

EXAMPLE 12

- Find the TON when odor is first detected in a flask containing 50 mL of sample water.

$$TON = \frac{A + B}{A}$$

$$TON = \frac{50 \; mL + 150 \; mL}{50 \; mL}$$

$A + B \; will \; always = 200 \; mL$

$$TON = \frac{200 \; mL}{50 \; mL}$$

$$TON = 4 \; TON$$

Laboratory Calculations

1. The average water temperature for a utility is 18°C. What is this temperature in degrees Fahrenheit?

2. Determine the temperature in degrees Celsius for a water sample that was measured to be 65°F.

3. A chemical shipment is delivered. The SDS shows the density of the substance to be 19 lb/ft^3. What is the specific gravity of this chemical?

4. Determine the density of a substance in lb/gal that has a specific gravity of 1.46.

5. An operator wants to get a measure of the average alkalinity in his distribution system. He decides to collect 8 representative samples for a total volume of 2 liters. If the water is flowing at a rate of 158 gallons per minute, how many milliliters of sample should each sample collected be? The system produces 0.25 MGD on average.

6. A water sample is tested for phenolphthalein and total alkalinity. If the phenolphthalein alkalinity is 10 mg/L as $CaCO_3$ and the total alkalinity is 52 mg/L as $CaCO_3$, what are the bicarbonate, carbonate, and hydroxide alkalinities of the water?

Applied Math for Water Treatment
Laboratory Calculations

Temperature Conversion

1. Convert 43°C to degrees Fahrenheit.

2. Mechanical seals should never exceed 160°F. What is this temperature expressed in °C?

Alkalinity

3. A 100-milliliter (mL) water sample is tested for phenolphthalein alkalinity. If 1.40 mL titrant is used to reach pH 8.3 and the normality of the sulfuric acid solution is 0.02 N, what is the phenolphthalein alkalinity of the water (in mg/L as $CaCO_3$)?

4. A sample of water contains 25 mg/L phenolphthalein alkalinity as $CaCo_3$. If the total alkalinity of the water is 121 mg/L as $CaCO_3$, what is the hydroxide, carbonate, and bicarbonate alkalinity?

Percent Removal

5. What is the percent removal across a settling basin if the influent turbidity is 8.8 ntu and the effluent turbidity at the settling basin is 0.89 ntu?

6. What is the turbidity removal efficiency through a water plant if the source water turbidity is 18.8 ntu and the treated water entering the distribution system is 0.035 ntu?

Specific Gravity

7. Determine the specific gravity of a polymer solution that weighs 10.67 lb/gal.

8. Find the density (lbs/gal) of caustic soda that has a S.G. of 1.530.

Practice Problems

9. The phenolphthalein alkalinity of a water sample is 12 mg/L as $CaCO_3$, and the total alkalinity is 23 mg/L as $CaCO_3$. What are the bicarbonate, carbonate, and hydroxide alkalinities of the water?

10. The atomic weight of a certain chemical is 66. If 35 grams of the chemical are used to make up a 1-liter solution, how many moles are used?

11. To determine the average turbidity coming into a plant, an operator collects 5 samples to combine into a 250 mL composite sample. The average flow at the intake is 230,000 gpd. If the flow at the time of the sample collection is 180 gpm. How many mL should the sample portion be at the time of collection?

12. A 100-milliliter (mL) sample of water is tested for alkalinity. The normality of the sulfuric acid used for titrating is 0.02 N. If 0.5 mL titrant is used to pH 8.3 and total of 5.7 mL titrant to pH 4.6, what are the phenolphthalein and total alkalinity of the sample?

13. An 800 mL solution contains 1.6 equivalents of a chemical. What is the normality of the solution?

14. Find the density (lbs/ft^3) of a certain oil that has a S.G. of 0.92.

15. A 100 mL water sample is tested for phenolphthalein alkalinity. If 2 mL of titrant is used to reach pH of 8.3 and the sulfuric acid solution has a normality of 0.02 N, what is the phenolphthalein alkalinity of the water (in mg/L as $CaCO_3$)?

16. Determine the specific gravity of a gold bar that weighs 521.47 lb and occupies a space of 0.433 ft^3.

17. What is the molarity of 2 moles of solute dissolved in 1 liter of solvent?

18. How many pounds of liquid can be pumped per day?
    Pump rate desired: 25 gpm
    Liquid weight: 74.9 lbs/ft^3

19. If 2 equivalents of a chemical are dissolved in 1.5 liters of solution, what is the normality of the solution?

20. Convert 170°F to °C.

21. Three hundred grams of calcium is how many equivalents of calcium? (The equivalent weight of calcium is 20.04.)

22. A gallon of solution is weighed. After the weight of the container is subtracted, it is determined that the weight of the solution is 9.1 lb. What is the density of the solution in lb/ft^3?

23. The magnesium content of water is 25 mg/L. How many milliequivalents/liter is this? The equivalent weight of magnesium is 12.15.)

24. The density of an unknown liquid is 74.1 lb/ft^3. What is the specific gravity of the liquid?

25. What is the iron removal efficiency through a water plant if the source water iron content is 4.25 mg/L and the treated water entering the distribution system is 0.030 mg/L?

26. The effluent of a treatment plant is 23°C. What is this expressed in degrees Fahrenheit?

27. What is the specific gravity of a polymer solution that weighs 11.1 lb/gal?

28. If 2.9 moles of solute are dissolved in 0.8 liter of solution, what is the molarity of the solution?

29. Convert 17°C to degrees Fahrenheit.

30. A water sample is found to have a phenolphthalein alkalinity of 0 mg/L and a total alkalinity of 67 mg/L. What are the bicarbonate, carbonate, and hydroxide alkalinities of the water?

31. What is the density of a substance in pounds per cubic foot if it weighs 29.27 kg and occupies a space of 0.985 ft^3?

32. The molecular weight of calcium is 40. If a total of 28 grams of calcium are used in making up a 1-liter solution, how many moles are used?

33. Alkalinity titrations on a 100-mL water sample gave the following results: 1.5 mL titrant used to pH 8.3, and 2.9 mL total titrant used to pH 4.5. The normality of the sulfuric acid was 0.02 N. What are the total, bicarbonate, carbonate, and hydroxide alkalinities of the water?

34. The magnesium content of a water source averages 0.24 mg/L. What is the percent removal if the treated water averages 0.020 mg/L Mg?

35. Find the density (lbs/gal) of ferric chloride that has a S.G. of 1.140.

36. A 100-milliliter (mL) sample of water is tested for phenolphthalein and total alkalinity. A total of 0 mL titrant is used to pH 8.3 and a total 6.9 mL titrant is used to titrate to pH 4.4. The normality of the acid used for titrating is 0.02 N. What are the phenolphthalein and total alkalinity of the sample (in mg/L as $CaCO_3$)?

37. A 1.7 molar solution is to be prepared. If a 900 mL solution is to be prepared, how many moles solute will be required?

38. A certain pump delivers 14 gallons of water per minute.
    a. How many lbs of water does the pump deliver in 24 hours?
    b. How many lbs/day will the pump deliver if the liquid weighs 8.1 lbs/gal?

39. Calculate the percent removal of settleable solids if the settleable solids of the sedimentation tank influent are 16 mL/L and the settleable solids of the effluent are 0.8 mL/L.

40. A tank holds 1,240 gallons of a certain liquid. The specific gravity is 0.93. How many pounds of liquid are in the tank?

41. If the influent turbidity for a water plant is 17.5 ntu and the effluent turbidity is 0.03, what is the percent removal?

42. If 2.3 equivalents of a chemical are dissolved in 1.4 liters of solution, what is the normality of the solution?

43. The influent to a treatment plant has a temperature of 75°F. What is the temperature expressed in degrees Celsius?

44. Find the density (lbs/ft^3) of potassium permanganate that has a S.G. of 1.522.

45. What is the molarity of a solution that has 0.5 moles solute dissolved in 1800 mL of solution?

46. What is the specific gravity for a solution that weighs 9.44 lb/gal?

47. To preserve a bacteriological sample, the sample must be cooled to 4°C. What is this expressed in degrees Fahrenheit?

48. What is the turbidity removal efficiency through a water plant if the source water turbidity is 22.6 ntu and the treated water entering the distribution system is 0.040 ntu?

49. A certain pump delivers 23 gallons per minute.
    a. How many lbs of water does the pump deliver in 1 minute?
    b. How many lbs/min will the pump deliver if the liquid weighs 71.9 lbs/ft^3?

50. A 780-milliliter solution contains 1.3 equivalents of a chemical. What is the normality of the solution?

51. What is the specific gravity of an unknown liquid that has a density of 68.4 lb/ft^3?

Answers

1.) 109.4°F
2.) 71.1°C
3.) 14 mg/L
4.) H = 0 mg/L
C = 50 mg/L
B = 71 mg/L
5.) 89.89%
6.) 99.81%
7.) 1.28
8.) 12.76 lb/gal
9.) H = 1 mg/L
C = 22 mg/L
B = 0 mg/L
10.) 1.89
11.) 56.35 mL
12.) PA = 5 mL
TA = 57 mL
13.) 2.0 N
14.) 57.41 lb/ft^3
15.) 20 mg/L
16.) 19.3
17.) 2.0 M
18.) 360,481.28 lb/day
19.) 1.33 N
20.) 76.67°C
21.) 14.97
22.) 68.07 lb/ft^3
23.) 2.06 milliequivalents/L
24.) 1.19
25.) 99.29%
26.) 73.4°F
27.) 1.33
28.) 3.63 M
29.) 62.6°F
30.) H = 0 mg/L
C = 0 mg/L
B = 67 mg/L
31.) 65.45 lb/ft^3
32.) 0.7 mol
33.) H = 1 mg/L
C = 28 mg/L
B = 0 mg/L
34.) 91.67%
35.) 9.51 lb/gal
36.) 69 mg/L
37.) 1.89 mol
38.) A. 168,134.4 lb/day
B. 163,296 lb/day
39.) 95%
40.) 9,617.69 lb
41.) 99.83%
42.) 1.64 N
43.) 23.89°C
44.) 94.97 lb/ft^3
45.) 0.28 M
46.) 1.13
47.) 39.2°F
48.) 99.8%
49.) A. 191.82 lb/min
B. 221.08 lb/min
50.) 1.67 N
51.) 1.10

Section 11

Fluoridation

Fluoridation

Fluoridation

- The process of adding fluoride to drinking water to prevent dental caries in children

Common Name	Chemical Formula	% Purity	Available Fluoride Ion (AFI)
Sodium Fluoride	NaF	98%	45.2%
Sodium Fluorosilicate	Na_2SiF_6	98.5%	60.7%
Fluorsilicic Acid	H_2SiF_6	23%	79.2%

Fluoride Feed Rate

$$Feed\ rate, \frac{lb}{day} = \frac{\left(dose, \frac{mg}{L}\right)(flow, MGD)\left(8.34 \frac{lb}{gal}\right)}{(Available\ fluoride\ ion)(Purity)}$$

- For fluoride saturators

$$Feed\ rate, gpm = \frac{(flow, gpm)\left(dose, \frac{mg}{L}\right)}{18{,}000\ \frac{mg}{L}}$$

Example 1

- A water plant produces 2 MGD. The desired fluoride concentration in the finished water is 1.3 mg/L. If they feed sodium fluorosilicate, what is the feed rate in lb/day? (AFI=60.7%; % purity=98.5%)

$$Feed\ rate, \frac{lb}{day} = \frac{\left(dose, \frac{mg}{L}\right)(flow, MGD)\left(8.34 \frac{lb}{gal}\right)}{(Available\ fluoride\ ion)(Purity)}$$

Example 2

- A saturator is used to fluoridate 180 gpm to achieve a concentration of 0.9 mg/L in the finished water, what would be the feed rate in gpm? (AFI=98%; % purity=45.2%)

$$feed\ rate, gpm = \frac{(flow, gpm)\left(dose, \frac{mg}{L}\right)}{18{,}000\ \frac{mg}{L}}$$

$$flow = \frac{(4000\frac{gal}{min})\left(1440\frac{min}{day}\right)}{1{,}000{,}000\frac{gal}{MG}}$$
$$flow = 5.76\ MGD$$

Example 3

- If a plant's flow rate is 4000 gpm and the dosage needed is 0.8 mg/L, what is the fluoride feed rate (lb/day) when feeding fluorosilicic acid? (AFI=23%; % purity=79.2%)

$$Feed\ rate, \frac{lb}{day} = \frac{\left(dose, \frac{mg}{L}\right)(flow, MGD)\left(8.34\frac{lb}{gal}\right)}{(Available\ fluoride\ ion)(Purity)}$$

Fluoridation

1. A water plant produces 2.88 MGD and the city wants to add 1.1 mg/L of fluoride. If the plant feeds fluorosilicic acid, what would the fluoride feed rate be in lb/day? (% purity = 23%; AFI = 79.2%)

2. If it is known that the plant rate is 2000 gpm and the dosage needed is 0.5 mg/L, what is the fluoride feed rate (lb/day) for 98.5% sodium fluorosilicate? (AFI = 60.7%)

3. A water plant produces 800 gpm and has approximately 0.3 mg/L of natural fluoride. Using a saturator, what would the fluoride feed rate (gpm) need to be to obtain 1.0 mg/L in the water?

Applied Math for Water Treatment
Fluoridation

1. A fluoride dosage of 1.6 mg/L is desired. The flow to be treated is 989,000 gpd. How many lb/day dry sodium silicofluoride (Na_2SiF_6) will be required if the commercial purity of the Na_2SiF_6 is 98% and the percent of fluoride ion in the compound is 60.6%? Assume the raw water contains no fluoride.

2. A plant feeds 1.0 gallons per minute of sodium fluoride from its saturator to treat 20,000 gpm of water. What is the calculated dosage?

3. If it is known that the plant rate is 4,000 gpm and the dosage needed is 0.8 mg/L, what is the fluoride feed rate in lbs/day using fluorosilicic acid?

4. A small water plant has a daily production rate of 180 gpm and the natural fluoride level is 0.1 mg/L. If 1.0 mg/L fluoride is desired in the water, what feed rate in mL/min of sodium fluoride from a saturator must be maintained?

5. A flow of 330,000 gpd is treated with sodium fluoride (NaF) at the rate of 6 lb/day. The commercial purity of the sodium fluoride is 98%, and the fluoride ion content of NaF is 45.25%. Under these conditions, what is the fluoride ion dosage (in mg/L?

6. A plant uses 1.9 gpm of solution from its saturator in treating 36,000 gallons per minute of water. What is the calculated dosage in mg/L?

7. Express a concentration of 27 lb per million gallons as milligrams per liter.

8. A flow of 810,000 gpd is to be treated with sodium fluoride (NaF). The raw water contains 0.08 mg/L fluoride, and the desired fluoride level in the finished water is 1.2 mg/L. What should be the chemical feed rate (in lb/day)? The chemical purity of the sodium fluoride is 98% while the percent fluoride ion in the compound is 45.2%.

9. A desired solution feed rate has been determined to be 80 gpd. What is this feed rate expressed in milliliters per minute?

10. Convert 1.6 mg/L to lb/million gallons.

11. A small water plant uses sodium fluoride from a saturator at a rate of 1.0 gpm and the plant treats 4500 gpm. What is the calculated dosage in mg/L?

12. Convert 28,000 mg/L to percent.

13. A flow of 1,880,000 gpd is to be treated with sodium fluoride (NaF) containing 0.44 lb of fluoride ion. The raw water contains 0.09 mg/L and the desired fluoride level in the finished water is 1.4 mg/L. What should be the chemical feed rate (in lb/day)? The chemical purity of the sodium fluoride is 98% while the percent fluoride ion in the compound is 45.2%.

14. How many lb of sodium fluoride (98% pure) must be added to 600 gallons of water to make a 3% solution of sodium fluoride?

15. A water plant produces 1.0 MGD and has less than 0.1 mg/L of natural fluoride. What would the fluoride feed rate be in gpm to obtain 1.0 mg/L in the water using a fluoride saturator?

16. A flow of 2,880,000 gpd is to be treated with sodium silicofluoride (Na_2SiF_6). The raw water contains no fluoride. If the desired fluoride concentration in the water is 1.4 mg/L, what should be the chemical feed rate (in lb/day)? The manufacturer's data indicate that each lb of Na_2SiF_6 contains 0.8 lb of fluoride ion. Assume the raw water contains no fluoride. The chemical purity of the sodium fluoride is 98.5% while the percent fluoride ion in the compound is 60.7%.

17. Express a concentration of 25 lb/million gallons as milligrams per liter.

18. Convert 6600 mg/L to percent.

19. Express 2.6% concentration in terms of milligrams per liter concentration.

20. A flow of 3.08 MGD is to be treated with sodium fluoride (NaF). The raw water contains no fluoride, and the desired fluoride concentration in the finished water is 1.1 mg/L. What should be the chemical feed rate (in lb/day)? The chemical purity of the sodium fluoride is 98% while the percent fluoride ion in the compound is 45.2%.

21. A flow of 2.88 MGD is to be treated with a 20% solution of hydrofluosilicic acid. The raw water contains no fluoride, and the desired fluoride concentration is 1.1 mg/L. The acid weighs 9.8 lb/gal. What should be the solution feed rate (in milliliters per minute)? The percent fluoride content of acid is 80%.

22. Express a concentration of 22 lb/million gallons as milligrams per liter.

23. Express 29% concentration in terms of milligrams per liter.

24. A fluoride dosage of 1.5 mg/L is desired. How many lb/day of 98% pure dry sodium fluoride (NaF) will be required if the flow to be treated is 2.45 MGD? The percent fluoride ion in NaF is 45.25%.

25. Calculate the feed rate for fluorosilicic acid in mL/min give the following data:
    Flow rate is 53.5 MGD — Treated with 24% solution of H_2SiF_6
    Fluoride desired is 1.1 mg/L — Fluoride ion percent is 79.1%
    Fluoride in raw water is 0.15 mg/L — H_2SiF_6 weighs 9.86 lb/gal

26. Calculate the feed rate for fluorosilicic acid in gallons per day given the following information:
    Flow rate is 43.5 MGD — Treated with 21% solution of H_2SiF_6
    Fluoride desired is 1.0 mg/L — Fluoride ion percent is 79%
    Fluoride in raw water is 0.30 mg/L — H_2SiF_6 weighs 9.83 lb/gal

27. A fluoride dose of 1.20 mg/L is needed to treat a flow of 2,850 gpm. How many pounds per day of sodium fluorosilicate (Na2SiF6) with a commercial purity of 98% and a fluoride ion content of 60.6% will be required? The water being treated contains 0.12 mg/L fluoride.

28. A fluoride dose of 1.0 mg/L is used to treat a flow of 7 MGD. How many pounds per day of sodium silicofluoride with a commercial purity of 98% and a fluoride ion content of 60.6% are needed? The water being treated contains 0.15 mg/L fluoride.

29. A fluoride dose of 1.10 mg/L is needed to treat a flow of 2,800 gpm. How many pounds per day of sodium fluorosilicate with a commercial purity of 98% and a fluoride ion content of 60.6% are needed? The water being treated contains 0.37 mg/L fluoride.

Answers

1. 22.22 lb/day
2. 0.9 mg/L
3. 211.12 lb/day
4. 34.11 mL/min
5. 0.97 mg/L
6. 0.95 mg/L
7. 3.24 mg/L
8. 17.08 lb/day
9. 210.56 mL/min
10. 13.36 lb/MG
11. 4.0 mg/L
12. 2.8%
13. 46.37 lb/day
14. 153.18 lb
15. 55.52 gal/day
16. 56.24 lb/day
17. 2.99 mg/L
18. 0.66%
19. 26,000 mg/L
20. 63.79 lb/day
21. 44.35 mL/min
22. 2.64 mg/L
23. 290,000 mg/L
24. 69.11 lb/day
25. 595.23 mL/min
26. 155.72 gpd
27. 62.24 lb/day
28. 83.56 lb/day
29. 41.33 lb/day

Section 12

Miscellaneous

Miscellaneous

Water Use,

- The average amount of water each person in a particular area uses on a daily basis

$$Water\ use, gpcd = \frac{volume\ of\ water\ produced, gpd}{population}$$

Example 1

- A water utility is expanding their treatment plant. They want to be able to supply 21 MGD to 125,000 persons. What would be the gallons/capita/day?

$$gpcd = \frac{volume\ of\ water\ produced, gpd}{population}$$

Averages

- By calculating averages, a group of data is represented by a single number

$$Average\ (arithmetic\ mean) = \frac{Sum\ of\ all\ measurements}{Number\ of\ measurements\ used}$$

Example 2

- What is the average temperature for a week given the following data:

$$72°\text{F}, 70°\text{F}, 79°\text{F}, 80°\text{F}, 77°\text{F}, 77°\text{F}, 73°\text{F}$$

$$Mean = \frac{Sum\ of\ all\ measurements}{Number\ of\ measurements\ used}$$

Geometric Mean

- Indicates the central tendency or typical value of a set of numbers by using the product of their values
- The n^{th} root of the product of n numbers

$$[(X_1)(X_2)(X_3)(X_4)(X_n)]^{1/n}$$

$$or$$

$$\sqrt[n]{(X_1)(X_2)(X_3)(X_4)(X_n)}$$

- When calculating geometric mean, any value of **0** will be put into the equation as a **1**

Geometric Mean

$$60 \quad 100 \quad 0 \quad 0$$

$$Geometric\ Mean = [(X_1)(X_2)(X_3) \ldots (X_n)]^{1/n}$$

- Step 1: 1/n
  - 1 divided by the number of test results. For our example above, there are four test results.
  - $1 \div 4 = 0.25$ (write this number down, you will use it in Step 3)
- Step 2: Multiply all of the test results together and punch the = button on the calculator. Remember to count 0 as a 1.
  - $60\ x\ 100\ x\ 1\ x\ 1 = 6000$ (Do Not clear out your calculator)
- Step 3: Input into calculator

$$6000^{0.25} = 8.8011$$

Example 3

- Calculate the geometric mean for the following fecal coliform test results: 60, 100, 0, 0, 40, 20, 20, 45, 55, 60, 20, 20

$$[(X_1)(X_2)(X_3)(X_4)(X_n)]^{1/n}$$

Step 1

$$^1/_{12} = 0.08333$$

Step 2

$$(60)(100)(1)(1)(40)(20)(20)(45)(55)(60)(20)(20) = 5{,}702{,}400{,}000{,}000{,}000$$

Step 3

$$5{,}702{,}400{,}000{,}000{,}000^{\ 0.08333}$$

$$20.3$$

Leakage

- To determine the amount of water lost due to a leak

$$leakage, gpd = \frac{volume, gal}{time, days}$$

Example 4

- A water leak is found in a pipe gallery. It is estimated that approximately 3,000 gallons was lost over a day and a half. What is the leakage in gallons per day?

$$leakage, gpd = \frac{volume, gal}{time, days}$$

Slope

- The **slope** is a measure of the steepness of a line, or a section of a line, connecting two points

$$slope, \% = \frac{elevation\ change}{distance} \times 100$$

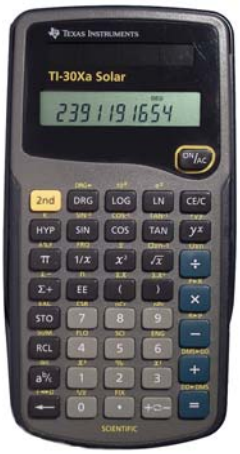
Example 5

- Determine the slope between two meters that are 500 feet apart if the elevation of the first meter is 45 ft and the elevation of the second meter is 79 ft.

$$slope, \% = \frac{drop\ or\ rise}{distance} \times 100$$

Applied Math for Wastewater Treatment
Geometric Mean

Geometric Mean Using a Texas Instrument TI-30Xa



Example:
60 100 0 0

Geometric Mean – $(X_1)(X_2)(X_3)...(X_n)^{1/n}$

Step 1: 1/n → 1 divided by the number of test results. For our example above, there are four test results.

- 1 ÷ 4 = 0.25 (write this number down, you will use it in Step 3)

Step 2: Multiply all of the test results together and punch the = button on the calculator. Remember to count 0 as a 1.

- 60 x 100 x 1 x 1 = 6000 (Do Not clear out your calculator)

Step 3: Punch the y^x button and then type in the number from Step 1, then punch =.

- 6000 y^x 0.25 = 8.8011

Geometric Mean Using a Texas Instrument TI-30XIIB

Example:
60 100 0 0

Geometric Mean – $(X_1)(X_2)(X_3)...(X_n)^{1/n}$

Step 1: 1/n → 1 divided by the number of test results. For our example above, there are four test results.

- 1 ÷ 4 = 0.25 (write this number down, you will use it in Step 3)

Step 2: Multiply all of the test results together and punch the = button on the calculator. Remember to count 0 as a 1.

- 60 x 100 x 1 x 1 = 6000 (Do Not clear out your calculator)

Step 3: Punch the ^ button, then type in the number from Step 1, & then punch =.

- 6000 y^x 0.25 = 8.8011

Miscellaneous

1. A water system wants to expand their treatment plant. The new facility will be able to support 500,000 persons with 96.5 MGD. What is the amount of water used in gallons per capita per day?

2. A 36 inch water main has a leak of 32,000 gallons. It takes 4 days to find and repair the leak. How many gallons per day did the line leak?

3. Two hydrants are located 750 feet apart. The elevation of the first hydrant is 157 ft and the second hydrant is 103 ft. What is the slope of the line between the two gauges?

4. Two hydrants are 1250 feet apart. To determine the slope between the lines, pitot gauges are installed on each hydrant. The pressure reading at the first hydrant is 75 psi while the pressure reading at the second hydrant is 64 psi. What is the calculated slope between the two hydrants?

Applied Math for Water Treatment
Miscellaneous

1. What is the average in pounds per day for chlorine used given the following data?

Mon	Tue	Wed	Thur	Fri	Sat	Sun
74	78	81	84	77	73	70

2. Determine the geometric mean for the following samples:

   Sample #1 = 45.0 mg/L
   Sample #2 = 61.0 mg/L
   Sample #3 = 98.0 mg/L
   Sample #4 = 150.0 mg/L

3. If a water treatment plant treats 15 MGD, and serves 150,900 persons, what are the gallons per capita per day?

4. A 45 ft diameter storage tank loses 15 psi of pressure due to a leak over a 24 hour period. What is the leakage rate in gpd?

5. Determine the slope for a pipe if the upstream pressure gauge reads 154 psig and the downstream pressure reads 149 psi. The two gauges are 3,820 ft apart.

6. Pressure readings on a main are measured at 2 hydrants separated by 750 feet. The pressure reading at hydrant #1 is 92 psi and the pressure reading at hydrant #2 is 75 psi. What is the slope of the main?

7. What is the leakage rate in gpd for a 48 inch main that ruptures? It is determined that in 6 hours the break emptied a storage tank that is 30 feet in diameter and contained water 17 feet deep.

8. The following flows were recorded for the week: 8.6 MGD, 7.6 MGD, 7.2 MGD, 7.8 MGD, 8.4 MGD, 8.6 MGD, 7.5 MGD. What was the average daily flow for the week?

9. Determine the geometric mean for the following samples:
   Sample #1 = 20.0 mg/L
   Sample #2 = 20.0 mg/L
   Sample #3 = 210.0 mg/L
   Sample #4 = 3,500.0 mg/L

10. Two hydrants are 750 ft apart. Hydrant 1 is located at an elevation of 129 feet. Hydrant 2 is located at an elevation 157 feet apart. What is the slope?

11. The pressure reading of a pitot gauge at an elevation of 231 feet is 45 psi. The pressure reading of another pitot gauge 2500 feet away is 69 psi at an elevation of 200 ft. What is the slope?

12. A 0.5 million gallon storage tank leaks 200 gallons over a 24 hour period. What is leakage rate in gpd?

13. A water plant serves 59,400 people. If it treats a yearly average of 7.82 MGD, what are the gallons per capita per day?

14. A water system has four storage tanks. Three of them have a capacity of 100,000 gallons (gal) each, while the fourth has a capacity of 1 million gallons. What is the mean capacity of the storage tanks?

15. The friction loss in a 10-inch pipe flowing at 1,400 gpm is 18.7 feet of head per 1,000 feet. At the storage tank, the pressure is 85 psi with the water flowing at 1,400 gpm. What will the pressure be 1/2 mile from the tank?

Answers

1. 76.71 lb/day
2. 79.7 mg/L
3. 99.4 gal/capita/day
4. 412,002.19 gal/day
5. 0.30%
6. 5.24 %
7. 359,354.16 gal/day
8. 7.96 MGD
9. 130.94 mg/L
10. 3.73%
11. 3.5%
12. 200 gal/day
13. 131.65 gal/cap/day
14. 325,000 gal
15. 63.62 psi